tently, and the remainder slept in the presence of negligible background fields.

At the Energy Department's annual EMF Research Review Meeting in San Diego last November, Graham and Cook reported that the intermittent fields—and only those fields—disturbed 6 of 10 measures of sleep quality. They not only contributed to broken sleep and shorter periods of deep, dream-stage sleep, they also led to more reports of feeling unrested in the morning.

In an upcoming report in BIOELECTROMAGNETICS, Graham's team links those same intermittent fields to decreased heart rate variability in 77 college-age men. In healthy people, heart rate tends to vary somewhat from second to second in response to the body's need to maintain blood pressure, temperature, and so on. Often, individuals with heart disease exhibit a more stable heart rate—an indication, Graham says, "that their heart is no longer as well connected to the nervous system."

While the young men that Graham studied exhibited normal heart rate variability during the nights they were exposed to background fields or constant EMFs, that variability diminished substantially on the night each was exposed to intermittent fields. Graham is planning follow-up studies to probe the long-term health implications of this provocative finding.

"What concerns me," Graham says, is that the public "tends to get so worried about the magnitude of a field. The bigger it is, the worse it's supposed to be." In fact, Löscher has found that very high fields, as well as those below a certain strength, have little impact on tumor growth. Only those across a relatively narrow range consistently foster tumors and other negative health effects.

"We've seen the same thing in our studies," Graham told SCIENCE NEWS.

Moreover, he says, it's beginning to appear that a field's magnitude matters less than its intermittency or other features, such as power surges called electrical transients.

These surges can pack a big burst of energy into a short period of time. They occur whenever lights or other electric devices turn on, when motors or compressors (such as those in refrigerators and air conditioners) cycle on, or when dimmer switches operate. "Being transient doesn't mean they're rare, just quick," Graham notes. Transients are hard to avoid because they may stem from surges elsewhere—in a neighbor's house or even power lines up the street.

Little research has been conducted to untangle the potential health impacts of EMF characteristics other than field strength, Graham notes, and money for such EMF studies is all but drying up.

The two major federal programs dedicated to financing research on EMF effects on health are slated to shut down in October. A program funded by electric utilities through the Electric Power Research Institute will also end this year.

One should expect that "research on EMFs in the United States will take a big nose-dive," says Graham.

One ray of hope, Liburdy notes, comes from the recent proliferation of government funds for endocrine-disrupting pollutants. While magnetic fields are a type of radiation, they functionally resemble many environmental pollutants that mimic hormones. In fact, he observes, EMFs may actually fit the definition of an endocrine disrupter better than these chemicals do. That's because magnetic fields appear to elicit their effects by acting on and through hormones, rather than as hormones. □

Technology

Flying toward all-electric airplanes

The in-flight movie may be airplane passengers' prescribed form of entertainment, but those who score seats above the wings can watch an alternative show. The wing flaps rise and fall, extend and retract, in a carefully orchestrated dance that helps control the flight of the plane. Complicated hydraulic systems running throughout the plane transmit the pilot's commands to actuators that move the wing parts.

NASA's Systems Research Aircraft in flight.

Now, engineers at NASA's Dryden Flight Research Center in Edwards, Calif., have successfully tested a device that may help eliminate a plane's reliance on heavy, temperamental hydraulic systems. The device, an electrohydrostatic actuator, moves wing components called ailerons that control the side-to-side movement of the plane. The new actuator responds to commands by using an electric motor to pump a small amount of hydraulic fluid to the aileron.

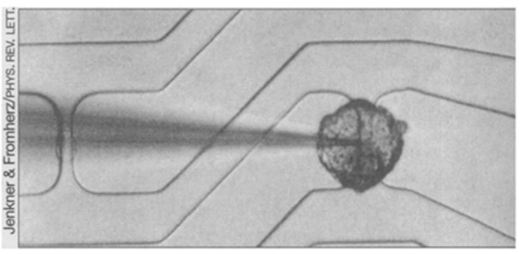
Replacing many of the hydraulic control lines with electric wires would save weight, making military aircraft easier to maneuver and commercial planes more fuel-efficient, says David Voracek, chief engineer for NASA's F/A-18 Systems Research Aircraft, the plane used to test the device.

Electric systems also need less maintenance than hydraulic ones, which require "a lot of tender loving care," adds engineer Stephen Jensen. The Dryden team also plans to test an electromechanical actuator, one that eliminates hydraulic fluid altogether. —*C.W.*

Neurons switch when stuck on a chip

A neuron fused to a silicon chip represents a true meeting of the minds—one biological, the other computational. Researchers have fabricated such a hybrid component, a neuron transistor, and are studying its electronic properties.

Martin Jenkner and Peter Fromherz of the Max Planck Institute for Biochemistry in Martinsried, Germany, deposited a single nerve cell from a leech onto a transistor etched into a silicon wafer. After piercing the neuron with a microscopic glass electrode, they stimulated the cell with pulses of current and recorded its behavior.



An electrode pierces a leech's nerve cell stuck to a silicon transistor. The cell is about 80 micrometers in diameter.

At first, they recorded via the transistor only a low voltage in response to cell stimulation, but by plunging the electrode deeper into the cell, they triggered a far greater response to the same stimulus. The researchers could switch between these two responses simply by sliding the electrode back and forth about 3 micrometers inside the neuron.

Jenkner and Fromherz report their findings in the Dec. 8, 1997 PHYSICAL REVIEW LETTERS, where they suggest a mechanical explanation. Pushing on the electrode may open ion channels in the neuron's membrane, thus increasing electrical conductance and creating the larger voltage.

However, they need to learn more about the ion channels in leech neurons before they can describe details of any mechanism for the switch. —*C.W.*