Science of Forensic Investigation

Transcript of public lecture by Dr Sheila Willis, Director of the Forensic Science Laboratory, on "Science of Forensic Investigation" at the Royal Irish Academy in Dublin on 16 November 2007, as part of Science Week.

Science of Forensic Investigation – part one

Peter Brabazon: "My name is Peter Brabazon. I'm the programme director for Discover Science & Engineering and we're responsible for Science Week. I'm very pleased that you could all be here today on such a lovely day outside and in such a lovely building, of course, here as well. The National Museum is very much associated with science and indeed when this site opened back in the 1800s, this was known as the Museum of Science and Art. And we're glad to say that science has returned here today. We're very happy, of course, to be working with the Women in Technology and Science, particularly with Sadhbh McCarthy who has been organising quite a lot of this today with my own colleagues in Discover Science & Engineering.

"I think we're on for a truly interesting time, a bit like the forums of the past in this great building. We're going to hear science forensics, forensic science, a very interesting and topical subject these days, and indeed helping to solve quite a lot of problems and ensuring that we have a good, safe democracy, which is so important.

"And of course, certain people like OJ Simpson today may regret in fact that there is forensic science. I just heard that as I came out of the taxi. He looks like he might be in a bit of trouble because of forensics.

"We're very fortunate today to have Dr Sheila Willis, who is Director of the Forensic Science Laboratory, a key part of our national institution. She's going to really talk to us, I understand, about the real world of forensic science, because, obviously, probably most of us have seen CSI. I guess there's other aspects to it as well and I'm looking forward to hearing that myself.

"We're also very fortunate to have as your MC today David Harvey. David, of course, has a very strong and personal interest in the topic as well because he was the man that used to front Crimeline on RTE. Subsequently, he's kept up his interest, but he's been setting up television stations and he's now the CEO of City Channel and it's growing rapidly around the country with a presence not only in Dublin, but also now, I believe, in Waterford and Galway. He tells me he's going to capture the rest of the world as well. So he's after your minds as well. But I'm going to hand over now to David and enjoy the presentation, I'm sure you'll be fascinated. Thank you very much for your time."

David Harvey: "Well, good afternoon everybody. It's great to be here. This used to be the ceramics room, well it still is known as the Ceramics Room of the National Museum. They've moved the ceramics out so it makes a wonderful room to have a meeting like this in and it's great to be here today.

"Thank you Peter for that nice introduction and I suppose Peter's already said in what context I'm here. I was involved as the producer and also the co-presenter of RTE's Crimeline show for eleven years. We did one hundred and thirteen programmes before we decided we'd had enough of it but I was also involved in making a series for RTE on the subject of crime solving, or not solving as the case may be, called 'Solved and Unsolved'. And in that particular programme we had a lot of access to forensic information and subjects like murder and rape and so on, subjects where there had been a huge intervention from the new science of crime solving. That is what Dr Willis is going to bring to us today.

"The whole change, the radical change there's been, in what was originally a non-scientific, yet scientific in its own way, method of solving crime, the art of deduction, elimination, the plod, if you like, of the local detective. And in this country, I think, a huge part of the crime solving was down to the fact that we are a small country so the word got round when something happened. But one had to build a case based on evidence, a case based on interview and so on, so that little tiny piece of the jigsaw, which has now become such a huge piece of the jigsaw, was left out. That is what Dr Willis is going to talk about today.

"One of the particular crimes I cam across in my tenure was that of Marilyn Rynn and maybe Dr Willis would enlighten me but I believe that it was the first criminal trial in this country which was solved with the aid of DNA evidence. You may remember, this was a civil servant lady who

was murdered in 1996, and her body was found after Christmas in the Liffey Valley Park/Tolka Valley Park area and it was the DNA evidence that convicted the killer in that particular case. So it's a relatively new science but one which, I think, has revolutionised the whole area of crime fighting.

"Just to tell you a little bit about our distinguished speaker. Dr Willis is the director of the Forensic Science Laboratory. Prior to that she was deputy director and head of the chemistry section. She went to UCD and she also carried out PhD research on organo-metallic chemistry, under the supervision of Professor Manning there. She was recently chair of the European Academy of Forensic Sciences and has been active in the European Network of Forensic Science Institutes since its inception.

"Now she's going to deliver a lecture we're told today, but I know it's more than that, it's an insight into this terrific subject. She's going to use PowerPoint but I think what we'll have afterwards is hopefully a very interesting and informative strong exchange of views in our question and answer session. I've talked enough. Let's get on with the real business of today. Please put your hands together and welcome Dr Sheila Willis."

Sheila Willis: "Thank you very much David and good afternoon ladies and gentlemen. I'm very pleased to be here in this venue and hope I can one quarter live up to the expectation of that introduction I've just had. I'm going to talk to you about forensic science and how it's involved in the investigation of crime.

"One of the interesting things about forensic science is that it has been, for a long, long time, inextricably linked up with the world of fiction. I have often said in previous presentations that we're still trying to play catch-up with Conan Doyle's invention, which was back in the late nineteenth century. That, at that time, was really the work of science fiction, although I'm sure it wasn't called that at the time. And today, although people may not have much to do with Sherlock Holmes, very many people are familiar with CSI. And I say that with a bit of a tone of 'Oh my goodness' in my voice because it has both positives and negatives from my perspective. Lots of people know about forensic science and therefore that's good to some extent. But it also has created huge expectations of what we in the world of real forensic science can deliver. And what I'm hoping to do now in the next thirty minutes or so, is give you

some sense of what it's like in the real world as opposed to what it's like on the forty-nine minutes or so that we get on the CSI slot.

"My laboratory, the Forensic Science Laboratory, has the mission of assisting in the investigation of crime and helping the administration of justice by our staff carrying out analytical work and also delivering expert evidence. That's a bit of a mouthful, but I put it there to give you some idea of the breadth of what forensic science is about. And the realisation that, and this is something that I feel passionately about, it's not about a black box solution in a corner. Forensic science is about a process and it begins at the scene and it finishes when the evidence is actually delivered in court. Obviously the piece in the middle where the analytical work is done is critically important, but in a way that's easier to control than the other bits.

"And I put that bit in at the end because I was preparing this clip art the other day and I thought, I'd love if I could get a hydra because the difference between the real world and CSI is that in CSI virtually every role is performed by these trendy, beautiful looking people who are able to do the investigation, the analysis, the interpretation and all the whole thing in one. Whereas in our world you find that different people are involved in different parts of the process.

"So let's look at the lab end first. We are involved to some extent in all parts of the system, in that occasionally we attend scenes. This would happen in certain instances where – obviously, we're a relatively small number of people, by the way, in comparison to the investigative force of the Gardaí – but occasionally there would be scenes where there is a value in the forensic scientist attending the scene, either because they may be able to prioritise what work they'll do when they go back to the laboratory, or they might be able to advise on the best samples to be taken. We also are involved in court although you would be surprised, I think, to find that a relatively small number of cases that go through the laboratory end up in contested court cases, but it is an important aspect of the work. We provide a helpline and a lot of training to the Gardaí as well. But the core work of the laboratory is the analytical work and I will talk about that in a bit more detail.

"There is some work that would be considered to be forensic science work that's not part of the functions of our laboratory, but is performed by technical sections of the Garda Síochána. The present Technical Bureau was established in 1937, I think, and it provided a technical service to the Gardaí in all ranges of materials until the Forensic Science Laboratory was established in

1975. So there's a bit of overlap of our functions but the more analytical, biological, chemical things are dealt with in the laboratory whereas the Gardaí, they do crime scene investigations, fingerprint detection, firearm examination, photography and they also do document and handwriting examinations. Now in some countries, that range of activities would be in an isolated laboratory, in some countries different so there's no real ideal model for the delivery, I suppose, of forensic science.

"Let's get back to the actual analytical work in the laboratory. The laboratory is divided into four functional areas and the biggest one, which is reflected in the number of times you hear it in the news, is in the analysis of materials that are thought to contravene the Misuse of Drugs Act. It's maybe the less glamorous end of forensic science, it's not the bit that you hear about in fictional detection work, but approximately nine thousand cases come through our laboratory every year in which the main purpose is to find out if there is a controlled drug present. The range of drugs varies in different eras, at different times. Cannabis resin has remained the most popular throughout the time but in the past sometimes the second most popular would have been heroin, or ecstasy or whatever. The list on the slide there reflects the present order of popularity, if you want to say that, in terms of materials being submitted at the moment.

"The chemistry section is almost a misnomer. It's a section dealing with a very broad range of crime types and analyses. And both biology and chemistry fit into the category of looking to make links. The forensic scientist has two possible ways of operating. And one is the actual analysis of material which we saw in relation to the drugs case, where the significance is that something is actually identified as being heroin or cocaine or whatever. The second area, which I'm going to talk about in more detail, is one where the analysis and comparison is carried out in order to check whether or not there's a link or not between places and people or between victims or suspects, for example.

"So, in that context, in the chemistry section, case types such as armed robberies, burglaries, traffic accidents, fires, explosions and so on are examined. And in order to help with those investigations, materials such as paint, glass, soil, firearm residue, fire accelerants, explosives, are some of the materials that are analysed on a routine basis. The cases in chemistry tend primarily to be cases against property, while in the biology section – these divides, by the way are a little bit artificial, it's just how we're separated – in the biology section it's primarily offences against people. By its nature we're talking about biological materials so we're talking about the detection of blood, semen, saliva. In this section the staff are involved in, first of all

actually locating such samples, because high sophisticated analytical techniques are not really possible unless you can say where you should start. It's like, you know, a haystack and a needle, you've got to be able to locate where you're going to look. Sometimes, in fact a lot of times, the positioning of something is actually more significant than the comparison or discrimination later on.

"The forth section is the newest one in the laboratory, and that's the section dealing with DNA profiling and samples are submitted from all the other sections into DNA. I have on the PowerPoint there a brief resumé of the development in the technology in DNA over a relatively short period of time. David mentioned earlier on that it is a relatively new area and I'll talk about it later on in the presentation. But if you look at the slide, the sample on the – that went without my touching anything folks – well, the bigger sample was the size that we needed when the technology was first introduced and nowadays DNA can be carried out on samples where you can't see it with the naked eye. So the sensitivity of it as a technique has continued with time, which causes its own problems, maybe we'll talk about that again.

"I've said that forensic science is an end-to-end process. It involves using science in a context, and again David said in the beginning that crime investigation was carried out by traditional investigative police activity. I would make a strong point that that skill is still absolutely vital if forensic science is to be used properly. Forensic science doesn't have magic answers that can be plucked out of the air and plugged in to give you a solution. Forensic science has to be used by people who understand both the potential and the limitations and know where and when it's going to be useful. That's, I think, one of the reasons that it's critical, that we as a society in general and that the police and the people involved in the criminal justice system have an understanding of how to use it. It's not a science of absolute solutions and even when there's very high discrimination, by which I mean that you can separate samples to a great degree, it's still not associated with certainty. Because all science, if you like, is growing on the back of predecessors.

"This may seem a trivial point but I put in some slides to the presentation to remind me of the tension and frustration that is sometimes there when science and the law meet, which they do in forensic science. My perception is that, when I present evidence in court, there is a need, by the court of me, to give yes and no answers and black and white solutions and, of course, science is full of grey and it's changing, it changes all the time and that has all sorts of problems associated with it. And you use the literature, and just as a little anecdote to prove

the point I'm making about the difference between science and the law: I can remember being in a situation where the judge would not allow me to give an opinion because it was based on literature references and I hadn't carried out the work that the literature was based on. I mean, that would just be such a crazy world for a scientist and yet that seemed to make sense for that particular lawyer.

"I said we're not into the realm of black and white, yes and no answers, so where do we get our answers? Statistics are used quite a lot to evaluate findings and for that reason, I know there's a lot of students in the audience, I would encourage students who are interested in science to concentrate and focus on mathematics as a key skill, regardless of what branch of science that you're interested in. I think traditionally there may have been – I'm deviating now from forensic science – but there may have been an interest in thinking that if you're doing physics, chemistry, you should have the maths but I think it's very much the world of biology as well. All measurements in science have uncertainty associated with them, and that's something else we need to be conscious of if we are doing our analysis in the laboratory.

"There's very little real academic work associated with, purely with forensic science. Forensic science tends to be an application of other scientific techniques and I'm going to come to that in a bit more detail. The exception to that is work by Evett and co-workers in the UK and I put it here because it's emphasised the point I think I'm trying to make, that the interpretation of scientific evidence is carried out within a framework of circumstances. It's not an isolated fact.

"Interpretation, if it's meaningful, has to look at two competing hypotheses, at least two competing hypotheses, and the scientist should be in a position where they're commenting on the probability of the evidence, rather than the probability of the hypotheses, and CSI is a bit different in that. CSI is always able to look in, and you know the way they have these flashbacks and they can see the thing being relived, well science is never in that realm, not today in this world anyway."

Science of Forensic Investigation – part two

Sheila Willis: "The scientific theorem that we use to do this probabilistic stuff is Bay's Theorem and there's a lot of maths in the background to that that is not used much in court but is used a lot in the laboratory to help us evaluate our findings.

"The scientist, because they're at the interface between the investigation and the eventual evaluation in court, is sometimes working in one role and sometimes in another. At an early stage in the investigation they're working as an investigator where they're helping the Gardaí develop leads and develop lines of investigation and they may not have absolute certainty, well they'll never have absolute certainty, but they may not be right even with the leads they're supplying at that stage. By the time it actually comes to deliver the evidence at a court stage, the scientist has to have weighed up what is the probability of this evidence and be in a position to assist the court in saying what value is there to what they've found or what they're producing.

"Other aspects that make forensic science a little bit different from other areas of analytical chemistry, although I think as time goes on people realise that although we don't talk about it as the chain of custody that it's also relevant in lots of other fields. It's very important that when the samples come to the laboratory, that we can be clear that they are the ones that everybody identifies as coming from a particular part of the scene. That might seem a trivial point but actually can be a cause of great confusion and the law is quite strict in how that's carried out and causes a lot of difficulty.

"I thought for the next couple of slides what I'd do is try to park that sort of general stuff and talk a little bit about case histories that might give you some idea of how the science is actually used.

"I put the slides together before we had that dreadful tragedy recently in a fire. The first one I chose anyway was a fire case. If you can imagine a situation where a suspect is apprehended by the Gardaí, maybe fleeing away from a fire or maybe soon afterwards. In that situation their clothing would be seized and packed in a particular type of nylon bag that has the ability of trapping any volatile material that might be associated with the clothing. The scene itself, of course, would be examined and samples of debris would be recovered from the scene as well. Those samples are heated up such that the volatile material goes into the atmosphere of the bag, sample extracted and put into a gas chromatograph or GC/MS, where, if there are accelerants such as petrol or paraffin or diesel or any other accelerants present, they can be identified because they vary in their pattern in the chromatography as seen there, I have a petrol and a paraffin sample up. And if you wanted further discrimination you could go and look at each of those peaks using mass spectroscopy.

"I did mention earlier on that the position of trace evidence is important but if we talk a little bit about a case where trace evidence might be relevant: I can think of one I dealt with myself where there was a robbery at, not a bank but a similar kind of money institution anyway, the glass was broken in the getaway car and later the raiders moved from the car to a motorbike which crashed with an innocent party, they abandoned the motorbike, discarded their outer clothing and were later apprehended some distance away.

"So in that scenario, samples from the various scenes would be transmitted to the laboratory: the clothing that were recovered, and indeed the clothing that the guys were in when they were arrested. So the possible evidence is the possibility of glass fragments on the clothing, but remember now we're dealing with, there's a set of clothing discarded, so the chance of glass on the clothing of the actual suspects is much less and what we've got to consider is how do we look for links that might suggest – we first of all have to check that we think we have the right guys and if we have the right guys what kind of evidence would we expect?

"And in that instance there was impacted paint on the knees of the trousers where the motorbike crashed into the car, on the discarded clothing that is. The discarded clothing also had fibres on the inside that matched and linked with the fibres that the suspects were wearing at the time they were picked up. That's typical of the kind of case that might happen.

"There were shots fired in that case as well and in that instance what we'd look for is firearm residue. When a gun is discharged there is the equivalent of a mini explosion which generates a range of particles that fall back on the hands or the clothing of the person who either fired the gun or is nearby. One of the tests that is possible is to use a scanning electron microscope to look for these particles. There is another case in the media at the moment with this very type of evidence, not used well in my opinion, but that's a different story.

"With the glass, the test that we use is quite a, almost a trivial one, which is to measure the refractive index of the glass and it's a useful technique because the refractive index varies with very, very small variations in the composition of the glass. It is particularly useful because it has the ability to enable us to measure very, very small fragments. If I were to, God forbid, go and break a window in this historic room, although a percentage of the glass would fall back away from me, about twenty per cent would fall back in the direction of the blow, so that the

person delivering the blow would have very minute fragments of glass on their clothing. We search clothing and recover those small fragments and measure their refractive index.

"The next slide is a lead in to cause me to talk about what I consider to be essentially what has been a paradigm shift in forensic science. The use of DNA in solving crime has really changed the world of forensic science.

"People may be familiar with the early story associated with it, but I think it's worth retelling because the first time DNA was used by Alec Jeffries in the investigation of two murders on the Welsh-English borders, it was used to actually exonerate a suspect. I think it continues to be used in this very, very powerful way right today through all different countries. My presentation tends to be concentrating on cases where there are links but it's vitally important that we realise that showing where there are not links, when that's significant, is very important as well. And that was the first case.

"DNA is in the nucleus of every cell except red blood cells. We get half of it from – I'm sure everybody in the audience knows this kind of stuff, but just to kind of settle me down – half from our mother and half from our father. We use it in forensic science whether to compare two samples or to help identify human remains, or it's also used, not in Ireland but in other countries, as an intelligence tool, as a database, which I'll come back to again.

"The process of how it's used… the first thing is the location of the evidence. If you remember back to the early part of the talk when I said in the biology section actually identifying where the samples might be, it's not a trivial question, that can take quite a lot of time. Then the DNA is extracted and amplified, a profile generated and the profile compared with reference samples. If ten loci match we consider it's a match and the rarity or not of the match is judged according to how frequent those numbers are in a population database.

"So you were right and wrong, David, in terms of when it was first used. Marilyn Rynn was the first case where it was done here in Ireland but there was a case prior to that. The early work, the analytical work was done in England. We're operating here in Ireland since '94 and during that period different technologies are used. The present one of SGM Plus, with ten loci plus a sex gene, is the one that's in routine use in Ireland and a lot of other European countries and

it's in use in the UK database, which means it's likely to last quite a while because there's been a lot of money pumped into that.

"So how would that operate in a case? It's not really that unexpected. Something like a murder happens and the investigating Gardaí will, either based on information they have from elsewhere or their enquiries, develop a suspect in some shape or form, which can often involve large, large volumes of material being submitted to the laboratory. Sometimes the challenge is to identify where you are going to start on what comes in. Inevitably it will include some samples from houses or cars or clothing belonging to the suspect. In the example I have here on the screen, the small picture on the bottom left hand side as I look at it is a wheel brace and in the inside of the wheel brace there are tiny splashes of blood. That's from a real case. That would be highly significant because that turned out to match the victim in a particular case. And I use it to show that, as I've said before, finding the material can actually be as challenging as carrying out the analytical work afterwards.

"DNA databases as an intelligence tool are, in my opinion, one of the most powerful ways where science can be used in a robust way to provide intelligence to the Gardaí. And if I could speak to it for a little while; different countries have decided different segments of the population should be put on a database. In the UK it's almost anyone who brushes up beside a policeman. In other countries it might be people involved in serious crime. Other countries somewhere in between. The Law Reform Commission here in Ireland have published a report on this and they are recommending a limited database in Ireland. In other words they are recommending not that the whole population would be analysed, which is one option, but that a limited percentage of it and it's yet to be clarified what level of crime will dictate whether or not someone goes on the database.

"So, what are the advantages? If the crime scene samples are put on a database you can establish links between different crimes, whether it's a selection of burglaries, or an armed robbery could be linked with a rape case, or a suspect in a rape case identified with a burglary some time ago, that sort of link. It has the facility of excluding a large number of suspects, and I'd emphasise that exclusion capability of DNA again as being very powerful. The one that probably gets talked about most is where there is what's called 'cold hit' where a sample from a crime scene is loaded onto the database, and matches a person who's there from some previous case. In most countries the need to resample, once that hit is identified, the Gardaí

would then be left with investigating the crime with this information that there's been a hit on the database and then they would have to resample.

"I don't think I intend to go into this, this is some definitions of forensic science that kind of interest me but I think I'll finish at that and thank you very much for your very good attention. Thank you."

Science of Forensic Investigation – part three

David Harvey: "We're going to open up the floor to you folks so if you – what we'd like to do is make sure we know what questions are coming up in advance, so maybe if you have a question during a question, if you know what I'm saying, you can put up your hand and we can get the microphone to you for the next question. So, think about what you have to ask. I think that Dr Willis could sit here all day and answer questions, in the same way as she could stand there all day and talk about forensic science and its applications. So it's really for you to draw out the sort of questions that you have, perhaps related to the sciences that you're interested in, but also, I think, to some of the practical applications, which I think from my point of view is the real meat of the issue and, in fact, you answered my question in a roundabout way, that I had, Dr Willis, which was, what if everybody who has nothing to hide, like, I presume, everybody in this room, gets sampled at birth, that we all carry a DNA, that the State has our DNA sample from day one. Would you see that as being a positive thing? I'm not going to put you on the spot but would you – is that something that could be achieved or is it something that people seem to think violates our human rights as individuals?"

Sheila Willis: "I think that if that approach were taken it would certainly have the point of being equal, everybody being equal, everybody's treated equally. So I think it's an issue for society to decide whether or not they want to expend the time and energy and money in taking that approach. Something like ninety per cent of the samples would not have any useful function because any studies will show that most crime is in the recidivist category, so if you were to look at it from a value for money point of view, it wouldn't be a good value for money situation, but ethically it would probably be quite a fair solution."

Harvey: "Would anyone here object to having a DNA sample taken as part of just a general thing the State were doing, not for, obviously, any criminal - only one. Very good. Or is that someone asking a question? I'm not quite sure. Maybe it's both. Is that a question down the back?"

Audience member: "No, it's an objection to my DNA being taken."

Harvey: "Do you want to stand up? Will you stand up?"

Audience member: "No, it's just an objection. I think the science you've talked to us about is very, very interesting but I'd have a fundamental problem with my DNA being put on a database to be used in this way. Like you say it's an ethical question over a scientific one."

Harvey: "Well, would you not accept that if you have nothing to hide it shouldn't cause a problem?"

Audience member: "It's an infringement of my basic rights as a person. As a scientist I see the point behind it but it infringes on my person as such and I would have an issue in that case, whether or not I have anything to hide."

Willis: "Can I just come in because there's something I meant to say in the course of the presentation and I didn't remember to say it. I should have emphasised that DNA, as used in forensic science, is based on what's termed 'junk science'. As opposed to being able to link genotype and phenotype, the information that we probe doesn't enable us to identify that someone has brown hair or long fingers or, you know, high IQ or anything like that. It's a series of numbers; the only phenotypic information that's available from it is sex, whether it's from a male or a female. I just want to put that piece of information in as we discuss it."

Harvey: "There's a gentleman at the front here. Yes sir?"

Audience member: "I was just wondering, with the DNA database, if it was on a national level, who would you like, or recommend, to be in charge of the security around it?"

Harvey: "Who should hold the DNA register if there was one?"

Willis: "Well, of course I'd say the Forensic Science Laboratory. And I think there should be safeguards and it should have governance and that will be recommended. That would be the norm in most countries."

Harvey: "Could I just ask you while we're moving to the next question, how long does it take to do a DNA sample?"

Willis: "It depends on the source of the DNA. I mentioned that DNA is in every cell and we're extracting sometimes from blood, sometimes semen, sometimes saliva, and so on. There's different extraction procedures for each one. You could, in absolute ideal circumstances, get a result in a day, but mostly we're talking about a process that takes a few days."

Harvey: "But no more than that?"

Willis: "No more than that."

Harvey: "Gentleman there. Keep them coming folks."

Audience member: "To put it in context, I'm just wondering do you have any database at the moment? Just in the Marilyn Rynn case you mentioned and I think the perpetrator gave the DNA sample on the basis that he believed that because she had been frozen, because of the time that had elapsed, and the fact that she was frozen, was preserved the DNA sample. Do you have any access to any database or do you get any cold hits at all at the moment?"

Willis: "No. What we keep are samples from scenes so that is a database in a sense because there aren't people associated with, well there are but not in the way we have them, this array of crime scenes. But in that case you're talking about, a number of suspects were sampled and the man who – I can't remember his name – was included in that. And that wouldn't be that unusual in investigations where the police would develop a number of suspects. I actually find that this is one of the values and strengths of DNA evidence because it very quickly eliminates a very large number of their suspects which from, when you think about it, the point of view of time and money that go into the investigation or, more relevantly, that somebody could be under suspicion in the wrong."

Audience member: "Can I just ask one further question? Is there any advantage in going back over DNA samples in cold cases, that is to say the murdered women, if you are now doing it ten years after can you get samples or…?"

Willis: "Yes there have been a number of spectacular examples, mainly in other countries. There's one example in this country and the Gardaí have set up a unit to look at cold cases at the moment but I have some concerns about that approach because what we don't know is how samples were handled some time ago. Depending on the case you could get results but you could get misleading results as well and I worry that we might have expectations that won't be delivered on. It's been successful, the States have used it quite a bit in the exoneration of people that are on death row, and that's fine, that's a perfectly legitimate use, but in terms of trying to solve unsolved cases we've got to be very careful in ensuring that the correct samples are there and that they've been handled in a correct manner in the intermediate time."

Audience member: "The sample that you mentioned of the blood inside the socket, how long would you have, in other words, if you didn't recover that for four years -"

Harvey: "How long before it dries up?"

Audience member: "Exactly. How good is the sample is what I'm saying?"

Willis: "Nowadays you'd get a profile from that for a good few years afterwards, yes."

Harvey: "That's an interesting point you raise because you talk about that as well, or people talk about it in the context of looking back into the sixteenth, seventeenth, eighteenth century and derive some sort of DNA evidence. Surely if we move far enough along that a fresh blood sample taken three or four years ago is going to last as long as something that's able – or how are they able to pick up information that far back?"

Willis: "I'll try and get it in two ways and I realise that as I answer I'll fall into the trap of -"

Harvey: "Presume I'm stupid."

Willis: "No, I realise I fall into the trap of not using enough information because you're asking me about a blood sample, and if you can actually identify a blood sample, you will be able to analyse that and probe that for years afterwards and I don't have concerns about that in cold case review situations.

"Where I have concerns is where the technology is now sufficiently sensitive for us to be able to identify DNA profiles from my handling the mic or from very slight exposure and the worry about contamination or samples being mixed up or put together in instances where you're not clearly identifying the biological stain. So if it was a visible blood stain, no matter how small, that's fine. But if it's, you know, maybe trying to recover samples from the back of a jacket or, as I say, handling a glass or something, you would be more concerned about those types of situations.

"Now when you talk about older cases, a lot of the older cases are based on mitochondrial DNA which is not something we use as a matter of routine in our laboratory. In fact, if we want mitochondrial DNA done it has to go to England because the number of times it's used is quite small and we don't see the value of keeping it up as an area of expertise. But there's been a number of spectacular examples, the Romanov family is the one that comes to mind, where there was mitochondrial DNA, that's DNA that's in the mitochondria instead of in the nucleus and it goes via the mother line rather than coming from each parent and as a result it's not as discriminating, it's open to – there are a lot of issues with it but it can be used well to identify in situations like that."

Harvey: "I think it's worth mentioning as well, in the cold case files, one of the big problems they have is that they're missing people as distinct from, they're not murder cases yet, so it causes them problems on the DNA front as well. Peter, you were next there."

Brabazon: "Thanks very much. I must say, what you describe is fascinating and very interesting and obviously very complicated. Just one point in terms of the general science and then maybe we'll talk about what are the careers, what people actually do. My first point, just on the DNA databasing. Would it be of any benefit, as a nation, to have a database of the full spectrum of DNA information from the point of view of health, from which you would then get a subset of information for your analysis? Or does any country even do that? And then maybe on the question of careers after that. Thanks very much."

Willis: "I, personally, would be much more uncomfortable with the idea of looking at the full profile. I think that there are lots of ethical issues in storing full DNA profiles and I think that the reason I was anxious to clarify the fact that in forensic science that's not what we're looking at, that in the discussion about what's held in DNA a lot of people think that it's the full profile that enables you to identify your tendency to have a disease or your likelihood to have a heart attack or whatever. I think that's a huge question that we haven't grappled with at all in society and I think it's far too early to think of it as part of what you might do to solve crime. But I would see it as quite separate as to how the technology is being used in the criminal world. Does that answer your question?"

Harvey: "Yes, gentleman down the middle there?"

Audience member: "Dr Willis, since the development of the DNA in 1994, has there been any other significant breakthrough in forensics?"

Willis: "The use of IT in the investigation of crime is another major area. We are not doing so much of it in our laboratory but in other countries the other growth area would be the information that's available from either computers or mobile phones. So it's hard to say that it's a new development as such but it is an area where science is used in investigating crime."

Audience member: "Thank you."

Harvey: "Just to ask you, Dr Willis, this awful, awful case in Omagh during the week and they're talking about accelerants being found at the scene, does that have to be subject to the sort of forensic work you're talking about post-scene or does it have to – I found it difficult to understand how they would see there were traces of petrol at a scene that has been completely destroyed?"

Willis: "Fire is a particularly fascinating area of forensic science because usually you're looking at something that looks completely destroyed and it's difficult to imagine where you would even start. A fire investigator would – and I don't know the details of Omagh obviously – but they would look for patterns of burning and if you had intense burning in certain areas that might lead to a proposition. The samples then could be sampled in those areas, the sampling itself is a trivial, short procedure that could happen in an hour, so it may be that samples are taken and it's sampled already or maybe that there's particular, you can get mobile detection devices that are used at the scene, so there's a number of different ways that they could get that information particularly if there's a very high level of – the other thing that you might assume is that if petrol was used in a fire that it should be all consumed in the fire. What happens is, supposing we had a go of burning this stage here, we'd sprinkle the petrol -"

Harvey: "Anyone got a match?"

Willis: "- start a bit of a blaze and the likelihood is that something like the screen here might fall down and trap, the oxygen would stop the fire of the carpet here and trap some of the remains of the petrol left in the carpet. So fire investigation often involves excavation and out with the shovels. One of the things that I probably should have emphasised is that there's nothing clean and clinical about the work of forensic science, it's full of dirty rubbishy samples."

Harvey: "Questions? Questions?"

Willis: "There was a question I didn't answer, I'm sorry, from Peter, because I forgot because he was asking me about careers in forensic science. One of the down sides of CSI as I see it is that it's used to give people an interest in forensic science and I think that's wonderful. Because obviously as a scientist, as a career scientist I feel very strongly about the value of science for all sorts of reasons. But I think it can be misleading in thinking that there are lots of careers in forensic science. In our laboratory there's a staff of eighty and there's going to be one hundred, there'll be a staff of about one hundred. You can imagine that means that the turnover in terms of opportunities for careers is relatively small. You could say, 'Well, what about in other countries?' There might be about five thousand forensic scientists in the UK but if you think about that as a percentage of the population it's something similar. So in terms of aiming for it as a career option, I always advise young people not to think of it as an only end game.

"So therefore if you were thinking of plotting it as your career, my advice to any student interested is to be sure to get a good basic science degree. I tried to convey to you in the presentation that what forensic science is really about is using various branches and aspects of science to help investigate crime. It's an application of science. Now maybe in time it will become a special discipline but if I'm looking for new staff members, I'm more interested in the value of their good basic science background than I am in some conversion course or something with the word 'forensic' tacked in just for the sake of it. Does that answer your question?"

Harvey: "Just before we come to this gentleman here, I noticed, particularly in the Jill Dando case that's going on at the moment, a small trace of gun powder or gun residue or something is the key to the case, yet they're now saying that it wasn't handled properly. Why does this happen over and over again that cases appear to break down on the basis of what was taken from the scene not being handled properly? That the security, the integrity of the sample, which puts you, your profession in a very [unclear] position?"

Willis: "It does indeed, and why it keeps happening I can't answer for the sins of my father so to speak, but I do feel very strongly that there's a tendency not to grapple too much with the science and if somebody says something then that's it as a fact, while I think that the science, if it's part of the proof in a case, should fit very clearly in a case and should be what you'd expect rather than just a spurious piece of evidence thrown in."

Science of Forensic Investigation – part four

Audience member: "How well resourced is your section?"

Sheila Willis: "Not well enough."

Audience member: "I knew you'd say that."

Harvey: "I don't think that's the end of the question."

Audience member: "I'm not asking you to put your job at risk but crime has, well the perception anyway, of expanding at a great rate, and if your department is involved then in investigations in various places are you very much overstretched?"

Willis: "We always have more work than we can handle."

Harvey: "That's called diplomacy by the way."

Willis: "It's not something I'm known for but I'm learning."

Harvey: "Any further questions out there? And just because you ask a question we're not going to take your DNA sample, don't worry. So there is, yes? There's one, just one here."

Audience member: "Hi Dr Willis. Just a quick question or two questions really quickly. I'm interested first of all, as a woman have you found that the field that you're in is particularly male dominated, and if it is, how have you dealt with that as you've progressed in your career? And also, some of the details of the cases you come across must be quite disturbing and, I'm sure,

effect the staff on a psychological level. How do you deal with that within the laboratory as well? Is there counselling available to the staff or anything like that?"

Willis: "OK, I'll go to the first one first and go back a long time. When I applied for this job almost thirty years ago, a long time ago, I really felt that there wasn't a hope of my being successful because I thought, I'm a woman, and this is really going to date it, a married woman at that, unlikely to get a job in what was a male dominated area i.e. criminal investigation. I really thought I hadn't got a chance. Not only was I successful but of the eight people employed at that time, half of us were women. We were a bit unusual, at that time we were a bit unusual as a laboratory because we went and met colleagues in different parts of the world and we had this almost female domination in our little patch. It wasn't common.

"Nowadays, when I interview for jobs there are almost inevitably more women candidates than male, which I find interesting and I sometimes wonder is that connected with the fact that it's a civil service job and the security of a state employment is more attractive to women or not, I don't actually know the answer. That's within the science world of the laboratory. The world of the investigation of crime is definitely male dominated. Did I find it impeded my career? No, I didn't.

"In relation to the case types, like lots of jobs where there's emotionally distressing information that you are dealing with, if you were to get emotionally involved you couldn't survive. I was quite, from my own point of view, quite interested to find that when my neighbour, who is an elderly woman living on her own, was burgled, I found it much more emotionally draining than some of the horrific cases I see in the laboratory because in some way I think your mind just separates out. The final point you raised about whether or not there's counselling, in recent times there is and I don't know what the take-up is like."

Audience member: "Sheila, I just wanted to ask you, just on the preponderance of the sciences that you use: do you think it's more biology or more chemistry or more physics? I know you said about maths earlier, you need maths for everything, but for anyone who might be considering that career, which is the one that you think is used the most in the lab? Or is that a hard question to answer?"

Willis: "No. because you know I'm going to answer and say that chemistry is the centre of the world. Because of DNA the biological sciences are increasing in their importance in forensic science but, in a way, what is the analysis of DNA other than some form of chemistry? The divide in the laboratory would probably be a split between chemistry and biology, more and more molecular biology."

Harvey: "Does that answer your question?"

[Muffled words from audience member]

Cameraman: "I'm supposed to be behind this camera but I have a question for you: what is the crossover and what connection do you have with the pathology and Marie Cassidy and her team?"

Willis: "Little enough, it might surprise you to find. When there is a murder the pathologist, obviously, has to establish the cause of death and frequently the pathologist will be at the scene, almost always at the scene. Sometimes we're also at the scene and in that case you'd have interaction of that nature but there's no formal interaction. Sometimes our people will go to the PM in the same way that they'd sometimes go to the scene but it will be very much from the point of view of informing what they do afterwards as opposed to a kind of clear chain or link between the two areas."

Harvey: "That's the point I was just asking you about earlier on about the integrity of the chain of evidence. Do you pick up your own samples?"

Willis: "No, the Gardaí – we don't have any legal authority to seize samples of any sort so the Gardaí have the responsibility of actually taking the samples and submitting them to the laboratory."

Harvey: "But is that not always going to ask you, is a good barrister not going to say, 'Were you happy with the manner in which you received the sample? Are you sure it came from the body?'"

Willis: "Well, I tried to raise that point earlier on, that establishing the chain of custody is a critical part of the process."

Harvey: "So the person who picked it up has to effectively swear that they picked it up from where they say they picked it up?"

Willis: "And ideally seal it there and then at the time and be able to say that that's when they sealed it."

Harvey: "But it's clearly an issue, isn't it?"

Willis: "Oh, of course it's an issue, yes. And it's the issue I referred back to with the cold case review because whatever about good practice, as time goes on and the sensitivity of tests becomes more and more sensitive, the actual sample handling becomes more and more critical. That case you referred to, it's one part of it, well the possibility of transferring one particle by one person handling something is very real."

Harvey: "Very interesting. Yes, further question down the back please?"

Audience member: "Hi. I just have a more practical question. The people that come into your work organisation, apart from general science degrees, what other qualifications do you look for. Do they need postgraduate qualifications also?"

Willis: "When we advertise for vacancies in the laboratory, there's very high interest and as a result we're in a very fortunate position where we have a great choice in terms of candidates, so by and large people will have further qualifications although it's not a necessity for the job.

The job calls for an honours degree, the vast majority of the people who come in will have some further qualification. The other things that we look for, and I had a slide there later on in the presentation, forensic science is also about how well you can communicate what you find to the court, such that the court has some chance of evaluating the strength or the value of your evidence, so one of the things that we would look for at selection stage is candidates who are in a position of being able to effectively communicate to a lay audience. That's an area that we provide training for in the laboratory later on as well."

Audience member: "Hi. What actually interested you in science? What got you interested in the very first place? If you were to pick two key things, what were the conversion points or moments?"

Willis: "I have to confess to being in a pub last night and we were chatting because one of my colleagues is retiring and we were talking about his career and various people talking about what areas interested them or what attracted them to science. I was remembering that at primary school level, and it really again brings me back into the dark ages, there wasn't easy availability of the Internet or large amounts of information, and a particular teacher used to cut out sections of a book and pass them around the class. I can clearly remember the one I got on the composition of air and I was really fascinated, more so than the one she gave me on how the heart worked."

Harvey: "OK folks, have we any further questions?"

Audience member: "I have a question. This is in relation to the collection of evidence, I think you might have covered it in the beginning of your presentation but I missed a few minutes. You were saying that the Gardaí are the ones that actually collect the evidence. This is in relation to a murder case there a few years ago where there was a man killed in a house and it was kind of gruesome, they chopped up his body, disposed of the body and then -"

Harvey: "Kind of gruesome?"

Audience member: "Yes, quite gruesome. They cleaned up the scene completely, apparently the house looked completely normal and then later on – I mean I think it was quite a long time later, several months, maybe even a year – the Gardaí went in and they did gather samples but it was in the cracks of the lino and the tiling of the tiles. First of all, how do they know where to look, I mean, when you go into a house and it doesn't look like there's been blood splattered, how do they know? And do you direct them? Do you give them advice and say 'Look here' and 'Use this chemical'?"

Willis: "We would be very likely to be at a scene like that. It's a case of using your head as to what you might expect. There are no magic answers and you do expect – it's a liquid so you expect it to go down through cracks. There may be instances where – I'm not aware of a case in this country although I'm open to correction on that – but I remember in the Soham murder case, I saw that guy's house after the police had examined it and there wasn't a screed of curtain material, of carpet, they just pulled the place apart. Now the difficulty with that, I spoke to the scientist afterwards because I was there looking at this presentation and thinking 'Oh my God, where would you put the things? How would you deal with them?' because the logistics of how you actually deal with the case is, you know, another challenge. And he said, you know, 'They're still packed in the garage in such and such a place'.

"Because wood for trees is one of the things that kind of crops up. When you're at a scene you don't usually have a chance to go back to it again and again and again so you have as much as possible to get as much as you can at that stage. But then there's the competing thing of how do you get it such that you're getting samples that are going to be meaningful afterwards? So what you're trying to do is, well, what would you expect in this situation and find a sample that will support or not that expectation."

Harvey: "Yes sir?"

Audience member: "I've asked you before but I think for legal reasons you haven't gone into that much case histories, but if I can ask what is the most significant case that you worked on and made a breakthrough? And the most amazing case, is there something that happened to you?"

Willis: "Phew. I suppose the most significant case was probably the very first case I did which was the murder of Lord Mountbatten where I did the paint analysis in that case. It was significant for lots of reasons. The evidence was quite critical, it was at a very relevant part for my career and it had a lot of public interest and so on associated with it at the time. I think the most amazing, I think the DNA work at the moment, and it's hard to isolate a particular case, it's almost like magic. I'm not exaggerating. It's just amazing, the amount of information that's obtainable from almost nothing."

Audience member: "Is there a particular case that would come to mind where, without DNA, there wasn't a possibility?"

Willis: "I think there are loads of cases going before the court every day now that if we didn't have the DNA they wouldn't be there."

Harvey: "Thank you. Down the back there? Yes?"

Audience member: "Hi. I wanted to know, when you have crime scenes in the water, freshwater or seawater, does that effect the evidence? Do you have to take special precautions? What do the underwater guards give you, I guess because seawater or freshwater must contaminate evidence?"

Willis: "Well, we may not get anything from a sample that's been in the water. It depends on the case. I can remember a case where we got fibre evidence as trace evidence because it was retained even though it had been in water. I'm not sure whether or not we've had cases where the DNA is relevant although you would – we frequently have cases where the request is to say can the body be identified that's been in water where the water's not going to affect it."

Audience member: "You know we all hear on the news and we see on TV programmes where everybody throws the knives or the guns into the Grand Canal or what have you. You know you were talking about when a gun is fired, you can get all this dust?"

Willis: "You wouldn't get, the chances of getting firearm residue particles in that situation is extremely, extremely unlikely. With a knife you might get blood remains in the crevices still, depending on the design."

Harvey: "Thank you."

Audience member: "Actually it's kind of following on from that question in a way; you mentioned before about the TV programmes, CSI and Bones and so on. Do you ever think that because of all those programmes and the amount of information they're giving us about how you examine crime scenes and the types of forensic evidence you're looking for, that they're kind of helping criminals in a way? Because they are telling us, 'There's the type of things we should not leave behind'."

Willis: "They certainly change the dynamic, you know, there's kind of a mediated reality about the world. I don't think you can turn back the clock in relation to that. I don't think you can say this is a secret or whatever. It hasn't actually stopped forensic science being used for both for and against suspects in lots of cases."

Harvey: "OK folks. We'll take just the last one there."

Audience member: "No sorry, I think I was calling for one last question there."

Harvey: "You were? That's my job. If we have one more question we'll take it. Otherwise we'll move on and say to all of you thank you very much for your participation. The questions are great and I hope that what has happened here today has given you a better understanding of something that is, in the main case, scientific but of course it has such a massive impact on our daily lives. Please put your hands together and give our thanks to Sheila."