Helping chlorine-eating bacteria clean up toxic waste

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Cornell researchers hope to learn how certain bacteria that break down pollutants do their job and then to make them more effective in cleaning up toxic wastes.

Bacteria called Dehalococcoides ethenogenes, discovered in Ithaca sewage sludge in 1997 by James Gossett, Cornell professor of civil and environmental engineering, and isolated and studied by Stephen Zinder, Cornell professor of microbiology, are now in wide use to detoxify such carcinogenic chemicals as perchloroethylene (PCE) and trichloroethylene (TCE). They do this by removing chlorine atoms from molecules and leaving less-toxic compounds behind.

But D. ethenogenes strains work well at some sites and not so well at others, and nobody knows for sure why. In fact, very little is understood about how these organisms live and breathe. Normal laboratory procedures haven't provided enough answers, because the bacteria are hard to grow in a petri dish, said Ruth Richardson, Cornell assistant professor of civil and environmental engineering, who is following up on Gossett's and Zinder's work, in continued collaboration with them.

She is partnering with Gene Network Sciences (GNS), a firm specializing in computer simulation of biochemical processes, to create computer models of the inner workings of the bacterium. The project is funded by a three-year, $381,000 grant from the Department of Defense, which has some 6,000 toxic-dump sites of its own to clean up.

Richardson explained that in the field "the bacteria sometimes start and then stop. We might improve conditions for the organisms." For example, she said, it has been found that Dehalococcoides needs vitamin B-12, so the vitamin is added to cultures that are injected into cleanup sites. The bacterium also grows better in a mixed community with other kinds of bacteria. "There are some factors it needs from other organisms, and we don't know yet what they are," she said.

Her laboratory will test the D. ethenogenes strains under a variety of different conditions, such as exposing them to different chlorinated compounds one at a time, varying the environment or the nutrients supplied, and then observing which genes are expressed and what proteins are manufactured. The data will go to GNS, which will try to build computer models of how the bacteria's proteins work together under each condition and whether the pathway for each condition is the same for PCE and TCE, and if not, what steps they have in common.

It will be an "iterative process," Richardson said. If a model shows that changing a particular condition produces a particular result, the lab will try it out and see if the result matches the model. Eventually, Richardson said, some commonalities should appear.

"There will be a suite of models, and we can highlight features that are common across several models," she said. "As we develop the model, we can begin to look at the genomes of other strains of Dehalococcoides. If genes that are important in our strain are found in others ... then we can do the same experiments with the others." Finding which genes are at work with which pollutants might lead to understanding how to remediate other kinds of pollutants, such as PCBs, dioxins, chlorobenzenes or chlorophenols.

Richardson, who grew up in the Hudson River Valley, notes that such pollutants are common in the river's harbors. "There are still thousands of sites around the country that need to be cleaned up," she said. "Ithaca has three or four, and that's not atypical."

Source: Cornell University