THE Ames Laboratory
Creating Materials & Energy Solutions

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Designing with DNA

Researchers use nature as their guide to produce tiny magnets

Living organisms create all manner of unusual substances, from the silk produced by silk worms to the paper made by wasps. But certain types of bacteria create some of the most extraordinary substances of all: nano magnets.

We use the term nano to describe these magnets because they're so small you could place one hundred million or more of them end to end, and they'd stretch out less than a meter.

Now scientists at the U.S. Department of Energy's Ames Laboratory are applying genetic engineering to imitate how bacteria create nano magnets. The synthetic magnets the researchers are making could be used in fields such as medicine and electronics.

Bacteria are tiny one-celled organisms that thrive just about everywhere in our world. The special types of bacteria that grow nano magnets inside their cell walls are known as magnetotactic bacteria. The type of magnet these bacteria create is called magnetite, and it consists of the elements iron and oxygen.

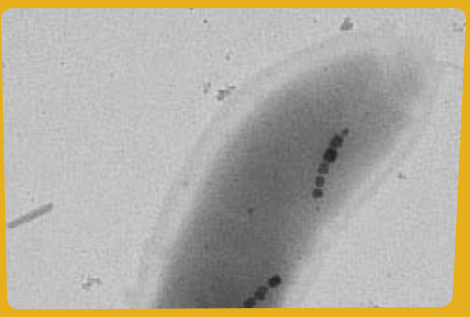
While no one knows exactly why magnetotactic bacteria create magnetite, it is known that in marine environments, these organisms can be found in areas between water that contains oxygen and water that lacks oxygen. This unique domain may be what prompts the bacteria to absorb thousands of times more iron than other bacterial strains. Some believe the tiny magnets produced by magnetotactic bacteria help the organisms locate areas that contain more oxygen, which they require in order to breath.

Nano magnets made in the lab

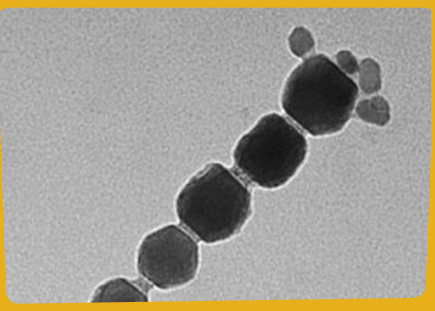
Before they embarked on their research, the Ames Laboratory researchers already knew that tiny magnets, similar to those the bacteria produced, could have a variety of uses.

They could be included in extremely small motors, for example, or in medicines able to be guided to a diseased part of the body, simply by leading them along with magnets. Still another valuable use for nano magnets might be as a new way to store lots more information on computers.

Unfortunately, creating useful nano magnets in the lab has proven difficult. The researchers hoped that by using the tools of biotechnology, they would be able to make magnets more easily and that the end product would be better suited for use in products someday.



Some tiny bacteria can create magnets naturally. The magnets appear as black dots in this magnified image. Using DNA material from the bacteria, scientists at the Ames Laboratory have created similar magnets on their own.



Ames Lab scientists were able to extract this microscopic-sized chain of natural magnets from a bacterial organism. One day, doctors may use magnets like these to deliver drugs to the exact area of the body where they're needed.

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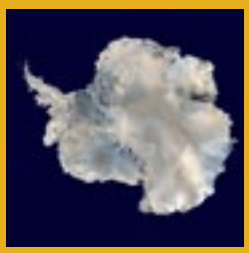
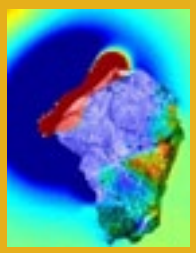
Tiny crystals (below, right), discovered inside a meteorite from Mars that crashed into Antarctica 4.5 billion years ago, are identical to those found in magnet-producing bacteria here on earth, leading some scientists to conclude that life once existed on the Red Planet.





DID MAGNET-PRODUCING BACTERIA ONCE EXIST ON MARS?

Magnetotactic bacteria and their ability to produce magnets have long intrigued scientists. The organisms have even flown aboard the Space Shuttle so researchers could study how they reacted to the earth's magnetic field when in orbit. But some of the most intriguing work in the area of magnetotactic bacteria took place in the late '90s.

That's when Dennis Bazylinski, one of the Ames Lab team members involved in synthesizing biomagnets, studied tiny magnetite crystals — so-called magnetofossils — embedded in a 4.5-billion-year-old meteorite uncovered in Antarctica in 1984. Further research revealed the meteorite was from Mars.

Most astonishing of all, the research team determined that many of the crystals found in the meteorite were identical to those produced on earth by a particular strain of magnetotactic bacteria. No other known natural process is thought to be capable of producing crystals of the type made by these bacteria.

While not everyone agrees that the crystals found in the Martian meteorite were created by bacteria from Mars, the crystals studied by Bazylinski and his team just might be evidence of life elsewhere in our solar system.

As a first step toward creating artificial magnets, the researchers decided to add another element to the iron oxide the bacteria produced on their own. The element they decided to add was cobalt, which would make the magnet more powerful.

Next, the Ames Lab scientists analyzed the magnetotactic bacteria's DNA. They were looking for proteins, which are special molecules found in all living organisms. The researchers especially wanted to find proteins that could attach themselves to iron.

One protein known as Mms6 neatly fit the bill. The researchers used the bacteria's DNA to clone – or make numerous copies of – the Mms6 protein. The protein molecule's structure acted like a mold that enabled the new magnet, consisting of cobalt, iron, and oxygen, to form.

By adding cobalt to magnets, the Ames Laboratory scientists proved they could make new materials from bacteria DNA. Their work isn't done, however.

Many other elements might be added to the magnets, creating other materials that will be useful in as yet unimagined ways. In the years ahead, we'll likely see hundreds of new products made possible by this early research at the Ames Laboratory.