THE FUTURE OF DNA

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ABSTRACT: Drawing on lessons from the history of the use of DNA in the United Kingdom since the 1980's, I will illustrate the increasing use of DNA as the various technologies and approaches have developed. Key elements of the FSS DNA research programme will be described alongside the collaborative approaches within ENFSI and Europe. I will conclude with a vision of contributions that DNA and other physical evidence could be making in the investigation of crime in 5–10 years time.

KEY WORDS: DNA; Database; United Kingdom.

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We've come a long way since the 1980's with the use of DNA in forensic science. Its now transforming the way we use forensic science in the UK and in the future with the development of technology – automation, miniaturisation, digitisation – it will change this even further. But if we are to realise all the benefits all the criminal justice agencies will have to work together.

In this presentation I would like to talk about the contribution DNA is making to the investigation of crime and the presentation of evidence in the UK. I'll draw on what we've achieved so far and how we see this might develop over the next 5–10 years with reference to some key elements of the FSS research programme and the work we're doing with colleagues in ENFSI.

I'll mention the improvements in DNA profiling itself, the National DNA Database, how we're using DNA in partnership projects with the police, the move to quicker and more efficient analysis, the information we can get from DNA analysis and how we might make better use of all this in the courts.

Where are we now? These DNA profiles are the ones we obtained in the very first DNA case we ever did back in 1986 in the Colin Pitchfork/Narborough murders case. This was a notable case because not only was it the first case in which DNA profiling was used in an investigation and the conviction of the offender in court, it also exonerated the main suspect at the time, Richard Buckland, and it led to the first DNA mass screen being carried out. We were then using MLP profiling. We needed 500 ng of blood (a 2–3 cm stain), it was quite discriminating (match probabilities of 1 in several million), but very labour intensive and slow, it was very imprecise and

unsuitable for creating databases, and it was useless at dealing with mixtures and degraded samples. Since then we have moved on through SLP profiling, the introduction of PCR with the HLA DQ technique and then STRs. With these we can get profiles from sub nanogram amounts of blood. We have match probabilities of better than 1 in a billion, the analysis process is amenable to automation (reducing the numbers of staff required), we can do analysis much more quickly, we can use DNA profiling in a much wider range of situations because of the increased sensitivity and our ability to get results from degraded samples and the analysis of mixtures, and its 1 bp precision makes it highly suitable for databasing and the rapid provision of intelligence information.

National DNA Database facts and figures. We're now loading something like 40–50 000 profiles to the Database every month.

Two brief examples of how we're using DNA profiling in projects with the police – first Pathfinder – domestic burglaries and autocrime with GMP – providing intelligence using the LCN technique and then converting this to successful prosecutions to demonstrate what can be achieved in situations where they thought DNA profiling was inapplicable.

Operation BRIL with WYP – adding to other initiatives the police are pursuing to prevent crime and to bring offenders, particularly PYOs, to court very quickly.

In one such case, for example, the police used evidence from the MO and the blood left at the scene to apprehend the offender.

He was young, with a history of previous offending.

And the success was in securing a quick conviction so that he could more readily associate his sentence with the offence he had committed. But we can still do better and our aim is to have turn around times in the laboratory of 1–2 days for DNA profiling so that the police can charge suspects whilst they are still in custody instead of having to release them on bail whilst they are waiting for results and allowing them to commit further offences.

We are achieving faster throughput in a number of ways. First, automation of analysis of suspect samples – robots for solid phase extraction + quantitation/dilution/PCR set up + post PCR manipulation – using microlitre plate format – and semi-automated electrophoresis, using the ABS 3100 16 channel CE machine which we find is the best machine for this application – 4.5 hour runs and > 95% first pass success rates.

Then quicker interpretation using expert systems – STRess (FSS) and True Allele (Cybergenetics) in tandem, and only human intervention where there is a discrepency. On our automated CE line we are processing over 30 000 samples a month and have 100 analysts reporting the results – 300 interpretation per RO per week. And we are aiming to raise this to 500.

For the future, miniaturisation will make things even faster and cheaper, and the equipment will be portable.

We will be able to collect our samples at the scene, analyse them locally with a "lab on a chip" (which will handle the purification, amplification and analysis of the PCR product), remotely challenge our databases and have the result immediately available to the investigating officer.

We already have micro PCR blocks and PCR product detection technology available at the prototype stage – by either hybridisation or electrophoresis. But of course there is still much to do. In particular we have yet to develop DNA extraction and purification on a chip and develop microchip plumbing so that we can move around microvolumes of reagents. But we are making progress and this vision is not as futuristic as perhaps it might sound.

We can also make process improvements as well as technical improvements – in the DNA units and through the forensic science laboratory as a whole – for example, in the FSS we now have specialist evidence recovery teams who examine items and recover the biological material from items submitted, and this has streamlined the front end of the process considerably. And we can do a lot more to understand and improve how we report our results and how the police and courts use them.

In the future we will also be able to get DNA profiles from smaller amounts of material again (e.g. gun cartridges, manual strangulation, jewellery, etc.) and from even more degraded material using developments such as single nucleotide polymorphisms (SNPs). And we will be able to provide the investigator with a lot more information about the offender (physical characteristics, regional and ethnic origin – e.g. from rare alleles – there is apparently a rare Welsh one Keith but we don't have the Dai's to use with it – even surnames).

With SNPs – their very small size is what gives them the better sensitivity. Degradation of biological materials results in the DNA fragments getting smaller. The black lines represent different lengths of DNA and the top red one the size of our STR amplicons, so you can see that there is a limit to how small a fragment of DNA we can work with with these. The bottom red line shows the size of SNPs and thus how much smaller DNA fragments then become amenable to anlaysis. We are doing a lot of work in our Research programme to characterise and validate SNPs and we anticipate introducing them into casework within the next couple of years.

With STRs and SNPs used together we will be able to learn so much from the same sample by multiple testing.

We are learning all the time about how DNA is transferred and how long it stays around. About "shedders" and "non-shedders". So we will be able to consider a wider range of sources for DNA at the scene, use our portable de-

vices for the analysis, and link it to other information to provide the police with immediate intelligence.

Simultaneous testing will give us clues to help identify the offender (SGMplus will already give gender and ethnic inference; there is a known genetic propensity to obesity; Print Genolics have developed the test for brown and blonde hair and eye colour; the FSS has a red hair test; and so on).

The results of the test together with other police information then lead to the identity we are looking for. So that what he's been up to and why he's not here!

We have a result, but what does it mean in the context of the case? How can we best use the information? The answer here is through Bayesian nets and Bayesian inference – using the case assessment and interpetation model, asking all the right questions, combining the DNA data with that from other evidence types and consulting all the right databases and other information sources. Bringing it all together. This one relates to an LCN profile from a watch strap at the scene of a particularly vicious sexual assault with a windscreen wiper and the LCN profile matched that of the suspect.

You can see how it helps us formulate the alternative propositions we then have to address.

To be really effective however, we have to deliver the different bits of information at the right time to the right people.

We have to recognise the various phases of an investigation and the services most appropriate to those phases.

We have to ensure all the different agencies are involved and work together with them.

The information flows are currently not efficient or joined up.

In the future we will have networks for knowledge transfer in which forensic science is an integral part.