Audio file

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Transcript

OK, everybody. Right, our first line of this term, very interesting one, I think. The UCL Armage of Security and Crime Science, very interesting topic. And Dr. James French has been kind enough to come along today and give the lecture to you. can see it's putting the science into forensic science and it's about trace evidence. I think it's a really interesting topic. Use this as a perfect opportunity to practice your note taking after the term one listening exam. Some of you did very well, some of you maybe not quite so well. Make sure you try your best with your notes today for the seminar next week. Thank you very much, James.

No problem. OK.

OK, everybody. Thanks very much.

OK, good afternoon, everyone. Apologies I didn't bring any cake. But hopefully, I have brought you some interesting stuff about forensic science, which you may know a little bit about already, but hopefully by the end of this hour session, you'll know a little bit more about. So yeah, I'm going to be talking to you about forensic science broadly, but specifically, I'm going to talk to you about what we mean by trace evidence in forensic investigations, talk to you about gunshot residue in particular, and a few other issues. considerations of things that are going on in forensic science at the moment. As Martin mentioned, I'm based at the Department of Security and Crime Science, which is just over on Tavistock Square down the road. So really not far. And I did my undergraduate degree in geography. So I'm kind of at home within this building as well. So yeah, I'm going to crack on. So I want to do a few things today. I want to talk to you a bit about forensic science, introduce you to some ideas and thoughts around forensic science that hopefully will cause you to realise that it's a little bit more complex than what we see on the television, on programmes like CSI. I'm going to talk to you about why we need to do research in forensic science so that we make sure that the forensic science we do is robust. I'm going to give you a bit of a course in the science of gunshot residue analysis, which is a particular area of interest of mine. And I'm going to introduce some experimental work that we carried out to help us to understand how we might use gunshot residues within casework. So forensic science. Like all good lectures, we'll start with a definition. So hopefully you know what we mean by science. OK, so science involves trying to explain phenomena and explain why things are the way they are by developing theories and then subjecting those to experimental testing and carrying out observations. So science is familiar to us. Forensic just means that it's related to or appropriate for courts of law or in the criminal justice process. So effectively, it's the application of different scientific techniques and methods to criminal investigation or legal proceedings. And that's what forensic science is. Forensic science interacts with a lot of other spheres. So there is a relationship with policing. So the main function of our police is actually to prevent crime. But what most people consider is that the police's role is out there to kind of solve crime, okay, and provide justice, okay? And forensic science is a tool that can be used for the police to do that job. It is a tool to try to identify offenders, what happened, reconstruct crimes. But also, forensic scientists, like me, rely on the police doing their job very well. It relies on police kind of identifying evidence and preserving evidence at the crime scene, maybe cordoning off a crime scene to prevent contamination. There's A relationship with science, and I'll show this to you in the next slide. As forensic scientists, we borrow from lots of different disciplines like biology, chemistry, genetics, and we apply that science to criminal investigation. There's a relationship with industry. Industry provides us with new kit, new technology that we can use within forensic science. And there's a relationship with the law, okay? The role of a forensic scientist or the duty of a forensic scientist is to the court in reaching its decision. We may be employed by the prosecution or the defence, but we're meant to be neutral and objective, okay? And we help the court reach its decision. And in the UK, that decision is reached in a criminal court by a jury. We have a jury system here. But there's also kind of political decisions that affect the way we do things. Who does forensic science? Forensic science costs money, okay? So the forensic response, if you have your bike stolen, will be almost nothing, okay? You might get a crime reference number, almost nothing else. If someone is murdered or sexually assaulted or there's a violent robbery, the forensic science response is completely different, okay? There may be DNA samples taken, we're looking for finger marks, we're looking for blood, we're carrying out digital forensic analysis. So forensic science costs money and the forensic response will be proportionate to the severity of the crime. So volume crime, things like theft and burglary that unfortunately we have a lot of, won't get any forensic response. There just isn't the time and there isn't the budget to do that. More serious crimes get a lot more forensic response. And here at UCL, we tend, most people when they think of forensic science, they think of things at the crime scene or they think of things in the laboratory, okay? At UCL, we place an emphasis on thinking about forensic science holistically, okay? And that means we focus on the forensic science process from crime scene right through to the courtroom. So we're interested in the journey of a piece of evidence, if you like, from its discovery or creation at the crime scene right through to the courtroom. Can anyone give me an example of a crime scene? If I say crime scene to you, what do you think of? Yep? A murder scene. A murder scene. So maybe a room in a house that's covered in blood with a body. Yep, classic kind of crime scene. Anything else? A shop. A shop? Yep. Maybe there's been an armed robbery in a shop. Yes, we're thinking of a building. What other crime scenes do you think of? Yep. Car accident. Car accident, yeah, like if somebody's been hit by a car and there's a suspected drink driving, for example, that'll be sealed off and investigated as a crime scene. Anything else? Yep. Homicide. Sorry? Homicide. Yeah, homicide, murder scene, yeah. Houses, people thinking of domestic settings. Crime scenes can take all different shapes and forms. During some riots in London, the whole of Oxford Street was a crime scene because there was a running brawl from one end to the other. We can have multiple different crime scenes for the same crime. So if we've got a murder or homicide, you might have a burial site, you might have a victim's home, you might have a car that was used to transport a body, and you might have several crime scenes. And they are spaces or locations that might yield evidence in relation to that crime, okay? But also, increasingly, we have non-physical spaces, right? So a laptop could be a crime scene, a mobile phone could be a crime scene, if it's been used for communications in relation to criminal activity, for example. So when we identify a crime scene, we need to process that crime scene, we need to cordon it off in whatever way we need to, and we need to collect evidence in a systematic way and retain that material and take it away from the crime scene. We then have to analyse that material, that evidence, to tell us where it's come from, okay, to try to identify what we've got, okay, and where it might have come from. So we've got some red liquid substance on some walls. We first need to see whether it is indeed blood. And then we might want to do some analysis around whose blood is it? OK, where's it come from? How long has it been there? OK, so all of that analysis usually takes place in the laboratory. Increasingly, we can do some analysis in real time at the crime scene as technology improves. OK, so we've got some outputs of our analysis. And this is a key point. We then need to interpret the outcomes of the analysis. What does the analysis tell us? OK, It's this person's DNA, but how did it get there? We've got a mixture of DNA. Who's the most recent contributor to that mixture? So the interpretation is where the forensic science adds their value. And we then present our findings in court, often in the form of a written report, but sometimes we stand up and give oral testimony in court to help the court reach its decision. So forensic evidence, and we're going to leave digital to one side, okay? I run a module on digital forensic science, mobile phones, laptops, routers, smart watches, AirTags, all those kind of things. But it's such a growing field and very new, we're going to kind of leave it to one side. And what we're going to focus on is kind of more traditional forensic science today. So imagine another big circle, which is digital, over here. But we tend to divide forensic evidence into two main spheres, trace materials and patterns, marks and impressions. So trace materials are bits of stuff. So fibres, hair, pollen grains, gunshot residues, DNA. Patterns, marks and impressions are where a pattern or mark has been left by a surface. So a finger mark, footwear mark, tool mark, those kinds of things. Handwriting, where we are comparing a mark from a crime scene to a print on file. And there's some overlap between. And most people, when they think of forensic evidence, they tend to say fingerprints or DNA. Perhaps I should have asked you that in advance. People tend to less often think about things like pollen grains and soils, OK? But all of these things can be used as evidence in criminal investigations. So everyone has a different fingerprint. Everyone has a completely different-- if you're unrelated to someone, you have a different DNA profile. Individual items of clothing have different fibre characteristics that we can look at under microscopes and distinguish between different types of clothing. Same with hair. So obviously in the root of the hair there is DNA. But the hair itself can be used as an exclusionary tool. People have different coloured hairs. People have different lengths of hair. Some people dye their hair. And we can use these indicators to kind of distinguish between different sources of hair. Soil and pollen kind of fall into geo-forensics. So pollen varies spatially. So the pollen assemblages, the amount and types of pollen in Regent's Park will differ from pollen in the Lake District. And they can be really useful to determine where somebody's been and when. It also varies over time. If you get hay fever like me, you'll know that there are particular types of pollen that are prevalent at different times of year. So again, you can work out when somebody's been weathering an item of clothing, or perhaps when a body that was buried was last above ground by looking at the pollen that's retained on the clothing. Soils, again, vary from place to place and over time. So if somebody comes to you with a pair of muddy boots that have been taken from a suspect, who is under suspicion because his partner has been murdered and the body has been found at a burial site, you might compare the soil on the boots to the soil from the burial site. You might want to do some comparisons there. So that's the logic. Footwear marks and tool marks often used as well. So different types of footwear leave different footwear impressions and we can compare the mark left at the scene to a a suspect's shoe that's recovered during a search, for example. So a range of different types of material. And they all rely on this central principle of forensic science, which is every contact leaves a trace. This is Edmund Lockard. He's working with the French police, sort of 1930s, published quite a lot of material. And he's remembered for these five words. Lockard's exchange principle, every contact leaves a trace. The idea that every time 2 surfaces, So they might be two people, or a person and a surface, or two surfaces, two items of clothing, whatever it is, come into contact with each other. There is an exchange of material. A gives material to B, and B gives material to A. So by touching this desk in front of me, I'm depositing skin cells, which contain my DNA, and bits of sweat, and probably finger marks to this desk. I am picking up little bits of dust, little fibres, probably the lecturer's DNA who was here beforehand, okay? And there's an exchange of material. By sitting in the seats you're sat in, you are giving up fibres from your clothing, okay? If you're wearing woolly jumpers, you'll give up lots and lots of fibres. If you're wearing denim jeans, fewer fibres, but you will still give up fibres. And you'll be picking up fibres, hopefully not chewing gum, but hair, and probably Possibly pet hair, if somebody's sat in the seat before you. The idea is that we're an exchange of material. And those exchanges of material, those materials, are then indicators of where you've been, what you've been into contact with, and possibly when you've been there. So we can use them to, what we say, reconstruct an event. Reconstruct people's movements in space and time. And as I mentioned, in forensic science we borrow from a lot of different scientific disciplines. So as forensic science is what we call an applied science. So we apply theories, methods and techniques from other disciplines to the investigation of crime. So for example, the discovery of DNA, was made by geneticists, okay, and biologists. We apply that to criminal investigation. The work that I do in gunshot residue relies on some chemistry, okay, and chemistry analytical techniques. People who are experts, forensic anthropologists who are experts in being able to identify skeletal remains and tell you the sex of the, biological sex of the the owner of that skeleton, how old it is, and how long it's been there, are by training archaeologists and anthropologists. So we tend to borrow from all of these disciplines and apply to investigations. And you can see this in a real case. So this is like a fictional homicide. So we might have a body that we've discovered, and we might have a range of different specialists, forensic specialists, that are contributing to the investigation here. We might have a forensic chemist or ballistics expert who's looking at spent cartridges at the scene if there was a shooting. We might have some digital or cyber forensics people who are looking at the victim's mobile phone records. They might also be looking at the activity around the cell towers at the time to identify possible possible suspects or even witnesses. We might have a forensic geneticist who is doing DNA analysis. If we found some blood at the scene, we want to know is it the victim's blood or has the offender cut themselves or something in a struggle and could that help us to find the offender. And we might have a forensic statistician who's able to do weight of evidence calculations. Calculations to tell us how much our evidence supports one hypothesis or another. Now, forensic science is often mostly reactive. So there's a crime that's taken place, and forensic science is involved in investigating that crime and trying to solve it. But we can also use the principles of forensic science to prevent crime before it happens. So a good example of this is something called Smart Water. Have people heard of Smart Water? Have people seen the sign? Okay. So it is an inorganic liquid that you can buy to secure your property. Okay. If you own a business, for example. And each kind of batch of that liquid has a unique forensic signature, which when analysed, tells you exactly where it's come from. Okay. It's very, very resistant. So if you try to burn it, won't burn. And it's very resistant to different environmental conditions. It's used to link offenders to crime scenes, and there are a million users or businesses worldwide that use this. And because it's a threat to criminals, so it enables us to detect criminals, and it supported their convictions, what it has is a deterrent effect. So if criminals are thinking that they might want to rob a cash in transit van, so where they deliver cash to ATMs, or a van containing lots and lots of expensive tools, or break into a shop, a jewelry store, for example, they might think twice, okay, if they see the SmartWaters sign, and they might actually move on to a different target. So it has lots of applications. We can use forensic science and the principles of forensic science, not only for investigations, but also for prevention of crime. So forensic science, I've painted a pretty rosy picture so far. Everything is good. It's really helpful. Why do we need to do research in forensic science? Why does our department exist that does research in forensic science? Well, kind of for many years, a lot of forensic science was kind of expert led. So kind of Sherlock Holmes-esque kind of figures who'll be able to kind of, through some process of inference making at the crime scene, be able to tell you exactly where certain things had come from, at the exclusion of all other possibilities. And sort of as our scientific thinking has increased, around 2009 there was a report sort of criticizing the scientific foundations of many forensic science disciplines and questioned the validity of the methods that were being used and therefore the validity of the conclusions that were coming out of using those methods. There are some, thankfully few of them, but there were some quite high profile errors, particularly in fingerprint identification. So if you're interested, the cases of Shirley McKee in the UK, in Scotland, and in America, the case of Brandon Mayfield. You might want to look those up after the lecture. But they are very famous. or fingerprint identifications that have taken place where innocent people have been implicated within investigations. You don't have to look too far on Netflix or whatever streaming service you use to find a documentary about a miscarriage of justice or an error, okay? Often relate to things like witness identification, lineup identification, which are kind of notoriously unreliable. But they've served to underline just why it's so important to get things right in forensic science, okay? If you don't get things right in forensic science, one of two things could happen. You could inadvertently send someone to prison that shouldn't be there, or equally as seriously, you may deny a victim justice and a trial falls apart through error. So it's really, really important that we get things right, okay? There are really high stakes in forensic science. And I'd argue that it's only medics and medical science where there are kind of similar stakes involved. OK? If you get something slightly wrong in a biology lab-- don't tell people in biology or chemistry this. If you get something slightly wrong in a biology or chemistry lab, it doesn't really matter. You run the experiment again. Your supervisor will say you've wasted a lot of equipment, and you have to go again. OK? In forensic science, if you make a mistake in the lab, potentially a case falls apart. There are cases in the UK where it's been found that suspect and victim cases in a rape trial have been kept too close to one another and not separately, and the defense have argued for contamination within the laboratory and a case has fallen apart. Really serious consequences if you get this wrong. And incidentally, most A lot of the exonerations that happen where we identify wrongful convictions use DNA technology. So maybe people have been convicted many years ago based on witness identification, for example, and it's DNA that identifies the real perpetrator many years later. We've got a lot of new technology within forensic science, and we need to know how to use it. We need to know how reliable it is, and we need to understand its possibilities and limitations. There are huge economic and funding issues. The forensic science is pretty poorly funded. Police budgets have been slashed, and we need to be able to demonstrate that what we're doing is cost-effective and is yielding good results. And it reflects this kind of move from forensic science as an art and an expert-led domain to a scientific inquiry. And as I've argued, forensic science and doing it right, ensuring that our conclusions are robust, really matters to society. So I'm going to talk to you a little bit about my area of interest, which is gunshot residue forensics, just to kind of do a bit of a case study on a particular evidence type. So this is an image, you've probably seen something similar to this before, probably not in real life. But this is a revolver being fired. This is most obviously the bullet. What we're interested in from a forensic point of view is the material that's contained within this, which is called the blast cloud. And the blast cloud comes out of the muzzle of the gun in the direction of the bullet, but it also comes out of the ejection ports at the side in a revolver. And there's materials deposited within this cloud, formed during the combustion that goes on in the bullet. And that material comes to rest in the vicinity of the discharge. If you're firing a gun like that, like this chap is here, you'd expect some of that material to spread out from the gun and also be deposited on the hands, particularly the back of the hands, the face, hair and clothing of the shooter. And it's potentially interesting from a forensic point of view. Those materials are called gunshot residues. Sometimes called firearm discharge residue, if you want to read about it, sometimes it's called FDR rather than GSR. It's the same thing. So gunshot residues are produced every time a gun is discharged. And what they are kind of microscopic particles that are formed from burned and unburned material from different parts of the bullet. So from the propellant in the bullet, the priming compounds, from the bullet casing itself, the cartridge, and from the inside of the firearm. When a gun is fired, what happens behind the scenes, like in the bullet, is that there's a chemical reaction. A lot of heat and pressure is produced. That pressure pushes the bullet out of the gun. And Because there's a lot of heat, there's a lot of molten material there, very small microscopic materials, but they cool and condense as they come into contact with the cool atmosphere, and it's deposited like a fine dust that you can't see. And. And we're looking at very small particle sizes from less than a micrometre right up to 100, typically around 10 micrometres in diameter. So you need a very powerful scanning electron microscope to be able to see these. You won't be able to see them with a naked eye, and you won't be able to see them with a light microscope. And we're able to tell that we've got gunshot residue, and we're able to determine this as forensic scientists, because we look at the chemical elements that are present within the gunshot residues. And those chemical elements relate to the priming compounds that are contained within the bullet. So if a bullet contains lead, a lead-based primer, the gunshot residue will also contain lead. So that's how we're able to tell that we've got gunshot residue in our sample. So just to expand on that a little bit, this is a This took me ages to do on a, so I hope you appreciate it. So this is a 9mm bullet and you can imagine that it's been cut through lengthways, there's a cross section. This is the base of the bullet. So here you have the primer, okay, and you have some propellant, which is the grey. You've got some bullet casing and then you've got the bullet itself. And what happens, And this is a self-loading pistol, where basically when you pull the trigger, the firing pin hits the base of the bullet. And then in one mechanism, because of a series of springs, the bullet comes out, the cartridge case is ejected onto the floor, and the next bullet goes into the chamber. So you're able to fire continuously without reloading. And this is a mock of a police issue self-loading pistol. so when you pull the trigger, the firing pin, which is at the back, hits the base of the bullet, this little circle, and it pushes the primer and the propellant together. And they're two chemical compounds. There's a chemical reaction that produces the heat and pressure that I mentioned previously, which pushes the bullet out of the muzzle of the gun, okay, and then the cartridge case is just ejected. So that shows you how this works. So we can use gunshot residue to tell us a number of different things about a criminal event involving a firearm. So obviously, lots of different possible crimes could involve firearms. For context, we have very little firearms crime in the UK. Levels of firearms crime are really, really, really low in the UK. Why is that the case? Because it's very difficult to get hold of firearms here. There aren't many and it's very difficult, very expensive to get hold of firearms. If you go to some other parts of the world, including certain states in the US, there is lots of firearms crime. So a useful bit of context depending on what jurisdiction you're working in. But the types of firearms crime that we have, obviously shootings of people, They might be in person or from a car drive-by shootings. Armed robberies, where the firearm is discharged or not discharged, and possession handling offences. So lots of different types of events that could involve firearms. Now we can tell a number of different things by looking at the gunshot residue analytically. So if we look at it under a microscope, if we, firstly, if we're able to collect it and we can identify its presence, and then we can look at it in more detail, we can tell a number of different things. We can tell something about the ammunition that was used, okay? As I mentioned, the chemical elements present relate to the ammunition. So if we've got lead in our gunshot residue, what does that tell us about our bullets? that they have lead in them. Particularly useful if, let's say, we've got a shooting has taken place and we've recovered from some gunshot residue from the scene. Later on, a suspect emerges, perhaps through some sort of witness identification or something. There's a search that takes place of their property and under a concealed floorboard we find a box of ammunition. We could take some of that ammunition And we could fire it ourselves at the firing range, and we could compare the gunshot residue characteristics that are produced on the firing range to those which were identified at the scene. And we can see whether they're from the same source. So really useful, used a lot of the time. Firearm characteristics. So different firearms have different dispersion patterns of gunshot residue. So long arms like rifles have different dispersion patterns than small arms like revolvers and things. A lot of the literature, a lot of the scientific literature focuses on shooting distance and direction. So looking at the deposits, so gunshot residues are deposited along the path of the bullet. So if you look at the kind of depleting or decreasing amount of gunshot residue, you can tell something about the distances between shooter and target. And you can also tell something about the directionality, which is important for reconstructing events. Sometimes it can be difficult to identify where a bullet went into a target and where it came out, for example, a body. Very useful to understand this, particularly where we've got questioned homicide or suicide. And I advised on a case recently in Portugal around this. And we'd expect to find gunshot residue deposits around the entry wound rather than the exit. But also we can use the presence of gunshot residue on someone's face, hands or clothing to tell us whether we think they've been involved in using firearms. Now being involved in using firearms doesn't just mean firing them. It could tell you whether somebody has fired a gun, but it could also be gunshot residue can be transferred when somebody handles a gun. or they've been in the vicinity of a discharge. If I was to fire a gun from the front of here, I'm not because that would, I think UCL wouldn't, or you wouldn't invite me back next year, whether it was a birthday or not. I'd expect some gunshot residue to be deposited around here and on the people on the front row and perhaps further away. And I'll show you some experimental data later on. So how do we determine whether gunshot residue is there? Yes, we're looking for the elements that are present within the bullet. So there are two different types of ammunition, those which contain lead and those which don't, okay? And depending on which bullets are used, we're looking for different combinations of elements. Typically, we're still in this country, most of the other parts of the world have moved towards lead-free, but we still see a lot of lead-based primers here and in the US. And we're looking for lead, barium and antimony in combination. And that's characteristic of gunshot residue. So how do we identify those elements? Well, we use a piece of kit like this. So this is a scanning electron microscope with an energy dispersive X-ray spectrometer. So it's shortened to SEMEDX. And we use these stubs. These are very small, about the width of your little finger. And on there is a sticky surface. We dab that over the hands. We coat it in carbon, we put it in the machine. The machine allows us to visualize what's on there, so we get pictures of what's on the stub, but we can also get elemental signatures of what's there. And I'll show you that in the next slides. So if you're interested, this is how scanning electron microscopy works. Has anyone used a normal microscope before? A light microscope? Most people, often you have them with your kids, most people have used them at school to look at, maybe you looked at leaves in biology class or something, or insects or rocks or something. So similar with a scanning electron microscope, but instead of a light bulb at the top, okay, with a beam of light, you have a beam of electrons. Electrons are negatively charged particles, for those of you who've done a bit of chemistry or physics before. OK, so we use this beam of electrons to scan over what's on our stub and we get a replica in black and white, very high magnification, high resolution on a computer monitor. So this is an insect eye, that's a kind of crystal structure of a rock and I think that's a volcanic particle. OK, so These are the sorts of applications traditionally we use SEM for. So magnifying things and getting really good high resolution images, so very small things. How does it work? Well, we heat a filament. So in older scanning electron microscopes like the ones we have here, this is how it works. And heating that element creates the electron beam. It's carried out within a vacuum, otherwise it would burn. And we can focus using electromagnetic coils, because remember the electron beam is negatively charged, we can move the electron beam over our sample. And we can look in very close detail. Now what happens as the electron beam goes over your object, and we're looking at a very small scale here, it dislodges electrons from our specimen, from an atomic level. And there are detectors that attract those electrons, and depending on the number of electrons that reach the detector and the atomic number of the element, they register as different levels of brightness. So basically, heavy elements, metals, show up very, very bright, okay? And things like carbon are a black background. That's why we use carbon disks on our stubs. These are the pictures of some gunshot residue particles that I've taken. As you can see, Generally very rounded, they're very small, some cracking due to the heat and pressure. OK, so scaling electron microscopy with EDX. So we're looking for morphology, so we're looking for rounded particles, and we're looking for lead, barium, and antimony in combination. If you've got a particle that looks like this, and you've got those elements present, you can be pretty sure you've got gunshot residue present. How do we get those those spectra, well the electron beam when it's fired at the particle will dislodge electrons from the inner shell at an atomic level, whatever we're looking at. That vacancy is filled by an electron from an outer shell and the difference in energy is emitted in the form of X-rays. Those X-rays are measured and they correspond to elements of the periodic table. So you can match them up and show what elements are present depending on the X-rays that are detected. And these are the peaks that are of interest. We have lead, barium, and antimonic. Fortunately, we have some software that maps these elements to their X-ray signatures, so we don't have to go across the periodic table. The trouble is, when you're looking for something tiny and really, really, really small, And you might only be looking for one particle in a case, on a stub. It's like looking for a needle in a haystack. Fortunately, we have some automated detection software now that will run the microscope overnight for you and find levels of brightness to subject to analysis. And then you can come in the morning, and then you can have your results. What it means is you can ensure that you haven't missed anything. And I tried it manually, and I was falling asleep going across. It takes hours and hours and hours and you miss things. So this software is really helpful. So let's say we've got our forensic scientists and they've said, look, we've got lead, barium and antimony in our sample. That means we've got gunshot residue. Well, not necessarily. There are lots of environmental activities and sources of very similar particles. So there's a lot of lead in plumbing, barium in fireworks, antimony in match heads, and lead and barium within older brake pads of cars. And different academics and researchers have reported finding similar particles from these different sources, including kind of most recently more interested in cartridge operated tools like nail guns will produce very similar particles. So the message here that is you need to be a very experienced analyst an observer of GSR to be able to distinguish these environmental sources from the real thing, as it were, to ensure that what you're looking at within casework is indeed gunshot residue. We also have background levels of GSR. So there might be background levels of GSR, probably not so much in this country, but probably depending on what tube line you take or who's been on it before, there's possible avenues of contamination. Police facilities, Perhaps a firearms officers or people have been training at, there's been some studies done on this, training at a firearms range, firing range, and then later go and arrest a suspect, they could transfer gunshot residue to them. If people have been in police cars associated with gunshot residue, they could be potential sources of transfer. And people use guns for legitimate reasons, hunting and recreational shooting. Okay, so we need to understand expected levels of transfer from those if those are offered as potential explanations. So if someone says, yeah, I wasn't involved in that, the reason I've got gunshot residue is because I went to a shooting club 2 weeks ago, we need to understand, okay, what kind of guns were being fired there, how likely is it that somebody still has gunshot residue on their clothing 2 weeks after being at a shooting club, for example, and then we can work with that in the investigation. One of the bits of research that we've done, I led, was around gunshot residue transfers. This was trying to understand whether gunshot residues could be transferred from one surface to another. There wasn't much in the literature on this at the time, a little bit, but not much. So we did a research project with a police firearms unit. So these guys here were all too happy to fire some guns for us and we got them to do certain things to see whether we could identify transfers. And we were mimicking scenarios in real-world cases. So we had five different scenarios, five different experiments. We had an experiment where somebody simply fired a gun five times, five or six times, I can't quite remember. And we wanted to see the amount of gunshot residue that was deposited on the hands of a shooter. We then had another experiment where The shooter would then shake hands with somebody who wasn't present at the scene of the firing. We had another scenario where somebody would fire a gun and then pass the dirty or used firearm to another individual to see whether the gun itself could act as a mechanism for transfer. We had a fourth scenario where we had two handshakes, so this was the shooter shaking hands with somebody else who would then immediately shake hands with a third individual. And then we had a scenario where guns were fired and two people stood in proximity behind the shooter to kind of mimic a multiple actor kind of shooting. We sampled from the front and the back of the hands using those sticky carbon stubs that I've shown you, which have like a little disc and it's a bit like a piece of sticky tape. You dab all over the hands and then you seal it within a tube to avoid any contamination. You bag it to avoid any atmospheric or environmental contamination. And these are the results. So these are the different runs of the experiment. In all of the experiments we ran the scenario more than once because there's quite a high degree of variability between different runs. And these are the numbers of particles that we found. So you can see, unsurprisingly, when someone fires a gun, they get quite a lot of GSR on their hands. So up to, in the order of several 100 particles, as many as 834 in run 4. So we're looking at quite a lot of material here. What hadn't been reported in the literature was a transfer from person to person. So this is the handshake scenario. And we found, you know, even like run 3, quite a substantial number of particles were transferred to somebody who wasn't there at a crime scene. And you can imagine if that person was implicated in an investigation, got gunshot residue on her hands, there is a possible explanation that actually they've just come into contact with the person who was the real shooter. We also found that the gun would act as a vehicle for transfer as well. What definitely hadn't been reported here was that we can have tertiary transfer, which is where somebody has shaken hands with somebody and then that person has shaken hands with somebody else. And we're getting a number of particles being transferred there, similar to those standing behind in proximity. So it does complicate matters a little bit when trying to interpret. Remember what I said about interpretation at the start? We're analysing and finding what GSR we've got there and how much we've got, but how did it get there is kind of another question and potentially takes a bit more unpicking. So every contact leaves a trace and every further contact leaves a trace. So it makes sense when we remind ourselves of this principle. So we made a number of conclusions, which is that low and moderate levels of GSR were detectable on non-shooters, and the presence of gunshot residue alone doesn't necessarily support a conclusion that the suspect fired a gun. There are other explanations, and they can be quite challenging to distinguish. I just want to end by talking a little bit about DNA to underline that forensic evidence is a powerful tool, but it's careful interpretation that's the key, which hopefully is a message that's getting across. So most people have heard of DNA, DNA science in forensics. So DNA profiling or fingerprinting, DNA typing means the same thing. Invented in this country by this guy Sir Alec Jeffrey in 1986. And it's got lots of applications, most famously criminal investigation, but also parentage testing, finding out biological parents, but also analysing animal populations and things like that, diversity. It's been used to detect perpetrators in a lot of different cases, from volume crimes right through to serious offences, but remember what I said at the start, you're only going to really get DNA analysis taking place for the more serious crimes. Application to cold cases. Again, don't have to look too far on Netflix to find a cold case documentary. Cold cases are unsolved cases, perhaps from, I don't know, the 1970s or 1980s, where we didn't have this technology. And then later on, we've reanalysed a cigarette **** that was found at the Chrome scene, and miraculously, we found the real offender. So really powerful tool. But there are a lot of issues. We often get mixtures of DNA. There are transfer issues. They're drop in and drop out, which is a technical term when you interpret DNA signatures. Analytical sensitivity, different instruments performing differently, and issues around contamination. So DNA is a molecule present in all living organisms. And we're interested in the profile, which is the small set of variations that are different in all unrelated individuals. So if you're unrelated to someone, I'm unrelated to all of you, so I will have a completely different DNA profile to you. And the sets are so variable that it's so extremely unlikely that the same will be found in unrelated individuals. And in the UK, we can constrain that to one in a billion. So it can be deposited via touch, via blood, saliva, sweat, semen. And we take a sample, we extract the profile, and then we do comparison. So between the profile that we've got from the scene, to a profile that we might have on file or a profile that we've taken from a suspect. And you can see this on the slides. You can see that you can get DNA from loads of different surfaces in relation to loads of different crime types. We can also use non-human DNA in the investigation of crime. If you want to read about this, is a group at Leicester University who created the UK's first cat DNA database. Now, the cat wasn't the murderer or the murdered, OK? The body that was located was covered in a curtain, OK, that was covered in cat hair. And the main suspect, which was the neighbour, had a cat, and he also didn't have any curtains. But to identify whether the cat hair was the same as the cat from the suspect's house, they needed to create a database that tells you how variable cat DNA is within a population. So they did that for this case. But we need to be aware of contamination. So every contact leaves a trace, okay? So we can have unwanted contacts and transfers as well. And as we're able to look at smaller and smaller quantities of DNA, okay, we risk detecting material that was transferred before the criminal event. So we need to be really careful when we collect DNA and interpreting it. I've got a case study just to end with. So this case is called the Phantom of Heilbron, and it concerns DNA evidence that was recovered from 40 crime scenes in Austria, France and Germany between 1993 and 2009. So the same female DNA profile was found at 40 different crime scenes across three different countries over 16 years, okay? So this is somebody who is doing, an individual who's committing a lot of different crime across borders. So murders, burglaries, drug offences, firearms crimes, theft and muggings. They found DNA on loads of different surfaces, cups, weapons, projectiles thrown through windows. And in January 2009, there was a reward for information leading to arrest of 300,000 euros, which is a lot of money. What transpired is that the DNA profile belonged to a factory worker who worked at the factory where the test tubes and the swabs that were used to collect that DNA were produced and packaged and sent out to different police forces. So their contamination measures weren't sufficient. So her DNA profile was making its way onto lots of batches of this stuff and was being found at crime scenes. She wasn't implicated in any way, but it shows you just how easily this material can get transferred and just how important it is to be aware of other possibilities. So there was nothing wrong with the scientific equipment that was being used to analyse the DNA. Nothing wrong with the interpretation. It was indeed her DNA. But it was the processing and the collection that was an issue here. Fortunately, she wasn't falsely incriminated, but a lot of crimes went unsolved. A lot of police time was wasted, and a lot of victims went without justice. So there are important consequences of getting this stuff wrong. So we've just about finished on time. If you've got any questions, I'm happy to answer one or two.

Otherwise, here's my e-mail address if you do want to. It's not there. It's at the start. If you want to e-mail me to follow up, if you've got any questions, please feel free. To do that after the session. All right, I hope you enjoy the rest of the course.