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