Lodestone compass inside bacteria

Some bacteria swim toward light, others swim toward food and an increasing number are being found that swim toward the north. Experiments with magnets show that those bacteria are able to orient in a magnetic field as weak as that of the earth. So far such "magnetotactic" bacteria have been found in both fresh and salt water and in as diverse places as the Baltic Sea, San Francisco Bay, and a Cape Cod swamp, Richard B. Frankel of Massachusetts Institute of Technology told reporters at the Washington meeting of the American Physical Society.

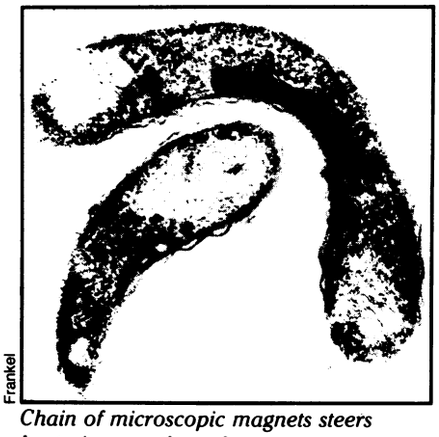
New information on how the bacteria steer their course has resulted from the recent ability to provide one species with a laboratory home. Richard P. Blakemore, now at the University of New Hampshire, and Ralph S. Wolfe at the University of Illinois grew a freshwater species of magnetotactic spirillum in a solution of known chemicals, rather than in the natural bog water, swamp sediment environment.

Frankel, Blakemore and Wolfe found that each bacterium contains a chain of cubic crystals, 22 on the average. Each crystal is approximately 500 angstroms on a side. The scientists reported in the March 30 SCIENCE that spectroscopic technique shows the iron in the magnetotactic bacteria is mostly Fe_3O_4, which is called magnetite or lodestone. That mineral was used by ancient mariners in the earliest compasses, so Frankel finds its identification in bacteria particularly satisfying.

Several lines of evidence indicate that magnetite is really an internal compass. For example, after growing magnetotactic bacteria for several generations in an iron-deficient medium, the scientists find bacteria that do not orient in a magnetic field. Those bacteria lack the internal magnetite particles. In addition, if a strong applied magnetic field changes the polarity of the internal magnets, the bacteria thereafter swim south instead of north. "There is sufficient, but not excessive magnetite present to orient a bacterium in the earth's magnetic field, overcoming Brownian motion." Frankel calculates.

The particular size of the magnetite particles is crucial to magnetic action, Frankel explains. In smaller crystals, thermal energy reorients the molecules and the magnetic property is lost. In a larger crystal, different magnetic regions point in different directions, canceling the overall magnetic moment. "Thus the bacteria have solved an interesting problem in physics by producing particles of magnetite just the right size for a compass," Frankel says.

The chemically defined surroundings of the bacteria allowed the scientists to determine that the bacteria make magnetite from iron compounds in the media. Although magnetic bacteria have not yet been observed in the act of cell division, the scientists hypothesize that half the magnetite chain is allotted to each daughter cell, maintaining the magnetic orientation. The scientists are interested in determining how the daughter cells accumulate iron, convert it to magnetite and limit the size of the particles they add to the inherited chain.



Frankel

Chain of microscopic magnets steers bacterium northward.

"If you are a bacteria, why would you want a compass?" Frankel asks. He suggests the compass is used to locate the vertical direction. At Woods Hole, Mass., where the spirillum was found, north is also down; that is, the vertical component of the earth's magnetic field is greater than the horizontal component. The bacteria may use the up-down orientation to find their way home to the sediment or to find the water depth with the preferred amount of oxygen.

The proposed significance of the bacterial compass predicts that there should be no magnetotactic bacteria near the equator, where the earth's magnetic field is horizontal. Also any magnetotactic bacteria in the southern hemisphere may have their magnets aligned to orient south instead of north. So far no such bacteria have been found near or south of the equator.

Frankel suggests diverse implications of the findings. For instance, ancient bacteria may be partly responsible for the magnetic properties of some sedimentary rocks. Industrial scientists who need to produce tiny magnets might eventually learn from, or even use, bacteria. Frankel suggests that microscopic magnets might be useful in electronic miniaturization, or perhaps to target medications to a body region.

Bacteria are not the only example in biology of orientation by magnetic field. Behavioral research has indicated that pigeons and bees can use the earth's magnetic field for directional clues. Recently magnetite has been detected by other researchers in bee abdomens and pigeon heads. So magnetite may also act, in a more complex way, as an internal magnet in some higher organisms. □

NIH may take lead in radiation research

Attitudes appear to be changing within the federal government as to whether the public has been protected adequately from unnecessary exposures to ionizing radiation and as to whether current institutional arrangements are adequate to ensure a conscientious probing into the biological effects of radiation.

For example, a draft report issued last week by the Interagency Task Force on Ionizing Radiation (SN: 3/10/79, p. 151) — representing seven federal agencies — recommended that that National Institutes of Health, not the Department of Energy, be given the lead in researching health effects of radiation. It also suggested formation of several new agencies to coordinate and oversee radiation research and protection. Meanwhile, congressional hearings (in Las Vegas this week and in Salt Lake City last week) have been probing into whether the federal government acted responsibly in its efforts to safeguard the health and property of civilians exposed to fallout from atomic-bomb tests.

Through the years, DOE and its predecessor agencies (the Energy Research and Development Administration and the Atomic Energy Commission) became the major sponsors of research to determine the health risks of nuclear technologies and operations. In fiscal year 1978, for example, 60 percent of the $76.5 million spent by the government to study biological effects of radiation came from DOE.

But in recent years, the public and Congress alike have voiced fears that this arrangement poses a potentially dangerous conflict of interest. To allay this concern, the report recommends turning over the lead in responsibility for coordinating radiation health-effects research to an agency specializing in health research, namely NIH. The report also proposes setting up an interagency radiation-research committee to be chaired by NIH.

Including representatives of all major research, regulatory and user agencies, it would coordinate the government research program, set research goals and priorities, recommend the most appropriate agency to carry out or support certain programs, ensure that needs of regulatory agencies are given high priority and tackled "in a timely manner," and avoid unnecessary duplication of effort. This group would also set criteria for managing and reviewing the quality of research programs and ensure that results are promptly published in scientifc journals.

The interagency report makes similar recommendations for regulation of radiation protection. Regulations on radiation have been fragmented within so many agencies that "jurisdictional conflict" and "a blurring of lines of responsibility" have

resulted — as evidenced recently in the area of environmental monitoring at the Three Mile Island nuclear plant. The report recommends creation of a committee representing affected agencies, and perhaps the public, to coordinate action and set standards. It suggests placing an agency with primary enforcement responsibility — perhaps the Environmental Protection Agency — at its head. This report, part of a series, was drawn up at President Jimmy Carter's behest last year.

Recently declassified documents, made public at congressional hearings last week, demonstrate just the sort of conflict-of-interest that the interagency task force seeks to rout out. Under the joint aegis of Edward Kennedy's (D-Mass.) Senate subcommittee on Health and Robert Eckhardt's (D-Tex.) House subcommittee on oversight and investigations, researchers have waded through files of the AEC and Department of Health, Education and Welfare. Records show that during the 1950s, studies about health hazards from bomb fallout and the concerns of some AEC officials were ignored by AEC commissioners for fear that any adverse publicity their attention might bring could slow the U.S. weapons-testing program or even close the Nevada test site.

Under President Eisenhower's advice, the agency was told to "keep [the public] confused about 'fission' and 'fusion'" to defuse local concern about whether the unexplained deaths of livestock might be due to fallout. What's more, a press release issued by the AEC about the death of sheep in Utah falsely claimed that the Public Health Service concurred with AEC officials that fallout could not be blamed, according to testimony and records furnished by HEW's general counsel, F. Peter Libassi and by Donald Frederickson, NIH's director.

One nuclear test dumped fallout on St. George, Utah, exposing residents to 6,000 millirems. Although the AEC's own permissible-exposure limit for a 13-week period at that time was 3,900 mR, it repeatedly assured residents that exposure levels they received were too low to be harmful. Recent tests now indicate the incidence of leukemia among children growing up there during the 1950s was twice that for children born earlier or later. Memos documenting similar examples fill the files. Not coincidently, more than 500 lawsuits have been filed against DOE by cancer victims or their heirs asking compensation for fallout-related cancer.

And the Washington Post reported last week that it had obtained agency documents showing that the AEC deliberately discredited a study by Edward S. Weiss in 1965 that had showed a fallout-leukemia link after meeting with the White House and Public Health Service to discuss the government's potential liability. The article, which had been submitted for publication, was withdrawn and never published, the Post says. □

International views on quake prediction

It's a tricky problem, earthquake prediction; tricky from two standpoints — scientific and public policy. So, when more than 200 delegates from 42 countries attended the recent International Symposium on Earthquake Prediction in Paris, it was more than a scientific kaffeeklatsch. Sponsored by the United Nations Educational, Scientific and Cultural Organization, it gave many earthquake-susceptible but less scientifically developed countries a chance to hear the big four in prediction — the United States, China, USSR and Japan — bat about research results and policy plans.

What emerged scientifically, according to attendee Robert Wesson, chief of the U.S. Geological Survey's Office of Earthquake Studies, is that earthquake prediction is becoming "more systematic and broadscale." For example, as C.B. Raleigh of the Survey's Menlo Park office pointed out, in 1974 the Chinese program was almost entirely empirical and depended on isolated observations of anomalous events. Since then, Raleigh said in an interview, the Chinese have begun to develop and use laboratory models for earthquakes. In addition, about 10,000 people monitor a systematic array of instruments and sites for geodetic measurements as well as for changes in well-water levels, radon concentrations, electrical resistivity and animal behavior. The Paris meeting was the first opportunity to see some of the results, such as an analysis of very long term precursors to the disastrous Tangshan Quake of July 28, 1976 (SN: 8/7/76, p. 87). Raleigh said the Chinese delegation reported a steep, uniform drop in well-water levels two to three months before the quake, a decrease in electrical resistivity one and a half years before (it had been constant for four years), an increase in the vertical component of the magnetic field six months before and a strange, one-and-a-half-year-long local change in gravity without an associated elevation change.

The move to a methodic, broadscale attack is also apparent in other countries. Japan reported that it has developed a commercially available, continuously measuring radon monitor, which it has used for four years in a network that blankets the active Tokai district and Izu Peninsula. Through cooperative programs, the USSR is beginning to pick up the U.S. emphasis on finding an underlying hypothesis for eathquakes. And the United States is picking up the Russian approach of simply collecting data. "One message we get [based on successful Soviet predictions]," said Wesson, "is that we don't pay enough attention to water levels. We will pay more attention in the future."

While their research may differ only in detail, the countries' public policies toward making predictions vary as much as, and mostly because of, their cultures. Wesson pointed out that the United States is the most open about the problems of issuing a public prediction. In the United States, he said, a prediction would be made public early on and would be revised continually. Local officials would take action based on that information. The Soviets, however, feel no need to keep the citizenry up to date and, unlike the United States, both the Soviets and Chinese can issue evacuation orders without challenge.

The differences are clear in the administrative structures. Japan, which must be ready to move its millions quickly in the event of the great Tokai quake, has a coordinating committee on earthquake prediction that constantly evaluates data from various networks. China uses provincial seismological brigades that concentrate on local events. Only "if they think something big is coming," says Raleigh, do they involve the state seismological bureau in Peking. In the United States, Wesson told the meeting, California and the federal government have each established a council whose roles will be to evaluate predictions made by scientists and to communicate information. □

Carter urges scientists' support

In an address to the 116th annual meeting of the National Academy of Sciences last week, President Jimmy Carter called on scientists to help pass his proposed oil windfall profits tax and urged them to take part in the debate over nuclear arms control.

Reminding scientists that part of his proposed tax on the oil industry would go to research on alternate energy sources, Carter charged that opponents of the tax are trying to "hoodwink" the public, to "plow under" those research dollars and "kick back" revenues to the oil industry. He called on scientists to support the tax and to create new energy technologies.

In asking their support of the current arms control debate, Carter said the public will look to science for knowledge about the debate. "If science gave us nuclear weapons, it is no less true that science has given us the extraordinary means of verifying compliance with treaties to control those weapons," he said.

Carter also called on U.S. scientists to promote international research projects and to push for Senate approval of an Institute for Scientific and Technological Cooperation, which will give advice to developing countries. Emphasizing that he has asked for a 25 percent increase in funding for basic research, Carter urged scientific innovation to improve the competitive position of American industry. □