ELF-zapped genes speed DNA transcription

Epidemiologic studies have suggested a link between extremely low-frequency (ELF) electromagnetic fields and an increased risk of cancer, particularly brain cancer and leukemia (SN: 2/14/87, p.107). But those studies do not establish a cause-and-effect relationship, and scientists have very few clues to how ELF fields might influence cancer growth if a causal relationship exists. Now, two researchers in New York City offer one such clue, suggesting that genes normally expressed in cells dramatically accelerate their DNA transcription when exposed to ELF fields *in vitro*.

ELF fields exist wherever electricity flows and thus are virtually unavoidable. At these frequencies – below 300 hertz – electrical and magnetic fields behave independently: Electrical fields show little penetration through body tissues, while magnetic fields penetrate the body readily.

Earlier cell-culture studies by Reba Goodman of Columbia University's Health Sciences Center and Ann Henderson at Hunter College revealed an ELF-related increase in the DNA transcription rates of normally expressed genes in human white blood cells and in salivary-gland cells from fruit flies, Goodman says. Transcription is the process by which the DNA code is copied and relayed to protein producers within a cell.

In their latest study – which Goodman described last week in Washington, D.C., at a meeting of the Federation of American Societies for Experimental Biology – the team focused on the transcription rates of five genes normally expressed in a human leukemia cell line. These included two proto-oncogenes, which trigger cancerous cell division if "turned on," or expressed. The researchers also studied a sixth gene normally unexpressed in leukemia cells.

They exposed some cells to a 60-hertz, continuous-wave field typical of household appliances; others received a 72-hertz continuous wave or a 72-hertz pulsed wave, both used clinically to help heal bone fractures. Field intensities ranged from 0.5 to 500 microvolts, and exposures lasted 10 to 40 minutes. The team then compared genes from these ELF-exposed cells with genes from unexposed control cells.

Goodman says the five ELF-exposed, normally expressed genes showed a 100 to 400 percent increase in transcription rates compared with the unexposed genes. In contrast, she says, the unexposed genes and the exposed, unexpressed gene never exceeded the normal rate required for cell division.

Transcription increases did not vary with field frequency but did vary with intensity and exposure time, Goodman reports. Even 10 minutes at 0.5 microvolts prompted 100 percent increases, she notes. The 400 percent increase occurred with 20-minute exposures at 5 microvolts.

According to Charles Rafferty of the Electric Power Research Institute (EPRI), the magnetic field emitted at 5 microvolts in Goodman's lab corresponds to occasional, high-level occupational exposures such as those a utility worker might encounter when working near a power generator. Funding for the study came from EPRI (the electrical industry's research arm, based in Palo Alto, Calif.), the U.S. Department of Energy and the Office of Naval Research.

Goodman speculates that genes respond to ELF fields only if they are normally expressed. Though exposed cells stepped up their protein production, cell division did not increase, she adds. "It's too early to draw conclusions about how our findings relate to epidemiologic evidence of increased cancer risk," Goodman says.

Biologist Marvin E. Frazier of Pacific Northwest Laboratory in Richland, Wash., asserts that the results may offer a "potential mechanism one could tie to increased cancer [rates]." And biochemist Christopher D. Cain says they "have the potential to be revolutionary" to an understanding of how ELF fields affect cells. Cain, of Loma Linda (Calif.) University, says he has exposed cultured human bone cells to pulsed-ELF fields and measured changes in levels of important cell regulators, including enzymes and cyclic AMP. He suggests those changes correspond to what might occur with increased transcription in genes normally expressed in the bone cells.

Goodman and Henderson's results "certainly don't show a specific [cancer] link at this time," says EPRI's Rafferty. "It is a consistent picture with the possibility that these fields may be carcinogenic, but it's not causal. But the finding that the fields can cause changes in gene expression is, I think, an important one."

– C. Decker

Air-launched rocket orbits two satellites

April 5 marked the first time engineers have sent satellites into orbit without using a launch pad to start the trip. Instead, the rocket carrying the two small orbiters left Earth on a B-52 jet, which took off from the NASA Dryden Flight Research Center in California's Mojave desert and flew to an altitude of about 42,000 feet over the Pacific Ocean. The jet then released the three-stage rocket, which fell for about 5 seconds before the motor of its winged first stage ("It looks like an X-15," said one official) ignited and separated, carrying the payload into a pole-crossing orbit 508 to 687 kilometers above Earth.

NASA

B-52 sets the satellite-carrying Pegasus on its way.

The air-launched rocket, called Pegasus, was developed by Orbital Sciences Corp. (OSC) of Fairfax, Va., and funded by the Defense Advanced Research Projects Agency (DARPA) in Washington, D.C.

Attached to Pegasus was the satellite Pegsat, which in turn carried a small Navy communications-relay satellite that it released the same day for a variety of meteorological and oceanographic purposes. Pegsat itself holds two canisters of barium, which will release their contents later this month or early in June for studies of Earth's magnetic field. As solar ultraviolet radiation ionizes the neutral barium particles, Earth's magnetic field lines will capture the glowing particles, allowing ground-based cameras to photograph the magnetic field's structure, says Robert Pincus of the NASA Goddard Space Flight Center in Greenbelt, Md.

The Pegasus rocket was instrumented to measure the temperatures, pressures, structural loads, vibrations and other phenomena of the system's maiden orbital flight. The next Pegasus mission, due this summer, is to launch seven small, experimental communications satellites, called Microsats, for DARPA.

OSC officials say Pegasus offers several advantages over a conventional, vertically launched system. One is the cost savings of assembling and testing everything with the rocket lying flat on the ground rather than having to build special structures to hold it upright. Starting with a jet also offers freedom from most of the weather problems that threaten a fixed launch pad. Concern about a possible buildup of electrostatic discharges during the ascent through the clouds led planners to postpone the flight for a day despite clear weather over the part of the Pacific where the plane would release the rocket, but OSC officials say such constraints will diminish once they amass more experience with the system. Other advantages include greater ease of launching missions on short notice and the ability to launch the rocket at a wide range of angles.

– J. Eberhart