New oxygen producing mechanism proposed

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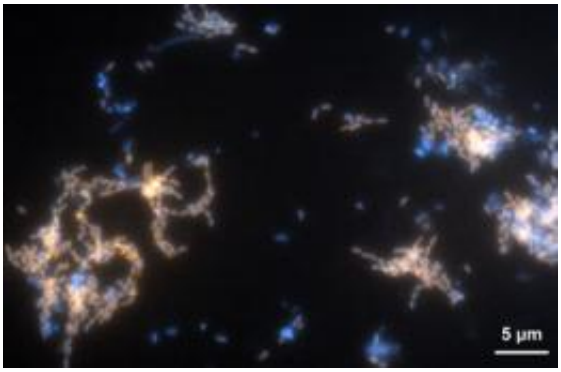

Microscopic image of Methylomirabilis oxyfera under fluorescent light. Image: Max Planck Institute for Marine Microbiology

(PhysOrg.com) -- Photosynthesis is the mechanism by which plants generate oxygen, but new research on a novel type of anaerobic bacteria supports the theory that bacteria produced their own oxygen long before the evolution of photosynthesis.

The research team of Dutch researchers and the University of Queensland's Dr Margaret Butler, working in The Netherlands at the Radboud University in Nijmegen, have found a microbe that makes oxygen within itself, which is only the fourth mechanism known by which oxygen is produced on Earth. The others are photosynthesis, which releases oxygen as a waste product, cellular generation of oxygen by bacteria from chlorates and enzymatic conversion of reactive oxygen substances.

The subject of the study, a microbe (provisionally dubbed *Methylomirabilis oxyfera*) collected from oxygen-starved sediments in drainage ditches and canals in the Netherlands, is one of the so-called NC10 bacteria, first found in the caves under the Nullarbor Plain in Australia. It was thought to be able to convert methane and nitrite to carbon dioxide, so the researchers carried out experiments that traced labeled nitrogen and oxygen going into and leaving a chamber containing the microbes.

The team found the bacteria could consume methane and were producing oxygen by a previously unknown biochemical process. In the presence of nitrates there was no consumption of methane, but when nitrites were added, the bacteria consumed methane and released nitrogen. The microbiologists proposed the bacteria produce nitrogen and oxygen from two molecules of nitric oxide, which in turn is produced from the nitrites. The oxygen would then be used to burn the methane for energy, with the nitrogen released as a waste product. The enzyme or enzymes used in the process are so far unknown.

The researchers were unable to grow a pure culture of NC10 bacteria (as is often the case for environmental bacteria), so they grew them in a bioreactor with other microbes, and later reconstructed it from the DNA they extracted from the mixture.

The team sequenced the full genome of the proposed new bacteria and also studied the proteins it was producing. Their analysis of the most highly expressed proteins and the genes sequences led to the suggestion an enzyme was producing the oxygen, although they were not able to identify it. One of the team, Katharina Ettwig, said the cells “make hundreds of unknown proteins, and all of them are candidates.” Some of the genetic sequences suggest the bacteria share metabolic pathways seen in other bacteria, including those consuming methane in oxygen-rich environments.

In the paper published in the journal *Nature*, Dr Butler said the results tell us that bacteria might have been producing and using oxygen in this novel way when the early Earth's atmosphere was rich in methane but low in oxygen, and the findings may also be relevant to the study of methane cycles on Earth. The proposed oxygen producing pathway might also allow life to exist in high methane/low (or no) oxygen atmospheres, such as those found on planets and moons in the outer solar system.

More information: Ettwig, K. F. et al. *Nature* 464, 543-548 (2010). dx.doi.org/10.1038/nature08883