



Only by going alone in silence, without baggage, can one truly get into the heart of the wilderness. All other travel is mere dust and hotels and baggage and chatter.

John Muir (1838–1914)

REMEDICATION

Radio-Free Bacteria

In 1956 a food technologist at Oregon State University made a startling discovery: cans of meat that had supposedly been sterilized with gamma radiation contained a thriving organism, subsequently named *Deinococcus radiodurans*. *D. radiodurans* has been shown to survive and continue to function after being exposed to radiation doses up to 10 times those that would kill most bacteria. In addition, it is able to survive nutrient-poor environments, including weathered granite in a dry Antarctic valley, and periods of extended desiccation. The organism has been tapped as a strong candidate for bioremediation of sites contaminated with radiation and toxic chemicals.

Recently, the genomic sequence for this radiation-resistant bacterium was completed by a team of scientists led by Owen White and Claire M. Fraser of The Institute for Genomic Research in a project reported in the 19 November 1999 issue of *Science*. *D. radiodurans* was selected for genetic sequencing because among six closely related species it was the most amenable to genetic manipulation. According to Michael Daly of the Department of Pathology at the Uniformed Services University of the Health Sciences in Bethesda, Maryland, who collaborated in the research, this amenability has already enabled him and colleagues “to introduce bioremediating gene functions into *D. radiodurans* from other organisms that can

detoxify wastes but that are very sensitive to and are killed by radiation.”

In work published in the October 1998 and January 2000 issues of *Nature Biotechnology*, Daly and colleagues developed bioengineered forms of *D. radiodurans* that can transform toxic ionic mercury into much less toxic elemental mercury, turn soluble uranium(VI) into insoluble uranium(IV), and detoxify toluene and related chlorinated aromatic compounds.

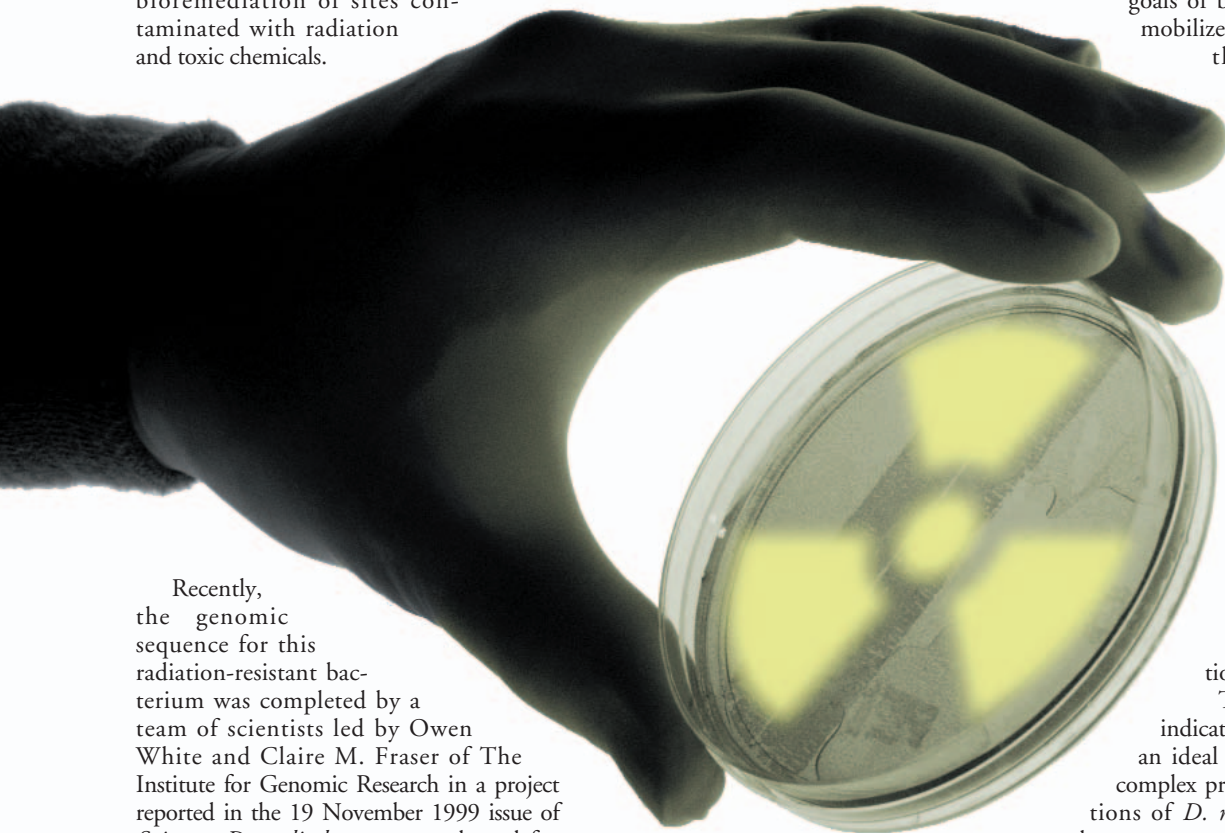
Despite this promising work, Jacqueline A. MacDonald, study director of the National Research Council’s Committee on Technologies for Cleanup of Subsurface Contaminants in the DOE Weapons Complex, believes that “although

in a dry setting). Second, the degradation of highly chlorinated hydrocarbons produces metabolites that, if not themselves further degraded, are often more mobile and more toxic than the original compounds. Third, the delivery of the necessary organisms and supporting nutrients to underground zones of low permeability or low heterogeneity may be difficult, particularly if these zones are at some depth. Also, many of the subsurface contaminants at Department of Energy sites contain both organic and inorganic compounds.

The challenges in treating inorganic contaminants such as metals and radionuclides can be extremely difficult because they generally cannot be broken down into less-toxic components. Here, the primary goals of bioremediation are to either mobilize such contaminants so that

they can be removed and treated elsewhere, or immobilize them and keep them in place. Mobilization can be accomplished through the use of biological agents to reduce inorganic contaminants to a soluble state, or by chemically reducing metal oxides to a soluble form. Immobilization can be accomplished by using an organism to chemically reduce certain contaminants to an insoluble form. To prevent remobilization, care must be taken to ensure continuation of conditions that favor the immobilization reactions.

The data gathered thus far indicate that *D. radiodurans* may be an ideal organism to apply to these complex problems. Before field applications of *D. radiodurans* are attempted, however, several major challenges need to be overcome. One is to recognize that soil and groundwater contaminants vary from site to site and that organisms will need to be tailored to meet each site’s specific needs. Second is to gain public acceptance of such applications; until more studies are completed and more experience is gained, many Americans will remain concerned about the release of genetically modified organisms into the environment. —**Dade W. Moeller**



the use of microorganisms to degrade organic chemicals . . . has been known for years, this approach has a host of limitations that still need to be overcome.” First, bioremediation generally requires a wet environment for the bacteria to flourish (although the fact that *D. radiodurans* can withstand adverse conditions means it may perform better than other types of bacteria

LAND USE

Accounting for Lost Acreage

Privately owned forests, wetlands, and croplands in the United States are disappearing at alarming rates due to development and erosion, according to a report released by the U.S. Department of Agriculture (USDA) on 7 December 1999. The report, which summarizes the USDA's 1997 National Resources Inventory (NRI), reveals that development has doubled during the last decade to more than three million acres a year. In announcing the report in an address to the USDA's National Conservation Summit at Iowa State University, agricultural secretary Dan Glickman said, "Conservation challenges are mounting and intensifying more quickly than we are solving them." Glickman urged Americans to join in a collaborative effort to improve the declining health of America's private land, which accounts for about 75% of total land cover.

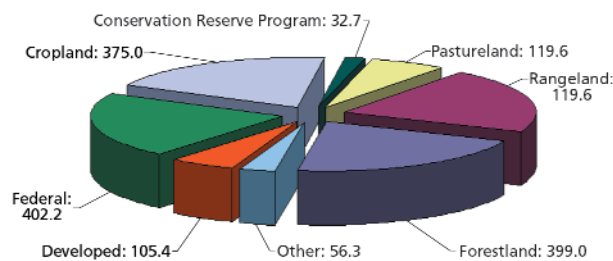
The NRI, which is conducted every five years (1997 is the latest), is a statistical analysis-based survey of nonfederal land. It comprises data on land use, soil erosion, farmland and wetland loss, and other natural resource information from 800,000 selected locations in the United States.

Conversion of agricultural land to other purposes such as subdivisions and industrial areas is traditionally thought of as happening only around major metropolitan areas. The NRI report shows that growing numbers of small and mid-sized cities are also contributing to land loss. According to the NRI, states with the highest acreage conversion rates include California, Florida, Georgia, Michigan, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Texas. In a 6 December 1999 statement, Vice President Al Gore said that the high agricultural conversion rates do not threaten American's food supply but do result in land fragmentation and loss of family farms that raise produce for urban markets, as well as elimination of open spaces.

"It's shocking to see to what extent states have experienced rapid conversion from farmland," says Don Buckloh, a farmland information specialist with the American Farmland Trust (AFT), a nonprofit organization that works to prevent productive farm-

land loss and aims to keep private land in private hands. The AFT uses the NRI to closely analyze agricultural conversion in each state and to develop conclusions about the most threatened farmland areas. In past years, the AFT published its analysis of the NRI in a report called *Farming on the Edge*. Currently, the AFT is updating its publication with the new information released in the 1997 NRI report. Buckloh says that the *Farming on the Edge* reports take the resource information further than the NRI reports since they focus on the most productive farmland and conversion in areas experiencing the most threat.

U.S. Land Use in 1997
in millions of acres; not including Alaska



Source: National Resources Inventory; background and highlights. Washington, DC:USDA National Resources Conservation Service, 2000.

In response to the problems of land natural resource loss, President Bill Clinton's Fiscal Year 2001 proposed budget includes a significant increase in funds for a Farm Conservation Programs Initiative, which would provide resources to state and local governments to enter into agreements with farmers to preserve farmland and encourage environmentally sound land management. This program, combined with various legislative proposals and other ongoing programs, would provide more than \$11 billion for additional assistance to the rural economy during 2000–2002. Increases are also proposed for five ongoing conservation programs, the Wetland Reserve Program, the Conservation Reserve Program, the Farmland Protection Program, the Wildlife Habitat Incentives Program, and the Environmental Quality Incentives Program. In a 7 February 2000 statement outlining the Fiscal Year 2001 proposed budget, Glickman said that "the president's budget is fiscally sound, while making key strategic investments in the farm safety net, protection of our natural resources, anti-hunger efforts, and further economic development of rural America."

According to Gore, the Clinton administration will also continue to help communities address urban sprawl through the Livable Communities Initiative, an array of programs that provide tools and resources to protect open spaces, strengthen local communities, and help ease traffic congestion. —Lindsey A. Greene

Growing Better Plastics

Cargill and Dow Chemical have jointly developed a new plastic from the carbon stored in plant sugars that is environmentally sustainable and competitive with conventional hydrocarbon-based polymers in terms of cost and performance. A new facility is scheduled to begin production of the material, called polylactide (PLA), by late 2001.

Corn is the current source of the polymer feedstock, and researchers are working to convert the process so that plant materials such as rice, wheat, sugar beets, and even agricultural waste can be used. According to Cargill Dow Polymers, production of PLA requires 30–40% less fossil fuel than traditional plastics production, and reduces net CO₂ emissions since the feedstock crops remove the gas from the air. The new material fits with standard waste management practices and degrades in composting facilities. PLA can be used in a wide number of products including apparel, carpet, food containers, and diapers.

Putting Algae on a Diet

Australian researchers led by Malcolm Robb of the Water and Rivers Commission and D. Grant Douglas of Australia's Commonwealth Scientific and Industrial Research Organisation held the first trial of a method for reducing blooms of toxic blue-green algae. The method involves spraying a clay-based substance called Phoslock over water. It sinks to the bottom, forming a thin layer of sediment that absorbs phosphorus, depriving the algae of a major food source. (In earlier tests, Phoslock absorbed over 90% of phosphorus from water and sediment.) The test was conducted in Perth on a 700-meter stretch of the Canning River, where summer algal blooms are common. Researchers also aerated sections of the river in an attempt to remove another algae food source, nitrogen.

Douglas emphasizes that Phoslock is not a "quick fix" for affected bodies of water, but an interim step that must be followed up with actions to reduce the flow of nutrients into the water.

Little Doubt of Drought

Research on the history of drought in Africa, published in the 27 January 2000 issue of *Nature*, suggests that a catastrophic drought will occur within the next 50–100 years. The study, led by Dirk Verschuren of the University of Minnesota in Minneapolis and the University of Ghent in Belgium, used sediment samples from Lake Naivasha in Kenya to reconstruct a 1,100-year history of the rainfall in east Africa.

In an 8 February 2000 article in *The New York Times*, Verschuren said that such a drought could result in drastically decreased agricultural outputs for periods possibly lasting 10–15 years, and would affect an ever-increasing human population—one that has doubled in the last 25 years. Verschuren stressed that the findings show the need for Africans to plan for future megadroughts and reduce their reliance on irrigation-supported agriculture.



INFECTIOUS DISEASE

Plague Linked to Precipitation

For the first time, researchers have confirmed a long-suspected link between precipitation and plague. After reviewing nearly half a century's worth of data, a team of scientists from New Mexico and Colorado have found a strong tie between above-average precipitation during New Mexico winters and an increase in human cases of the still-dreaded plague. Their research, funded by the National Science Foundation, was published in the November 1999 issue of the *American Journal of Tropical Medicine and Hygiene*.

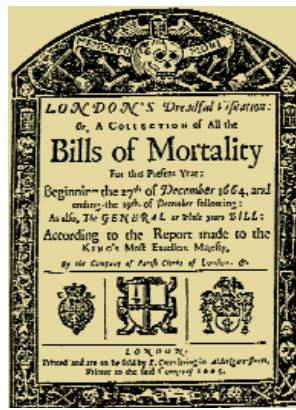
A pattern of wet years followed by outbreaks of plague has been observed around the world for more than a century, but a direct link to precipitation, particularly in a specific season, has never been proven. "That's what makes this dramatic," says Paul Epstein, associate director of the Center for Health and the Global Environment at Harvard Medical School in Boston, Massachusetts.

Plague, caused by the bacterium *Yersinia pestis*, can kill within a matter of days if not treated with antibiotics. High rodent populations are one well-known factor governing the spread of the disease among humans (plague is transmitted by the fleas carried on rodents). Team leader Robert Parmenter, a research associate professor in the biology department at the University of New Mexico at Albuquerque, says he and his colleagues knew that rodent numbers tend to increase when higher levels of precipitation lead to increased food availability.

But they also knew that human factors such as crowding, behavior, sanitation, and land use practices, along with the biology and behavior of both fleas and their rodent hosts, could influence the spread of plague. Some 1,000–3,000 cases of the disease are reported worldwide each year, according to the World Health Organization, including 10–15 cases in the United States. Fifty-five percent of U.S. cases have occurred in New Mexico.

To test whether precipitation alone might influence the spread of plague, Parmenter's team examined data on precipitation and 211 plague cases that occurred from 1949 to 1996 in 38 New Mexico locations. They found that 60% of the cases occurred in years with above-average precipitation from October through May, as measured within about 20 kilometers of each plague case. They also saw a hint of increased plague cases with above-average local summer precipitation and with above-average precipitation when viewed statewide (during summer and winter) or on a global scale (during winter alone), but these numbers weren't statistically significant.

In some years, the team found a marked drop in plague cases when local precipitation fell to a range of 10–25% below mean annual levels, particularly when the condition persisted for years in a row. When such a dry spell occurred in the mid-1950s, no plague cases were recorded for seven years. But when the converse happened in the mid-1980s and



Rain of plague. Above-average precipitation is linked with increases in cases of plague.

precipitation was consistently above the yearly average, the number of cases per 100,000 residents peaked at more than four times its annual mean.

Parmenter's team found many exceptions within these patterns, but that's somewhat predictable since the biology of plague is poorly understood, says Janine Bloomfield, a senior scientist with the Environmental Defense Fund. To help fill in the gaps revealed by those exceptions, Russell Ensore, an environmental

health specialist at the Fort Collins, Colorado, office of the Centers for Disease Control and Prevention, is developing a mathematical model that builds on Parmenter's study. His preliminary results suggest that summer temperatures may be a key factor, since a few weeks of temperatures above 95°F can negate an entire wet winter. "It just shuts the cycle off," says John Pape, an epidemiologist with the Colorado Department of Public Health and Environment who has been following the study. Ensore is shooting for publication in the *American Journal of Epidemiology* later this year.

Public health officials in New Mexico aren't waiting, because Parmenter's study already offers a new tool: "It will help us craft and time our public health messages," says Gary Simpson, medical director for infectious diseases at the New Mexico Department of Health, who helped get the study under way. —**Bob Weinhold**

RADIATION

Microwaves and Memory Loss

New research published in the January 2000 issue of *Bioelectromagnetics* suggests that exposure to microwaves may affect long-term memory function in rats. Henry Lai, a research professor in the bioengineering department at the University of Washington in Seattle, and Baoming Wang, a visiting professor from Tianjin Medical University in China, reported an alteration in long-term memory and learning in rats following exposure to microwaves.

In the study, one group of rats was exposed to pulsed microwaves for 1 hour at a frequency that Lai says is twice as high as cell phone emittances. A control group of rats was not exposed to microwaves. The researchers placed the rats in a tank of water clouded with powdered milk and trained them to swim to a submerged platform that they couldn't see. The rats were then reintroduced to the pool at different locations to see if they could remember how to find the obscured platform.

"The microwave-exposed rats were much slower in finding the platform during the training session. They tended to spend more time attempting to climb the wall of the pool or swimming along the wall," Lai says. The difference in the rats' ability to find the platform was attributed to a deficit in long-term memory and learning ability rather than motivation or motor skills since the different groups' swimming speeds were the same.

After repeating this process several times, the researchers removed the platform and observed that rats in the control group spent most of their time swimming in the area where the missing platform had been located. The irradiated rats didn't show a tendency to search for the missing platform, and instead behaved more randomly. "They seemed to have trouble making a map in their heads, like the normal rats did, so they could recall where the platform was," said Lai in a November 1999 press release from the university. "Their spatial reference mapping or 'place learning' strategies [using the relative position of various different cues as guides] seemed to be affected after their exposure."

Disturbance to the central nervous system may lessen the animals' learning capacity, Lai suggests, forcing them to resort to simpler learning strategies. However, critics of the study point out that there are other potential interpretations of the data. For example, effects such as those seen in both the training and testing phases of the experiment could be attributed to an emotional component in the rats.

Lai says that the frequency is similar to devices such as radar and other microwave equipment. The question remains whether or not this same type of long-term memory loss could affect humans exposed to similar microwaves. "It's difficult to extrapolate from these animal data whether or not the effect would be the same on humans." Lai says.

—**Lindsey A. Greene**



The Ecotourism Society



The World Tourism Organization has estimated that over 595 million people traveled internationally in 1997. Although tourism overall has been growing at an annual rate of 4%, nature travel, also known as ecotourism, is increasing at an estimated annual rate of 10–30%. The Ecotourism Society (TES) of North Bennington, Vermont, was founded in 1990 as a tool for both consumers and ecotourism professionals to help make travel an environmentally responsible activity and to contribute to the conservation of natural resources and the well-being of local people. The organization also fosters a sense of synergy between ecotourism entrepreneurs, researchers, and conservationists. TES is an international nonprofit organization with over 1,700 members in more than 70 countries.

The TES Web site at <http://www.ecotourism.org/> provides visitors with vital facts on ecotourism and tourism in general as well as “nuggets of personal wisdom” acquired by explorers in the field. Visitors can begin by clicking on the Your Travel Choice Makes A Difference link on the home page. This leads to further links that show visitors how to consider travel from a more holistic perspective, teach them about tourism’s impact and how tourists can build sustainable economies, and lead them in exploring the world of ecotourism so they can learn how to choose responsible destinations, tours, and accommodations. In addition, the site provides information on how visitors can experience ecotourism with member tour operators and lodges around the globe.

The In Search of True Ecotourism link leads to reports filed by Megan Epler Wood, TES president, who is currently on sabbatical from TES. With titles such as “Healing the Scarred Mayan Forests” and “In the Shadow of Machu Picchu,” the reports recount Wood’s journey through Central and South America in 1998–1999 and investigate “the lives of the entrepreneurs, idealists, indigenous people, and activists who are bringing true ecotourism to life and bringing the reader to their doorstep.”

Because tourism development is often uncontrolled, especially within the relatively new realm of ecotourism, there are many environmental and political questions that are still being answered. Each year, TES identifies key issues in the field of ecotourism and works with other organizations around the world to bring these issues into public awareness. By following the TES Initiatives link on the home page, visitors can explore issues tackled by the organization over the past decade. Past issues have included creating policies for the economic development of the ecotourism industry, helping ecotourism businesses meet standards for sustainability, and recognizing the effects of ecotourism on local communities.

The site offers visitors lots of practical information. The Eco-Professionals link, for example, leads to resources to help professionals in diverse fields use ecotourism to support conservation. Two links on this page provide information on how to conduct ecotourism research and how to use ecotourism as a conservation tool in the area of biological assessments, and a third link provides a forum for entrepreneurs working in the ecotourism business. Links in the forum provide access to useful business reports from TES members as well as a set of guidelines for nature tour operators. —Ron Chepesiuk

A Cleaner River to Run through China

China has begun construction on a large-scale project to reduce the 700 million tons of untreated wastewater annually flowing into the world’s third longest river, the Yangtze, and one of its main tributaries, the Jialing. The pollution has contaminated the river valley in Sichuan Province and threatens the environment of the Three Gorges region, a popular tourist area.

The project, which has a scheduled completion date of 2004, consists of a 92-kilometer-long network of underground pipelines that will collect household wastewater and transport it to two processing plants. The World Bank and the Chinese State Development Bank will provide most of the \$310 million cost of the initiative, which is being implemented by Chinese state agencies and the Chongqing municipal government.

Going Public with Chemical Information

To promote public understanding of the health and environmental risks associated with high production volume chemicals, basic health and environmental information on over 2,000 such chemicals is being released through the EPA’s HPV Chemical Challenge Program.

The program, part of Vice President Al Gore’s Chemical Right-to-Know Initiative, makes available to the public screening-level toxicity data on chemicals produced or imported into the United States in amounts exceeding one million pounds per year. The information has been voluntarily provided by 403 chemical manufacturers. The database established through this program will support a screening-level hazard characterization.

Evolving Dangers of *E. coli*

According to a report in the September–October 1999 issue of *Emerging Infectious Diseases*, an estimated half dozen new strains of toxin-secreting *E. coli* may account for over 55,000 cases of illness per year in the United States. The report states that “the importance of some of these organisms in the United States is seriously underestimated,” possibly because the bacteria cannot readily be identified in U.S. laboratories.

Most of the public health focus on *E. coli* has been on the O157:H7 strain, but outbreaks of the O111 strain, one of which killed a seven-year-old Ohio girl in October 1998, have been turning up in the United States. In a 20 December 1999 Cox News Service article, David Acheson, director of the Food Safety Initiative in Boston, said that U.S. regulatory agencies have not been proactive enough in researching these new bacteria, especially since their adverse health effects have been reported in Canada and other countries. Paul Mead, head of the Centers for Disease Control and Prevention’s infectious disease unit and lead author of the *Emerging Infectious Diseases* report, says that his agency is now developing a clearer sense of the dangers of *E. coli* strains other than O157:H7.