NEUROBIOLOGY

# Giving Personal Magnetism a Whole New Meaning

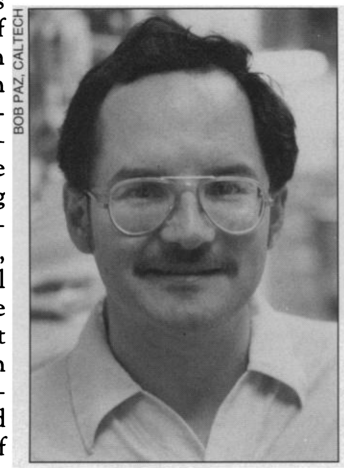
Tiny Magnets Found in Human Brain!! May Cause Cancer!! That may sound like a headline from the checkout counter of your local supermarket, but in fact it's not as far-fetched as it seems. Earlier this week Caltech geobiologist Joseph Kirschvink and his colleagues Atsuko Kobayashi-Kirschvink and Barbara Woodford announced they had found crystals of the mineral magnetite in human brain tissue. Their results are in press, not in the *National Enquirer*, but in the *Proceedings of the National Academy of Sciences*.

Kirschvink vigorously plays down the cancer connection, but he does concede that the presence of magnetite in the human brain could shed some new light on the highly controversial question of whether weak electromagnetic fields might have biological effects, including cancer. There are other implications for the work as well, and they are far from usual tabloid fare: the magnetite may help explain aberrant dark spots that show up in some magnetic resonance images of human brains. And then there is the matter of function—the magnetite could be merely a means of storing iron, or part of a magnetic sensing system, as it is thought to be in other organisms where magnetite has been found. Although the paper might have a bearing on these issues, its relationship to them is speculative at best, according to every researcher who spoke to *Science* about the finding. "People are saying, 'That's interesting, but what does it mean?' " says William Wisecup, executive director of the Bioelectromagnetic Society.

Kirschvink says it was the magnetic resonance imaging (MRI) results that inspired him to look for magnetite in human brains. "I did a back-of-the-envelope calculation," he says, and concluded that "the only way you [could see such spots] is with magnetite." Unlike some people who scribble on envelopes, Kirschvink was well positioned to check out his hunch. His group has led the way in searching for magnetite in animals, and has developed ways of preparing tissue without contaminating it with iron fragments from surgical tools or magnetic dust particles—problems that have plagued past studies. His group had also found a means to fish the tiny magnetic crystals out of homogenized brain tissue and examine them under the electron microscope.

When the researchers applied this method to human brain tissue, they found magnetite crystals of a size and shape that suggest they are not contaminants but are formed by a biological process, says Richard Frankel, a physicist who studies magnetite-containing bacteria at California Polytechnic University in San Luis Obispo and has seen the Caltech samples.

If these particles are indeed part of the normal brain, then Kirschvink will have plunged smack into three controversial areas. The first concerns whether weak electromagnetic fields (EMFs) from power lines or appliances are capable of having biological effects on humans. Controversial epidemiological studies have suggested that exposure to EMFs is linked to some cancers, including leukemia and primary brain cancer (*Science*, 7 September 1990, p.1096; and 21 September 1990, p. 1378). Biologists have also found that the fields have effects on mammalian cells in culture. But skeptics argue that there is no known mechanism that could link the EMFs and the observed effects.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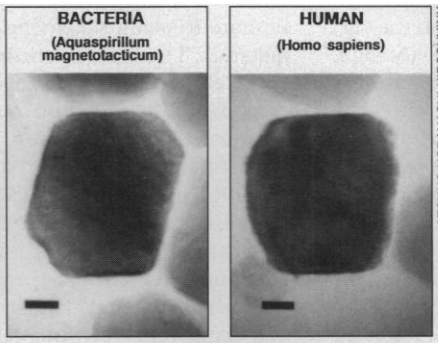

ATSUKO KOBAYASHI-KIRSCHVINK

**Iron man.** Joseph Kirschvink of Caltech has found crystals of magnetite in the human brain that closely resemble those found in certain bacteria. The scale bars on both figures are 10 nanometers long.

The magnetite finding—if it's confirmed— could change those views. "Physicists have gone along for years assuming there is nothing ferromagnetic in humans," Kirschvink says. If there is nothing magnetic in a tissue, then the only way the fields could affect it is by inducing very weak electrical fields inside the cells. But if the brain or other tissues (which Kirschvink has not yet examined) contain magnetite, it could interact directly with weak magnetic fields, possibly making the tissues more responsive to EMFs.

"With magnetite there, you can detect a field smaller than without magnetite there," says Dean Astumian, a biophysicist at the National Institute of Standards and Technology who has been studying the potential for EMFs to cause biological effects. But, Astumian says, that doesn't answer the main question that the skeptics raise: whether the weak magnetic or electrical signal will be swamped by background "noise" in the cell. New background calculations must be done, he says, before that question can be answered.

While the presence of magnetite in the brain may not solve the EMF-cancer link, it may nevertheless help researchers understand another puzzle—the dark patches that appear in certain MRI images of brains and are apparently caused by the presence of iron. Seymour Koenig, a biophysicist at the IBM Watson Research Center who studies the molecular mechanisms underlying MRI contrast, says Kirschvink is right in his conclusion that it must be iron in magnetic form that causes the spots. Koening and colleagues have shown that the iron-storage protein, ferritin, contains enough magnetic iron to "totally explain the quantitative results seen in imaging," but they hadn't identified the magnetic material in the ferritin. Some of the magnetite found by Kirschvink's group may be from the ferritin, Koenig says.

If magnetite does exist in the human brain, it isn't there to cause cancer or put dark spots on MRI images. What is it doing? In magnetite-containing bacteria, the answer is simple: Magnetite crystals turn the bacteria into swimming compass needles that orient with respect to the earth's magnetic field. Magnetite has also been found in animals that navigate by compass direction, such as bees, birds, and fish. But how—and even whether—magnetite is involved remains a mystery, since no one has yet found neurons that contain or interact with magnetite.

In the magnetite-containing tissues of birds, bees, and fish, the concentration of the mineral is a few orders of magnitude higher than it is in the human brain. Kirschvink suggests that while the magnetically well-endowed animals may turn out to use magnetite as a navigational aid, for humans it may just be a vestigial remnant from our migratory ancestors, or merely a way for cells to store excess iron. After all, humans certainly aren't known for their capacity to navigate by sense alone, and experiments suggesting any talent in that arena have been unpromising and unrepeatable. So, in this area, as in the others, certainty remains elusive. "We don't know why [the magnetite] is there," he says. "All we know is that it is there."

–**Marcia Barinaga**