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CHEMISTS WHO UNRAVEL CRIMES

Forensic scientists analyze, interpret, and testify about trace pieces of evidence

LOUISA WRAY DALTON, C&EN WASHINGTON

A FORENSIC SCIENTIST IS, MORE OFTEN THAN NOT, a chemist. The traces of gunpowder, strands of hair, and chips of paint that can link a suspect to a crime are best analyzed by chemical instruments, methods, and problem-solving approaches. "For an analytical chemist," says J. Graham Rankin, professor of forensic science at Marshall University, Huntington, W.Va., "the forensic world is the ultimate."

And the more powerful the instruments and chemical methods of analysis have become over the years, the more forensic science has leaned on chemistry. Even fingerprint analysis, one of the oldest tools of forensic examiners, is highly chemistry-dependent. "When I first started," says David E. Burow, a graduate student in forensic science at Marshall, "I thought that all you did was powder fingerprints and poof, they appear." But after he started an internship with the Secret Service, Burow learned that developing fingerprints on various kinds of surfaces requires a myriad of different types of chemical processes.

Burow loves his research at the Secret Service and readily displays his lab notebooks packed with fingerprints. He freely acknowledges, however, that the work itself can be less than glamorous. The end goal may be catching criminals, but the drama of the work is often nowhere near how "CSI" and other popular TV shows portray forensic science, Burow says.

"It takes a lot of time, and you have to be very dedicated. It is very tedious to take a la-

tent fingerprint that you have developed from a piece of paper, a glass, or a knife at a crime scene. You have to look at it and study it, see where all the points of identification are on that fingerprint, and compare it to known samples. You have to sit there and look at each finger to make sure you have the right guy. You can't get it done in five seconds like on 'CSI.' That doesn't happen."

The painstaking chemical analysis is what Burow, who was a molecular biology major and chemistry minor as an undergrad, was looking for. "I wanted to see the other side of things—not the criminal part, not go chasing after the bad guy—but really the grunt work, how it actually works."

Such an attitude is helpful in the field of forensic science, says Reta Newman, forensic laboratory director for the Pinellas County Forensic Laboratory in Largo, Fla. "Sometimes when I interview people, I get vigilantes who want to put the bad people in jail. That is the wrong reason to get into forensic science. If you don't have objectivity, you cannot do the job properly."

So if forensic science isn't rounding up a posse, what exactly is it? Forensic chemists have three major tasks. First, they analyze evidence, primarily in a laboratory. They answer questions such as, Did the body have morphine in it and at what concentration? Second, they interpret that analysis. This is a more subjective process; they try to answer questions such as, Could this morphine concentration have caused the death of the person? An interpretation is often done using library tools because it requires a thorough knowledge of any relevant literature. And the third part takes place in the courtroom, where forensic scientists testify about the analysis of the evidence and their interpretation.

ANALYSIS. Evidence comes in all forms: unidentified powder, ingested alcohol, paint chips, glass shards, DNA, fingerprints, half-burned wood, printing ink, and so on. Entire subfields have grown up around the analysis of the most common types.

"There are not a lot of generalists left," Newman says. "A generalist would be a person who does everything—like the 'CSI' people. Those people don't exist, by the way. They do everything. They do pathology; they do toxicology; they do chemistry; they do DNA, they do crime scene, they interview witnesses. That's not reality. Reality is typically that an analyst specializes in something. In my case, it is analytical chemistry."

Newman oversees a group that performs seize-drug analysis, which is the characterization of drugs before they get in the body. She also manages the toxicology sec-

tion, which analyzes drugs found in tissue—both living and dead tissue. This includes determining blood-alcohol levels.

Newman herself specializes in fire debris analysis. Using gas chromatography/mass spectrometry, she looks for a pattern of volatile hydrocarbons in the headspace of the burned material that would indicate the presence of an ignitable liquid.

Julia A. Dolan, a senior forensic chemist at the Bureau of Alcohol, Tobacco, Firearms & Explosives (ATF) Forensic Sciences Laboratory in Washington, D.C., also works on fire debris. She says that not only can forensic scientists identify the presence of an ignitable liquid, but they can also compare its pattern to the hydrocarbon pattern of a suspected source. "If a suspect was seen purchasing gasoline (on a gas station video, for example), then samples could be taken from the pumps and compared to the gasoline identified at the scene ... While it isn't a fingerprint, it can be very strong evidence."

Dolan sees growing opportunities in explosives analysis because of the U.S. government's emphasis on fighting terrorism.

Analytical chemists can even help determine the serial number on a firearm, Newman says. "Serial numbers are impressions. Even if they are filed off, the metal underneath it has been altered by that compression. There are chemicals you can add that bring [the number] back up." And the presence of gunshot residue—lead, barium, or antimony—can help place where a gun was fired.

The Secret Service has a large group that specializes in the chemical analysis of printing inks for tracking counterfeit currency, Burow says. GC/MS helps determine the actual components of the dyes. And different dyes absorb or fluoresce light at different wavelengths. Burow uses some of the same techniques when he is looking at fingerprints.

Some analysts specialize in the chemical composition and refractive indexes of glass shards. They determine if the glass caught in the cuffs of a suspect, for example, matches the broken glass at a crime scene.

Paint chips, often found on hit-and-run victims, can give clues about the year, make, model, and sometimes even the factory that built a car. Automobile paint has a very intricate and specific series of layers and paint shades. Analysts use infrared microscopy to study the layers.

And DNA analysis is a huge specialty.

INTERPRETATION. After the evidence is collected and analyzed, usually there are still many unanswered questions. Was the starter fluid found on the fire debris used as an accelerant? Was the alcohol level at the time of the accident enough to impair driving ability? Sometimes these questions of interpretation are unanswerable. However, forensic scientists can offer expert opinions based on cases they have seen before and examples they know from the literature. Forensic toxicologists are asked for expert opinions especially often.

"It can be extremely difficult," says Nicholas T. Lappas, professor of forensic toxicology at George Washington University. "The easiest call is probably a blood-alcohol level—it's the easiest to interpret because we've had so many years of experience and there is enormous literature on the subject. If I know a blood-alcohol level, I can tell you the kinds of effects that that blood-alcohol level would have on the person. If it is 0.2%, we know that the person is significantly impaired, may be ex-



LIGHT TOUCH Modern fingerprint identification uses dyes and light to sharpen the image.

periencing drowsiness, may actually be asleep. With other drugs, that correlation between blood level and the effect is not as clear-cut."

Yet even with blood alcohol, Lappas says, there can be confounding factors. For example, alcoholics can tolerate higher blood-alcohol levels than nonalcoholics can. "You might have an alcoholic who is driving a car at 0.3%, whereas you or I would be unconscious, possibly in a coma." Along with tolerance issues, there are age, gender, and ethnic differences in the way each body handles a drug.

Lappas cites the case of a man going in for surgery who gets a dose of narcotic and dies before surgery. "The question is, Was too much drug administered? We have to take into account the facts that the man was an

alcoholic and that he was using other drugs. Also, his body weight factors into it. How would his specific body have handled this drug?"

In a court of law, Lappas says, he is asked to state his opinion "with a reasonable degree of scientific certainty."

"And that means 50-plus %—just a little bit better than a flip of a coin, which isn't a very high standard," Lappas says. "But that is the standard that the law applies. It's not a 95% standard, which scientists are accustomed to dealing with."

Lappas says experience, education, training, and knowledge of the literature all go into formulating an opinion. "In certain areas, I feel very comfortable. How much alcohol did this person drink? I can come up with a very good estimate. But how much cocaine did this person use? I probably wouldn't touch that with a stick."

TESTIMONY. The work of the forensic scientist culminates in the courtroom. ATF's Dolan says it is crucial for forensic scientists to be able to communicate. "Even if you are the most brilliant chemist in the world and you find some fabulous evi-

dence—if you can't explain to a jury how significant that is, then it doesn't really matter what you did."

Lappas says communicating in a courtroom involves listening carefully to questions, answering no more than the question that was asked, and defining terms that the jury may not understand.

Even if forensics experts don't actually testify, they may play a large role behind the scenes in consultation with lawyers: reviewing other expert reports, preparing questions for the attorney, and looking for the strong and the weak points of the opposing expert.

Dolan says that some years she can go to court six times and some years not at all. Those who work in federal agencies—including the Drug Enforcement Agency, the Secret Service, the Federal Bureau of Investigation, and ATF—tend to get more high-profile cases and travel more. But those who work in local forensic offices tend to testify more often.

SO IF YOU LOVE chemistry, can easily talk about your work with nonchemists, and like the challenge of a good puzzle, forensic science may be for you.

With the advent of forensic science TV shows and the more visible face of forensic chemistry, the number of college programs has increased and the number

of applicants per open position has correspondingly increased, Newman explains. "For every opening, we get hundreds of applications." Both getting a master's degree and doing an internship are practically requirements now.

In addition, Newman says, "it sounds kind of trite, but don't do drugs. Even

though [applicants] may have the required chemistry and the required degrees, you would be surprised at how many people never get past the background check." If you've used illegal drugs in your past, she says, you are probably not going to get hired to help catch those who are using them now. ■

"For an analytical chemist, the forensic world is the ultimate."

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