Toxicology

The sensitive analytical methods that toxicologists use can prove from a few strands of hair that a suspect used illegal narcotics weeks earlier, or detect vanishingly small quantities of poison in one drop of a murder victim's blood. But the bulk of the work in a busy toxicology lab concerns a legal drug—alcohol.

ILLEGAL DRUGS ▲
An immunoassay drug-testing kit for amphetamines would give a positive result if a subject had taken ecstasy (MDMA) tablets like these.

Though roadside tests roughly measure alcohol in drivers' breath, this test is inadmissible in court. So drunk drivers' samples of blood or urine are tested in the toxicology lab. Because of the number of samples, testing is automated, though it is no less rigorous than other toxicology procedures.

Drug abuse testing

Testing for other drugs follows a similar pattern: a simple test to establish whether a suspected chemical is present, followed by a more sophisticated procedure that measures quantities and provides proof. The initial test is usually an immunoassay kit, which changes color when drugs in a urine sample combine with antibodies in the kit. If they get a positive result, toxicologists proceed with more sophisticated tests. Drug tests are carried out not only in relation to suspected abusers and athletes, but also on behalf of some employers who have implemented a random testing policy.

Identifying and measuring

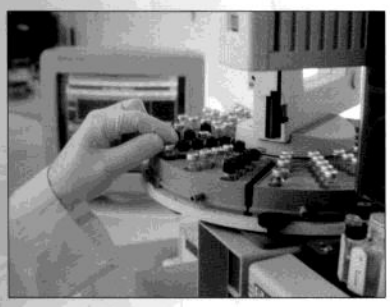
For both drugs and alcohol, these tests are likely to involve chromatography, a method of separating chemicals according to the speed at which they move in gas or liquid. The indispensable tool of the toxicology lab is gas chromatography (GC). At its heart is a narrow tube, usually loosely packed with special solid granules. Through this flows a nonreactive gas, such as nitrogen, which is called a "carrier gas." When a vaporized test sample is injected, every chemical in

BLOWING IN THE TUBE
British police administer more than 200,000 breath tests every year. Around 1 in 25 drivers gives a positive result.

it passes through the tube at a different speed. By timing when each reaches a sensor at the exit, it is possible to identify the constituents of any mixture. Output from the sensor drives a computer display. Test substances appear as peaks on a graph; peaks matching those of a known drug indicate a positive result. Two other chromatography techniques are often used, depending on what needs to be tested. These are: high performance liquid chromatography (HPLC), which uses a liquid rather than a gas for the carrier phase; and thin-layer chromatography (TLC)—see image at top right.

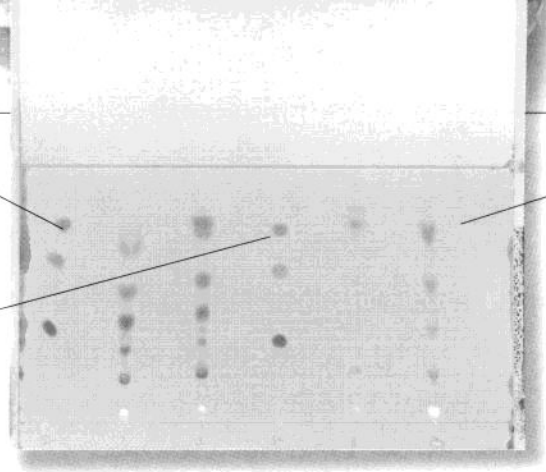
MASS SPECTROMETRY

A gas chromatograph (GC) is often linked to a mass spectrometry (MS) instrument and called GC/MS. This instrument breaks up chemicals into ions (charged particles). Accelerating these ions in a magnetic field and measuring their charge relative to their mass gives a characteristic spectrum that identifies the chemical composition.



Poisoning

Chromatography is also widely used in the other major branch of toxicology, poison. Whether accidental, suicidal, or homicidal, the subject of testing here is not a suspect, but a victim—usually the lab test samples a pathologist has taken at an autopsy. Blood and liver are the most common, but pathologists sometimes send other samples. Bile concentrates anti-depressants, morphine, and heroin. Volatile substances such as solvents show up in the lungs, and hair stores a neat chronological record of poisoning in bands along the length of a strand. Toxicologists analyze these samples with techniques similar to those they use on blood and urine samples from living subjects—usually immunoassay and chromatography.



First track on the plate is a control sample containing methadone, which forms the top spot.

The top spot of the suspect sample has risen to the same height as the corresponding spot on the control, suggesting the presence of methadone.

Spraying the glass plate with a reagent, or viewing it under ultraviolet light, makes the formerly colorless tracks visible.

▲ THIN-LAYER CHROMATOGRAPHY
Spots of sample material—usually in liquid form—are pushed up a specially coated plate by an organic solvent soaking up from the base. Components in the sample move up at different speeds and separate.

Poison sleuth

The popular image of toxicology is of a baffling murder solved by a maverick scientist, but the reality is usually more prosaic. Most poisons leave symptoms pathologists easily spot in the morgue, and poisoning homicides are now rare.

Biohazard emergencies such as the 2001 anthrax attacks in the US are the headline-grabbing exception. In these types of situations, toxicologists are in the spotlight: they take and analyze samples from the scene; they study the effects of the lethal agent on plant and animal life; they advise on how the outbreak might be contained; and they supervise the treatment of victims.

A few murder cases still really do conform to the "poison sleuth" image. In 1979, for example, Georgi Markov, a Bulgarian dissident living in London, felt a stab in his leg. Looking around, he saw a man carrying an umbrella hail a taxi. The tiny wound in Markov's leg quickly became infected and he died four days later. Pathologists suspected poison but found not a trace of toxin in his body, just a tiny pellet in the wound. Detectives concluded that the man hailing a taxi was a Bulgarian agent who had fired the poisoned pellet from the umbrella. Markov's symptoms suggested the poison was ricin, which is rapidly metabolized by the body and vanishes without a trace.

BIO ALERT
When bioterrorists strike, toxicologists take no chances. The sterile suits they wear to take samples are carefully decontaminated (right), and back at the lab they study specimens in sealed glove-boxes.