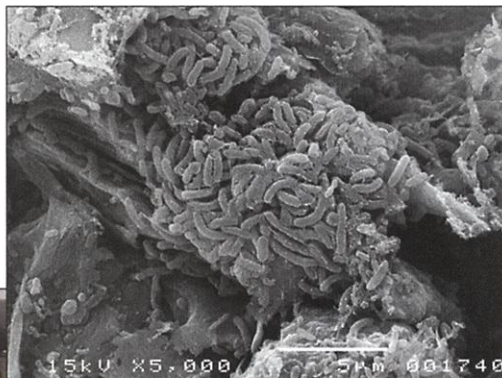


bacteria use organic material in the sea floor. These bacterial batteries will probably never power a car, but they should be adequate to run underwater sensors, says Derek Lovley, a microbiologist at the University of Massachusetts, Amherst, who with Daniel Bond led the work on these unusual energy sources.

Because organic sediments are so abundant, "theoretically there could be an inexhaustible source" of fuel, Lovley notes. And because many pollutants are organic, these portable generators might also help get rid of hazardous materials. "The whole field is very exciting," says Greg Zeikus, a microbiologist at Michigan State University in East

surrounding the number of electrons transferred to the anode and then to the cathode. Even in these crude experiments, the current was enough to power a small calculator, the scientists report.

After several weeks, the researchers identified the microbes that were growing on the mud-implanted electrodes. To their



surprise, Lovley and his colleagues found that one type of microbe—*Desulfuromonas acetoxidans*, from a family called Geobacteraceae—had all but taken over the battery electrode, ousting the others. These geomicrobes are famous for their ability to detoxify toluene and other organic solvents, notes microbiologist Caroline Harwood of the University of Iowa in Iowa City.

Previously, microbiologists had shown that different microbes could move electrons from oxygen-deficient to oxygen-rich substances through intermediate substances that they produced. "The microbes were involved, but not directly with the electrode," Lovley explains. But geobacters, as the family is commonly called, need no such go-betweens. They can convert the mud's organic matter directly, and that might prove quite useful in pollution control, he points out.

Before using organic pollutants to fuel electricity production leaves the realm of science fiction, Lovley and his colleagues warn, the work needs to be replicated in field conditions. And Harwood points out that the bacteria might quickly exhaust local organic fuels and have to be moved to a different spot. The efficiency of the transfer also needs improving, something that Lovley and others are fervently working on; otherwise, says Zeikus, it would take fields of electrodes to get enough energy to power many undersea devices.

—ELIZABETH PENNISI

TRANSPORTATION RESEARCH

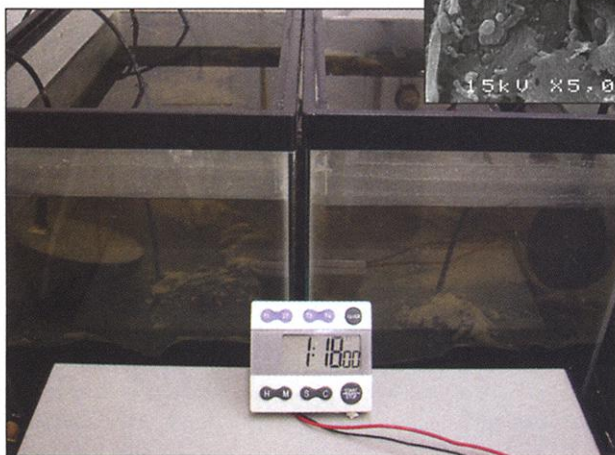
Bush Trades Hybrid for Hydrogen Model

The federal government's most prominent joint research project with industry moved onto a slower track last week. Secretary of Energy Spencer Abraham announced that he is junking the Clinton Administration's Partnership for a New Generation of Vehicles (PNGV)—an 8-year-old government effort to build superefficient cars—in favor of building vehicles powered by pollution-free hydrogen fuel cells. Abraham released no budget details of the new program, called Freedom CAR (Cooperative Automotive Research), but analysts say most of the old program's research efforts will continue. The deadlines for getting a car on the road, however, have been pushed way back.

In unveiling PNGV in 1993, the Clinton Administration promised to work with major automakers to create family sedans that, by 2004, could go nearly 36 kilometers on a liter of gasoline (80 miles per gallon). But some environmentalists and free-market advocates complained that the program was an industry subsidy that undermined efforts to increase mandated fuel efficiency standards (*Science*, 30 July 1999, p. 680). The government has spent more than \$1 billion on the partnership—including more than \$125 million this year—and the big three automakers spent even more.

The results to date have been uneven. In a series of annual reviews, the U.S. National Academies found that the project had made progress in developing lightweight materials and longer lasting batteries, improvements that are being incorporated into hybrid electric-gas vehicles due out within the next

5 years. (Toyota and Honda are already producing such cars.) Fuel cell developers also got high marks for their work on devices

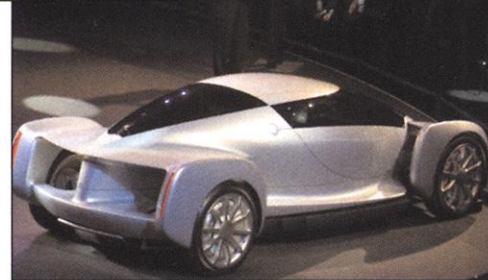


Zap! In experiments in fish tanks, this bacterium (top) can make electricity from organic sediments.

Lansing, because the work has broad potential for both helping pollution cleanup and providing a cheap power supply. "This work has come closer to developing accessible marine batteries as a way to meet our electricity needs."

Lovley's team was not the first to notice that microbes could steal electrons from oxygen-deficient mud and somehow transfer them to electron-accepting rods placed into the oxygen-containing sediments overhead. But now, Lovley and his colleagues "take a concept that has been known for a while and make good on it," says Diane Newman, a microbiologist at the California Institute of Technology in Pasadena.

The team used lab fish tanks to recreate the ocean's saltwater environment. Collaborator Leonard Tender of the Naval Research Laboratory in Washington, D.C., positioned graphite wires (which act as electron-accepting anodes) into oxygen-deficient sediments collected from the sea floor. Then he placed graphite wires (the cathodes) in the overlying oxygen-containing water to receive electrons. In three different experiments, the team mea-



Gas man. Energy Secretary Spencer Abraham calls for putting hydrogen fuel cell cars on the highway.

CREDITS: (BATTERY AND MICROGRAPH) D. BOND ET AL.; (ABRAHAM) CARLOS OSORIO/AP; (CAR) PAUL WARNER/AP

PUBLIC HEALTH

Anthrax Vaccine Begins A New Round of Tests

Almost everybody loves to hate the anthrax vaccine. It's old, inefficient, and the cause of many complaints. Indeed, when the U.S. government recently offered to vaccinate thousands of people who may have been exposed to anthrax spores in spiked mailings, only 130 rolled up their sleeves. Many in the U.S. military have also balked at orders to receive

PLANNED ANTHRAX VACCINE STUDIES

Immunological effects of changes in route of administration and dose reduction (CDC, Emory University, Baylor College of Medicine, Walter Reed Army Institute of Research, Mayo Clinic, University of Alabama, Birmingham)

Effect of different doses on immunogenicity and challenge in nonhuman primates (CDC, Battelle Memorial Institute)

Serological assays and studies of immune correlates of protection (CDC, FDA, NIH, USAMRIID, Battelle Memorial Institute, Emory University)

National survey of knowledge, attitudes, and beliefs regarding the anthrax vaccine among military personnel (CDC, DOD, Research Triangle Institute)

Testing hypotheses for adverse events using military medical database (CDC, DOD)

Survey of health care providers regarding the anthrax vaccine and the reporting of possible adverse events (CDC, FDA, DOD)

Comparative evaluation of the effect of anthrax vaccine on health-related quality of life (CDC, DOD)

Retrospective study of long-term adverse effects among vaccinated mill workers (CDC)

Study of hormonal correlates of adverse events among female clinical trial participants (CDC, DOD)

Studies of vaccine delivery and follow-up of adverse events (CDC, DOD National Vaccine Healthcare Center Network)

six anthrax shots plus annual boosters.

Approved 32 years ago, this vaccine made from a laboratory bacterial culture was designed to protect textile mill workers against skin infections. Now it is being used against inhaled anthrax, and the government is reexamining its safety and efficacy. Since 1999, Congress has given the Centers for Disease Control and Prevention (CDC) in Atlanta \$36 million for such studies, responding to complaints from service members and problems at the sole manufacturing plant—owned by BioPort Corp. in Lansing, Michigan. BioPort has been compelled to suspend production since 1998 for safety

checks. Researchers planning the CDC studies briefed an oversight panel at the Institute of Medicine (IOM) in Washington, D.C., last week—and got a mixed review.

Dennis Kasper, a molecular geneticist at Harvard Medical School in Boston, for example, saw “good progress.” But clinical microbiologist Patricia Ferrieri of the University of Minnesota Medical School in Minneapolis said to CDC scientists: “Forgive the plain language, but you need to get your act together.” It is “urgent,” she said, to move faster on this complex set of studies.

One of the most urgent CDC studies is a clinical trial of 1300 volunteers to test the effectiveness of fewer shots (four or five rather than the standard six) and a gentler route of injection (intramuscular rather than subcutaneous). This trial is on hold until the government permits BioPort to resume vaccine production. CDC's Nina Marano said she hopes that CDC can begin enrolling subjects this month.

Jairam Lingappa of CDC's special pathogens branch described a complementary study in macaques that's designed to reveal precisely how much vaccine is needed—and at what intervals—to protect against lethal infections. Researchers have tentatively defined an antibody test to measure the immune response in blood. If CDC finds a way to bridge animal and human data, this could become important for testing future anthrax vaccines. Sixty of a planned 108 monkeys have already received shots, but the trial is now being restructured.

While these groups examine efficacy, others are checking on safety and side effects. The CDC's Michael McNeil, for example, reported on an ambitious epidemiological study that will look for long-term effects by focusing on a textile mill “in the U.S. Southeast” that for 30 years required all employees to get anthrax shots. “Even the man who filled the Coke machine got vaccinated,” McNeil said. CDC hopes to get information on more than 1300 of the estimated 2778 people who received nine or more shots, looking at everything from cause of death to self-reported current “energy level” and “cognitive function.”

CDC is also planning a survey of military personnel to learn about their attitudes and experiences. It will mine data in military medical records, searching for problems and testing theories. U.S. Army clinical teams will conduct studies of vaccine procedures and adverse events.

The IOM panel's main critique of the CDC's large agenda last week was that it had not gelled. Some parts—such as the clinical trial—have been put on hold because of the vaccine shortage. Others were delayed by the terrorist and anthrax attacks, as Randy Louchart of CDC's National Immunization Program explained. Other CDC

that can convert hydrogen into electrical energy, with water as the only byproduct.

But the panels warned that the 2004 deadline for rolling out affordable supercars was unrealistic. And air-quality advocates complained that the power plant deemed the best bet by PNGV engineers, a hybrid diesel-electric engine, wouldn't meet clean air rules. Such problems led the panel last year to call for a serious rethink of the program's structure and goals.

Abraham's answer, announced on 9 January at Detroit's annual auto show, is Freedom CAR. It drops the emphasis on diesel hybrids in favor of PNGV's fuel cell effort, a shift welcomed by many environmentalists. But Abraham drew darts for failing to set deadlines for what he promised would be a decades-long “fundamental research and development” effort. “It remains to be seen how substantive the changes will be, but I'm concerned that we'll give up some important near-term work for benefits that we may not see for decades,” says Dan Reicher, a former Clinton Administration energy official now with the World Resources Institute in Washington, D.C.

The reaction of fuel cell advocates is decidedly more upbeat. “It makes sense,” says Vernon Roan, who heads the University of Florida's fuel cell laboratory in Gainesville and served on PNGV peer-review panels. “The government ought to support high-risk/high-payoff research that is in the national interest.” John Turner, a hydrogen fuel cell expert at the National Renewable Energy Laboratory in Golden, Colorado, agrees: “It's where we ought to be headed.”

Roan and other experts note, however, that the change in name from the unpronounceable to the patriotic (PNGV to Freedom CAR) may be the most noticeable immediate change. Much of PNGV's research agenda is expected to continue under the new program, because fuel cell cars will also need improved materials and better electrical systems, for example. Department of Energy (DOE) officials say the agency spends about \$100 million a year on fuel cell research, with about half of that going to polymer exchange membrane cells, the type most likely to be used in cars and trucks. DOE spends another \$30 million on hydrogen research, principally looking for efficient ways to generate and store the gas.

Turner calls this budget a start but says it's “small potatoes” compared to what will be needed to get fuel cell cars to market. One major challenge will be replacing the trillion-dollar, gasoline-based infrastructure with a network of hydrogen fuel stations. The cost of a hydrogen future won't be known until 4 February, when the president sends Congress his request for the 2003 budget.

—DAVID MALAKOFF AND ROBERT F. SERVICE