1. Declaration of interests: I am a forensic science academic, researcher and expert witnesses for the court. I operate within the UK and international arenas in forensic science, fire investigation and forensic drug chemistry. I publish on the subject and have current research grants relating to forensic science. I hold awards for my research and public engagement in this area. I am the Director of the £10 Million Leverhulme Research Centre for Forensic Science (LRCFS) established in 2016.

2. LRCFS has the remit to disrupt positively the forensic science ecosystem by fostering communication, collaboration and community co-creation of research questions that address core research gaps as identified by the forensic science ecosystem. We aim to underpin forensic science, where it is possible to do so, through the utilisation of technologically advanced high quality scientific research. We are also developing innovative large scale scientific surveys and citizen science approaches to inform the interpretation of evidence through the generation of various databases.

2. I very much welcome the establishment of the House of Lords inquiry into Forensic Science and the opportunity to provide comments through this consultative process. I have restricted my comments to certain areas as befits my experience and professional expertise.

Questions

1. Is forensic science contributing to the delivery of justice in the UK?
Yes, forensic science is critical contributor to the criminal justice process. Forensic science is widely described as the use of science to address medico-legal questions and is an essential tool, contributing on a daily basis to the delivery of robust justice in our Criminal and Civil Courts.

Forensic scientific has the potential, if used correctly, to provide transparent and objective information to the courts to help the trier of fact, (the jury), deliver a just outcome. Forensic Science is also considered as circumstantial and corroborative evidence providing assistance in determining the presence or absence of individuals and materials at particular locations or providing an understanding as to whether there has been contact between materials and between individuals. It can be used to assess competing propositions relating to the reconstruction of a sequence of events. The essence of forensic scientific evidence is not the analytical measurement but the framing of the interpretation of that evidence within the context of a specific set of case related circumstances.

2. What are the current strengths and weaknesses of forensic science in support of justice?
Forensic science can deliver information which can be used in the investigative phase of a criminal inquiry as well as evidence that can be admitted into the courts. There are broadly two types of forensic science evidence, one where an objective measurement is undertaken, usually using an analytical instrument, and one where a subjective comparison of (mainly) visual characteristics is undertaken.

For objective measurements, many of the scientific tests used are well grounded and follow what would be considered as routine analytical processes. This is particularly true of analytical regimes relating to, for example, the analysis of DNA, drugs, poisons, explosives and ignitable liquids. In these cases the scientific aspects of the tests are well known and well researched, and where a single DNA profile is analysed or the target drugs are well known, forensic scientists provide clear and robust evidence to the court which can be unequivocal (for example in the identification of a controlled substance where a known certified standard is available to compare against). This delivers high quality, objective and scientifically valid evidence for consideration by a jury.

There are, however, interpretative challenges in using data generated from objective measurements which stem from at least two areas; firstly the rapid changing nature of the materials under test – this is evidenced by, for example, the emergence of new drug compounds (sometimes known as ‘legal highs’) or change in poly drug use where more than one controlled substance are taken in combination with each other. In such cases there may be a lack of analytical standards against which casework samples can be compared, and a lack of understanding of the metabolism of drug mixtures rendering the interpretation of toxicological data for such compounds and mixtures very challenging. Secondly, technological advancements in DNA sample capture have resulted in the development of highly sensitive techniques which now commonly deliver more complex mixed DNA profiles. This has raised the (perhaps) unintended consequence of the need for the development of algorithms to un-mix the resultant data. Some of these algorithms have been heavily criticised by the judiciary because of the lack of transparency around how they work.

Much of the types of evidence which rely on a comparison process are more heavily criticised with some suggestions that they remain little better than exercises involving a ‘spot the difference’ approach. This includes the comparison of fingerprints, toolmarks, footwear, tire marks and ballistics. In these cases, there is little, if any, robust science involved in the analytical or comparative processes used and as a consequence there have been questions raised around the reproducibility, repeatability, accuracy and error rates of such analysis.

The lack of robust datasets, freely and openly available to forensic practitioners and researchers, which relate to the background abundance of materials as well as the transfer and persistence of materials given a set of activities, remains one of the most significant gaps in our knowledge. Their absence severely hampers the interpretation and evaluation of the meaning of recovered materials within the framework of circumstances relating to any given alleged activity. Such data sets need to be open access and available to all.
Finally, the clear and unambiguous communication of scientific information to non-scientists is of paramount importance. Science in the courtroom is only as good as it is communicated.

**Understanding and use of Forensic Science in the Criminal Justice System**

3. **What is the scientific evidence base for the use of forensic techniques in the investigation and prosecution of crimes? Are there any gaps in that evidence base?**

There are many decades worth of research publications, text books and caselaw in existence providing an evidence base for the use of forensic science techniques at a global level. The challenge lies in assessing the quality of both the scientific (or otherwise) approaches of individual researchers, research groups and forensic science practitioners as well as collective bodies of work and knowledge. A number of reports present a critique of the status of the scientific evidence base relating to the robustness of scientific and social science research (for example studies on bias, risk and human factors) presented to underpin different types of forensic evidence. These reports include:

- National Academy of Science report: Strengthening forensic science in the United States¹
- President’s Council for Advice in Science and Technology Report on forensic science²
- American Association for the Advancement of Science³,⁴
- Work presented in the Philosophical Transactions of the Royal Society B⁵

These criticisms are significant and are largely accepted within the forensic science and other relevant communities within the criminal justice sector as being well founded. This raises challenges for forensic scientific evidence, how that evidence is presented within the courts and represented to the jury.

Challenges in the scientific accuracy, repeatability, reproducibility and robustness of analytical and interpretative methods also opens up enormous opportunities to address deficiencies, undertake interdisciplinary and high impact research and adapt, adjust, and revise current thinking in both the operational use of forensic science evidence and its ultimate contribution to the criminal justice process. Some of these opportunities and novel applications lie within the research council’s current National priority research areas and the potential transformational nature of research applied into the forensic science space were signposted within Sir Mark Walport’s 2015 Go Science report -Forensic Science and Beyond⁶.

4. **How can the Criminal Justice System be equipped with robust, accurate and transparent forensic science? What channels of communication are needed between scientists, lawyers and the judiciary?**

There are two aspects to consider in answer to this question. Firstly, how do we generate robust, accurate and transparent research in forensic science and secondly how do we effectively communicate the scientific results obtained between scientists, lawyers, the Judiciary and the public who form the Jury? To address these aspects, the different communities need to first come together
and understand each other. They also have to agree the evidential ‘need’ in the judicial process. What evidence needs improving? What kind of crimes need better science? What decisions are unscientific? A dialogue and needs analysis is required that has the service of justice at its heart.

Forensic science research is highly applied and requires to be appropriately contextualised and referenced to the challenges faced by the end user communities which include scientists, legal practitioners and judicial colleagues as suggested by the question. I would also add into this grouping, colleagues in law enforcement.

There should be a range of tools and mechanisms used to functionalise collaborative discussions across the forensic and criminal justice ecosystem such that a collective view is reached of the research challenges and objectives. This is one of the core aims of the Leverhulme Research Centre for Forensic Science which successfully facilitates such conversations and develops co-owned and co-shared imaginative and creative research pathways arising from genuine interdisciplinary engagement.

Galvanising the wider scientific community, industry and entrepreneurial leaders to address these co-designed research challenges together is highly desirable. Such an approach would facilitate the introduction of a range of exciting scientific solutions from across the breadth and depth of the natural sciences and beyond, creating a new and dynamic research culture in forensic science which the UK is well placed to take a global leadership position on.

5. What is the level of understanding of forensic science within the Criminal Justice System amongst lawyers, judges and juries? How can it be improved?

In my experience the understanding of science across the legal community is mixed. Some have a solid grounding in the limitations surrounding both the science being used and its implementation into the criminal justice space while others do not. I would also add that the understanding of law enforcement and policy makers is equally mixed.

Similarly, the understanding of scientific evidence across juries is difficult to ascertain but may be influenced by popular television, crime novels and science programs etc. What does appear to be the case is that juries appreciate the expertise and experience of the scientists and find the evidence they present more digestible and understandable when it is presented as a narrative rather than on numerical scales.

Improvement can be made by focusing on both education/training and on the development of science communication skills across the full span of the ecosystem where such communication is tuned and audience specific. This is an area of work that LRCFS is currently engaging in.

Communication may also be achieved by providing accurate and accepted guidance written in simple prose, on the validity of a particular scientific discipline or concept together with the current understanding of the strengths and limitations of that technique when used within the context of the criminal justice system. The recent production of Judicial primers, led by the Lord Chief
The activities of the Royal Society and LRCFS facilitate collegiate and active engagement across academics, researchers and practitioners within the fields of science and law.

6. **Is the current training available for practitioners, lawyers and the judiciary appropriate?**

If the question is relating to training in basic science, the principles of forensic science and the principles of using statistics to address comparative case related hypothesis based on available scientific evidence then my answer would be ‘no’.

Equally, I do not believe that forensic scientists in general are sufficiently well trained in basic numeracy, the foundations of statistical and probabilistic analysis and in how to use data to support or refute a variety of competing propositions with the probable exception of DNA evidence. Neither are they well trained in how to undertake research or in some instances, differentiate good quality scientific research from poor quality work.

Forensic scientists are also, in my experience, not particularly well trained in the legal framework and in the expectations that the courts have in terms of the requirements of being expert witness’. Training in science communication to non-expert audiences is also almost universally absent.

**Standards and regulation**

7. **Is the current market for forensic services in England and Wales sustainable? Are changes needed to ensure forensic science provision is maintained at the level required? What are the risks of a market approach, for example what happens if a provider goes out of business? And what is the impact on quality?**

The current commercially driven delivery of forensic science in England and Wales has marketised forensic science to such an extent that it is now at risk of being delivered in a siloed and passive mode. Forensic scientists are being asked to examine and analyse samples with little or no case context. This potentially restricts their ability to contextualise their results to the specific framework of circumstances of the particular case and as a consequence their abilities to interpret and evaluate the evidence within that case context may be severely limited. In my view change is certainly needed, forensic science should be viewed as a service to society rather than a commodity to be bought and sold where profit becomes the driver rather that the effective use of science in the service of justice.

8. **Is the system of accreditation working successfully to ensure standardised results and the highest quality analysis and interpretation of significance of evidence?**

There are two issues in terms of accreditation. Firstly, what the requirements for accreditation within the forensic science landscape are and, secondly, whether accreditation delivers standardised results and the highest quality analysis and interpretation.
Firstly, the delivery of forensic science into the criminal justice system can be monitored by accreditation. In the UK, the activities of UKAS\textsuperscript{9} and the office of the Forensic Science Regulator\textsuperscript{10} have successfully driven the accreditation process for commercial forensic science laboratories operating in England and Wales. Accreditation is a requirement for commercial providers working within the private market place in England and Wales. In Scotland and Northern Ireland, the forensic science providers have also chosen to become accredited using the Forensic Science Regulator’s guidance documentation.

Accreditation is not yet a requirement for forensic services delivered directly by police forces in England and Wales. Some police forces have achieved accreditation for the services they deliver, others are in the process of undergoing accreditation but many police forces have not achieved accreditation. With no statutory powers, the Forensic Science Regulator is hampered in her ability to enforce the accreditation requirements across the police services. This has essentially resulted in a two tier system where commercial forensic science providers must be accredited in order to operate in the market place while police providers of forensic services to the criminal justice system are still not accredited despite having deadlines set for accreditation.

The quality of analysis and the interpretation of evidence may not necessarily be governed by an accreditation process. While standard operating procedures required as part of a quality management system will often incorporate the underpinning basis of an examination, they do not necessarily ensure the scientific validity of the analytical approach used. If the analysis undertaken is not scientifically valid in the first place, then accreditation of the process will not address these scientific deficiencies.

The interpretation of the significance of evidence depends heavily on the case context and in order to be at its most effective the forensic scientist requires to have an understanding of that context. Equally the role of the expert in terms of evidence interpretation is to evaluate the factual scientific evidence against a range of alternative propositions, only one of which will be the prosecution hypothesis. For this evaluation to be truly effective, information about the case context and data bases relating to the background abundance of materials as well as the transfer and persistence of materials is key.

9. What role should the Forensic Science Regulator have? If the Forensic Science Regulator is to have statutory powers, what should these be?

The Forensic Science Regulator’s primary role is to ensure that an appropriate scheme of scientific quality standards is implemented across the provision of forensic science services to the Criminal Justice system. After public consultation it was agreed that the Forensic Science Regulator should be provided with statutory powers. The UK Government reiterated its commitment to deliver statutory powers to the Forensic Science Regulator in the Home Office Strategy published in 2016. In 2018 a private members bill was finally used in an attempt to deliver statutory powers for the Forensic Science Regulator and at this time that process is still ongoing.
The current position within England and Wales is that unaccredited police organisations are providing forensic science services to the criminal justice system. The statutory powers provided to the Forensic Science Regulator should at the very least, address this and allow the Regulator to compel such organisations to comply with her quality code and to obtain accreditation to the same International standards as the private commercial forensic science providers are required to.

10. What lessons can be learned from the use of forensic science in Scotland and Northern Ireland? What can be learned from the use of forensic science overseas?

There are many lessons to be learned from review of other delivery models for Forensic science both within the UK and beyond its shores. This is not a straightforward task and would require some resource to undertake a properly constructed independent and external review perhaps tendered to a professional consultancy service. The remit must include the delivery of an unbiased and evidence based picture of the international landscape.


The Forensic science strategy produced by the Home Office in 2016 was the subject of an Inquiry by the House of Commons select Committee on Science and Technology. The overarching final comment of that committee, after taking written and oral evidence from a wide variety of witnesses, was that:

"the Government should acknowledge that the Forensics Strategy is an incomplete document which leaves too many issues and possible ways forward under-developed to constitute a coherent description of the Government’s policy and direction in this important area. The Government should now aim, on the back of the hopefully imminent publication of its long-awaited Biometrics Strategy and the conclusion of the police's currently underway forensics service 'scoping work', to present a revised 'draft Forensic Strategy' for a full public consultation. Once that is done, we would hope to see a Strategy that justifies such a description”.

In my view, the forensic science strategy provides a vague and superficial overly optimistic perspective on a possible future development of forensic science in England and Wales. It is fixated on delivery of a ‘value’ led commoditised forensic science ‘product’ for the criminal justice system without a full understanding of what value looks like. To my knowledge no comprehensive work has been undertaken since the release of the strategy to attempt to move this forward in any way.

Forensic Science research landscape

12. How should further research funding for forensic science be justified? What should be the focus of such research? What is the role of UK Research and Innovation, especially considering the interdisciplinary nature of much forensic science?

This is a complicated set of questions.
Firstly, the justification for research can be viewed as needs based. We need to gather data that is useful in the interpretation of the competing propositions that the forensic scientists is tasked with answering within the courts. To do this we need to have imaginative and far reaching foundational research undertaken to develop open source, accurate, well curated large scale data bases of known data (ground truth databases) relating to:

(1) the background abundance of materials across society (for example, prevalence of controlled substances, explosive traces, gun shot residues, soil, fibres, glass, paint on clothing and surfaces),

(2) the transfer and persistence of trace evidence such as fibres, paint, soil, pollen, DNA, glass, drugs, explosives, gun shot residue and other materials.

Secondly, we need to make use of the advances in foundational and transformational science that is being delivered across the Higher education institutes in the UK which are aligned with the core areas of UKRI’s funding priorities. In particular there are opportunities to explore advances in the fundamental physics and chemistry associated with materials science to generate an understanding and algorithmic modelling capability for the movement of materials from one place to another given specific activities. This allows forensic science applications to emerge at the very cutting edge of the development of novel sensors, nanomaterial technologies, applications of artificial intelligence and machine learning, materials design and many others. Forensic science should embrace the rapid developments in these and other areas and needs to expose its challenges and application potential to research leaders and teams working at the very forefront of science. Such exposure has the potential to bring the best scientific innovations and transformations into sharp focus within this important application area. This in turn facilitates the emergence of a cost-benefit discussion where the forensic science application of an emerging transformational scientific development can be viewed as an added advantage.

13. Where are the gaps in research and understanding of forensic science? How and by whom should the research questions be articulated to fill these gaps?

There are many research gaps relating to the establishment of the foundational scientific validity of many forensic evidence types and the gaps are clearly articulated in reports such as the NAS and PCAST documents.

Large scale data sets are required relating to transfer and persistence or background abundance. This may be best suited by taking a different approach to research and the development of citizen science based projects and coordinated short term research projects harnessing the global interest in forensic science at undergraduate and master degree level, designing research projects that are achievable and deliver a worthwhile open source data set, using common methods.

Whatever research is needed must be co-created and decided by members from across the forensic science ecosystem and in particular should involve the ultimate end users which are the Judiciary. It is for them to decide whether a
particular piece of evidence is admitted in front of the jury and in order to do that, we as the scientific community, must be able to demonstrate the robustness, and scientific validity or the detection, recognition, comparison, interpretation and evaluation of that evidence.

14. **How can a culture of innovation in forensic science be developed and sustained?**
A new approach to collaborative working in forensic science is needed, one that is owned and driven by scientists and tensioned by the judicial and legal need. The forensic scientists at the coal face must be provided with opportunities to articulate their concerns, scientific challenges and interpretative and evaluative needs to academic research teams who work at the very frontiers of scientific discovery so that the latest technological solutions can be evoked. This co-production of truly interdisciplinary research is transformational in nature and will begin to develop the building blocks that drive an economic cluster associated with the development and understanding of efficient, effective and relevant solutions to deliver accurate, robust and valid science for the criminal justice system.

15. **Are there current or anticipated skills gaps? Who should have responsibility for and/or have oversight of training?**
Forensic scientists need to be good scientists first and foremost. They need to be numerate and statistically competent, they need to be good at solving abstract problems and they need to be good at science communication. Learning the various aspects of the application of their core scientific skills and knowledge into the forensic science domain can come after a basic training to at least undergraduate level in science or engineering or other appropriate discipline.

Currently the training of forensic scientists is undertaken once they are in post by their employers. There is a range of professional bodies for different specific areas of forensic scientific practice, many with codes of practice which also establish the specific skills and knowledge that a given practitioner within those disciplines should have, recent examples exist for forensic anthropology\textsuperscript{10} and fire investigation\textsuperscript{11}.

The responsibility and oversight of training falls to the academic institutions where the delivery of core scientific training at undergraduate level occurs as well as to employers of forensic scientists.

Academic institutions, I would suggest should be encouraged to include numeracy, critical problem solving and statistical skills, research development and science communication in their degree programs. Many, but not all, current undergraduate degrees in forensic science, in my experience, rarely deliver a sufficiency of core knowledge in chemistry, biology, physics or mathematics to their students.

**Digital Forensics**

16. **Are there gaps in the current evidence base for digital evidence detection, recovery, integrity, storage and interpretation?**
There are many gaps in even the articulation of what digital evidence is, how it can be legally captured and how it could and should be investigated. Gaps include, but are not limited to;

- the development and agreement of a common definition of digital evidence and digital forensics,
- the agreement of a National and International lexicon of terms,
- an agreed understanding of how digital devices and information can be legally seized
- how investigations should be undertaken
- how information recovered from digital devices can be triaged and scrutinised
- how to prevent victim of crime from being revictimised because their devices are seized as part of an investigation
- ethical considerations

17. **Is enough being done to prepare for the increasing role that digital forensics will have in the future? Does the Criminal Justice System have the capacity to deal with the increased evidence load that digital forensics generates?**

This is an enormous issue and given the rapid growth in how much the digital revolution is impinging on daily life, I do not believe that enough understanding or planning is in place to even understand the impact this will have on the investigation of crime. The solution is not trivial and perhaps needs to be the subject of a new Inquiry in its own right.

**References**

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