Few people decide when they’re children that they’d like to study the chemistry of death for a living. But Maiken Ueland set herself firmly on that path when she was a teenager—and she hasn’t looked back. Today, Ueland serves as deputy director of the Australian Facility for Taphonomic Experimental Research (AFTER) at the University of Technology Sydney; taphonomy is the study of decay processes in once-living organisms. Ueland and her colleagues use donated human cadavers to characterize the volatile organic compounds (VOCs) given off during decomposition.

Although researchers have known for almost 3 decades that decaying humans emit a characteristic lineup of volatiles, improved analytical instrumentation can more precisely reveal that mixture’s composition and help pinpoint unique biomarkers of decomposition. Ueland is using this knowledge to develop better tools—such as portable electronic “noses” that can detect those biomarkers—to find victims of crimes or mass disasters. Alla Katsnelson talked to Ueland about her research on developing such tools for finding human remains, as well as how the forensic science shown in crime dramas misrepresents reality.

This interview was edited for length and clarity.

How did you start studying the chemistry of human decomposition?
I was 15 when I first realized this was what I wanted to do. I’ve always loved crime novels; I loved solving puzzles, and I also had a big love for chemistry and trying to understand...
how things work. Everything came together when I found forensic taphonomy. I get to be outside and study the chemistry of how the body breaks down, and I get to use that to work with law enforcement to help solve crimes and to try to help victims and victims’ families.

What guides your work today?
A major focus of my work is developing better tools to locate victims in mass disasters. Mass disasters are increasing worldwide due to climate change and an increased threat of terrorism. You want to make sure that you are ready before the disaster strikes and not just scrambling afterward. I’m also applying the same principles we rely on for human detection to develop methods that can detect illegal wildlife trafficking, which is a massive biosecurity risk because of the potential for infectious diseases to transfer from these animals to native plants and animals, including people.

Where does chemistry come in?
When humans and other organisms break down, they produce chemical byproducts, some of which are volatile organic compounds. From these, we can identify VOCs that are biomarkers for decomposition. We use these VOCs to answer a range of questions—for example, to locate missing persons, particularly in mass disaster recovery, and to ascertain time of death by tracking how these VOCs change.

How do you identify the right VOCs?
These volatile elements are incredibly complex, so the field is still in an exploratory stage where we’re trying to figure out exactly what all these compounds are and how they change. So we take an untargeted approach, paired with some targeted analysis of compounds that have already been identified as biomarkers.

In the past, researchers often used pigs as a model species for human decomposition or used instrumentation that has now been improved upon. We use gas chromatography/mass spectrometry a lot, more recently with comprehensive, 2D chromatography with time-of-flight mass spectrometry. There’s been an evolution in the type of instrumentation that can deal with these complex mixtures. We’ve gone from finding hundreds of compounds to, now, thousands. We hope to use that to either help law enforcement better train their scent-detection dogs or to create portable scent-detection technologies.

What methods are used now to search for missing persons or disaster victims?
Currently, people rely on several methods. One is physical searches, which can carry risks to the search personnel themselves. Imaging techniques can be done remotely but may not work in all scenarios. Or people use scent-detection dogs, which today is the best tool available. But dogs are very expensive to train and deploy, they cannot be used in any hazardous environments, and they have limited working hours. So we are developing an instrument that does what the dog does: an electronic nose.

We use benchtop instruments to find some key target compounds or compound groups, and then we basically train the electronic nose to recognize them. The instrument is set to detect alcohols, sulfides, nitrogen-containing compounds, and certain hydrocarbons that are found in human decomposition. The sensor technology is ever evolving, and we are continuously working on getting better sensors that detect these key volatiles. We’re now doing field trials on our third prototype to test that the sensor is tuned to detect the right compounds. We’ve had some good success, with it being able to pick up human remains hidden underneath debris and rubble in a simulated disaster.

AFTER is the only taphonomic facility in the southern hemisphere. Why is that so important?
Decomposition is highly influenced by the climate. Until we opened in 2016, the only similar facilities were in the US, where the climate is very different and so is the insect population, which also impacts the decomposition rate. We couldn’t just take data from the US facilities and apply it to casework here. AFTER was opened to get that local environmental data so that we can really understand how the decomposition process works in Australia.

How does decomposition differ in the two countries?
The biggest difference is in the rate of decomposition. Here in Australia we see a lot of mummified tissue occurring on the human remains. That really slows down the decomposition process, so a body that appears like it’s been there for 4 months, according to US data, might actually have been there a year.

What would you say is the biggest mismatch between peoples’ perceptions of forensic science and reality?
I think it’s pinning down the time of death. It’s such a key piece of information for corroborating witness statements or for trying to exclude or include people from the investigation. On television it looks super easy: They just go, “Oh, this person’s been dead for 4 weeks and 3 days, and they died at 5:22 a.m.” But, actually, it’s a very challenging question to answer.

Bodies can have slightly different decomposition trajectories even if they’re placed in the same environment on the same date and they’re undergoing exactly the same
external influences. That’s because factors such as people’s fat content, internal microbes, or what they ate when they were alive influence the decomposition process.

A lot of methods are very subjective, relying on visual cues that people might interpret slightly differently, so we’re looking for more objective ways of measuring that decomposition trajectory.

Alla Katsnelson is a freelance contributor to Chemical & Engineering News, an independent news outlet of the American Chemical Society.