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The e-nose will know

Philadelphia scientists are working on a sophisticated electronic nose to rival the keenest bloodhound and go where canines can't.

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The merest whiff of colorless gas is sent bubbling into one end of a plastic tube.

It comes out the other end, enveloping a small electronic chip.

Immediately, a nearby computer registers the impact: a minuscule drop in electrical current of 20 nano-amps - about 20 billionths of the amount of juice flowing through the average lightbulb.

Presto! The chip has tentatively identified the gas as dimethyl methyl phosphonate, a laboratory stand-in for deadly nerve gas.

How does it know? It's a nose. But not the humble body part of Cyrano or Pinocchio fame.

The chip marks the beginning of an electronic nose - a device that one day could be used to sniff out dangerous chemicals, detect overripe food and even diagnose disease.

This "e-nose" is the work of scientists at the University of Pennsylvania and the nearby Monell Chemical Senses Center - a research institute familiar to West Philadelphians for its giant mouth-and-nose statue in front of the building.

The scientists envision one day making a handheld device that could perform many tasks now handled by dogs - which, aside from their more familiar use as bomb- and drug-sniffers, have been trained to detect certain cancers simply by smelling a patient's breath.

"It's a little awkward to bring a dog into the ICU," said Penn anesthesiologist Bill Hanson, who is not part of the effort but has studied previous e-noses.

Such products have been on the market since the 1990s, used mainly for quality control in factories. But most are limited in the number of odors they can detect reliably. They contain a mere fraction of the smell sensors found in a dog, and generally fall far short of the animal's performance.

And sometimes they are just plain wrong. Just Wednesday in Washington, for example, hundreds were needlessly evacuated from the Russell Senate Office Building after an electronic monitor incorrectly warned of a possible nerve agent.

The Penn-Monell collaborators have pioneered a new approach they say may one day be able to "smell" hundreds, if not thousands, of different scents, with a sensitivity rivaling that of the keenest bloodhound.

The key is a curious combination of the latest space-age material with a biological substance almost as old as life itself: carbon nanotubes coated with a thin layer of animal DNA.

The genetic information in the DNA has nothing to do with noses or the sense of smell. It is used merely because it is a flexible, easily manipulated material that can form weak chemical bonds with a host of different odor particles.

"From our point of view, the genetic meaning could be zero," said Monell neuroscientist Alan Gelperin. "It doesn't matter."

The DNA is used to coat the nanotubes - cylindrical molecules that measure just one or two billionths of a meter in diameter.

The nanotubes serve as miniature transistors, and are hooked up to tiny electrodes and fed with current.

When particles to be "smelled" bond with the DNA, that somehow affects the amount of current flowing through the underlying nanotubes, but in ways that are not fully understood.

Penn physics professor A.T. Charlie Johnson, who is working with Gelperin on the nose project, said that in some cases the current is changing as the result of electrical charges associated with the weak bonds formed between the DNA and the odor particles.

In other cases, the current could be changing due to a physical deformation of the nanotube, again brought about by the bonds between the DNA and odor particles.

"We're still working out exactly what's happening," Johnson said.

Whatever the case, the reason the "nose" works is that different sequences of DNA react to different odors at varying levels - a principle discovered by other scientists at Tufts University.

A given odor might provoke a 10 percent response in a nanotube coated with one DNA sequence, a 20 percent response in a nanotube with another sequence, and a 30 percent response in yet another.

Another odor might trigger different levels of response in each of those nanotubes.

The eventual device would analyze the overall response pattern to determine what is being smelled, much as the brain analyzes the response in each of the 300-plus kinds of receptors in the human nose.

Dogs, by the way, have more than 1,000 kinds of receptors, Gelperin says. And, as anyone who owns a pooch can attest, they can detect smells at far lower concentrations than their owners.

To date, graduate students in Johnson's lab have made nanotubes with just two different DNA sequences, but for certain chemicals they appear to be as sensitive as a dog, responding to smells in the parts-per-billion range.

The goal is to make a chip with 100 kinds of sensors, ideally with several of each kind, able to perceive different levels of smell intensity.

In this day of genetic engineering, countless different sequences of DNA are readily available. The ongoing project will involve testing which ones are best for responding to a wide variety of smells - a process that will be speeded up by computer simulation.

With the use of sophisticated neural-network software, a 100-sensor nose could pick out a target chemical even within a mixture of dozens of other, unknown substances, Gelperin says.

In a September issue of the journal Nano Letters, Johnson, Gelperin and other authors reported success in detecting five chemicals, including the nerve-gas stand-in.

Physicians are most excited by the possibility of finding out if people are sick.

The use of odor in medical diagnosis is thousands of years old for certain diseases that can be detected by the human nose.

Diabetics have sweet breath, for example, whereas the breath of people with liver disease can have a distinct musty odor, says Penn's Hanson.

Sinus infections, pneumonia, tuberculosis and cancer all generate more subtle smells, for which an electronic nose would come in handy.

Such a handheld device would be a noninvasive early warning system, especially for patients in fragile condition, Hanson says.

But for some odors, the human nose still works just fine, to the dismay of some of Johnson's graduate students.

Samuel Khamis, one of the students, says he's learned to keep a low profile on days when he tests trimethylamine, an especially pungent chemical that smells like rotting fish.

A whiff of bad seafood gets a strong reaction. "People say, 'It's that fish smell. Oh no!' " Khamis said ruefully. "They'll smell something, and they're like, 'Sam, what are you doing now?' "