Transcript

Good afternoon, everyone. Pleasure to talk to you today. As Martin said, I'm Dr. James French. I'm an Associate Professor in Crime and Forensic Science from our Department of Security and Crime Science. And I'm going to talk to you today about forensic science, putting the science into forensic science and investigations. I'm going to talk to you a bit about gunshot residue as the main focus, a little bit about DNA as well, and some of the big issues in forensic science at the moment, and a bit of a whistle-stop tour through this field that I'm really interested in. Okay, so I'm going to talk to you about forensic science, so we're all on the same page, going to define what it is, and show you that while what we see on TV is is interesting and accurate to some extent, there's a bit more to things than what goes on TV. I'm going to talk to you about the importance of doing experimental research in forensic science. I'm going to talk to you about my own specialism, which is the field of gunshot residue analysis and interpretation. I'm going to talk to you about some of my experimental work that I've done on understanding GSR. So forensic science, okay? Let's define it. So forensic science, what is it? So hopefully you know what science is. Science is about observing things and trying to provide explanations of why things are the way they are using measurement and experiments and that kind of thing. Okay, forensic just means related to or used in courts of law. or the use of science and technology in the investigation and the establishment of facts in law. So any scientific technique that's applied to criminal investigation and the legal process, that's forensic science. And we can think of forensic science as interacting with all of these other different kind of spheres. Forensic science assists the law and the legal process in providing criminal justice. It borrows from lots and lots of different scientific disciplines, as I'll show you later, from chemistry, from biology, from genetics. We rely on industry to generate kit, tools, and analytical machines that allow us to do our analysis. And we're a tool for policing. So the police go out there, and one of their jobs, other than preventing crime, is to solve crime. And forensic science is part of the toolkit that you can use to catch bad guys, basically. So we're a part of the toolkit that the police use. There's also all these other different kind of inputs. Forensic science costs money, and what we do, what we can do, depends on how much money we have, and that depends on how serious the crime is. So the forensic response to a murder is very different to the forensic response to a phone theft or a bike theft. There are ethical issues around the storage of biometric data on databases. You might have seen facial recognition in the news recently. We have a very large DNA database in this country that has ethical issues and debates around it. And who does forensic science, who provides forensic science, who regulates the quality of forensic science is a political issue. We have a private marketplace for forensic services where each police force pays for private laboratories to do their forensic work. It wasn't always like that. We used to have a government organisation called the Forensic Science Service that used to do all of our forensic work. And that model is applicable in different parts of the world. So the context in which we do forensic science has an effect on what we can do in the real world. It's useful to think of forensic science as a process. This is one of the things I tell all of my students. Forensic science isn't just dropping reagents in a test tube in a lab. It's not just collecting bullets from a crime scene. It's a process. From crime scene to court. You have a crime scene, and that might be a room in a house. It might be a burnt out car. It might be a body deposition site in the woods. It might be a laptop. It might be a phone if the crime has been committed online. So a space or place that pertains to that crime where evidence could be collected. The evidence then has to be collected and packaged and secured. It then is usually sent away to the laboratory for analysis. Sometimes that analysis is done at the crime scene. That analysis, those techniques will produce results. Those results then need to be interpreted in the context of the case. Okay, this person's DNA is there, is present, but how did it get there? What's the certainty associated with that? And then we write up our report to assist in the courtroom, and we might be called to give testimony. But at each part of the process, we kind of add value to the evidence. So it's useful to think of forensic science not just as someone in a lab coat, but it's an entire process. Forensic evidence. I'm going to leave digital evidence to one side. So this is things like mobile phone evidence, evidence that you can get from laptops or wireless devices or whatever it happens to be. And we're going to focus more on traditional forensics today. So you can divide forensic science into kind of two categories, forensic evidence into two categories. Trace materials. So these are like bits of physical material. So things like hair, pollen, fibres, glass, paint, gunshot residue, DNA to an extent. And then you have patterns, marks and impressions. So these are things like finger marks, ear prints, footwear marks, okay, things where a source has left an impression and you compare the mark from the scene to the suspected source. So you might find a footwear mark on the floor and you might have a suspect's shoe and you might compare the mark and the print from the shoe. There's 2 categories. Most people, when you ask them, if you ask a random person on the street, what do you think of when you think of forensic evidence? They often just say fingerprints and DNA. Those are the ones most people have heard of. They're most often used, and DNA is by far and away the most powerful tool that we have. But I will show you later that it's not infallible. So fingerprints and DNA, very often used. Footwear, we have a very large footwear database in the UK that's used a lot. But there are a whole host of other different evidence types. I've listed fibres there. So you'll be giving up fibres from your clothing to the seats that you're sat on. And you'll be picking up fibres and hair from people that have sat there previously. Soil and organic material, components of soil, pollen grains from the environment, tool marks from tools that have been used to access buildings or cars. Now, the principle that underlies the use of all of these techniques is this principle called Lockard's principle of exchange. So Edmund Lockard was an early pioneer of forensic science in France in the 1920s and 1930s. And he wrote some of the first papers on the use of physical forensic particles that he called dust traces. in investigation. And his idea is that every time 2 surfaces come into contact, there is an exchange of material. So, for example, when I touch this desk in front of me, I am giving up a little bit to skin cells that are suspended with my sweat. OK, they contain my DNA. But by touching this desk, I am also picking up the DNA of the previous speaker, or some tiny particles of saliva when somebody's been speaking. It really makes me want to wash my hands, yeah? And you'll be doing the same. So every time 2 surfaces come into contact, whether that's two people, a person in a car seat, a person in an item of clothing, or a hand and a firearm, or a hand and a knife, there is an exchange of material. Surface A leaves something on surface B, and surface B leaves something on surface A. And if we can capture those traces and understand what they're telling us, we can reconstruct movements and events. That's the logic of forensic science. So what I want to get across is that in forensic science, we're very much a multidisciplinary or interdisciplinary field. And that means we borrow lots of theories, methods, and analysis techniques from different fields of science and apply them to criminal investigation. So forensic scientists, by training, I have a geography background, was interested in physical geography, understanding soils and sediments, and therefore their role in criminal investigation. We've got chemists, botanists, geneticists, psychologists, lawyers. So we borrow from all of these different fields and apply them to criminal investigation. Now to give you a kind of example, let's say we've got a murder scene. You might have a range of different experts from different fields working on this investigation. You might have a forensic chemist or ballistics expert who's interested in trace evidence if there's been a shooting. You might have a forensic geneticist or a DNA expert who's interested in identifying a potential offender using DNA from the scene. You might have a digital forensic scientist or cyber forensic specialist who's retrieving mobile phone records from cell towers around the location to see which phones were in the vicinity and making calls and receiving data at the time. And you might have a forensic statistician who's performing weight of evidence calculations to try to understand what that evidence means in the context of the case. How likely is it that evidence supports a theory that person was there or not? So you can see we've got lots of areas of expertise coming to bear on this murder scene. So mostly when we think about forensic science, we think about investigations when crime has occurred using this Lockard's principle of exchange that every contact leaves a trace. In addition, we can use that principle to prevent crime before it happens. This is something called smart water. You might have seen this around London. You know, you'll spot it now, I've pointed it out. So smart water is a chemical that is used to secure products. So it's a water-based inorganic traceable liquid and each batch of this liquid has a unique forensic signature. If you try to burn it or you try to wash it off, it's really resilient. And what it's used for is to link offenders to crime scenes. So the idea is that if a If a thief goes along and steals something or steals from a shop that's kind of marked with smart water, they get that all over their hands and face. They can't wash it off. Later on they're arrested and you can match the liquid on their hands to that from the products. There's a million users of this, of businesses that use this worldwide. It's used on things like, if you see those cash in transit vans that deliver cash to ATMs, They'll be marked with smart water, jewellery stores, high-end clothing stores, vans that carry lots and lots of expensive power tools and things. And it's well known to criminals. So the idea is that if I'm a criminal and I walk up to a Target that's marked with smart water, I think, actually, there's quite a high risk I'm going to get caught here. I'm going to go over here instead. And it has what we call a deterrent effect. So this is using forensic science to kind of prevent crime rather than just go out and catch bad guys afterwards. So forensic science is really powerful. It's a really useful tool that's used in lots and lots of cases. Why do we need to do research? Why is research important? Well, recent reports, relatively recent, have reported a lack of scientific foundations in many fields. So there's been a lot of concern about a lot of the methods that we use and whether they're valid and robust. And that's important, right? Because if we're deciding whether somebody is guilty or not guilty, we want to be pretty sure that the evidence that we're relying on is reliable. We don't want to end up with convicting innocent people or letting guilty people walk free. There have been some high-profile errors and miscarriages of justice that have involved forensic and non-forensic techniques. You don't have to look too far on Netflix to find a documentary about one or more of these. And it underlines the high stakes in forensic science, why we want to make sure we get this right. There's a lot of new technology. We want to understand its possibilities, but also its limitations, how we use that technology. And we've gone more from sort of an art of forensic science, if you read Sherlock Holmes, like this process of kind of intuition when you walk into a room and you suddenly know what's happened. more towards kind of scientific inquiry, development of theories and hypotheses and testing those. And I've underlined this point at the bottom, that forensic science really matters. It's only really, I think, in medical science where the stakes are as high and the consequences of getting it wrong are quite so severe. So as promised, I'm going to talk to you a little bit about my own area of research, which is gunshot residue analysis. This is a high-speed photo of a bullet being fired out of a revolver. And what you'll see here are a number of things. You can obviously see the bullet that's going towards its intended target. What we're interested in, though, is this cloud, and specifically what is suspended in this cloud. This is called a blast cloud. And material, hot gases and a kind of dust material, products of burning are emitted from the firearm as it's discharged out of the barrel of the gun, but also at the ports of the side. And within this blast cloud are gunshot residue particles that can be very useful forensically. They go from, they go out towards the path of the bullet, but also out of the sides of the gun, back towards the shooter, and can be recovered from the face, hands, hair, and clothing of the shooter. So gunshot residue evidence, GSR for short, sometimes called FDR or firearm discharge residue. So every time a gun is fired, these particles are produced. And what are they? They're a combination of burned and unburned material from different parts of the bullet, which

I'll show you in a minute, and different parts of the firearm. When a firearm is discharged, behind that trigger, sorry, my team keeps picking up, When you fire the trigger, okay, you get a chemical reaction is going on, and I'll show you why that occurs. And there's a lot of high temperature and high pressure. And what you have are these molten particles within the blast cloud, but when they come into contact with the cooler environments, they cool and condense, and they form like an invisible dust around the firearm. So you can't see them with the naked eye. Particle sizes vary from less than a micron to 100 microns, typically around 10 micrometres in diameter. And these are some pictures that I've taken on the scanning electron microscope over in Earth Sciences of some of these particles. This is what you're looking for under the microscope. Now what we can do is some analysis of this to understand the chemical elements that are present in these particles. And they relate to the priming compounds in the bullet. So what do we mean by priming compounds? So this is a 9mm self-loading pistol and the 9mm bullets that go inside. What I've done, this took me ages to draw, so please appreciate it, it's a cross-section. So imagine it's sliced through lengthways. What you've got is a primer compound at the bottom of the bullet in red. You've got some propellant, which is another chemical compound, and they're all housed within a bullet case. And at the end is the bullet. So when the firing pin hits the base of the bullet, it pushes the primer and the propellant together, and you have this chemical reaction. That produces heat and pressure and gas. And what it does is it pushes the bullet down the barrel of the gun and out of the muzzle. In A self-loading pistol, then, this is all in one action. So you pull the trigger, So the trigger is pulled now. The firing pin hits the base of the bullet. Bullet goes out of the end. Cartridge case is ejected. That's what you find at the scene. And the next bullet goes into the chamber. So because the compounds from the bullet produce the gunshot residue, we can use, if we capture, collect, analyse and interpret our gunshot residue, we can reconstruct different elements of the event. Most obviously, we can determine something about the ammunition that was used. So if we've got gunshot residue that contains lead, we know our ammunition contains lead. Okay? Now, this is really handy because let's say we've got a murder victim and they're covered in gunshot residue and there's gunshot residue at the scene. And later we arrest a suspect, we search the house and we find a box of 9mm ammunition. What can we do? We can take some of that ammunition, we can fire it, we can capture the GSR and we can compare it to the GSR from the scene. And there's lots of variation between different bullets, different manufacturers and different chemicals and propellants and primers that are using different bullets. Interestingly, the police and armed forces in some countries use ions within their ammunition, lanthanide ions, which when you look at them under a microscope, shine like a beacon so that you can see that was police issue ammunition. You can also determine something about the firearm that was used. So if you look at the pattern and distribution of gunshot residue, you can tell whether a rifle has been used or a handgun, for example. If you look at those dispersion patterns, you can determine something about shooting distance and direction. Now this is often very important because you might want to reconstruct the distances and directionality if who fired first or how far away was the shooter and the target when that firing took place is a question in a case. Entry and exit wounds, you can look at gunshot residue patterns on the skin to determine where a bullet went into a body and where it came out. That's often useful when you are trying to determine whether it was homicide or suicide. But also if we detect gunshot residue on hands, potentially we can determine whether somebody fired a gun, the identity of the shooter, whether somebody's had contact with a firearm, Or whether they were standing in the vicinity. Of a discharge, the literature is. showed us that you can get gunshot residue on your hands given all of these activities, firing a gun, having contact with a firearm, or being present in the vicinity of the discharge. So how do we analyse for GSR? We look at it under a microscope and we look at its elemental composition. And we use this kind of table to determine whether we've got gunshot residue or not. There are two types of ammunition. lead-based ammunition and lead-free. And depending on what we're looking for, we're looking for different combinations of elements to tell us whether our gunshot residue is characteristic of GSR, which means we're pretty certain or consistent with. It could be something else. We use a piece of kit like this, which is a scanning electron microscope, and we typically collect the GSR using these sticky stubs. We then carbon coat them and put them into this machine. This machine will then allow us to visualize what's on the sample, so magnify the particles so we can have a look at them, and we'll also be able to do some elemental analysis. So how does it work? So put your hands up if you've used a microscope, a normal microscope at school. Okay, pretty much everyone. Okay, it relies on a beam of light, basically. So light illuminates your specimen, and then a series of lenses helps to magnify it. It's a similar principle, but instead of a beam of light, the SEM scanning electron microscope uses a beam of electrons. And that beam of electrons scans over the object, and it creates an image of the object. OK, in very high resolution, high definition, high magnification. These are some rock and crystal structures and some insects here. So how does it work? You heat a filament, a bit like an old light bulb in an older SEM, and that produces an electron beam. It's a vacuum in there so that the filament doesn't catch fire. And the beam is focused and moved across the surface of the specimen using electromagnetic coils. So we can move very precisely back and forward over our tiny specimen. As it does this, it interacts with the surface of the object and dislodges electrons from our specimen. And then we've got a detector at the top of the machine that attracts those electrons And depending on the number of electrons that are received by the detector, it registers as different levels of brightness. So basically, when you've got very heavy elements, you see them very bright on the microscope. And then the background is black, OK, because it's carbon. So you end up with some images like this. And all of these are pretty typical of what you'd expect if you were looking for GSI. So very rounded metallic particles. some blistering and cracking that's a result of high temperature and pressure, and quick cooling and condensation. But all very typical. Sometimes you see them in little clusters. But under a microscope, when you look at things, there are lots and lots of things that look like this. Lots of other metallic particles that have nothing to do with firing a gun. So how do we discern and separate out our gunshot residue from other particles that might be present? because we've got a dual detection method. So it's scanning electron microscopy with energy dispersive X-ray spectrometry, SEMEDX. So we're looking for things that look like this shape-wise, so we're looking for a similar morphology, but we also look for an elemental composition. So the elements contained within that particle are lead barium and antimony. So this elemental signature spectrum is from this particle because we fired an electron beam at it. Now how does that work? If you've done a bit of chemistry or physics, you'll know what I'm talking about here when I talk about inner and outer electron shells. So an electron beam will dislodge an electron from the inner shell at the atomic level. That vacancy is filled by an electron from an outer shell, and there's a difference in energy, and that's emitted in the form of X-rays. Those X-rays are measured using a spectrometer. And the energy and signature of those X-rays correspond to the atomic number of the specimen. So the detector is able to compute the energy of the X-rays and correspond that back to the element that's present. So you see what element is present. And if you look closely at a periodic table, you can see the energy levels, X-ray energy levels listed on there. So we're looking for certain peaks of interest, lead peaks, barium, and antimony. And very fortunately, we've got software now that allows the machine to do this automatically, which is handy because looking for a tiny, tiny particle, okay, on a stub is like looking for a needle in a haystack, okay, without automation. So we have automated techniques that will go and scan across Look for particles that are bright, subject them to the electron beam, and you can walk away from the machine and come back. That saves time, but also improves accuracy. Because I can tell you firsthand that scanning over the microscope like that for hours and hours and hours, not only do you feel like falling asleep, but you are very likely to miss things. So with the validated automated technique, we can be a bit more sure that we're detecting what we should be detecting. So let's say we've done some analysis of our sample. We've got some lead, we've got some barium, we've got some antimony. That must mean we've got gunshot residue. Not necessarily. There are a number of different environmental and occupational sources of particles that look quite similar to GSR under the microscope. So you've got to really know what you're looking for. There are some studies in the literature on this, some of them quite old now, but they all They will document the existence of similar particles that could be mistaken for GSR, produced by older brake pads, by fireworks, bariums used in fireworks, antimonies are used in the heads of safety matches. Cartridge operator tools like nail guns produce similar particles. You've got to be very, very careful about what you're looking for. But also there are background levels of GSR. The point being that you don't just run the risk of having GSR on your person just because you fired a gun at a crime event, okay? There might be background levels of GSR on public transport, depending on where you're travelling from and to, depending on where you are in the world. It's likely to be quite low, okay, but it's not zero. And people have been convicted based on evidence of 1 particle being present on them. So we need to understand something about background levels. particularly in jurisdictions where police routinely carry guns. So lots of states in the US with lots and lots of gun crime. There is a background level of contamination of gunshot residue in things like interview rooms, police cars, cells, and so on. You can see that being a problem, okay? If you pick someone up because you think they've been subject to a shooting, involved in a shooting, you stick them in the back of a patrol car where lots and lots of people that have been up to all sorts of things have sat before you and it's not been cleaned. Then you go and test them for GSR. How do you know that GSR has come from them or they haven't picked it up in the back of the car? People carry and use guns for all kinds of legitimate reasons as well, hunting and recreational shooting. And in many jurisdictions, carrying firearms is legal. So how do you separate the noise from what you're interested in? Now I said a few slides ago that we can understand something, looking at the presence of GSR, we might be able to tell whether somebody fired a gun or handled a gun or was in the vicinity of a discharge. Is it possible to separate those out? Is it possible to understand the levels of expected transfer under these different scenarios? So we addressed this via a research project. We had some police officers that fired weapons. and we wanted to see how much gunshot residue is recoverable from their hands given different activities. So we had five different activities, one where they just discharged 5 rounds, one where they discharged 5 rounds and then shook hands with somebody who wasn't there, another scenario where they fired a gun and then passed the dirty fired gun to somebody else, Another scenario where somebody fired a gun, shook hands with somebody else, and that person shook hands with somebody else to see whether transfer could occur along a chain. And we had the final scenario where people were standing behind the shooter when they fired the gun. We collected, used the stubs to collect from the front and the back of the hands, and then we sealed them within bags to prevent contamination. And these results are published now, so we did nine runs of the straight firing. And you can see that you'd expect hundreds of particles after somebody's fired a gun. Interestingly, what hadn't been reported before was that you can actually get quite high levels of transfer to somebody who wasn't present when that shooting took place. Also, you can pick up quite substantial levels by handling a gun, even if you didn't fire it. These are secondary transfers. We also saw an example of tertiary transfer. So the shooter shook hands with somebody else, who then shook hands with another person, and these levels were detectable on the third individual. And you can see similar levels when you're standing nearby. So the conclusion that we came to was that every contact leaves a trace, and that low and moderate levels of GSR are detectable on non-shooters. Crucially, from an interpretation point of view, The presence of gunshot residue doesn't necessarily mean that somebody fired a gun. You need other information within the context of the case. And distinguishing roles can be challenging.

So to keep on this theme of forensic evidence being a powerful tool, but it's in the interpretation that we need to be very careful. I just want to finish with DNA. So most people have heard of DNA evidence. DNA profiling, fingerprinting, DNA typing was invented in this country. by this guy, Sir Alec Jeffries, in 1986. He's been around for a long time. And the power of this technique has increased over the years. So it used to be the case that you'd need a big pool of blood or other body folioid to generate a DNA profile. Now you can get a DNA profile just from touch. So the analytical equipment is improved, but that comes with interpretation challenges. So it's used for many different applications for crime investigation, which we're most interested in. Also to determine parentage. It's used to, you know, on non-humans as well, so to understand population dynamics in animal species and so on. It's been used to detect perpetrators, convict criminals in many, many cases. It's the most, by far and away, the most powerful identification tool we have. It can be used in any type of offence, but it costs money. So if you have your phone stolen, okay, or your bike stolen, I'm sorry, but they won't be doing any DNA recovery here, because it's just too expensive to justify for volume crime, okay? But if it's a murder, a serious assault, a sexual assault, the response is very, very different. You've probably seen documentaries where it's been applied to cold cases, cold cases being those that are unsolved. Classic example might be a murder from the 1970s before DNA, where there's a cigarette **** from the crime scene that's reanalysed. And hey, presto, we get a partial DNA profile. We'll run that through the database and we'll find someone who did that. But there are lots and lots of issues here. Often, because we're picking up very tiny amounts of material, what we get is mixtures. If I was to swab this desk, I'd probably get my DNA profile, maybe two or three other people who were here before me, okay? Other lecturers that were speaking, students that came up to speak to them, cleaners that were cleaning here last night, you might get lots and lots of DNA profiles there. How do you unpick them? How do you determine which is the most significant or recent contributor is a real challenge. DNA can be transferred from one surface to another. Potentially, I could transfer some DNA to a knife, okay, in my kitchen. That knife could be taken to a murder scene, and my DNA is at the murder scene. So how do we understand those transfer dynamics? Drop in and drop out are technical terms when analyzing profiles. Analytical sensitivity, contamination. Contamination is a big one. Okay, so what's DNA? We all have DNA. It's A molecule that's present in the cells of living organisms. And what we're interested in is what's called the DNA profile, which is a small set of variations within that molecule, and it's different in all unrelated individuals. So if you're not related to someone, okay, you will have a different DNA profile. Now, we understand due to laws of genetics, how variable these are, and there are statistical models that support this. So the sets are so variable that it's extremely unlikely that the same will be found in unrelated individuals. And we constrain that here to a random match probability of one in a billion. So there's a one in a billion chance that you've got a random match. And what we do is we take a reference sample. Perhaps we've got a suspect, we take some cheek cells, or we've got something on the database and we compare that to a sample from the scene. It can be deposited via various body fluids or touch, okay, of saliva, whatever it is. And we take a sample from the scene, we generate a profile and then we do the comparison. And there's some newspaper headlines that show that, you know, you can find it on all kinds of different surfaces in all kinds of different settings. There's also an example that you might want to read about, which is where cat DNA was used to solve a crime, and this was where a body was found that was wrapped in a curtain that was covered with cat hair. The suspect in the case had a cat and some missing curtains, but they wanted to see whether the cat hair came from the suspect's cat. So they had to create a database to do this, to understand how much variation there was within the cat population. But contamination is really important. We need to be aware of potential contamination issues. As our analytical capabilities increased, we can look at smaller and smaller quantities of material and generate a profile. But because of that, increases the possibility that we're picking up mixtures and lots of other material that was deposited before the event. Okay, so if I committed a crime here today, okay, at the front, Somebody came in later, swabbed from my DNA. They'd also pick up several people before, because we're looking at that tiny scale. So we need to be very careful when we're collecting and interpreting, because it's also possible that if procedures aren't followed and personal protective equipment isn't worn, that the person collecting that DNA profile could contaminate it themselves simply by breathing on it or talking around it. And we will see, and we do see, increased challenges to forensic evidence on the grounds of contamination. I wasn't there. It must be contaminated. So we need to be able to demonstrate that that's not the case. Now, a case that I think underlines this really well, it's quite old now, but I think it's a lesson that is still very relevant in forensic science. And this surrounds the search for an offender that was nicknamed the Phantom of Heilbron. So DNA evidence was recovered from 40 crime scenes across Europe over a 16-year period. So we're looking for an individual, one person, and it was a female, we knew that from the DNA profile, whose DNA had been recovered from 40 different crime scenes across Europe. They've committed murders, they'd broken into houses, they'd dealt drugs, violent acts, handled firearms, stolen cars, mugged people. This was an individual who was doing a lot of crime, a lot of bad stuff, really needed to get hold of them. DNA being recovered from a wide range of different materials at scenes. And in January 2009, there was a reward for information that was raised to 300,000 euros. It turned out that the DNA profile belonged to a factory worker that hadn't done anything wrong at all. They simply worked in the factory that produced and packaged and sent out the DNA swabs to various police forces across Europe. And the protocols that were in place within that factory weren't sufficient to prevent contamination. So unfortunately, every time that this individual was packaging up and sending these out, she was leaving her DNA profile on these swabs. And then it was turning up at the scene. Now, she wasn't convicted of anything, okay? There was no suggestion she was doing anything wrong. But there are a few lessons here. This is potentially what happens when we've got increased analytical power, okay? So no one questions the DNA. How did it get there? It's more about, you know, can we detect it? Can we detect a smaller and smaller quantity? So there's nothing wrong with the science. The machine wasn't telling us wrong. telling us anything wrong. The outputs weren't wrong at all. It was around the processes that were in place and the interpretation that was carried out by the scientists. No one thought that there could be an issue here. So we need to be very careful when collecting material, okay, processing it and interpreting it. And this has severe consequences. False incrimination, yes, this person wasn't incriminated in any way, But for lots and lots of victims of crime here, and for every crime there is a victim or victims, okay, they didn't receive any justice because all of the investigation efforts were going after this particular individual, trying to find out who they were. So lots and lots of offenders went on to commit more crime, and these victims didn't have any justice. So hopefully this gets across that, you know, this stuff is really important. We've got to be really sure about the robustness of our evidence and the validity of our techniques. It's quite a lot to have covered in sort of just less than an hour. I've got time for a question or two if you've got one, but otherwise I hope you enjoyed the talk and you enjoy the rest of your course.