

Science and Law: Contrasts and Cooperation

The Royal Society, London

Lord Neuberger, President of the Supreme Court

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1. Standing here before you at Carlton House Terrace giving a lecture gives rise to two strong emotions, pride and sorrow, each of which is attributable to my family background. Both my late father and my younger brother Michael, who died far too young two years ago, were very distinguished biochemists and Fellows of the Royal Society. Although I have been to a couple of colloquia, the only lecture I have attended in this building until today was Michael's Royal Society GlaxoSmithKline Prize Lecture in 2003.
2. But my recollection of the Royal Society goes back much further than that. Around 60 years, as a young child, I was occasionally taken at the weekend for a couple of hours by my father to the Society's previous premises at Burlington House in Piccadilly. Quite why he called in at the weekend I cannot recall, but I remember our occasional visits as being more enjoyable and less drawn out than our equally occasional visits to synagogue. And I still have childhood memories of my parents setting off for the Society's annual dinner on 30 November in full fig. At the 1965 dinner, I was allowed to go as my father's guest instead of my mother, who was unwell, and I recall listening to the first after-dinner speech which I ever heard, from your then new President, Patrick Blackett.
3. Two of my father's proudest moments were when he was elected an FRS in 1951 and when Michael was elected an FRS in 1993. I was brought up to believe that there was no greater achievement than to be a scientist who became a Fellow of the Royal Society. As a result, I went to University and spent four years trying to be a chemist, even rather ineptly carrying out

research into semi-synthetic proteins, until I realised that such abilities as I had were suited to another discipline. I still harbour a vestige of a sentiment that practising in any discipline other than a scientific one is a second best. To paraphrase what Lord Rutherford allegedly said¹, I have the sense that, when it comes to intellectual pursuits, there is maths and science and that everything else is stamp collecting.

4. But inept as I may have been as a chemist, I believe that my scientific training has been valuable in my career in the law. When I went to visit some impressive German legal academics at the Max Planck Institute in Hamburg in 2012, they were incredulous that anyone who had studied science for four years, and law for little more than a year, much of it part-time, could become a senior judge. I thought at the time that they had a point, and no doubt some readers of my judgments may agree with them. However, my answer was based on my observation that mathematicians relatively easily become physicists, physicists can easily become chemists, and chemists easily morph into biologists, but changing in the other direction – from physics to maths for example – is much harder and rarer. The explanation, I said, was plain: it is far easier to switch from a more rigorous subject to a less rigorous subject than the reverse. So, a move from chemistry to law was no problem. Edward Lear had a good description for my audience’s reaction – mingled affection and disgust².
5. Mingling was the order of the day, as my answer was intended to have a mingled message, part joke and part serious. If you are going end up as a professional lawyer, there is much to be said both for and against studying law for three years. However, in terms of mental training, at least on the face of it, science is, as I suggested in Hamburg, a more exacting discipline than law. Most scientific problems seem to have objectively verifiable, binary, solutions. The answer to a question involving Newton’s laws of motion or the laws of thermodynamics is universal and

¹ J B Birks *Rutherford at Manchester* (1962), p 108

² Edward Lear, *The Story of the Four Little Children Who Went Round the World in Nonsense Songs and Stories* (1871) – the description was of the four children’s reaction to the Co-operative Cauliflower

timeless: it is the same whether you are in the London in 2015 AD or were on the moon in 2015 BC. So, at least for exam-taking students, there is an independently verifiable right answer for the great majority of scientific problems and questions.

6. Legal issues are very different. A student's answers may seem right or wrong to an examiner, but law does not have the discipline of objectively verifiable answers. And unlike the laws of thermodynamics or of motion, legal laws are far from timeless. The most fundamental legal rights which we all take for granted in 21st century England, such as freedom from slavery or torture, or freedom of expression or religion, would have seemed alien, or at the very least controversial, in Tudor England 500 years ago, let alone at the time of Magna Carta 800 years ago. And today, opinions about fundamental legal rights are very different in parts of the Middle East from what they are in Western Europe. And, while there is agreement as to the basic law on the topic concerned, UK Supreme Court Justices can split 4-3 on issues such as whether the UK government has lawfully allocated EU regional funds³ or how insurers' liability to employers whose employees contract mesothelioma is to be assessed⁴.
7. However, while the consensus about what are appropriate legal laws may vary enormously with time and place, the law incorporates some fundamental and timeless principles, such as the importance of impartial justice, the need for enforceable and enforced laws, and the nature of legal reasoning. And science is not as timeless as it appears. At the end of the 19th century, classical physics was thought to be incontrovertible, but within a few years it was virtually turned on its head by the ultraviolet catastrophe followed by Max Planck's discoveries at the subatomic level and Albert Einstein's equations at the astronomic level. And this year marks the centenary of the first publication of the tectonic plate theory of continental drift⁵. A geology

³ R (*on the application of Rotherham Metropolitan Borough Council*) v Secretary of State for Business, Innovation and Skills [2015] PTSR 322

⁴ *Zurich Insurance PLC UK Branch v International Energy Group Ltd* [2015] 2 WLR 1471

⁵ Alfred Wegener, *The Origin of Continents and Oceans* (1915)

student who supported that hypothesis in the 1930s would have failed his exams⁶, whereas today it is received wisdom. And, 500 years ago, in a world of alchemy, converting lead to gold involved mystery and charlatanism; 150 years ago, in the early days of the periodic table, it was impossible nonsense; and in today's nuclear age it is an expensive reality⁷.

8. Further, if one turns to the cutting edge of science, there are many areas where there are currently no right answers. A familiar example is string theory, which is seen by some scientists to have “the potential to show that all of the wondrous happenings in the universe ... are reflections of one, grand physical principle, one master equation”⁸ and by others as an area on which far too much time and money have been wasted, on the basis that “string theorists prefer to believe that string theory is too arcane to be understood by human beings, rather than consider the possibility that it might just be wrong”⁹. (From a non-scientist's point of view, perhaps the rapper RZA had it right when he said “People can talk about string theory, parallel realities, different dimensions, it's still one plus one is two, baby”¹⁰.)
9. If one digs a little deeper, there are some fundamental similarities between scientific and legal thinking – not surprisingly as their aims are in some ways similar and they are each the product of human intellectual endeavour. On a relatively high level of analysis, science and law are both concerned with imposing order on chaos, and identifying laws which work - in the one case with the observable universe, and in the other case with human beings in society. And both scientific thinking and legal thinking rely in general on logical reasoning and on the evaluation of evidence. Scientists and lawyers each search for and assess hard facts from which they can

⁶ “For decades afterward, older geologists warned newcomers that any hint of an interest in continental drift would doom their careers” - Richard Conniff, *When Continental Drift Was Considered Pseudoscience* Smithsonian Magazine (June 2012).

⁷ “[A]ll you need is a particle accelerator, a vast supply of energy and an extremely low expectation of how much gold you will end up with” - John Matson, *Fact or Fiction?: Lead Can Be Turned into Gold*, Scientific American (31 January 2014)

⁸ Brian Greene, *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory* (1999).

⁹ Lee Smolin, who also said that “[t]he real question is not why we have expended so much energy on string theory but why we haven't expended nearly enough on alternative approaches” - *The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next* (2006)

¹⁰ Interview at the AV Club, <http://www.avclub.com/article/rza-34255>

establish the truth, whether of a particular theory or in a particular case, and they each use principles and reasoning to enable them to reach what they hope is the right conclusion. A law student no less than a science student learns to assimilate what are seen to be the currently significant facts, theories and hypotheses, and the currently important issues and principles, as well as how to question and reason, and how to look for and assess evidence.

10. Nonetheless, there are many significant differences between a professional scientist's approach to a scientific problem and a judge's approach to a legal dispute. As I have mentioned, the justice system and scientific method are both designed to get to the truth. However, as has been fairly pointed out¹¹, there are real differences in approach. Scientists observe the facts, form a hypothesis, and then test the hypothesis with experiments in order to establish a hitherto unknown law. On the other hand, a legal dispute appears to proceed on an almost reverse basis; a legal case starts with already established laws, which each party applies to a series of facts with a view to creating a hypothesis, which then becomes that party's case, and the judge then decides which of the two cases she prefers. And the validity of published scientific discoveries can be confirmed or falsified by repeating the published experiments, whereas the best the law can do about judicial decisions is a sort of peer review, namely by way of an appeal to a higher court; and as a recent study in the journal *Nature* showed, peer review is not always a guarantee of accuracy¹².

11. As to the relevant thought processes, scientific thinking is resolutely rational: there is, for instance, no basis for falling back on morality, let alone religion. Neither of those disciplines has any part to play in scientific thinking. That is not of course to suggest that scientists cannot be religious: but scientific thinking and moral and religious thinking inhabit different worlds. By

¹¹ Paul England, http://united-kingdom.taylorwessing.com/synapse/ip_patentlitigation.html

¹² M Baker, *Over half of psychology studies fail reproducibility test*, *Nature*, 27 August 2015, which suggested that of the results claimed in 100 peer-reviewed published papers on psychological research topics, only 39 were repeatable. See also *Trouble at the lab*, *The Economist*, 19 October 2013

contrast, moral principles are in some ways fundamental to the development of rules law in that many legal principles are based on morality – for instance much of the criminal law. As one of my judicial colleagues, Sir Rabinder Singh, recently put it, many of our laws are meant “to give effect to certain basic values of society”¹³, and since judges are responsible for developing the common law, they must have regard to these basic values when deciding broad issues of principle within the law.

12. However, that is as far as it goes in the 21st century. Judges do not bring their moral and religious views into the balance when it comes to deciding particular cases or issues. In the past, even at the beginning of the last century, judges considered that part of their function was to promote virtue and prevent vice, but as another of my colleagues, Sir James Munby, recently said, “the days are past when the business of the judges was the enforcement of morals or religious belief”¹⁴. But it was less than 200 years ago that a Chief Justice said “Christianity ... is part of the law of England”¹⁵. We should not, however, be too hard on law in this connection: less than 200 years ago, what were contemporaneously seen as serious thinkers were suggesting that God had made the fossil and geological records look as if they were hundreds of millions of years old, whereas in fact they were no older than the few thousand years which the Bible showed them to have been¹⁶.

13. It is also worth mentioning the contrasting role of common sense in scientific and legal thinking. It is more than twenty years ago that Lewis Wolpert convincingly demonstrated how many well-established scientific principles are positively contrary to common sense¹⁷. For instance, quantum entanglement, which appears to involve information being passed from one

¹³ Sir Rabinder Singh, *Law as a System of Values* (24 October 2013)

¹⁴ Sir James Munby, *Law, Morality and Religion in the Family Courts* (29 October 2013)

¹⁵ Best CJ in *Bird v Holbrook* (1828) 4 Bing 628, 641

¹⁶ See eg Phillip Gosse, *Omphalos: an Attempt to Untie the Geological Knot* (1857), published two years before Charles Darwin's *Origin of Species*

¹⁷ Lewis Wolpert, *The Unnatural Nature of Science* (1992)

sub-atomic particle to another faster than the speed of light, is a well-established principle. But it is one which even Einstein found hard to take, famously calling it “spooky action at a distance”¹⁸. By contrast, lawyers frequently rely on common sense – for instance, to take just a few examples from recent Supreme Court cases, in deciding what a commercial contract means¹⁹, in assessing whether particular damage or a particular death was caused by a particular action²⁰, and when deciding whether a director’s wrong-doing can be attributed to his company²¹.

14. By the same token, logic is absolutely fundamental to all scientific endeavours. A flaw in the logic of any step in a chain of reasoning of any scientific hypothesis will be fatal to the reliability of the hypothesis and to any conclusion it would otherwise appear to justify. By contrast, while logic undoubtedly plays a very important part in legal thinking, the precise extent of its role is uncertain. Indeed, a cynic might say that judges generally invoke logic to support a conclusion, but when they dislike the conclusion which appears to be compelled by logic, they fall back on common sense or human experience.
15. The ambiguous relationship between law and logic is reflected by comparing what was said by a great 17th century English Judge, Sir Edward Coke, “Reason is the life of the law”²², with what was said by a great 19th century United States Judge, Oliver Wendell Holmes, “The life of the law has not been logic; it has been experience”²³. More recently, fifty years ago, a Lord Chief Justice, with the agreement of two future Law Lords, said in a judgment relating to the topic of joint enterprise in crime, “[t]he law, of course, is not completely logical”²⁴ – one notes the “of

¹⁸ “Spukhafte fernwirkung” – Albert Einstein in a letter of 3 March 1947, *The Born-Einstein Letters; Correspondence between Albert Einstein and Max and Hedwig Born from 1916 to 1955* (1971)

¹⁹ *Rainy Sky SA v Kookmin Bank* [2011] 1 WLR 2900, paras 15 and 21, and *Arnold v Britton* [2015] 2 WLR 1593, paras 15, 20 and 62

²⁰ *AIB Group (UK) plc v Mark Redler & Co* [2014] 3 WLR 1367, paras 36, 89, 95, and *Rv Hughes* [2013] 1 WLR 2461

²¹ *Jetivia SA v Bilta (UK) Ltd* [2015] 2 WLR 1168, paras 7, 45, 72-80

²² Edward Coke, *Commentaries Upon Littleton* (1628) 97b

²³ Oliver Wendell Holmes, *The Common Law* (1881) p 1

²⁴ *R v. Anderson and Morris* [1966] 2 QB 110, 120, per Lord Parker CJ, with whom Edmund Davies and Roskill LJ agreed

course”. And in 1991²⁵, in the course of another judgment, Lord Oliver, a Law Lord, cheerfully described the law relating to liability for mental distress, as developed by the courts, as “not wholly logical”, but he did not suggest that it should therefore be changed. On the other hand, my colleague Lord Wilson recently observed in a judgment that “logic is the blood which runs through the veins of the law: allow it to escape and ultimately the edifice collapses”²⁶.

16. The different approaches to the assessment of evidence of science, with its emphasis on strict logic, and law, with its regard for common sense, may be seen in the judgment of Rose LJ in the 1996 Court of Appeal decision of *R v Adams*²⁷, where the defendant was appealing against his conviction for rape. The case against him was strong (as his subsequent re-trial and conviction demonstrated), based it was on DNA evidence. The defendant had been allowed by the trial judge to lead evidence said to be based on Bayes’ theorem, which connects conditional probabilities. The expert evidence in that case involved multiplying out chances of the rapist being a local man, the chances of the victim not identifying him, the chances of his not having an alibi, and the chances of certain other selected, relevant facts. I am no statistician, but I strongly suspect that this was a gross misuse of statistics and would have been disclaimed by the remarkable Reverend Thomas Bayes. However, for present purposes it is interesting to see what Rose LJ had to say about it. He deprecated “the attempt to determine guilt or innocence on the basis of a mathematical formula, applied to each separate piece of evidence”, on the basis that it was “simply inappropriate to the jury's task”, because “[j]urors evaluate evidence and reach a conclusion not by means of a formula, mathematical or otherwise, but by the joint application of their individual common sense and knowledge of the world to the evidence before them.” I think that precisely the same approach would be adopted in civil trials, by reference to the judge’s “common sense and knowledge of the world”.

²⁵ *Alcock v Chief Constable of South Yorkshire* [1992] 1 AC 310

²⁶ *In the matter of J (children)* [2013] 1 AC 680, para 75

²⁷ [1006] 2 Cr App R 467

17. Nonetheless, as I have said, logic does play a vital part in legal, as well as scientific, thinking. But a countervailing feature which inevitably raises its head in both scientific and legal thinking is human nature. Someone²⁸ famously said to Dr Johnson “I have tried ... to be a philosopher, but, I don’t know how, cheerfulness was always breaking in”. In the same way, a scientist and a lawyer both suffer from the fact that personal convictions and biases keep on breaking in. However much we try and allow for our own prejudices, it is almost inevitable that that insidious and uncontrollable imp, unconscious bias, will be hard at work. When a judge has to decide, as the Supreme Court did fairly recently, whether the absolute ban on assisting a suicide contravenes human rights²⁹, we all did our best to ensure that we discounted our own religious, social or moral views on the topic. More routinely, when a trial judge thinks that one party has behaved badly and the other has behaved well, it is tempting, but wrong, to take that into account when deciding the case, because what is required is a dispassionate application of the law.
18. Because scientists are human, scientific thought can suffer from similar problems, particularly when it runs into personal self-interest or wider policy issues. I referred earlier to string theory: if you have spent 20 years of your life devoted to string theory, you are going to find it hard to be dispassionate when it comes to the issue of whether or not it is soundly based. And the extent and likely consequences of the human contribution to climate change is a topic which should ultimately be a matter of open-minded and rational argument. However, partly because it is seen by many to give rise to issues which are important for the future, partly because of media coverage, but partly also because of preconceived notions, the argument has often been conducted with an evangelically theological fervour. Science would call for an impartial and informed analysis, as objectivity is surely a prized quality which scientists, like lawyers, should

²⁸ Oliver Edwards according to Boswell’s *Life of Johnson*, Vol 3, p 35

²⁹ R (*Nicklinson*) v *Secretary of State for Justice* [2015] 1 AC 657

seek to adhere to. But the external political and media pressures and the internal beliefs of many scientists encourage a departure from such objectivity.

19. Another feature which scientific and legal thought processes share is the reasoning process.

Karl Popper, with his theory of “critical rationalism”, helped to explode the notion of a scientist carefully and logically working his way from the known A to the unknown Z. Popper thought it more likely that a scientist has a bright idea, Z, and then tries to rationalise backwards to A to justify it – and then tries to see whether it works, normally by falsification. In truth, I suspect that the processes of scientific discovery and invention involve a mixture of thought processes – reasoning backwards as well as forwards. A judge does the same. Once she grasps the facts of a case, she often has an instinct for the right answer, and then tries to work out logically whether it is the right answer, and if so why. Of course, like a scientist, a judge may often have a change of mind as to the right answer or may decide that what she thought was the right answer cannot be justified as a matter of law. The similarity of thought process in science and law is scarcely surprising, given that they are both fields involving human endeavour.

20. The fact that there are no right answers is nonetheless more likely to be true in law than it is in science, but scientists have an enormous advantage over judges. When faced with a problem, a scientist can respectably say “It’s impossible to give an answer”; indeed, it may be the only intellectually respectable answer from the scientific perspective. And a scientist can say “I need more information before I can reach a conclusion; I will investigate”. A judge has to give an answer at the end of a case, and, far from demonstrating professional high standards, a judge who said at the end of a case: “It is impossible to give an answer” would be thought incompetent. And, at least under our common law adversarial system, a judge cannot insist on calling more witnesses, let alone carry out her own investigation of the facts³⁰.

³⁰ See *Re Enoch and Zaretsky, Bock & Co's Arbitration* [1910] 1 KB 327

21. Science and law not only have the human condition in common; there are many areas where they share an interface. One such area is that of patents. Patents are justified by two principles. First, it is in the public interest to reward research which results in technological advance, as that encourages such research. Secondly, it is in the public interest that an inventor discloses his invention to the public: otherwise the invention may be lost to the world or become subject to monopolies. Accordingly, a patent gives the inventor a monopoly of the invention for a fixed period from the date when he formally discloses his invention by making an application for a patent; and at the end of that period, anyone can freely use the invention. If the inventor does not publish his invention by applying for a patent, another inventor may beat him to it, and get the monopoly.
22. Many patent applications are made every year: over 270,000 were issued in the European Patent Office in 2014 alone³¹. Most patents turn out to have little if any value, but a few are valuable, and a very few immensely so. It is therefore inevitable that there are arguments about the validity of patents and also as to whether an article infringes a patent – ie arguments as to whether the monopoly should exist and, if it should, how broad its scope should be. These points can give rise to various issues, including: What does the patent actually claim as the invention? Is the claimed invention novel? Is the claimed invention obvious? Does the patent actually enable one to make the claimed invention? Does the allegedly infringing article actually infringe the patent?
23. In the United Kingdom, all these questions have to be decided by a judge in cases which involve full argument by lawyers. (Remarkably in the United States many such questions are often decided by lay juries). In most such cases, there are issues of science or technology, which a court in our common law system cannot decide without expert evidence. So, the judge will

³¹ <http://www.epo.org/about-us/annual-reports-statistics/statistics/filings.html>

normally hear from expert witnesses, who may give her expert evidence on such issues of meaning, novelty, obviousness, enablement and infringement.

24. Of course, patents are by no means the only area of legal dispute where scientific evidence is called for. On the civil side, sophisticated evidence on engineering, technological and IT issues is frequently given in the Technology and Construction Court, and not infrequently in the Commercial Court. And, almost by definition, expert evidence across the scientific and technological range may be needed in professional negligence cases, most commonly in medical negligence cases. Expert scientific evidence is also given at criminal and family law trials. DNA profiling evidence is an obvious example, and it has had a similarly revolutionary effect to fingerprint evidence a century earlier.
25. Perhaps the most striking example of DNA profiling's revolutionary effect to a person of my generation is the *Hanratty case*. In 1961, James Hanratty was controversially convicted of murdering a man, Michael Gregsten, and raping and attempting to murder a woman, Valerie Storie, and he was one of the last people to be hanged. For the next forty years, articles and books were regularly published, often by highly respected journalists and legal experts, claiming, with much supporting evidence³², that Hanratty had been wrongly convicted. Indeed, that was received wisdom in many quarters, and there was much pressure for a posthumous acquittal. Finally, the Court of Appeal entertained an appeal³³ in 2002, following a reference by the Criminal Cases Review Commission. To many people's surprise, Hanratty's conviction was upheld, partly because articles of clothing owned by Miss Storie, retained by the police, were found on analysis to contain DNA which, when checked against the DNA of his mother and his brother, constituted "certain proof of James Hanratty's guilt" as the Court of Appeal put it³⁴.

³² See eg Lord Russell of Liverpool, *Deadman's Hill: Was Hanratty Guilty?* (1965), Paul Foot, *Who Killed Hanratty?* (1971), Bob Woffinden, *Hanratty: The Final Verdict* (1997), p 332, and various articles by Ludovic Kennedy

³³ *R v Hanratty deceased* [2002] EWCA Crim 1141

³⁴ *Ibid*, para 127

26. In the 2002 *Hanratty* appeal, there was a dispute between expert witnesses in relation to the risk of contamination of the DNA samples³⁵, and, where a case turns on scientific issues, conflicting expert evidence is an inevitable feature of the hearing. It has long been accepted in all quarters as a fundamental principle that every expert witness owes an overriding duty to give his honest, impartial opinion to the court. Thus, in his seminal work on criminal law written nearly 150 years ago³⁶, Sir James Stephen stated that expert witnesses “knowing their business” should “giv[e] their testimony with absolute candour and frankness”; and he warned against them being “not really witnesses but counsel in disguise”. The naïve assumption behind the principle that experts should be impartial is that it should make it relatively easy for a court to decide most disputes of a scientific nature. However, as so often happens principle and reality are ships that pass in the night.
27. Frequently, the warring parties will each call equally irreproachably experienced and expert witnesses, who, with equally impressive credentials and confidence, will say precisely the opposite to each other. At trial, there is often a succession of expert witnesses, each giving evidence and then being cross-examined by the other side, and then the Judge has to decide which of those experts is reliable and which is not.
28. In some cases this is unsurprising. Many of the issues on which an expert has to give a view are matters of opinion or judgment rather than involving any sort of hard-edged or quantitative assessment. For instance, whether an invention was obvious over what was already known, or whether the relevantly skilled person reading the patent would have sufficient knowledge to understand how to make the invention from reading the patent, are legal-type issues on which, at least in many cases, reasonable scientists could differ. And in a case in which the stakes are

³⁵ *Ibidi*, paras 120-126

³⁶ Sir James Fitzjames Stephen, *History of the Criminal Law of England* (1882)

high enough, the parties may well each trawl through the scientists in the relevant field until they find one who subscribes to the view which suits their case. The judge will often have little idea which of the two scientific opinions is typical of what scientists in the relevant field think. And, because the question at issue is frequently a matter of individual judgement, the evidence on the issue is often incapable of being weighed in any logically meaningful way; accordingly, human nature being what it is, there is a risk that the judge may decide the issue by reference to who is the more impressive witness, rather than whose evidence is more impressive.

29. Expert evidence has long been a problem for the courts. It is very hard to find an expert who is genuinely independent; yet that is what the law expects from every expert witness. As the formidable 19th century Master of the Rolls Sir George Jessel said³⁷ 140 years ago, “[e]xpert evidence ... is evidence of persons who sometimes live by their business, but in all cases are remunerated for their evidence”. Accordingly, he said, unlike ordinary witnesses, “he is employed and paid in a sense of gain” so that “it is natural that his mind, however honest he may be, should be biased in favour of the person who calls him”. He described this as “very natural”, but added that the result was “that we constantly see persons, instead of considering themselves witnesses, rather consider themselves the paid agents of the person who employs them.” On top of that, expert witnesses often have many meetings with the lawyers acting for their client, where they discuss the issues and the evidence, and such discussions will almost always be directed to how to advance the client’s case and do down the opposition. All this will almost inevitably cause the expert witness to develop feelings of loyalty and commitment to his client’s case.

30. Some of these problems can be dealt with, albeit only to an extent, by enacting strict rules about independence, and then enforcing those rules, and steps have been taken in that connection in

³⁷ In *Lord Abinger v Ashton* (1873) 17 LR Eq 358, 373

the English courts over the past sixteen years, in the form of strengthening the rules³⁸, and of judges making strong statements about the need for impartiality on the part of expert witnesses.³⁹ Another partially successful solution involves the experts being ordered to meet with a view to agreeing as much as they can, and at least narrowing the issues. However, as both scientists and lawyers, of all people, should recognise, human nature, and in particular the impact of unconscious bias, cannot be legislated or educated out of existence. We can legislate and educate to ensure that expert witnesses are made as aware as possible of the nature of their duty, and hope that a culture will develop which minimises the existence of bias.

31. In the view of many people, the problems inherent in the expert witness system are exacerbated by the way in which they give their evidence, in a series of oral gladiatorial combats. Many informed spectators may think that in cross-examinations of experts, the forensic skill of the advocate and the quick-wittedness of the expert are more in play than the right answer to the question they are discussing. I accept that any system of resolving legal disputes is susceptible to criticism, and I am generally very sceptical about the suggestion that we should move away from our present common law procedural system. The grass is always greener on the other side of the fence. Indeed, on the international stage, the move is the other way: for instance, both Peru⁴⁰ and Mexico⁴¹ have changed from the inquisitorial system to the accusatorial system, and, in Europe, Italy has moved in that direction⁴².

32. Nonetheless, when it comes to expert evidence, I can see considerable attraction in the notion of the experts giving their evidence at a somewhat more informal basis, at a hearing which is

³⁸ See eg CPR 35, especially 35.3, and Protocol for the Instruction of Experts to give Evidence in Civil Claims (June 2005 amended October 2009),

³⁹ See for instance the passages cited by Sir Anthony Clarke MR in *General Medical Council v Meadow* [2007] 1 QB 462, paras 21-27

⁴⁰ <http://hrbrief.org/2014/03/reform-of-the-criminal-justice-system-in-peru/>

⁴¹ P Zweier and A Barney, *Moving to an Oral Adversarial System in Mexico: Jurisprudential, Criminal Procedure, Evidence Law, and Trial Advocacy Implications*, 26 *Emory International Law Review* 1

⁴² <http://www.hg.org/article.asp?id=26794>

more like a meeting chaired by the judge. Court rules⁴³ now permit such concurrent evidence, or hot-tubbing as it was dubbed by the Australians who developed the concept, and who now, I understand⁴⁴, adopt it in most civil cases. However, it is currently little used in this country, owing no doubt to what is, depending on your view, appropriate scepticism or innate conservatism on the part of lawyers and judges.

33. Lawyers may fear that concurrent evidence would result in a loss of control on their part, and judges may fear that it would involve greater preparation and early understanding of the issues on their part. Both fears are justified in fact, but do not represent good reasons to avoid hot-tubbing. So far as the justice system is concerned, lawyers are there to assist on getting the right answer⁴⁵. The fear of the judges may, at least in some cases, be partly attributable to the fact that there are very few judges, other than those who specialised in patent law when in practice, with any significant scientific education.

34. Gone are the days of John Fletcher Moulton Having obtained a first class mathematics degree in 1868⁴⁶, he went on to carry out experiments⁴⁷ on the passage of electricity through gases, and was elected an FRS in 1880, and served on an international electricity commission, and, having been an MP between 1885 and 1906, he was the first person to chair the Medical Research Council in 1913, and was responsible for the strikingly successful British war effort on explosives and (although he disapproved of it) poison gas. In parallel with all that, he became a very successful patent barrister from 1874, the go-to patents QC in 1885, a member of the Court of Appeal in 1906, and a Law Lord in 1912⁴⁸.

⁴³ CPR PD 35.11

⁴⁴ https://www.ashurst.com/publication-item.aspx?id_Content=9604

⁴⁵ See CPR 1.1(1), (2)(d) and 1.3. A lawyer's client may have a different view, but that is a matter between the client and the lawyer: the duty of the lawyer to the court overrides his duty to the client.

⁴⁶ He was the Senior Wrangler at Cambridge that year

⁴⁷ Many of them with Sir William Spottiswoode, future President of the Royal Society (1878-1883)

⁴⁸ William Van der Kloot, *Lord Justice of Appeal John Fletcher Moulton and explosives production in World War I: 'the mathematical mind triumphant'* Royal Society Notes and records (December 2013) and A Landsborough Thompson, *Half a Century of Medical Research*, Vol 1: *The Origins and Policy of the Medical Research Council (UK)* (1987) p 26

35. Moulton's career was breath-taking and his exceptional ability was appreciated by many. After meeting Moulton, Kaiser Wilhelm II apparently asked the UK Foreign Secretary "Who is this man? You say he is a judge, but he seems to know everything"⁴⁹ (as a judge, I enjoy the "but"). Today with ever-increasing information and complexity in every field, such achievements are much more difficult. So it is unsurprising that judges with no scientific training have to determine scientific issues, and often complex issues. In recent times science has moved forward very quickly and is subject to a much greater degree of specialisation than in the past, so it may be that having studied science at university thirty or more years ago is of limited assistance to a judge. And it is fair to say that scientific ignorance has not prevented some judges with no significant scientific education proving themselves to be very fine judges of scientific issues. Lord Hoffmann is a prime example and there are several still serving as judges whose names I shall not give to avoid embarrassing them - and also to avoid annoying any whose names I inadvertently omit.

36. In cases involving technical issues, the parties sometimes produce a primer for the judge, which gives her a good explanation of the basic scientific principles and state of knowledge, which is agreed by both parties. In the first big recombinant DNA technology patent case which I tried, *Kirin-Amgen v Roche and Hoechst*⁵⁰, I would have been seriously at sea without the benefit of a very clear and helpful primer which had been prepared by the parties⁵¹. There is no reason why that practice needs to be limited to patent cases⁵². Courts also sometimes sit with an independent expert to advise them on the science during the hearing, but, albeit that my experience is limited, I have found that rather an uncomfortable exercise, as the expert has to be very careful about

⁴⁹ Viscount Haldane, *Before the War* (1920), p. 258

⁵⁰ *Kirin-Amgen Inc. v Roche Diagnostics GmbH* [2002] RPC 1

⁵¹ Despite that, I did not get the answers to the issues entirely right: see [2002] RPC 31 and [2005] 1 All ER 667. Some people might say that I was pretty accurate when it came to the science, but not so successful when it came to some (or at least one or two) of the legal issues.

⁵² A primer is recommended by Sir Brian Leveson for criminal trials where there is expert evidence – *Review of Efficiency in Criminal Proceedings* (January 2015), para 237

what he can say. A better alternative may be to have one or two seminars with an independent expert before the hearing, as happened when the *Kirin-Amgen* case went to the House of Lords⁵³. Primers and seminars can clearly go a long way in enabling judges to understand the technicalities they need to appreciate in order to try a particular case.

37. More broadly, there is a danger that a judge, and indeed lawyers, can be beguiled by the simplicity or elegance of a scientific technique or by the confident assertions of a scientifically qualified expert into thinking that his evidence represents a flawless and easy solution to the problem which requires to be solved. Attractive though it often seems, much so-called scientific evidence is not as reliable as many like to think. In its excellent 2009 report⁵⁴, the US National Academy of Sciences warned that, “with the exception of nuclear DNA analysis, ... no forensic method has been rigorously shown” to constitute reliable evidence. This includes fingerprint and bite mark analyses. And even with DNA profiling, there are uncertainties and risks, as is exemplified by the *Hanratty* case⁵⁵ and also by more recent Court of Appeal decisions⁵⁶ relating to Low Copy Number (LCN) DNA, the analysis and interpretation of Low Template DNA.
38. And reliance on statistics can be dangerous, as the *Adams* case⁵⁷ showed. The *Sally Clark* conviction showed up in sharp focus the failings of a system where an expert trespasses into an area (statistics) outside his competence (paediatrics), and the judge, the lawyers and other expert witnesses fail to identify his error. It has to be said that the error was not particularly sophisticated. A mother was accused of killing one of her babies in 1996 and another in 1998, and her lawyers argued that they had each died from sudden infant death syndrome (SIDS). The evidence suggested the probability of a baby dying of SIDS was 1 in 8,543, and, in his evidence, the renowned Professor Meadow said that, as two babies were involved, “[y]ou have to multiply

⁵³ See at [2005] 1 All ER 667, para 135

⁵⁴ US National Academy of Sciences, *Strengthening Forensic Science in the United States: A Path Forward* (2009), p 7

⁵⁵ See footnotes 33-35 above

⁵⁶ *R v Reed* [2010] 1 Cr App R 23 and *R v Dlugosz* [2013] 1 Cr App R 32

⁵⁷ See para 16 above

1 in 8,543 times 1 in 8,543 and ... it's approximately a chance of 1 in 73 million.”⁵⁸. That went unchallenged. You do not have to be a potential member of the Royal Statistical Society to realise that this evidence could only be “valid if each of the deaths is truly independent of the other, that is without, at the very least, the shared genetic and environmental circumstances of the children being members of the same family”, as it was put in the Court of Appeal⁵⁹.

39. This case is one of a number which support the notion that judges, and indeed lawyers, could be instructed in the science appropriate for a particular case could be broadened out. Particularly with the increased specialisation we are seeing almost everywhere, cross-fertilisation between, and even within, cultures or professions seems to me to be inherently beneficial for members of the cultures and professions individually and for those cultures and professions, indeed for society, as a whole. The issue has recently been stimulatingly discussed by the journalist and anthropologist, Gillian Tett in her book, *The Silo Effect*⁶⁰, which constitutes a reasoned and readable plea for more cross-fertilisation between cultures and groups. The book focusses principally on the industrial and financial worlds, but I believe that its thesis is equally applicable to the legal and scientific worlds.

40. Once one starts to think of scientific topics which would be valuable for lawyers and judges to know more about, the list seems to be at risk of almost never ending. The use of DNA and other methods of detection and identification and the use and abuse of statistics are, as I have already implied, two possible topics. Neuroscience is another field, where developments may in due course provide real assistance on important legal issues such as the memory process, the age of legal responsibility, mental capacity, the connection between criminality and brain disease, the risk of re-offending, the extent of pain and suffering actually undergone, and the cause of head

⁵⁸ *R v Clark* [2003] EWCA Crim 1020, paras 96ff

⁵⁹ *General Medical Council v Meadow* [2007] 1 QB 462, para 132 per Auld LJ, when considering Professor Meadow's successful appeal against being struck off

⁶⁰ G Tett, *The Silo Effect: The Peril of Expertise and the Promise of Breaking Down Barriers* (2015)

injuries. These examples of areas in which neuroscientific developments could provide vital assistance within twenty years to the making and application of the law are given in a *Brain Waves* paper⁶¹ published in 2011 by the Royal Society.

41. (Incidentally, in section 2.4, the paper includes some very helpful “cautionary words” in connection with interpreting data, which is just the sort of information which any judge should bear in mind when looking at allegedly reliable data figures – the requirement of replicability, the need to demonstrate causality, the reverse inference problem, the risk of applying generalisations to individual cases, and the risks of the facile use of statistical evidence - including the problem which arose in the *Sally Clark* case⁶²).

42. As studies on the brain develop, no doubt we will start to learn about the way we react to events, to people and to ideas, and how we make decisions. So neuroscience will assist a judge not merely with assessing information and evidence which is coming into her brain through her eyes and ears, but also, and rather unsettlingly I suspect, with an insight as to how she processes that information and evidence once it is in her brain. Her conscious and unconscious biases and assumptions will be factors which she will have to know about and no doubt which she should allow for.

43. However, as another recent book suggests, what is (currently at least) a rather different area of science may conceivably be starting to outflank the human element in judging and advising on legal issues altogether. I have in mind of course artificial intelligence, whose influences on the professions generally, and the law in particular, are fascinatingly discussed by Richard and Daniel Susskind in their well-received book published last month⁶³. We all know that IT is developing techniques to deal with the more humdrum side of law, such as disclosure of

⁶¹ RS Policy document 05/11, *Brain Waves Module 4: Neuroscience and the Law* (December 2011)

⁶² See para 38 above

⁶³ *Richard and Daniel Susskind, The future of the Professions* (2015)

documents. But, no doubt thanks to the effect of Moore's Law, computer programmes are being developed which not only outplay the human world chess champion⁶⁴ and outperform human winners of TV quiz shows⁶⁵, but which can apparently outperform IP law experts in predicting the outcome of US Supreme Court patent litigation⁶⁶. The take-over of legal work by IT is very interesting to read and think about and it presents very important medium and long term strategic issues for the legal profession. However, for the moment at least, I think that there is little point in the judges making plans for the possibility of being replaced by AI. We should be concentrating on learning how to be as good at our judicial roles as we can, and that includes making best use of IT and in due course no doubt of AI.

44. Being as good judges as we can be also includes keeping informed and up-to-date about scientific, technological and other developments which affect, or can improve, our judicial performance. In that connection, I particularly welcome the *Brain Waves* paper because it contains recommendations for meetings between lawyers and neuroscientists, and for the inclusion of neuroscience in law education and training. The judiciary of England and Wales has its Judicial College, ably chaired by Dame Ann Rafferty, which does sterling work to provide both initial and on-going education for judges. I have long believed that such education should concentrate on judge-craft, procedural difficulties and sentencing, as opposed to substantive law. The sort of information I have been touching on this evening is very much in the judge-craft category.

45. The Royal Society is the oldest and most prestigious scientific association in the World, and it has an extraordinary wealth of scientific talent among its membership. In the UK, we have been

⁶⁴ IBM's Deep Blue beat Gary Kasparov in 1997, having lost to him in 1996.

https://en.wikipedia.org/wiki/Human%E2%80%93computer_chess_matches

⁶⁵ In 2011, the IBM computer Watson defeated two previous champions in the US TV quiz show, *Jeopardy*

[https://en.wikipedia.org/wiki/Watson_\(computer\)](https://en.wikipedia.org/wiki/Watson_(computer))

⁶⁶ Michael Mills, *Artificial Intelligence in Law – The State of Play in 2015?* Legal (IT) Insider (November 2015)

and are outstandingly successful in our science and our scientists, but we have been rather less good at putting our scientific discoveries to practical use. The Society of my father's time was a very successful and respected institution, but it was perhaps rather inward looking. I am delighted to see that, particularly over the past five years, there has been a marked change. I suspect that it is no coincidence that things have visibly improved on this front with Sir Paul Nurse's appointment as President in late 2010 and Julie Maxton's appointment as Executive Director the following year - although no doubt many others have contributed to that change, some of them before 2010. And from what I have heard about Sir Venkatraman Ramakrishnan, this situation should continue when he takes over the Presidency next week.

46. The Royal Society should be, as it now is, reaching out to the judiciary and the legal professions in order to ensure that judges and lawyers can obtain information and learn about techniques which will enable them to perform their duties more effectively and reliably – and, for our part, the lawyers and judges should be, as we are, welcoming you with open arms. It is indeed fitting that one area to which the Society has been reaching out is another very successful UK endeavour, namely that of law. The rule of law has helped to ensure that the UK has had an unequalled peaceful and civilised history at home for over 300 years. And the international reputation of the common law and the English legal system and judiciary is such that that English law is the law of choice, and the courts in London are the tribunal of choice, for a large proportion of international commercial disputes. But, like science, law cannot afford to be complacent: we each have to strive to keep ahead. So, here in the UK science and law should be reinforcing each other – excellence reinforcing and learning from excellence.

47. The Royal Society arranged and hosted a two day in-depth seminar on forensic science earlier this year⁶⁷, and only yesterday there was a joint seminar sponsored by the Society and the Judicial College chaired by my colleague Lord Hughes on memory, and next year there is to be

⁶⁷ <https://royalsociety.org/~media/events/2015/02/forensic-science/forensic-dm-programme910.pdf>

another seminar on probabilities. These are just the sort of events which ought to be happening. Hopefully, it will be possible to include seminars on relevant scientific topics, sponsored by the Royal Society as part of the Judicial College standard courses. As the Lord Chief Justice said in a speech, the judiciary have been “fortunate to have the engagement of scientists under the auspices of the Royal Society”⁶⁸.

48. Science thus has a great deal to teach the law, but I like to think that law has something to teach science. It is a topic which I have discussed with your President, and, interestingly, he mentioned dealing with scientific fraud and assessing the reliability of experimental results. Most judges and lawyers are well versed in dealing with dishonesty and its close relation self-deceit, and we are also well-practised in assessing the value and effectiveness of evidence, albeit perhaps on a more qualitative basis than most scientists. Perhaps with its tradition of structured, adversarial oral argument as a way of teasing out the truth, the law may also have something to teach science, but that is little more than conjecture on my part. Expert evidence is another possible topic, but there is already an Academy of Experts and other organisations who run courses for expert witnesses, so there may well be no pressing need in that connection.
49. More broadly, as Sir John Pethica and I have been discussing, law and lawyers can and should provide the framework within which science and scientists operate. The rule of law is absolutely fundamental to a civilised society, and particularly in the light of the far-reaching and fast-changing developments in so many areas of scientific endeavour, it is essential that scientists know the identity of the rules and the location of the legal boundaries appropriate to their work. And it is equally essential that lawyers are kept *au fait* with scientific developments, as the law needs to keep pace with technological developments. To give just a few topical examples, the relationship between surveillance techniques and data protection and the right to privacy, the implications of fracking on property rights, the patentability of inventions produced by stem cell

⁶⁸ Lord Thomas of Cwmgiedd, *Expert Evidence: The Future of Forensic Science in Criminal Trials* (October 2014), para 25

research (where most people think that the European Court of Justice took a wrong turn), the interrelationship of search engines and copyright (where most people think that the European Court got it right) and, of course, there is the environment where the relationship between law and science is key.

50. In conclusion, given (i) the disproportionate and continuing achievements of British scientists and British jurists, (ii) the importance of both science and law to the future of society, (iii) the increasingly competitive, complex and fast-moving world in which we live, (iv) the far-reaching developments in science, (v) the forensic experience of UK lawyers and judges, (vi) the increased amount of specialisation, and (vii) the fact that science and law have so much to offer each other, I suggest that it is clear that jurists and scientists owe it to each other and to society to listen to, and to learn from, each other's expertise and experience for their mutual benefit and the benefit of this country.

51. Thank you very much.

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