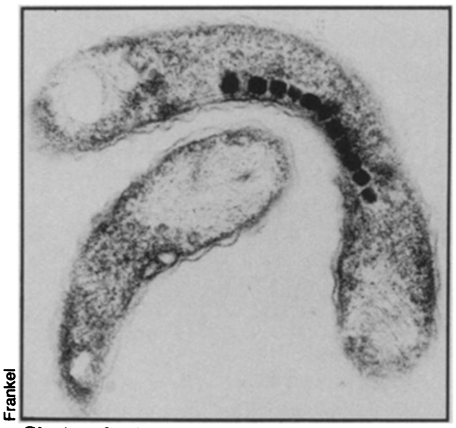
Lodestone compass inside bacteria

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.



Frankel

Chain of microscopic magnets steers bacterium northward.

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.

"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