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Sniffing Landmines

By Sarah Vos

Outside a U.S. military airbase in Kandahar, Afghanistan, eight teams of landmine detector dogs work through the desert brush searching for explosives. Insurgents had surrounded the airbase with landmines—buried explosives that blow up when a person steps on them or when a car drives over them.

Each dog works with its own handler. The dogs walk away from their handlers, sniffing in a straight line for 30 feet and then sniff their way back to the handlers, following the same line. Sometimes, one of the dogs sits and looks at a spot on the ground. By sitting, the dog indicates to the handler that an explosive is present.

Each time a dog finds a landmine, everyone else is pulled out of the area until "Explosive Ordnance Disposal" teams that are trained in handling hazardous devices containing explosive materials determine what the dog has found—an active or exploded landmine, a partial landmine, or another piece of explosive. Then they destroy any active explosives by setting them off.

In the spring of 2005, the dogs helped identify some 2,000 landmines over three months on the perimeter of the Kandahar airbase, saving human lives and clearing the way for an expansion of the base.

Throughout the world, dogs are increasingly being used to detect landmines to supplement the use of traditional metal detectors. Because of their strong sense of smell, dogs can detect very low amounts of vapor released by the landmines, thus helping to remove them safely.

PFC. RENATO LARA

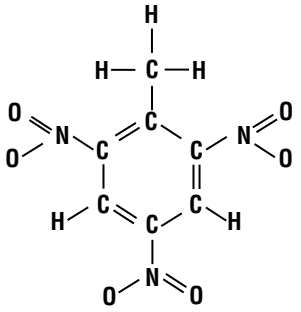
A Marine covers rear exits during a search of a residence in Rawah, Al Anbar Province, Iraq.

But not all dogs can do it and their training is uneven, prompting scientists and the federal government to develop programs to improve the training of these dogs and to find ways to select the most successful dog breeds. Other scientists have been trying to understand how dogs smell, hoping to make detectors that are as sensitive as a dog's nose in detecting explosives.

Cheap and dangerous

Landmines are cheap explosives buried close to the surface so that anyone or anything walking on them—even a dog or a child—will set them off. Landmines have been used in many war-torn countries by governments and rebel groups alike. When they explode, landmines maim and kill. Their presence cuts off access to water and prevents the use of agricultural land. They close down roads and paths and terrorize local inhabitants.

Landmines are made of a metal or a plastic casing that contains an explosive, usually the chemical trinitrotoluene (TNT).



TNT

When a landmine is set off, it causes a chemical explosion that spontaneously releases a large amount of hot gas. As the gas expands, it creates a shock wave that destroys anything it hits as it moves forward in every direction.

Near the explosion site, the shock wave from the explosion can travel as fast as 32,000 kilometers per hour (and then slows down rapidly with distance, becoming a sound wave). The shock wave causes molecules to break into fragments, which then recombine into stable gases, such as nitrogen (N_2), water (H_2O), and carbon dioxide (CO_2).

For example, when TNT ($C_7H_5N_3O_6$) is detonated, it decomposes into nitrogen (N_2), water vapor (H_2O), carbon monoxide (CO), and carbon (C):

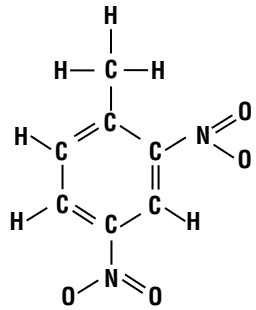
$$2\ C_7H_5N_3O_6 \rightarrow 3\ N_2 + 5\ H_2O + 7\ CO + 7\ C$$

In this case, the shock wave travels at 25,000 kilometers per hour, and the carbon forms the soot that is typical of a TNT explosion.

Escaping through the soil and into the air

When a landmine is buried underground, small amounts of the explosive inside escape through the casing either underground or into the air in the form of vapors. Dogs usually smell the vapor.

Some chemicals tend to release molecules into the air readily, making them easier to detect. This is the case with TNT, which releases an impurity called 2,4 -dinitrotoluene (DNT) that is easier to detect than TNT.



DNT

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Landmines and unexploded munitions found in Afghanistan.

In 1998, investigators at the Canine and Detection Research Institute (CDRI) at Auburn University, Auburn, AL, used this result to show that when dogs find a TNT landmine, they actually have learned to sniff DNT—not TNT—to detect landmines. This discovery later helped in the design of instruments for detecting landmines. Auburn University has one of the most extensive and comprehensive U.S. programs of research and technology development related to the use of dogs for the detection of explosives and other hazardous materials.

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A dog can smell chemicals up to a million times better than humans.

Dogs vs. metal detectors

The most common way to search for landmines is with metal detectors, a time-consuming process since metal detectors cannot distinguish between unexploded landmines, shrapnel, and other explosives. Also, during the past 30 years, more and more mines have been made of plastic, making metal detectors nearly unusable.

The second most common way to search for landmines is through specially trained dogs.

"Dogs can search an area a lot faster than a man with a metal detector," says Dan Hayter, president of Global Training Academy in Somerset, TX, a private company that, for the past 22 years, has been training dogs to detect bombs, mines, and drugs.

The teams working in Kandahar were supervised by Hayter. Dogs work best when they can narrow down the locations of suspected landmines, Hayter says. Then, when his teams find four or five landmines in close proximity to one another, Hayter calls metal detector teams to check the area.

The reason dogs are so successful at detecting explosives is that their sense of smell is more developed than that of humans.

"Compared to dogs, humans use their eyes more than their nose," says Paul Waggoner, director of CDRI. "Dogs are much better at smelling things but they don't use their eyes as much as humans do. They are odor-guided animals."

Scientists have shown that dogs can smell chemicals up to a million times better than humans. For example, while humans can usually smell hydrogen sulfide at a concentration as low as 10^{-6} %, or 0.000001%, a dog is able to smell that same chemical at a concentration as low as 10^{-13} %, or 0.0000000000001%.

Are landmine-detecting dogs reliable?

For the past 25 years, Larry Myers, a professor at the University of Auburn's College of Veterinary Medicine, has been trying to figure out what dogs smell. He has done experiments with explosives, illegal drugs, and substances arsonists use to start fires.

In one experiment, dogs were trained to identify gasoline. Gasoline is made up of more than 300 components, and Myers wanted to know which group of chemicals the dogs were sniffing to identify gasoline.

One year, the study showed that the dogs were tracking one group of chemicals. But the following year, Myers tested another group

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A handler leads his dog to a demining lane to detect trace levels of explosive vapors.

of chemicals on the same dogs. Surprisingly, the dogs were able to recognize this group of chemicals as being part of gasoline. The dogs had adapted, Myers explains.

Hayter trains his dogs in the United States using TNT and other explosives. Then, once overseas, the dogs are trained on landmines that have been removed from local mine fields before being deployed to actual mine fields. When TNT has been in the ground for years, the only chemical vapor available to the dogs may be DNT, although Hayter's dogs are trained on TNT.

"DNT doesn't smell like the original TNT, which is why we first use landmines that come from active mine fields so that the dogs can get used to the smell of these landmines,"

Hayter says. "This learning experience is critical because it allows dogs to learn the makeup of real mines that may have been in the ground for years."

Although dogs can recognize odors and improve over time, they need to be trained for a long period of time, typically for four to six months. "In our training, we make sure that when a dog has detected the explosive, it positions itself between the mine and its handler and then it sits staring at the place where the landmine is buried," Hayter says.

In turn, handlers are trained to keep a close look at their dogs and the areas being searched to watch for potential hazards that might harm the dogs. The handlers also learn to verbally encourage the dogs to continue the search and reward them when explosives are detected.

"The relationship between the dog and the handler is crucial to make it work," Myers says. "A handler needs to constantly encourage the dog and show it his or her full attention. Otherwise, the dog gets tired and distracted and can be used as little as only two hours a day."

Mimicking a dog's nose

Because of the time and efforts needed to train dogs, scientists are now trying to develop devices that mimic the dog's sense of smell.

A dog's olfactory system—both its nose and the part of the nervous system above it that is connected to the brain—works a lot like ours. When a dog comes into contact with an odor, it sniffs it. This concentrates the odor molecules and brings them up to the receptor cells in the dog's nose. But a dog has 20 to 40 times more receptor cells than we do.

Since the early 1980s, scientists have tried to mimic what goes on in the dog's nose and brain by developing odor-detection devices that are more sensitive than current sensors to various chemicals. Although these detectors have not reached the sensitivity of a dog's nose, they are currently used not only for the detection of landmines, but also to check environmental pollution and to make perfumes.

A major project called the Unexploded Ordnance Detection and Neutralization Program, sponsored by the Defense Advanced Research Projects Agency (DARPA)—the research agency of the U.S. Department of Defense—is seeking to develop a device called an electronic dog's nose that is more sensitive than current odor-detection devices. Through this program, DARPA has been funding various university projects.

In one of those projects, led by John S. Kauer, professor of neuroscience at Tufts University, Boston, MA, scientists developed such an electronic dog's nose. The internal surfaces of this nose were covered with chemicals that interact with very low levels of various explosives.

Then, in collaboration with Waggoner and a group of scientists led by Timothy M. Swager, professor of chemistry at the Massachusetts Institute of Technology (near Boston), Kauer's team tested the device at Auburn University. From 1998 to 2003, the researchers studied the sensitivity of various chemicals in the nose to DNT and TNT and found that an electronic nose covered with polymers was as sensitive as—and sometimes even slightly more sensitive than—a dog's nose. These experiments also allowed the scientists to make a computer simulation of how a dog's nose detects and discriminates various chemicals.

SGT. KEVIN L. MOSES SR.

JUPITER IMAGES

U.S. soldiers and Iraqi soldiers conduct joint patrols in Ameriyah, Iraq. U.S. Army Spc. Robert Dami and his working dog Jay search a home for explosives.

Another team of scientists led by Gary S. Settles, professor of mechanical engineering at Penn State University, University Park, PA, is studying the airflow inside a dog nose to understand how the nose samples the air and detects very small amounts of chemicals. Settles and colleagues (who had been previously involved in Kauer's project as well) are trying to understand in detail how chemicals flow in the dog's nostrils and how the hair inside the nostrils detect chemicals and relay that information to the brain. Settles and colleagues are now using their results to simulate a detector that works the same way.

Better dogs

While research to develop an electronic dog nose and similar devices is ongoing, other efforts seek to improve the training of dogs because training programs throughout the world and across the United States vary in quality and efficiency.

The Geneva International Centre for Humanitarian Demining, a United Nations organization specializing in mine clearance and victim assistance, has developed procedures to improve the efficiency of dog training programs. These procedures suggest choosing certain breeds of dogs that are more successful than others at detecting landmines.

At Auburn University, Myers is developing a program to make landmine-detecting dogs more reliable. Although the program has not been funded yet, its goal is to optimize dog training by looking at the best ways to both stimulate the dogs and teach the handlers how to work efficiently with their assigned dogs.

"The information collected over the past three decades about how these dogs behave is now helping us to devise more rigorous ways to train these dogs," Myers says. "If this program is funded, we should be able to provide guidelines to make dog training programs more consistent and more successful."

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