Cleaning Up Arsenic

Scientists modify plants to remove environmental toxins

By adding genes to common weeds, scientists have created a new tool for cleaning up environmental toxins: Plants that take up arsenic from the soil and sequester it in their leaves, where the pollutant can later be removed. One application would be to remove dangerous concentrations of arsenic that leach into drinking water.

Arabidopsis thaliana is a member of the mustard plant family.
Courtesy Ron Moles

The researchers added two bacterial genes to the weed *Arabidopsis thaliana*, which is the laboratory mouse of plant genetics. The first bacterial gene helps convert arsenic from soil to a form that can be 'sucked up' and stored. The second gene helps the plant detoxify heavy metals and accumulate the molecules in its leaves.

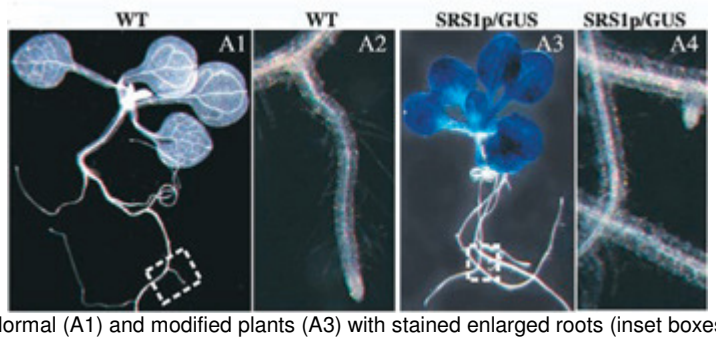
"Plants have incredible advantages when it comes to cleaning up the environment without damaging it," says Richard Meagher, a geneticist at the University of Georgia, Athens, who led the study. Meagher is a pioneer in the use of plants to clean the earth—a field called phytoremediation. Plants are cheap labor and use solar power, making them ideal for developing countries with expensive contamination problems.

The plants in the study are too small to be of much practical use. But Meagher and his colleagues are now experimenting on much larger plants like cottonwood and willow trees, which grow well in wet ground.

"If these genes were put into some tree species, it would be very useful for cleaning up the site," says Meagher. The research team reports the strategy in *Nature Biotechnology*.

The researchers say that thousands of plant genes might be useful in waste management—once they've been mapped. "This genomics boom is going to blow this field wide open," says Meagher.

More than a dozen labs worldwide are concentrating on using plants to clean the environment. Of those, roughly half have incorporated genetic technology into their approach.



Normal (A1) and modified plants (A3) with stained enlarged roots (inset boxes).

Phil Rea, a biologist at the University of Pennsylvania in Philadelphia, says interest in using genetic tools on toxin-scouring plants has increased in the last five years, as scientists have decoded the genomes of so many organisms.

Like Meagher and his colleagues, Rea's group works with *Arabidopsis thaliana* to make the plant a better magnet for heavy metals like cadmium, mercury and arsenic. Rather than using foreign genes, his group tweaks those already in the plant. For instance, the researchers have boosted the activity of a gene that produces an enzyme called phytochelatin synthase. This enzyme binds toxins and lets the plant shuttle them into vacuoles.

Why put bacterial genes that neutralize toxins into plants when bacteria can do the work? The problem with that approach, says Rea, is that harvesting the microbes from the soil is

much more energy intensive than simply harvesting acres of crops—something most of the world can do. "Agriculture has provided the machinery and the know-how," he says.

Rufus Chaney, a research agronomist with the US Department of Agriculture, says that if the genetically engineered crops can be brought to the field, "it will be an important technology." And not just for arsenic removal, but for the cleanup of other toxic elements as well.

Current methods to rid dirt of these poisons run about $1 million per acre-foot of earth (the volume of a foot-deep acre of soil). Using plants to do the same job, on the other hand, costs about $3,000. "You're going to save a hell of a lot," Chaney says.