HIGH-TECH DETECTIVES
BODY CHEMISTRY

Where Dead Men Really Do Tell Tales

A research plot where human corpses are studied as they decompose is yielding a bumper crop of insights into how the body decays

KNOXVILLE, TENNESSEE—Take one look at the half-naked middle-aged white man sprawled on a patch of gravel next to a wooded path, soaking up the summer sun, and you'd never know that a few weeks earlier he was wrestling with a weight problem. His leathery skin sags around his bones and is beginning to disintegrate. The muscles, organs, and other soft tissues are long gone, liquefied and consumed by bacteria and insects. Some of the flies buzzing around probably got their start as maggots that gnawed their way through the cadaver to the outside world.

The stench is overpowering.

The thought of being left out in the elements to rot may be a bit unsettling, but this anonymous man donated his body to science and presumably knew, before passing away, that he could end up at the "Body Farm." After suffering a fatal heart attack in mid-June, the man became part of a hunt for chemical markers that reveal the time elapsed since death. Behind a chain link fence topped with razor wire to keep out vandals, some 20 bodies lie prostrate in various states of decomposition. Most individuals died weeks ago and now appear human in outline only. Once inside, a trio of researchers led by Arpad Vass, a chemist at Oak Ridge National Lab in Tennessee, makes the rounds, taking soil samples from around the remains.

The site, officially known as the University of Tennessee, Knoxville's (UT's) Anthropological Research Facility, was started in 1981 by a pioneer in forensic science, UT's William Bass. His exploits identifying remains and fingering suspects inspired Patricia Cornwell's 1994 novel *The Body Farm*—a name that stuck, much to the scientists' chagrin. "We don't like to call it the Body Farm. It's not as respectful as it should be," says Vass. But whatever you call it, he says, "it's an absolutely one-of-a-kind facility."

The corpses are teaching scientists much about how to reconstruct the manner and circumstances of unexplained deaths. Perched above one body is a mechanical nose of sorts, a textbook-sized box with 32 separate chemical sensors that sniff noxious fumes wafting into the air. Back in the lab, the aromatic compounds are washed from the nose into a vial, from which they are fed into a gas chromatograph to identify each component. A neural network compiles unique patterns of chemical signals that correlate with precise times since death—patterns that might be discernible above other corpses. Ultimately, Vass says, he and his UT collaborators hope they will be able to pluck out a single compound that can do the same job. A handheld device that homes in on such a chemical could then be built for crime-scene investigators.

Postmortem interrogation. Oak Ridge's Arpad Vass *(right)* and UT grad student Jennifer Systelien do some Body Farm brainstorming.

CREDIT: C. BOLES/OAK RIDGE NATIONAL LABORATORY

Although several U.S. national labs are redefining their post–Cold War missions to include projects that aim to come up with new crime-fighting tools, Oak Ridge has enjoyed the most success at putting together a forensic science program. Ongoing projects are attempting to recover fingerprints too faint to see with normal dusting procedures; spot crimes on video surveillance tape by clearing out hiss, noise, and distortion from poor lenses; and build portable chip-based devices for gathering and analyzing chemical forensic evidence in the field. Oak Ridge's suite of projects "is pretty impressive," says Kevin Lothridge, co-director of the National Forensic Science and Technology Center, a Largo, Florida–based center that offers technical support for crime labs around the country. Since most funding for forensics gets plowed into casework, he says, new sources of novel investigative techniques are sorely needed.

Indeed, most forensics techniques leave ample room for improvement. Take, for instance, a case that Vass says helped convince him to get into this field. About 20 years ago, Bass—Vass's mentor—was called in to help solve the mystery of William Shy, a colonel in the Confederate army. Shy's grave on his Franklin, Tennessee, plantation had been disturbed accidentally by the home's current owners. The body they uncovered, however, was surprisingly intact, with flesh still clinging to the bones. Because of the seeming freshness of the remains, Bass presumed that the body was a recent murder victim disguised in Shy's clothing. But closer inspection revealed that the corpse had never fully decomposed. It was buried in a lead-lined coffin, and the metal had leached into the body and surrounding soil, rising to concentrations high enough to prevent bacterial growth and decomposition. Simply eyeballing the body had misled the seasoned expert into pegging it 110 years younger than it was. "I thought, 'There has got to be a better way to do this,' " says Vass.

There is now. While in graduate school, Vass worked out two new methods for dating remains. The first tracks the ratio of five fatty acids—valeric, and the straight and branched forms of propionic and butyric—which, he found, vary systematically as long as there is soft tissue. The various compounds can be sampled from any material around a corpse. Their concentrations rise and fall, but each day that passes after death brings a unique profile of all five, says Vass. A similar technique looking at ratios of seven inorganic compounds (including calcium sulfate and magnesium) that leach from bones into soil turned out to be an accurate marker after the flesh disappears, usually a few weeks after death.

These new techniques are already beginning to land criminals behind bars. In 1997, after police in Cheshire, England, found the bones of a murdered 11-year-old boy lying on property belonging to his fa-

Forensic Science on a Shoestring

With billions of dollars spent each year on law enforcement in the United States, one might think that funds for R&D on advanced crime-solving methods would be flowing freely. But the experiences of the U.S. national laboratories in trying to carve out a niche in forensics research suggest otherwise. "Justice and law-enforcement research funding isn't a blip on anybody's screen," says Kevin Lothridge, co-director of the National Forensic Science and Technology Center, which provides technical support to crime labs.

The main agencies that fund this sort of work in the United States—the FBI, the National Institute of Justice, and the Department of Energy (DOE)—together spend less than $50 million a year, Lothridge calculates. Although this amount "is much improved" over what was available a few years ago, he says, vagaries in year-to-year funding levels make it difficult to sustain ongoing programs. The insecure environment has snuffed out some fledgling crime-fighting efforts at the national labs. In 1995, for example, DOE gave researchers at Oak Ridge National Laboratory in Tennessee seed money to launch the Center for Applied Science and Technology for Law Enforcement (CASTLE). The program backed Oak Ridge projects such as a computerized system for rendering facial images from skeletal remains, a potentially faster and cheaper approach than the clay reconstructions currently in use. Compared to other national labs, Oak Ridge has sustained a healthy forensics research program (see main text). But CASTLE was phased out 2 years later after failing to raise enough grant money to keep itself afloat. In the end, says Vivian Baylor of Oak Ridge's national security program office, the computer facial reconstruction effort "withered on the vine."

That same pattern could be playing out at Lawrence Livermore National Laboratory in California, where researchers launched a Forensic Science Center (FSC) in 1991 to support local law enforcement and other agencies concerned with crime. Center scientists drew heat in 1994 over their controversial (and impossible to prove) hypothesis that a novel chemical reaction in a dying woman's blood produced a toxic gas, which sickened workers in a California emergency room trying to save her life. The circumstances surrounding her death remain a mystery. Among the FSC's achievements, however, is a portable gas chromatograph for analyses in the field. But the fancy hardware has not helped entice continued funding, says FSC chief Brian Andresen.

Besides struggling for research dollars, the FSC has failed to attract stable funding to support analytical services it has provided to law-enforcement agencies looking for help in cracking tough cases. Because the FSC must charge up to $1000 a day per investigator to cover costs, work on a single case runs as much as $30,000, says Andresen. "Local law enforcement just doesn't have that kind of money," he says. As a result, Andresen is scaling back his program to focus on one of Livermore's well-endowed core areas, chemical and biological weapons nonproliferation and counterterrorism. Over the years, Andresen says, he's heard plenty of rhetoric about how advanced equipment and techniques honed at the national labs could transform forensics casework. But "when push came to shove," he laments, "law enforcement just didn't come up with the money."

–R.F.S.

ther's family, they zeroed in on Dad as the chief suspect. But when investigators sent Vass samples of soil from beneath the body, he found no traces of the telltale inorganics—even though the boy had died nearly a year earlier. The evidence clearly demonstrated that the victim's remains had only recently been brought to the property, Vass says. The father apparently knew that his wife was having an affair with a neighbor. When confronted by police, the neighbor allegedly confessed to the slaying, admitting that he and the boy's mother had killed the child in a twisted effort to implicate her husband.

A recent case in Florida took a similar turn. In this instance, Vass says, a prisoner bragged to his cellmate that he had abducted a woman leaving a convenience store before raping and killing her. The prisoner also revealed that he had an accomplice help him bury and move the body several times, each time fearing they had been spotted. The cellmate told the police, but the prisoner later denied the story. Hoping for corroborating evidence, local police tracked down the accomplice, got his cooperation, and sent Vass soil samples from several potential temporary grave sites identified by the accomplice, including one on property belonging to the suspect's family. Analyzing the minerals and fatty acids, Vass found clear signs of the presence of a dead body in samples from all but one of the sites. The amounts of the chemical markers confirmed that they came from a large mammal, and the lack of fur or animal bones convinced investigators that the mammal was a person. The woman's body was never found. Still, after listening to the evidence, the defense attorney persuaded his client to accept a plea bargain for life imprisonment rather than possibly face the death penalty.

Time's expired. As this corpse decomposes, its bouquet reveals how long the body has been lying around.

CREDIT: C. BOLES/OAK RIDGE NATIONAL LABORATORY

Vass and his colleagues have now turned to volunteers willing to lend a hand (and then some) to help them expand their forensic chemistry toolkit. Their aroma studies are already beginning to pay off. With the neural network, Vass says, "we see significant changes between early and late individuals." Now they're trying to home in on a single marker. "We've tracked hundreds of compounds thus far," he says. At this point, the best candidate markers are phenols, ring-shaped organic compounds produced by the breakdown of amino acids that can even be detected in the air above shallow graves. If phenols live up to their promise, a handheld detector could prove a boon to detectives searching for missing bodies.

Beyond the Body Farm, other Oak Ridge projects could soon put new tools in the hands of investigators. The lab is among the leaders in developing new techniques for analyzing the age-old art of fingerprint analysis. And Oak Ridge researchers are nearing completion of a suite of new software tools to allow crime labs around the country to recover incriminating images on grainy video surveillance tapes. Here too, the work has already helped police investigators solve cases. But it's the Body Farm that has put the Tennessee team on the forensic science map.

–ROBERT F. SERVICE