BIOSENSORS AND BIOREMEDIATION

Leveling land mines with biotechnology

Frederick Bolin

Too often, when people think of biotechnology and warfare, they remember headline-generating stories about biotechnology's misuse in the creation of new weapons of mass destruction. But lost among the headlines is biotechnology's role in helping to ameliorate the effects of warfare—for example, in detecting the presence of land mines.

The need to do so has once again become poignantly clear in Kosovo, where it will take an estimated three to five years to clear all the mines that have been put out during the latest round of hostilities. Bosnia has an estimated 18,000 unmapped minefields, and dozens of people have already been maimed or killed by these weapons. Each month, worldwide, 2,000 people are maimed or killed by some of the estimated 120 million land mines scattered throughout 70 nations. In Cambodia, 1 out of every 250 people has lost a limb because of land mines. In the Kurdish-dominated regions of northern Iraq, land mines have killed 24,000 since 1991. The UN has destroyed about 200,000 mines over the last 10 years in Afghanistan. It is estimated that it will take up to seven more years to destroy the bulk of the remaining mines. The devastation will only continue. Each year an estimated 100,000 mines are cleared, but another 2 million are laid.

While 135 countries signed a treaty to ban the use of land mines in March of this year, President Clinton requested $50 million from Congress to develop a new type of land mine system. This budget request raises serious questions about the President's claim that the US will sign the treaty within 10 years and highlights the fact that safe and effective removal of the mines is a necessary part of any current solution, as the political will to end the manufacture and use of land mines does not yet exist in the US, one of the biggest producers of these weapons.

Biotechnology researchers such as Carl Fliermans at the Savannah River Technology Center in South Carolina are developing biosensors that are more effective, less expensive systems for detecting mines. Current methods for locating mines are archaic—visual sighting and digging in suspected mine areas—and include the use of metal detectors. Given that most areas containing land mines also contain metal shell casings and benign metal fragments, however, the use of metal detectors that lack the capacity to distinguish between a mine and a metal container wastes valuable time. Furthermore, metal detectors are useless in locating the many newer land mines made of plastic materials. These must be sought out by dog or, again, by hand.

Fliermans' approach uses bacteria that have been genetically altered to glow when they feed on the trinitrotoluene (TNT) chemicals that leech out of most land mines—some 90% of them. Taking advantage of the process by which, when these bacteria ingest TNT components, they begin to convert their "meal" into energy, these researchers insert a gene for luminescence or fluorescence beside the gene that controls digestion. Whenever the bacteria begin to digest TNT, they glow, signaling the presence of the deadly mines. Luminescent bacteria would be visible to the naked eye; fluorescent bacteria would require night vision goggles. Once identified, the mines could be flagged and removed safely. Once the mines have been removed, the bacteria will die off.

It is now estimated that it will take three to five years to clear all the mines that have been put out during the latest round of hostilities in Kosovo.

Other groups, such as the one headed by Jerry Bromenshenk, a biology professor at the University of Montana–Missoula, are looking at using insects such as bees as land mine detectors. The researchers are examining how the chemicals found in explosives such as TNT are taken up from the soil into plants, and, from there, through bees into hives, where they could be detected. They are also looking at ways to train bees to find the sources of explosives by associating the odor of TNT with bee food.

Additionally, research teams such as that of Neil Bruce and colleagues from the University of Cambridge (Cambridge, UK; *Nature Biotechnology* **17**, 491, 1999) have been trying not to detect, but to biodegrade, explosives in situ. Their target has been the high levels of explosives found in soils around munitions sites.

Certain microbes can denitrify nitrate explosives in the laboratory but have failed to thrive at these sites. To get around this problem, the researchers transferred this degradative ability from microbes to plants, which are more easily harvested and sustained in the field. The transgenic plants are able to withstand exposure to higher levels of explosives and break them down into harmless components.

Biotechnology may never rid the world of land mines and the rest of the detritus of armed conflict, but it may have a serious impact on the problem. Biosensor activities such as the ones described here tend to get crowded off the stage by more glamorous and well-publicized activity in the pharmaceutical and agricultural sectors.

Because developments in environmental and bioremediation biotechnologies are also relatively new and in their earliest experimental stages, workers in these areas are often hard-pressed to find funding. Fliermans' group, for example, has only a $900,000 grant. But given half a chance—say half of Mr. Clinton's $50 million new land mine system budget—think of what such groups could accomplish using biosensor and bioremediation technologies on the land mine and a wealth of other environmental problems. Land mines might not be put out of business, but surely any increase in support of these research activities is worth the savings in human suffering and loss of life. ///

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