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Press Release

Microbes use tiny magnets as batteries

Tübingen geomicrobiologists show that bacteria can use natural magnets found in soils and sediments as batteries

Tübingen, 27 March 2015

Microorganisms have long demonstrated a remarkable ability to adapt and survive in different environments by taking advantage of the materials around them. Some bacteria are even known to use iron for energy generation in nature. Now researchers from the University of Tübingen have shown that many of these microbes can use tiny magnets (magnetite nanoparticles that occur in many soils and sediments) in order to share electrons in the same way that we might use a re-chargeable battery, i.e. for energy storage and use.

Iron is usually only thought to be available as an electron source to microbes as dissolved Fe(II) ions, or as an electron sink in form of poorly crystalline Fe(III) oxides. Fe(II)-oxidizing bacteria have been shown to extract electrons from the dissolved Fe(II) to form orange Fe(III) minerals (i.e. rust). Other bacteria known as Fe(III)-reducers can reverse this process and transfer electrons to Fe minerals but only when the Fe(III) is poorly crystalline. The new results presented here show that to some organisms the iron is also available as an electron source and sink when it is present in a crystalline magnetic mineral (magnetite), which is present in many different environments on Earth and even on Mars.

In a study published in *Science,* researchers from the University of Tübingen, Dr. James Byrne, Dr. Nicole Klueglein, Prof. Erwin Appel and Prof. Andreas Kappler, together with Carolyn Pearce (University of Manchester, UK) and Kevin Rosso (Pacific Northwest National Laboratory, USA), incubated bacteria with magnetite and controlled the amount of light the cultures were exposed to. Using magnetic, chemical and mineralogical analytical methods, the team showed that in light conditions which replicated the day-time, phototrophic iron-oxidizing bacteria removed electrons from the magnetite, thereby discharging it. During the night-time conditions, the iron-reducing bacteria took over and were able to dump electrons back onto the magnetite and recharge it for the following cycle.

This oxidation/reduction mechanism was repeated over several cycles, meaning that the battery was used over repeated day-night cycles. Whilst the focus here has been on iron-metabolizing bacteria, it is thought that in the environment the potential for magnetite to act as a battery could extend to many other types of bacteria which do not normally require iron to grow, e.g. fermenters.

Publication:

Byrne J. M., Klueglein N., Pearce C., Rosso K., Appel E., Kappler A. (2015) Redox cycling of Fe(II) and Fe(III) in magnetite by Fe-metabolizing Bacteria. *Science*, in press.

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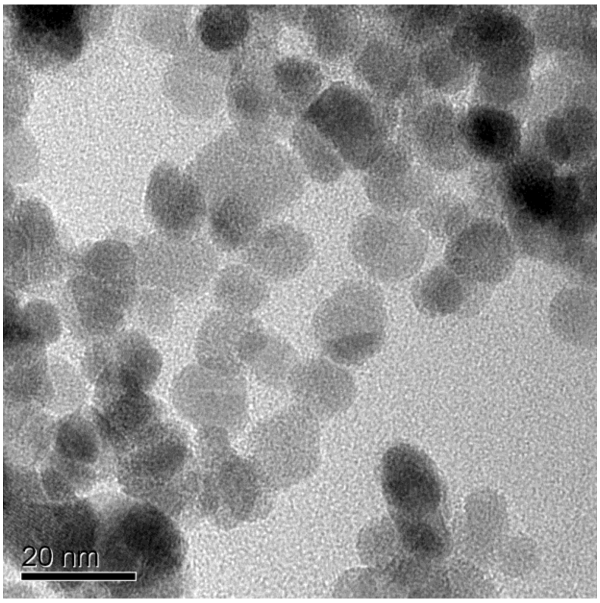
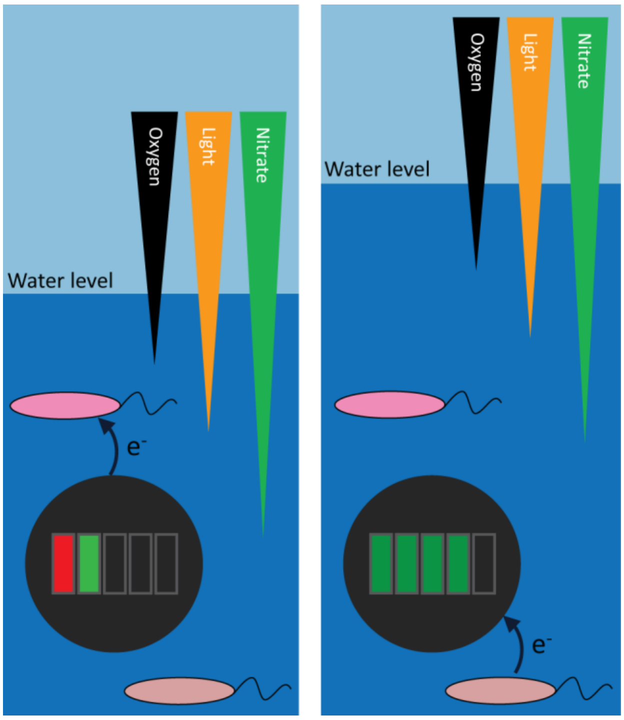
http://www.geo.uni-tuebingen.de/en/work-groups/applied-geosciences/institut/geomicrobiology/geomicrobiology/research.html

Images:



Magnetite Nanoparticles that can function as tiny batteries for iron(II)-oxidizing and iron(III)-reducing bacteria; electron micrograph taken by Dr. James Byrne

The phototrophic Fe(II)-oxidizing bacterium *Rhodopseudomonas palustris* TIE-1 with magnetite nanoparticles (sticking to a magnet at the right side of the bottle);photo taken by Dr. James Byrne



The Fe(II)-oxidizing bacteria remove electrons from the magnetite battery (discharging, left) whereas the Fe(III)-reducing bacteria deposit electrons onto the magnetite battery (re-charging, right side).