Can DNA Evidence Alone Convict an Accused?

Andrew Ligertwood[*]

Abstract

Whether undisputed DNA evidence alone can constitute proof beyond reasonable doubt of an accused's association with a crime raises questions fundamental to the nature of criminal proof, questions that appellate courts are reluctant to face. This article argues that criminal proof is 'inductive' rather than 'probabilistic'. Proof beyond reasonable doubt aspires to certainty and cannot be satisfied by a mere mathematical probability. It is argued that evidence of a DNA match may make out a case to answer but, so long as that DNA evidence also recognises the possibility of an innocent random match, the jury cannot convict unless satisfied, following consideration of other evidence necessarily before it, that the innocent match is excluded as a reasonable possibility. In reaching this decision it may have regard to the accused's failure to explain. To ensure this inductive approach, DNA evidence should be presented not as a likelihood ratio but as a frequency that emphasises the possibilities of innocent explanation.

Introduction

Can DNA evidence alone convict an accused? It was this general question that the applicant unsuccessfully sought to have considered by the High Court in *Forbes v The Queen* ('*Forbes*').[1] This essay critically examines why the Court regarded that case as inappropriate to raise this general question before turning to consider the general question itself.

DNA evidence is identification evidence, establishing a match with the accused, but also calculating the statistical chances of there being other matches. These chances indicate the evidential weight that can be given to the match with the accused. The question with which this essay is particularly concerned is whether, assuming the DNA evidence is either not disputed or is determined reliable, these statistical conclusions alone can convict an accused. This raises a fundamental

[1] [2010] HCATrans 45 (12 March 2010); [2010] HCATrans 120 (18 May 2010).

issue about the very nature of proof in criminal cases, an issue that, as *Forbes* illustrates, courts are reluctant to face. But it remains clear that courts in criminal cases do not accept the notion of 'mathematical' or 'statistical' proof, and continue to approach proof in what this essay calls 'inductive' terms. Proof in criminal cases is seen as an aspiration to certainty ('proof beyond reasonable doubt'), not as an aspiration to a statistical conclusion (applying in, say, 99.9 per cent or 999 cases out of 1000). This aspiration defines the inductive approach that courts take to criminal proof and sits uneasily with the statistical conclusions of the DNA scientist. Nevertheless, these statistical conclusions provide powerful evidence and must be accommodated within the inductive approach. It is argued that this can be achieved through expressing these statistical conclusions not as percentages or likelihood ratios but as simple frequencies, thus emphasising the numerical possibilities of a random match and enabling juries to envisage and consider carefully the possibly innocent explanations of the DNA match. When so presented it is argued that while the statistical conclusions of DNA evidence alone cannot amount to inductive proof, when taken in conjunction with evidence of the size of a suspect population, it will generally be sufficient to make out a case to answer and, in the absence of any contrary evidence capable of raising a reasonable doubt, may be sufficiently powerful to amount to inductive proof.

A Short Commentary on Forbes

Forbes was charged with the rape of a young woman. The complainant testified to the circumstances but was unable to identify the accused. Evidence established her failure to select the accused at an identification parade, and there were discrepancies between her descriptions of her attacker and the accused. However, traces of DNA were found in semen on the upper right thigh of her trousers and on the inner and outer surfaces of her brassiere. The prosecution proposed to call expert forensic evidence to establish that each of these three traces of DNA matched that of the accused and that there was a very small chance of them matching any other randomly selected member of the population. For the DNA found in the semen stains on the complainant's trousers the experts proposed to testify, on the basis of a random match probability of one in 20 billion, that it was 20 billion times more likely that the DNA originated with the accused than a randomly selected member of the population. The likelihood ratios for other DNA found on the complainant were compelling, but not so 'mind-boggling'.[2]

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[2]   The term is used by Mr Walker SC (appearing for the prosecution) in argument: *Forbes* [2010] HCATrans 120 (18 May 2010) [2050].

Defence counsel faced with such evidence has various options. One is to put the prosecution to strict proof of the reliability of the DNA evidence through questioning the circumstances under which the DNA evidence was collected by investigators and then transferred to and analysed by experts, thereby seeking to show the possibility of inaccuracy in the conclusion that the samples were genuine crime samples, or in the conclusion that they matched DNA from the accused. But even where there are no risks of transference or laboratory errors,[3] there are still judgments that analysts must make that are prone to error. For example, in *Forbes* one of the samples on the complainant's brassiere contained DNA from more than one source and careful (subjective) judgments are required in these circumstances to isolate accurately the DNA from each particular source.[4] Further, the defence might put the prosecution to strict proof of the statistical chances of a random match through questioning the validity of the sample populations used to generate those chances, or the appropriateness of those populations as suspect populations. In *Forbes*, the 'random match probabilities' were generated on the basis of DNA sampling in a small cross-section (620 people) of the ACT population[5] and the defence could have put the prosecution to proof of the adequacy of the sampling and the statistical validity of the sample population.

However, reluctant to risk the case turning on an attack on the accuracy of the DNA evidence, rather than contesting the DNA evidence in any of these ways,[6] Forbes' counsel reached an agreement whereby the prosecution would not present the 'random match probabilities' as a numerically expressed likelihood ratio, but would simply lead testimony from the experts that the DNA evidence was 'strong', 'very strong' or 'extremely strong' evidence connecting the accused with the DNA samples found on the complainant. Counsel also agreed, and it was revealed to the jury, that these expressions reflected likelihood ratios of, respectively, greater than 10 000 and less than 100 000, greater than 100 000 and less than a million, and greater than a million.[7]

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[3] An important, although it seems infrequent, source of inaccuracy: discussed, eg, by Margaret A Berger, 'Laboratory Error Seen Through the Lens of Science and Policy' (1996) 30 *UC Davis Law Review* 1081; Erin Murphy, 'The New Forensics: Criminal Justice, False Certainty, and the Second Generation of Scientific Evidence' (2007) 95 *California Law Review* 721, 795–7.

[4] See Erin Murphy, 'The Art in the Science of DNA: A Layperson's Guide to the Subjectivity Inherent in DNA Typing' (2008) 58 *Emory Law Journal* 489, particularly 501–8. Issue was recently taken with mixed samples in *R v Meyboom* [2011] ACTSC 13 (4 February 2011).

[5] *Forbes v The Queen* (2009) 232 FLR 229 ('*Forbes*') [31] (Higgins CJ and Besanko J).

[6] Ibid [34] (Higgins CJ and Besanko J).

[7] For a summary of the expert evidence put before the jury, see *Forbes* (2009) 232 FLR 229 [15] (Higgins CJ and Besanko J). For the extent of the agreement, see the

Having reached this agreement, defence counsel did not contest the admissibility of the DNA evidence, nor was there any submission, at the completion of the prosecution case, that there was no case to answer. Rather, with the very high likelihood ratios out of the way, the defence focused upon convincing the jury that, despite the DNA matches, these could not conclusively identify the accused and there was exculpatory evidence leaving a reasonable doubt. Some of this evidence had been revealed during the prosecution case — the failure of the complainant to identify the accused and discrepancies between the complainant's description of her attacker and the accused — but the crucial exculpatory evidence was defence evidence of an alibi, to which Forbes and his wife testified, that on the night of the crime Forbes was at home looking after his children.

When the trial judge summed up to the jury, defence counsel made no objection to the way in which the evidence was put to it and sought no further directions.

The jury convicted the accused. The clear implication was that, in finding the prosecution case proved beyond reasonable doubt, the jury found explicable the inconsistencies in the complainant's evidence and rejected the accused's evidence of an alibi.

The accused's appeal to the ACT Court of Appeal failed. That Court considered and rejected, on the basis of previous authority, the argument that DNA evidence alone was insufficient basis for conviction. It then analysed the evidence presented to find that the jury was entitled to ignore the inconsistencies in the complainant's testimony, to reject the evidence of alibi from the accused, to find the wife's evidence of the alibi unreliable, and to find, in the face of DNA evidence described at its highest as 'very powerful', that the accused was guilty beyond reasonable doubt. Following an application for special leave to appeal French CJ and Crennan J referred the matter to a Full Bench of the High Court. The Full Bench refused special leave to appeal, the only reasons being found in the following remarks delivered by French CJ at the conclusion of argument:[8]

> At trial in this matter the parties acquiesced in the statistical conclusions drawn from evidence relating to DNA profiles being expressed qualitatively rather than quantitatively. More particularly, they acquiesced in the expression of the statistical conclusions drawn from analysis of material taken from the complainant's clothing being compared with the applicant's DNA profile as comprising 'strong' or 'extremely strong' evidence in support of the contention that the applicant was the source of the material taken from the complainant's clothing

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respondent's argument in *Forbes* [2010] HCATrans 120 (18 May 2010) [2385]–[2390].

[8]   *Forbes* [2010] HCATrans 120 (18 May 2010) [2740]–[2755].

> without the jury being told that the particular conclusions made
> by the witness in the case had yielded a figure of greater than one
> in 10 billion.
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> It was open to the jury to conclude from the evidence that was led
> at trial that the applicant was guilty beyond reasonable doubt. In
> light of the way the parties conducted the trial this is not, in our
> opinion, a suitable case to consider the larger question which the
> applicant seeks to agitate. It is the opinion of all of us that special
> leave should be refused.

It is clear that it was the way in which the trial had been conducted that
made the case an unsuitable one for considering whether DNA
evidence alone could justify conviction. While the failure of the
prosecution to tender DNA evidence in statistical terms may have been
influential, the conduct most decisive was that of defence counsel in
failing to submit at the close of the prosecution case that there was no
case to answer, or otherwise seeking to have the case withdrawn, in
calling evidence by way of defence, and in simply acquiescing to the
jury reaching a decision upon all the evidence presented. Having
reached what defence counsel thought was a favourable agreement in
relation to the presentation of the DNA evidence, and having used that
as a platform for an exculpatory account, it was too late to raise the
general question on appeal.[9]

 But while one can understand the Court's reluctance to permit
the accused to change tactics after the event and have another bite at the
cherry, the accused still remained entitled to acquittal if the entirety of
the evidence that was presented was unable to support his conviction
beyond reasonable doubt. As the Court refused to agitate 'the larger
question', it is implicit that the evidence must have been regarded as
having gone beyond DNA evidence alone. What then was the evidence
additional to the DNA evidence identifying the accused? There was
evidence from the complainant, but it really did no more than describe
the attacker as a sexually active male person, because the complainant's
estimate of the age of the attacker and his circumcision failed to match
the accused. Evidence of the three places where the DNA was found
also matched her account and the coincidence that in each place DNA
was found matching the accused was some additional evidence.[10] But
the Court's emphasis upon the conduct of the parties suggests it was

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9 Mr Walker SC put the matter thus during argument ([2010] HCATrans 120 (18 May
  2010) [2480]–[2485]):
   [I]t is, from a prosecution point of view, a somewhat disquieting situation that
   something which is now criticised by the defence as being inadequate to support
   proof beyond reasonable doubt was, nonetheless, before the jury after disclosure
   of *voir dire* without objection, without challenge relevantly, in cross-
   examination, not being the basis of a no case submission and not being the basis
   in relation to its incapacity to prove underlying the address to the jury.

10 At the first application for leave the respondent argued this was additional evidence:
  Forbes [2010] HCATrans 45 (12 March 2010) [410]–[415].

the evidence put before the Court as a result of that conduct that was decisive — most notably the tender, and the subsequent rejection by the jury, of the alibi evidence given by the accused and his wife. The ACT Court of Appeal commented simply that the jury was entitled to reject the accused's testimony and entitled to regard the wife's testimony as unreliable. It should be emphasised that the prosecution, neither at trial nor on appeal, sought to rely upon the rejection of the accused's testimony as indicating a consciousness of guilt, nor were any directions given to the jury or sought by defence counsel about using a rejection to support such an inference (indeed, it would have been counterproductive for the defence to have invited rejection of the alibi evidence by seeking such a direction). Moreover, the failure to give directions was not made a ground of appeal. However, as Mr Jackson QC argued at the first application for special leave,[11] as Heydon J remarked during the Full Court application in passing,[12] and as Mr Walker SC submitted during that Full Court application,[13] the disbelief of the accused's alibi remained evidence that the jury was entitled to take into account in deciding the accused's guilt.[14] Consequently, as a result of the choices taken by defence counsel, there was evidence beyond DNA evidence before the jury and the evidence as a whole was regarded by the Full Court as sufficient to justify Forbes' conviction.

A further matter in French CJ's reasons requiring explanation is his reference to the remote statistical chances of a random match in rejecting the appeal. In the case of the semen stain on the complainant's trousers, this random match was in fact one in 20 billion.[15] However, leaving aside questions about the exact figure (and the fact that French

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[11]   Ibid [330]–[350], referring to *R v Hillier* (2007) 228 CLR 618 [50].

[12]   *Forbes v The Queen* [2010] HCATrans 120 (18 May 2010) [250].

[13]   Ibid [2555].

[14]   Mr Walker SC carefully avoided arguing that the disbelief could support an inference of a consciousness of guilt, arguing (at [2555]) in response to Bell J's reference to a 'consciousness of guilt': 'Please do not misunderstand me. I am not saying a disbelieved denial is evidence contributing to proof beyond reasonable doubt. I am saying that disbelieving of denial is part and parcel, indeed, must be part of a jury's decision to find guilt beyond reasonable doubt. The difference is not semantic, but it is to be borne in mind that the DNA evidence is not evaluated in isolation.' The point is that if the basis for the disbelief is simply an acceptance of the prosecution evidence, there is no independent evidence corroborative of the prosecution case, yet the disbelief remains evidence. Of course, generally directions are required where disbelief may be used by a jury to found an inference supporting guilt (deriving from the decision in *Edwards v The Queen* (1993) 178 CLR 193, 210–11), but Forbes' counsel sought no directions and their absence was not made a ground for appeal. In these circumstances the disbelief simply remained evidence. On lies as evidence, see further Andrew Ligertwood and Gary Edmond, *Australian Evidence* (LexisNexis, 5th ed, 2010) [4.88]–[4.89].

[15]   This figure was referred to at the *voir dire* and was frequently referred to by Mr Walker SC during argument: see, eg, *Forbes v The Queen* [2010] HCATrans 120 (18 May 2010) [1155]–[1160], [1575]–[1580], [1675 [2310]–[2315]; see also his reference to 'the mind-boggling figure of one to 20 billion': at [2050].

CJ expressed the figure as a random match probability rather than a likelihood ratio), this evidence was never before the jury, nor was it fresh evidence, and an appellate court was not entitled to consider it in determining the sufficiency of the evidence. Nevertheless, an appellate court was entitled to refer to it to explain that there were good reasons for defence counsel to conduct the case as he did, and to conclude that there was as a result, on all the evidence put before the jury, sufficient evidence to justify conviction.

Thus, the High Court did not decide 'the larger question' that the applicant sought to agitate on appeal and the argument and short reasons given by French CJ in *Forbes* provide no indication of how the Court might answer that question. In these circumstances, rather than further analysing the transcripts of argument seeking special leave to appeal and speculating upon the possible authority of *Forbes*,[16] this article considers the questions that would have arisen in *Forbes* had defence counsel made no agreement with the Crown and, without contesting the accuracy of the DNA evidence, had simply submitted at the completion of the prosecution evidence that the evidence was insufficient to support conviction. Can the statistical conclusions of DNA evidence alone make out a case to answer? Is such evidence alone enough to convict an accused? If so, how exactly should these statistical conclusions be expressed to the jury? As will be argued, the answers to these questions are dependent upon how one conceptualises the very notion of criminal proof.

Before answering these questions, however, it is necessary to explain more clearly the nature of DNA evidence.

The Nature of DNA Evidence

First, it needs to be noted that DNA evidence is by nature identification evidence. It is generally tendered to identify the accused's DNA with a sample of DNA found at the scene of a crime or on the person of someone associated with the crime, most commonly the victim. If identification is not in issue, generally DNA evidence will be irrelevant. By the same token, if there are issues beyond identification there will be no question of the DNA evidence alone being sufficient to justify conviction. All material facts in issue must be proved to convict an accused.

Secondly, it needs to be emphasised that DNA evidence is not presented as establishing conclusively the identity of two samples of DNA. It merely asserts that the samples match and then asserts the

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[16]   Cf J Gans, 'A Tale of Two High Court Forensic Cases' (2011) 33 *Sydney Law Review* 515.

probability of the crime sample matching a randomly selected person in a relevant suspect population. That population may be at large or limited to a particular race or other subgroup. But the DNA analysis is now such that, by identifying the alleles at 10 or more loci[17] in a particular section of DNA, and having the frequency of each of those alleles at those loci in the DNA of a relevant suspect population, then, by assuming the independence of these alleles at these loci and multiplying together their individual frequencies within that population, extremely low probabilities of the DNA in question randomly matching another person in that population can be calculated.[18]

This, of course, makes DNA different from other identification evidence.[19] Whether other identification evidence is from a witness seeking to identify the accused with a person observed by the witness in incriminating circumstances, or from a witness seeking to identify a forensic sample from the accused (for example a fingerprint) or associated with the accused (for example a ballistic sample from a gun associated with the accused) with a sample found in incriminating circumstances, in these cases the witness will generally give only a subjective (but often definitive) view of the strength of that evidence — for instance 'I am sure the accused is the person I saw committing the crime' or 'I have a long experience in examining fingerprints and these 12 matching points indicate to me that the prints have a common origin'.[20] Unlike DNA evidence, none of these conclusions are

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[17] It seems that in Australia up to 10 loci are considered (as in, eg, *Forbes v The Queen* (2009) 232 FLR 229 [33] (Higgins CJ and Besanko J)), whereas in the US it is now generally 13: see Andrea Roth, 'Safety in Numbers? Deciding When DNA Alone is Enough to Convict' (2010) 85 *New York University Law Review* 1130, 1136.

[18] For a fuller summary of this process and its presentation in court see, eg, Roth, above n 17, 1135–40. And see generally Michael Lynch et al, *Truth Machine: The Contentious History of DNA Fingerprinting* (University of Chicago Press, 2008).

[19] Including forensic evidence to identify: see generally Murphy, above n 3, 726–31 where she discusses and compares what she terms first and second generation forensic evidence, DNA being the foremost example of the latter.

[20] Michael Saks and Jonathan J Koehler, 'The Individualization Fallacy in Forensic Science Evidence' (2008) 61 *Vanderbilt Law Review* 199, 218 conclude:

> Forensic scientists are not able to link a fingerprint, a hair, a handwriting sample, a tiremark, a toolmark, or any other evidentiary forensic item to its unique source, but they assert that ability every day in court. The issue is not the sincerity of the beliefs of workaday forensic scientists. Instead, it is whether any scientific evidence exists that can support those beliefs. No basis exists in theory or data for the core contention that every distinct object leaves its own unique set of markers that can be identified by a skilled forensic scientist. Their claims exaggerate the state of their science.

See also David Kaye, 'Probability, Individualization, and Uniqueness in Forensic Science Evidence' (2009) 75 *Brooklyn Law Review* 1163, 1185, where he concludes:

> The optimal format for explaining the logical impact of a match is not self evident. But it is clear that if forensic scientists are to contribute fully to the just resolution of criminal cases, they need a less absolutist and more nuanced theory of identification than the traditional presumption of characteristics that are intuitively judged to be individualizing.

expressed statistically upon the basis of empirical evidence, and the witness must be carefully examined and cross-examined in an attempt to enable the jury to determine their evidential weight.

The irony is that while the use of DNA evidence alone is now being debated, it has long been accepted that a jury may find an accused guilty on the sole basis of this other less precisely expressed identification evidence. Not only is the identification by one witness to a crime sufficient (provided the fact-finder is directed to act with sufficient caution), but also a fingerprint may be enough to convict an accused.[21] Indeed it can be argued, as the respondent argued in *Forbes*,[22] that just as one might accept as proof the less than precisely expressed identification by an eyewitness, so one might accept DNA evidence expressed simply as 'extremely strong'.

But it is the analysis of this irony that shows that each form of identification evidence may be relying upon a different concept of proof. The question is, which concept should apply, or can the different concepts somehow co-exist?

Inductive and Mathematical Proof

Essentially there are two approaches that might be taken to proof in criminal cases. By the first, what is here called 'inductive proof', the fact-finder is simply asked to use its knowledge and experience of the world to assess the evidential strength given to a particular hypothesis or story put before the court.[23] Some academics describe this approach as seeking the best explanation for the evidence presented.[24] Others describe the approach in terms of it inductively testing against

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Michael Saks and Jonathan J Koehler, 'Individualization Claims in Forensic Science: Still Unwarranted' (2009) 75 *Brooklyn Law Review* 1187, 1208 conclude that:

> forensic scientists should not be permitted to capitalize on the lack of supportive scientific data about either characteristic frequency or their own diagnostic reliability by going beyond what is known and what can be stated on good grounds. They should not be permitted to say, in effect, 'trust me: that's the source.' Real scientists don't say 'trust me.' They provide data.

See further, Simon Cole, 'Forensics Without Uniqueness, Conclusions Without Individualization: The New Epistemology of Forensic Identification' (2009) 8 *Law, Probability and Risk* 233.

21 *R v Parker* [1912] VLR 152, critically discussed by Gans, above n 16. In *R v Hookway* [1999] EWCA Crim 212 (1 February 1999) ('*Hookway*'), a facial map alone was held sufficient to justify conviction.

22 *Forbes* [2010] HCATrans 120 (18 May 2010) [1585]–[1595]; see also the applicant's response: at [2605]–[2665].

23 Although a trier's knowledge may be supplemented by evidence from those with greater knowledge and experience – ie, experts – ultimately it remains the trier's prerogative whether to accept that supplementary knowledge.

24 Ronald J Allen, 'The Nature of Juridical Proof' (1991) 13 *Cardozo Law Review* 373 (relative plausibility); Michael S Pardo and Ronald J Allen, 'Juridical Proof and the Best Explanation' (2008) 27 *Law and Philosophy* 223.

the evidence presented the various hypotheses put before the court by the parties.[25] The expression of the standard of proof demanded in criminal cases, proof beyond reasonable doubt, reflects this inductive approach, requiring not merely that the evidence support the prosecution hypothesis or story but that all reasonably possible explanatory hypotheses or stories be eliminated before an accused can be convicted. The approach appears not to derive from normative assumptions. Rather it is descriptive of what happens in adversarial criminal courts, there being a striving for correctness (or truth) on the basis of the evidence before the court, having regard to the trier's experience of the world. While the approach is regarded as rational it is difficult to analyse this inductive approach in definitively normative terms. As might be expected, there is much empirical evidence suggesting that human beings reason in this inductive way.[26]

By the second approach, what is here called 'mathematical (or statistical) proof', a more normative probabilistic approach is taken. Like the inductive approach, the mathematical approach begins with our knowledge of the world, but whilst the inductivist assumes that this can be used to aspire to certainty, the statistician more realistically recognises that certainty is impossible and the best we can do is to assess the statistical degree of our ignorance. This can be done by quantifying probability judgments and using the equations of probability to show the relationship between particular judgments, and to calculate the overall mathematical probability of our ignorance concerning the material facts in issue. This approach fits easily with the modern approach to scientific knowledge which recognises that uncertainty is the very essence of that knowledge: 'Today, all scientific knowledge is conceived as inherently probabilistic, and both scientists and philosophers of science would dispute the notion that science is characterized by the production of absolute certainty or truth.'[27]

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[25] L Jonathan Cohen, *The Probable and the Provable* (Oxford University Press, 1977).

[26] Beginning with Nancy Pennington and Reid Hastie, 'Juror Decision-Making Models: The Generalisation Gap' (1981) 89 *Psychological Bulletin* 246, 251; Nancy Pennington and Reid Hastie, 'Evidence Evaluation in Complex Decision Making' (1986) 51 *Journal of Personality and Social Psychology* 242, 244; and see more recently Jonathan J Koehler, 'The Psychology of Numbers in the Courtroom: How to Make DNA-Match Statistics Seem Impressive or Insufficient' (2001) 74 *Southern California Law Review* 1275, 1299–300 (citations omitted) where he concludes that:
      research indicates that people think heuristically rather than probabilistically. That is, when presented with quantitative information, we do not perform algebraic computations and arrive at solutions by using tenets of logic and probability theory. Instead, we evaluate quantitative evidence via mental shortcuts and other rules of thumb. In the case of DNA evidence, the ease with which we can imagine scenarios or examples of a match other than the suspect may be the heuristic of choice.

[27] Roth, above n 17, 1162, quoting Simon A Cole and Rachel Diosa-Villa, 'CSI and Its Effects: Media, Juries, and the Burden of Proof' (2007) 41 *New England Law Review* 435, 468.

Most obviously, where a case turns on the testimony of an observational eyewitness, the accuracy of that testimony will be determined inductively. The fact-finder will consider all the evidence in the case and use his or her experience to determine whether the best explanation of the witness's testimony is its accuracy, rather than an alternative hypothesis, a lack of sincerity, mistake, etc. It may be possible that there is some empirical knowledge relating to the accuracy of observations by that witness, but while that evidence may be admitted it will not be definitive. All a fact-finder can do is to determine, subjectively upon all the evidence, and upon the basis not just of his or her own knowledge but upon the basis of any other admissible 'expert' knowledge, the best explanation for the testimony of the witness in question.

At the other extreme, the accuracy of DNA appears to be inherently statistical, expressing in mathematical terms, on the basis of empirical research, a match and a random match probability. Of course the random match probability remains a theoretical calculation that makes various assumptions — for example about the independence of the alleles at the various loci in the DNA helix and about the distribution of those alleles in a designated population based on a representative sample.[28]

But even accepting these assumptions,[29] on further consideration it is clear that in a criminal case the statistical conclusions of the expert are based upon procedures the accuracy of which are not expressed statistically. Forensic samples must be collected, often in less than ideal conditions in the case of crime samples, and these must be sent for analysis. The DNA must then be isolated from the samples (that may contain mixed or only partial DNA), and that DNA must be accurately analysed to determine whether there is a match with the suspect's DNA. There are many possible risks of inaccuracy (for example risks of contamination of forensic samples, risks of laboratory error etc),[30] but also subjective judgments to be taken into account,[31] in determining the weight to be given to the evidence of a match. Nor is the match based on a comparison between alleles at every locus in the DNA helix,

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[28]   Ian W Evett et al, 'DNA Profiling: A Discussion of Issues Relating to the Reporting of Very Small Match Probabilities' [2000] *Criminal Law Review* 341, 346.

[29]   There is nothing to stop counsel seeking to question these assumptions in a particular case but counsel will have great difficulty in persuading a court not to accept them: see *R v Karger* (2001) 83 SASR 1 where after a *voir dire* lasting six months Mullighan J admitted contested DNA evidence. Cf *R v Parenzee* [2007] SASC 143 (27 April 2007) where it was unsuccessfully argued that AIDS was not a virus. See also Murphy, above n 3, 781–3, discussing cases where basic DNA evidence assumptions have been called into question.

[30]   See generally Lynch et al, above n 18, ch 4 (chain of custody errors).

[31]   Murphy, above n 4, 501ff. See also William C Thompson, 'Painting the Target Around the Matching Profile: The Texas Sharpshooter Fallacy in Forensic DNA Interpretation' (2009) 8 *Law, Probability and Risk* 257.

but only upon a sample of loci. Once a match of alleles on the basis of those selected loci is declared, a random match probability is calculated upon the expected frequency of alleles at those same loci in a representative sample of the relevant population (at large or a subgroup). The probability of mistake or inaccuracy at all these stages must be taken into account in deciding whether to accept the match and the random match probability. Some of these probabilities may possibly be capable of empirical statistical calculation (for example, the probability of laboratory errors) but others cannot (for example, the probability that the samples were contaminated before being sent for analysis, or that the investigators were mistaken or dishonest in testifying that samples came from the crime scene, or assumptions made by analysts in sorting out mixed samples etc).

Evidence about 'a DNA match' is therefore the culmination of a great deal of other evidence. Furthermore, decisions about these other matters do not always involve simple mathematical calculations and, where contested, fact-finders must make their own decisions having regard to all the available evidence. While the inferences from this evidence may be assessed through subjectively assigning mathematical probabilities to them and using the equations of mathematical probability to combine them, generally this does not happen. To reduce all necessary inferential decisions to mathematical calculation is a sophisticated and complicated, and often controversial, exercise. Jurors and judges are generally not in a position and would not want to reduce all inferences to mathematical calculation in this way, preferring to exercise their inductive judgment in a less mechanical way.[32]

In *Forbes*, as discussed above, these complications were avoided through the defence accepting the accuracy of the statistical conclusions. However, in a case such as *Forbes*, as is discussed in the next section, even with such a concession and assuming the case is left to the jury,[33] it is not strictly accurate, whether proof is approached inductively or mathematically, to describe the case as turning on DNA statistical evidence 'alone'. The statistical conclusions of the DNA expert can have no meaning if considered in an evidential vacuum.

Can Conceded Statistical Probabilities
'Alone' Prove Guilt?

At the barest minimum, in a case identifying an accused through expert evidence of a DNA match, there will be evidence before the

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[32]   One suspects that if a fact-finder is unhappy with the overall result of such a calculation there would be a strong temptation simply to alter the values put on subjective probabilities to ensure a calculation in accord with the inductive judgment.
[33]   See further below, under heading 'Case to Answer'.

jury establishing the crime and its nature. This must be so even in those cases that are brought simply as a result of trawling through DNA databases to find a match — so-called 'cold hits'.[34] From this evidence some inferences narrowing the possible range of suspects can be drawn (for example 'a sexually active male'). In addition, the accused will have failed to testify or otherwise call evidence that may have supported other possible explanations only within the accused's knowledge. Assuming this bare minimum, it is instructive to consider how an argument to proof might proceed, first inductively, then statistically.

An inductive argument to proof might proceed along the following lines. That the person who was the source of the forensic sample in question committed the crime alleged is conceded. The decisive issue (the inductive hypothesis) is whether the accused was that source. Expert evidence establishes (it is not disputed) that the DNA in the forensic sample matches that of the accused and specifies the statistical chance of finding that same DNA in a randomly selected member of a population. If that chance is (say) one in a million, assuming any person in Australia might have been the source, and a population of 25 million, then one would expect to find 25 suspects with matching DNA. But other evidence necessarily narrows the suspect population. The DNA test will generally also isolate the sex gene of the offender and the complainant will testify that the culprit was sexually active. We can therefore assume a lower suspect population, say 10 million. This suggests, however, that there are still 10 persons in the country with matching DNA. If this is the only evidence against the accused, one might argue it cannot amount to inductive proof as there remains open the reasonable possibility that someone other than the accused left the forensic sample in question. But if the chances of a random match are one in 20 billion, as they were with the DNA found in the semen stain in *Forbes*, the case against the accused increases in inductive strength, as this makes it extremely unlikely that two persons with that matching DNA will be found in the suspect population of a mere 10 million. Although the chance of a random match is a theoretical figure[35] based on various assumptions, and although the chance of a random match says nothing about the distribution of matches within a population, yet one might argue strongly that the chance of a random match is so very small that, at least in the absence of explanation from the accused, it is not

34   See further Murphy, above n 3, 738–44 (chronicling the rise of the 'Cold Hit'); see also David H Kaye, 'Rounding Up the Usual Suspects: A Legal and Logical Analysis of DNA Trawling Cases' (2009) 87 *North Carolina Law Review* 425 (arguing that random match probabilities do not require adjustment where a match is obtained through trawling); and Roth, above n 17 (discussing cold hits to explain the rise in DNA-only cases).

35   Evett et al, above n 28, 346.

reasonably possible to envisage finding another person with matching DNA within the range of possible suspects. Inductively it is proved beyond reasonable doubt that the accused is the source.

If a mathematical approach to proof is taken then the expert evidence of a match and of the chances of a random match are used to determine whether the accused left the DNA sample in a quite different way.[36] The mathematicist is concerned only with calculating a mathematical probability of this decisive fact. Before considering the DNA evidence, the mathematicist must determine the prior odds that the accused left the forensic sample.[37] Again, assuming there is evidence that the culprit was a sexually active adult man and there are 10 million such men in Australia, the prior odds might be put at one to 10 million. To this the DNA evidence must now be added. For this purpose it is calculated as a likelihood ratio using Bayes' Theorem. By this theorem the initial odds are increased by the ratio of the probability of finding the DNA evidence if the accused is the offender and the probability of finding it if the accused is not the offender. If the DNA matches the accused and the random match probability of the DNA evidence is one in a million, then that likelihood ratio is 1 to 1 in a million — that is, it is a million times more likely that the DNA is that of the accused rather than of another randomly selected member of the suspect population. Using Bayes' Theorem to calculate in this likelihood ratio, the prior odds of one to 10 million are reduced to 1 to 10.[38] In percentage terms these odds of guilt are less than 10 per cent. If the likelihood ratio is based on a random match probability of one in 20 billion (a billion being a thousand million), becoming a likelihood ratio of 1 to 1 in 20 billion, then using the same prior odds, the subsequent odds become 2000 to 1.[39] In percentage terms these odds of guilt come very close to 100 per cent (99.95 per cent).

The problem for the mathematicist is then to determine what mathematical figure is sufficient to constitute guilt. As explained above, the inductivist, concerned with a striving for certainty, focuses on excluding any reasonable doubt and the mathematical calculation can be used in that process to determine how many other possible suspects might have left the DNA in question. The inductivist must exclude the reasonable possibility that these other suspects left the DNA before convicting the accused. On the other hand, the mathematicist is not seeking certainty; the mathematicist accepts that certainty is unobtainable and is concerned only to reveal the degree of

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[36] For an exposition of the mathematical approach, including the use of Bayes' Theorem, see Ligertwood and Edmond, above n 14, particularly [1.23]–[1.26].

[37] The very asking of this question emphasises that DNA evidence alone is not relied upon in computing the mathematical probability to convict an accused.

[38] $1/10^7 \times 1/1/10^6 = 1/10^7 \times 10^6 = 1/10$.

[39] $1/10^7 \times 1/1/(2 \times 10^{10}) = 1/10^7 \times (2 \times 10^{10}) = 2 \times 10^3/1$.

our ignorance. What degree can be tolerated for the purposes of action must then be decided through some sort of utilitarian calculation accepting the risks arising from any remaining ignorance.

What these inductive arguments emphasise is that, even where DNA evidence is crucial to identifying the accused, there is always other evidence to be taken into account in deciding whether the case is proved. What constitutes mathematical proof remains problematical and is not considered here because it is clear that judges do not accept that proof in a court of law is a mathematical exercise.[40] Trial judges are prohibited from explaining the criminal standard of proof to the jury in mathematical terms[41] — or, indeed, in any terms.[42] The aspiration is to certainty. A reasonable doubt is the doubt that a reasonable jury might hold.[43] Only where the jury believes that at all reasonable doubts have been excluded can it convict.

However, as the analysis above shows, the expression of evidence in mathematical terms is not inconsistent with an inductive approach. On the contrary, it is able to logically isolate and quantify possibly innocent explanations, an integral part of determining whether these leave reasonable doubts that prevent inductive proof. Judges recognise this, permitting experts to testify to statistical conclusions, and even to testify to the DNA random match in terms of a likelihood ratio.[44] But courts remain wary of confusing juries by encouraging them to make mathematical calculations. Nor do courts want juries to conceptualise proof in mathematical terms. Thus, whilst permitting experts to reveal likelihood ratios, trial judges remain prohibited from

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[40]   Cf the discussion of the criminal standard in the US, provoked by the case of *United States v Copeland* 369 F Supp 2d 275 (ED NY, 2005), in Peter Tillers and Jonathan Gottfried 'Case Comment — *US v Copeland*: A Collateral Attach on the Legal Maxim that Proof Beyond a Reasonable Doubt is Unquantifiable?' (2006) 5 *Law, Probability and Risk* 135; James Franklin, 'Case Comment — *US v Copeland*: Quantification of the "Proof Beyond Reasonable Doubt" Standard' (2006) 5 *Law, Probability and Risk* 159; Jack B Weinstein and Ian Dewsbury, 'Comment on the Meaning of Proof Beyond a Reasonable Doubt' (2006) 5 *Law, Probability and Risk* 167; Jon O Newman, 'Quantifying the Standard of Proof Beyond a Reasonable Doubt: A Comment on Three Comments' (2006) 5 *Law, Probability and Risk* 267.

[41]   Disapproval of a jury in a criminal case being left to consider the traditional standard in mathematical terms can be found in the following cases: *Chedzey v The Queen* (1987) 30 A Crim R 451 (CCA (WA)); *R v Flesch* (1987) 7 NSWLR 554; *R v Cavkic* (2005) 12 VR 136; *W v The Queen* (2006) 16 Tas SR 1, 11–19; *Forbes v The Queen* (2009) 232 FLR 229 [39]. See further, Ligertwood and Edmond, above n 14, [2.65].

[42]   *Brown v The King* (1913) 17 CLR 570; *Dawson v The Queen* (1961) 106 CLR 1, 18; *Thomas v The Queen* (1960) 102 CLR 584; *Green v The Queen* (1971) 126 CLR 28; *La Fontaine v The Queen* (1976) 136 CLR 62, 71, 80–1; *Darkan v The Queen* (2006) 227 CLR 373 [69] (Gleeson CJ, Gummow, Heydon and Crennan JJ).

[43]   *Green v The Queen* (1971) 126 CLR 28, 33.

[44]   See, eg, *R v Karger* (2002) 83 SASR 135; *Forbes v The Queen* (2009) 232 FLR 229; *R v Carroll* [2010] SASC 156 (28 May 2010) [36] (Sulan J) ('*Carroll*'); *R v Marticanaj* [2010] SASCFC 82 (23 December 2010) [20] (Gray J), [88]–[91] (Kourakis J) ('*Marticanaj*').

instructing juries about Bayes' Theorem as a tool to make logical use of those ratios.[45] There is an inconsistency here. However, as the above inductive analysis shows, the inconsistency can be avoided and the Bayesian logic preserved without asking the jury to apply Bayes' Theorem by expressing the chances of a random DNA match not as a likelihood ratio but in terms of a simple frequency within a suspect population. This approach remains consistent with inductive analysis and is an approach more likely to be understood by a jury.

Expressing Statistical DNA Evidence

in Inductive Terms

The question of how experts should express the statistical conclusions of DNA evidence arose recently in *Aytugrul v The Queen* ('*Aytugrul*').[46] The case involved a prosecution against a Turkish man for the murder of a Turkish woman who had been violently stabbed to death. This was not a case turning on DNA evidence alone. There was considerable circumstantial evidence connecting the accused with the crime: he had had a relationship with the victim, his offers to marry her had been rejected, he was upset by her having commenced another relationship, he had harassed her during the weeks before her death, and she had told witnesses that she was afraid of him. But there was little evidence connecting him with the forced entry to the victim's house on the night of the murder, other than his lies (about knowing where she lived, from whom he had obtained this information and about having visited her on one occasion with his young son) and evidence that DNA in a hair found stuck by blood to the victim's thumbnail matched that of the accused.[47] The prosecution tendered evidence of the expected frequency of DNA of that composition in the Turkish community and in the community at large. The controversy that arose on appeal was about the way in which these results were presented to the jury. The three experts differed in their random occurrence ratios, their figures varying from 1 in 1600,

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[45] *R v Denis Adams* [1996] 2 Cr App R 467, 481. Cf *R v T* [2011] 1 Cr App R 9 [88]-[91] where the court suggests that the use of Bayes' Theorem and likelihood ratios may be appropriate in 'the field of DNA (and possibly other areas where there is a firm statistical base)' but leaves open what accompanying directions to a jury would be appropriate. In none of the cases in the previous footnote where experts testified to likelihood ratios was any attempt made to explain Bayes' Theorem to the jury.

[46] [2010] NSWCCA 272 (3 December 2010). Special leave to appeal to the High Court has been granted (see [2011] HCA Trans 238, 2 September 2011) but the appeal not heard at the time of submission of this article.

[47] Mr Tunc, with whom the victim was having a relationship at the time of her death, admitted that he had visited the victim on the night of her murder, and traces of his matching DNA were also found on her body, but initial police suspicions that he was the culprit were soon allayed. Nevertheless, at trial the accused continued to argue Mr Tunc's involvement in the crime as a reasonable possibility.

1 in 2000 and 1 in 1000 in the general community, to 1 in 50 in the Turkish community, and the prosecution had the experts express these ratios in terms of an exclusion percentage. These produced percentages expressed to the jury as between 99.9 per cent and 98 per cent. In directing the jury, these were explained by the trial judge as the percentages of people in the relevant communities who could be excluded as having been the source of the hair, while leaving open the accused as a possible source, but not concluding that this was necessarily so.[48] The defence argued 'that the use of any percentage "close to 100%" was impermissible' and, in exercise of the exclusionary discretion, should have been excluded as unfairly prejudicial to the accused.[49] The basis of the argument was that the use of these figures close to 100 per cent left open an unfair risk that the jury would in effect commit the prosecutor's fallacy and regard these figures as indicating the probability of the accused's guilt rather than simply putting the accused within a range of possible suspects.

In dismissing the appeal, the majority held that the DNA evidence was not inaccurately expressed to the jury[50] and that as the trial judge made it clear to the jury that the evidence did no more than suggest the accused as a possible source — that is, a possible culprit within what was a circumstantial case — the accused could not contend there was any unfair prejudice in the presentation of the evidence. Nor did it regard the verdict as unreasonable or against the weight of evidence. McClellan CJ at CL, in dissent, was more critical, concluding that:

> his Honour should have excluded the exclusion percentages from the evidence, all of which invited a subconscious 'rounding-up' to 100. It was not sufficient for his Honour to warn the jury against the potential misuse of the percentages. The exclusion percentage figures were too compelling. To my mind his Honour's directions would not have eliminated the risk of unfair prejudice to the appellant.[51]

McClellan CJ at CL agreed there was a case to go to the jury but, as the DNA evidence was important in specifically connecting the accused

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[48]   [2010] NSWCCA 272 (3 December 2010) [76]–[77] (McClellan CJ at CL).

[49]   Ibid [62]–[63] (McClellan CJ at CL).

[50]   Simpson JA was of the view that:
>   Some formulations are likely to have greater impact than others. That merely means that some formulations have a greater educative force or persuasive appeal than others; or that some are more colourful, or more easily comprehended, than others. Provided that what is contained in the formulations is accurate, I see no reason to prefer one method of expression over another. By referring to accuracy I do not mean to suggest that evidence is inadmissible if it is incorrect: I mean that, provided the various means of expressing the conclusions correspond accurately with one another, there is no reason to prefer one over another. (Ibid [164])

[51]   [2010] NSWCCA 272 (3 December 2010) [99].

with the crime, he decided: 'because, in my view, use of the exclusion percentages had the potential to overwhelm the jury I would order a new trial'.[52]

As McClellan CJ at CL further comments in *Aytugrul*:[53]

> There are various equally mathematically valid ways of expressing the same DNA statistic. Using a random occurrence ratio of 1 in 1000, and taking the population of Australia as 21 million, these include:
>
> 1. 1 in 1000 people would be expected to have the DNA profile found in the hair specimen.
>
> 2. 999 out of 1000 people would not be expected to have the DNA profile found in the hair specimen.
>
> 3. 0.1% of people would be expected to have the DNA profile found in the hair specimen.
>
> 4. 99.9% of people in Australia would not be expected to have the DNA profile found in the hair specimen.
>
> 5. 21,000 people in Australia would be expected to have the DNA profile found in the hair specimen.
>
> 6. 20,979,000 people in Australia would not be expected to have the DNA profile found in the hair specimen.
>
> Formulations 1 and 2 express random occurrence rates as frequencies. Formulation 3 expresses what might be termed an 'inclusion percentage'. Formulation 4 is an exclusion percentage. Formulations 5 and 6 simply transpose the random occurrence rate onto an actual population, in this case the population of Australia.

In addition to these expressions, the random match probability can also be expressed in terms of a likelihood ratio, which expresses the likelihood of the DNA of that composition having originated from the suspect (the accused) rather than from a randomly selected member of the population. In the example given above by McLellan CJ at CL, it can be said that DNA of that composition is 1000 times more likely to have originated with the suspect than with another member of the population randomly selected.

Finally, as occurred in *Forbes*, the likelihood ratio might be expressed simply in terms of language — as 'strong', 'very strong', or 'extremely strong' — with the words reflecting ranges of likelihood rather than seeking to be more precise.

The issue is whether, given that courts insist upon approaching proof inductively, any one of these expressions is more appropriate

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[52]   Ibid [121].
[53]   Ibid [86]–[87]

than another in explaining the significance of the random match probability to the jury. It is submitted that it is the expression in terms of simple frequency that enables the jury to employ most effectively the inductive process. The frequency, recognising other possible sources of the DNA in question, compels the jury to consider other scenarios that might explain the match, and to ask whether these scenarios can be excluded, before concluding beyond reasonable doubt that the accused was the source. Empirical psychological research also suggests that expressing probabilities in terms of natural frequencies rather than in terms of conditional probabilities or likelihood ratios is not only better understood by laypersons but is also most conducive to the inductive approach demanded by the criminal standard of proof.[54]

Whether, given the inductive approach to criminal proof, any other expression of the random match should even be permitted is extremely doubtful. To express the match in terms of the proportion of persons in the population who would *not* match the sample appears simply unhelpful. The importance of the evidence is the fact of a match and how many other persons within the suspect population might have that DNA profile. Similarly, expressing the random match in terms of percentages is of no inductive assistance.[55] Inductive probabilities seek evidential support for the individual case, not a generalised number of cases, and the percentages add nothing but confusion to the jury's task. Although empirical evidence suggests the expression in terms of high exclusionary or low inclusionary percentages may be persuasive,[56] it is submitted that there is no inductive logic to that persuasion. In other words, the expression is unfairly prejudicial to an accused and should not be permitted.

Upon the same basis, the expression of the random match in generalised verbal terms is of no inductive assistance. In *Forbes* the verbal expressions failed to emphasise the jury's inductive task to exclude the possibility of another suspect, expressing the random match only in generalised prosecutorial terms — strong, very strong, extremely strong — rather than asking the jury to consider the possibility of there being another suspect who may have produced the

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[54]   See, eg, Gird Gigerenzer and Ulrich Hoffrage, 'How to Improve Bayesian Reasoning Without Instruction: Frequency Formats' (1995) 102 *Psychological Review* 684; Jonathan J Koehler, 'On Conveying the Probative Value of DNA Evidence: Frequencies, Likelihood Ratios, and Error Rates' (1996) 67 *University of Colorado Law Review* 859, 878–9 and 880ff (reporting on his experiment: 'Likelihood Ratios vs Frequencies'); see also Samuel Lindsey, Ralph Hertwig and Gird Gigerenzer, 'Communicating Statistical DNA Evidence' (2003) 43 *Jurimetrics* 147.

[55]   Exclusionary percentages were criticised by Spigelman CJ in *R v Galli* (2001) 127 A Crim R 493 [72]: '[I]f a figure of 98% was put to a jury, it is likely that many jurors would regard that as very significant evidence pointing to the accused, even though the Paternity Index ratio was very low, so that numerous persons in the general community could share the DNA profile'.

[56]   See Koehler above n 26.

DNA match. Furthermore, the verbal expressions could only be clarified through revealing the numerical probabilities upon which they were based — there was no point in attempting to fudge the evidence in question. As the English Court of Appeal in *R v T*[57] has emphasised, 'the practice of using a Bayesian approach and likelihood ratios to formulate opinions placed before a jury without that process being disclosed and debated in court is contrary to principles of open justice'.

The expression of the random match in terms of a likelihood ratio, an expression generally accepted by courts,[58] and favoured by forensic scientists,[59] creates different problems because, as explained above, a likelihood ratio can only be given logical significance through the application of Bayes' Theorem and courts are reluctant to confuse juries by trying to instruct them about its use. However, as is also demonstrated above, mathematical logic remains important in seeking inductive proof and, by using simple frequencies, Bayesian logic can be explained in inductive terms without using the theorem. It is thus quite unnecessary to put the random match probability to the jury as a likelihood ratio, a ratio that by itself would have little logical significance for the average juror[60] and, again, can only be unfairly prejudicial to the accused. In *Marticanaj*,[61] Kourakis J, while not having been asked to exclude DNA evidence expressed as a likelihood ratio and rejecting the argument that there was a risk that the jury may have misused the 'overwhelming' DNA evidence, nevertheless commented that to use the likelihood ratio in a DNA case was 'in a sense to state the obvious', that expression in terms of the chances of a random match was 'easier to understand and apply', and that it also reduced the risk of accepting the 'prosecutor's fallacy'.

In *Aytugrul*,[62] Simpson J was of the view that, 'provided the various means of expressing the conclusions correspond accurately with one another, there is no reason to prefer one over another', adding that she was 'at a loss to understand why a jury ought not to be assisted by having the evidence couched in the language most likely to be

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[57]   [2011] 1 Cr App R 9 [108].

[58]   In *R v GK* (2001) 53 NSWLR 317, 331 (Mason P), 341 (Sully J), likelihood ratios (relative chances of paternity) expressed as extremely high percentages (99.9995 per cent and 99.9993 per cent) were rejected as unfairly prejudicial, but not when expressed as simple ratios (220 000:1 and 147 005:1). In *Aytugrul* McClellan CJ at CL emphasised, with arguably implicit approval, that the evidence in that case had not been tendered as a likelihood ratio. Nevertheless, it remains common for DNA evidence to be so tendered: see, eg, *Carroll* [2010] SASC 156 (28 May 2010) [36] (Sulan J) and other cases cited above n 44.

[59]   Guest Editorial, 'Expressing Evaluative Opinions: A Position Statement' (2011) 51 *Science and Justice* 1.

[60]   Empirical evidence suggests that laypersons have little understanding of the nature and purpose of a likelihood ratio: see articles referred to above n 54.

[61]   [2010] SASCFC 82 (23 December 2010) [94]–[96].

[62]   [2010] NSWCCA 272 (3 December 2010) [164].

meaningful to lay recipients'.[63] The crucial question, however, is: Which expressions about the weight of DNA evidence are inductively meaningful? Without any analysis, Simpson J asserted that giving evidence of the random occurrence rate in terms of an exclusionary percentage, although 'not conclusive that the hair came from the appellant . . . was very powerful evidence to that effect'.[64] Further, she quoted Mason P in *R v GK*[65] to emphasise that:

> if relevant DNA statistical evidence is tendered through a witness of due expertise then its probative weight cannot itself be a ground for withholding it from the jury. Indeed its very significant probative weight is a factor in favour of admission notwithstanding the capacity of extremely high odds to carry a prejudicial overlay.[66]

But what is the probative weight in inductive terms of a bare exclusionary percentage? The very expression of the evidence in these terms is unnecessary and does no more than to create a prejudicial overlay that can be avoided by expressing the evidence simply in frequency terms. It makes greater sense to express probative weight in the inductive terms appropriate to the application of the individualised criminal standard of proof. And, given that the DNA sample matches the accused, the exclusionary percentage adds nothing to the jury's task of determining whether there is an explanation for the match other than that it came from the accused. It is the simple hypothesised frequency of that DNA in the suspect community that emphasises this inductive task. It does not hide the inductive strength of the evidence. Nor is the fact that the frequency of a random match is extremely low a reason for excluding it from the jury. To the contrary, where the frequency is extremely low this infrequency in itself may be regarded by the jury as excluding the reasonable possibility of the sample having another source. But an exclusionary percentage of 99.9, considered in relation to a large suspect population, does nothing to eliminate the reasonable possibility of a sample having a source other than the accused.

The inductive approach to the expression of random match probabilities advocated here provides a conceptual basis for McClellan CJ at CL's argument in *Aytugrul* that expressing random match probabilities in terms of exclusionary percentages is prejudicial to an accused.[67] It can indeed be argued that the inductive approach demands

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[63]   Ibid [170] (emphasis added).

[64]   Ibid [193].

[65]   (2001) 53 NSWLR 317 [39].

[66]   *Aytugrul* [2010] NSWCCA 272 (3 December 2010) [197].

[67]   In *Aytugrul* [2010] NSWCCA 272 (3 December 2010) McClellan CJ at CL was of this view despite the trial judge telling the jury that '[w]hat you have, at its highest, is evidence that you may or may not accept establishes that the profiles are the same and that then goes on to say that because of this the accused cannot be excluded as a source of the hair. It does not say he is necessarily, but it does say that it is possible

that the random match be expressed only in frequency terms. All other expressions, while they may be persuasive in some way to the jury, do nothing to convey the inductive logic demanded by the criminal standard of proof and are simply unfairly prejudicial to an accused. This is implicitly recognised by McClellan CJ at CL in quoting the empirical research of Koehler[68] to show that jurors have difficulties in interpreting statistics and are likely to give greater persuasive weight to statistical expressions 'framed in the language of probability (eg, 0.1%) in a way that highlights a particular suspect's chance of matching by coincidence' than to expressions 'framed in the language of frequencies (eg, one in one thousand) in a way that highlights the chance that *others* will match by coincidence'. Koehler's empirical work also shows that:

> the perceived probative value of a statistical DNA match (and, by extension, other forensic match evidence) depends on the ease with which triers of fact can imagine examples of others who would also match the DNA profile. When triers of fact find it hard to imagine examples of others who might match by chance, the evidence will be treated as compelling proof that the matching suspect is the source of the recovered DNA evidence. But when such matches are easier to imagine, the evidence will seem less compelling.[69]

In coming to the conclusion that the exclusion percentages should not have been tendered, McClellan CJ at CL in *Aytugrul* says:

> DNA profiling is an empirical scientific method. In an accusatorial system of justice, the duties of the Crown demand that all evidence and, in particular, complicated expert evidence be presented fairly *to the accused*. Where it strongly implicates the accused, it will speak for itself. Where it does not, the Crown should not have the advantage of the 'subliminal impact' of statistics to enhance the probative value of the evidence. To do so may come at the cost of a fair trial.[70]

Referring to empirical evidence suggesting the difficulty that laypersons have in assimilating statistical evidence, McClellan CJ at CL also adds:

> The response to the difficulty with the intelligibility of DNA evidence is not to banish all statistical evidence from the courtroom but to rationally determine the probabilistic formulations which are appropriate for use in a criminal trial.[71]

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that it came from him' (at [76]) and that the percentages were not 'the percentage chance that the hair belonged to the appellant' (at [77]) but were simply the percentages of the population that could be excluded from having that DNA profile.

[68] Koehler, above n 26. See also Jonathan J Koehler, 'When are People Persuaded by DNA Match Statistics?' (2001) 25 *Law and Human Behavior* 493.

[69] Koehler, above n 26, 1280.

[70] [2010] NSWCCA 272 (3 December 2010) [49].

[71] Ibid [102].

However, McClellan CJ at CL stops short of determining the appropriate presentation to ensure the accused a fair trial, leaving it to individual judges to determine as a matter of discretion whether the form of presentation of statistical evidence makes it more prejudicial than probative.[72] What is here argued is that only a simple frequency presentation is appropriate to the inductive approach expected by the criminal standard of proof. At the very least, a frequency presentation should always be made and any other presentation explained in the light of the trier's inductive task.

DNA Evidence Alone: Legal Issues

Case to Answer

Above, in discussing whether conceded DNA evidence 'alone' may amount to proof, it was assumed sufficient to make out a case to answer against the accused. It was argued that, as a consequence, the failure of the accused to testify could be taken into account in determining proof. In inductive terms this failure is crucial to a jury being satisfied that there are no explanations known only to the accused that might create a reasonable doubt. But is DNA evidence 'alone' (that is, evidence establishing the crime, evidence of the finding of the DNA, evidence of a match, and evidence of the chances of a random match) sufficient to make out a case to answer?

In every case, at the completion of the prosecution evidence an accused may submit there is no case to answer. The right to make this submission must be distinguished from the discretion a trial judge has to invite a jury, at any time before the completion of the trial, to enter a verdict of not guilty because the evidence is so unreliable that no reasonable jury could be persuaded by it.[73] While a judge is obliged to rule on a no-case submission, whether a jury is invited to enter a verdict of not guilty before completion of all the evidence on the ground that the evidence is unpersuasive is left to the discretion of the trial judge.

A case to answer is made out where, accepting the reliability of the prosecution evidence and taking it at its highest, it is capable of convincing a jury of guilt beyond reasonable doubt.[74] Thus, where a

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72   Ibid [103].
73   The so-called *Prasad* invitation: see *R v Prasad* (1979) 23 SASR 161; see also *Whitehorn v The Queen* (1983) 152 CLR 657, 672 (Dawson J). The procedure is accepted by the High Court in *Doney v The Queen* (1990) 171 CLR 207.
74   *R v Bilick* (1984) 36 SASR 321, 337; see also *Questions of Law Reserved on Acquittal (No 2 of 1993)* (1993) 61 SASR 1 5 (King CJ); *R v Macaskill (No 1)* (2001) 81 SASR 152 [13]–[16]; *Western Australia v Montani* (2007) 182 A Crim R 155 [6]–

witness testifies to having seen a person he or she later identifies as the accused commit the crime alleged, there will be a case to answer because, assuming that evidence is accepted by the jury and taking it at its highest, it is capable of supporting a verdict of guilt beyond reasonable doubt. Matters relating to the weight of evidence so capable are matters for the jury, not for a judge on a no-case submission. Even if a witness's testimony is so obviously false that no reasonable jury could accept it, that is technically not a matter relevant to determining a case to answer, although in this situation where it would be unsafe to convict on the evidence, a judge may at any time invite the jury to acquit.

In the same way as the testimony of a single witness is sufficient to make out a case to answer on the issue of identification, despite the chances of mistaken identification, so it might be argued that DNA evidence of a match is sufficient to make out a case to answer on the issue of identification, despite the chances that the DNA came from another source.[75] Even where those chances are so high that no reasonable jury could conclude beyond reasonable doubt that the DNA originated with the accused and a judge might invite the jury to acquit, there is still a case to answer.

DNA evidence might also be regarded as circumstantial evidence in that identity is inferred from the coincidence of finding particular matching alleles at a number of different loci. Where a case turns on circumstantial evidence, Australian authorities do not demand, before a case to answer is made out, that the prosecution evidence standing alone be capable of excluding in advance every hypothesis reasonably consistent with innocence.[76] Rather the question is whether taking the prosecution case at its highest it is capable of proving the accused's guilt. With DNA evidence, one explanation of the incriminating circumstantial evidence is that the DNA is from the

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[11]. The difficulties with this formulation are discussed by Ligertwood and Edmond, above n 14, [6.32].

[75] In *Forbes v The Queen* [2010] HCATrans 120 (18 May 2010) [960]–[980], Mr Hastings QC refers to *R v Rowe* [2004] SASC 424 (17 December 2004) [40] where Bleby J remarked of DNA identification that '[i]t probably founded a safer basis for a conviction than the frailty often attending the evidence of a single eye-witness who gives evidence of identification of an offender'; and also *R v Gum* [2007] SASC 311 (22 August 2007) [32] where Vanstone J says: 'Plainly the evidence that DNA matching the appellant's was found at each "scene" was extremely potent. The jury would have been entitled to view this evidence, standing alone as sufficient proof of either count.' In the same way, in *R v Hookway* [1999] EWCA Crim 212 (1 February 1999) expert evidence of facial mapping alone was held sufficient to make out a case to answer.

[76] *Thorp v Abbotto* (1992) 106 ALR 239; *R v Brady* (2005) 92 SASR 135 [10]–[14]; *Western Australia v Montani* (2007) 182 A Crim R 155; *Police v Leo* (2006) 94 SASR 496 [30]–[39]. Cf *R v P* [2008] 2 Cr App R 6 where the court said the central question was simply whether there was evidence on which a properly directed jury could convict, and innocent hypotheses did not necessarily exclude such a result.

accused. That there are other possible innocent explanations, expressed in the chances of a random match, does not prevent there being a case to answer. Just as in another circumstantial evidence case hypotheses consistent with innocence do not prevent a case to answer being made out, so the possibility of another source for the match does not prevent there being a case to answer. Again, if the chances are so high that no reasonable juror could ever conclude beyond reasonable doubt that the DNA came from the accused, then the judge may invite the jury to acquit. However, the reality is that the chances of a random match are becoming so small that it is increasingly unlikely that a judge would invite acquittal on this basis.

If this is accepted, then in every DNA-only case a court can determine a case to answer made out without making a decision about the evidential weight to be given to the chances of a random match. This does not mean that the accused will necessarily be convicted, only that there is sufficient evidence to request an answer from the accused, and to permit the jury to decide having regard to the accused's response (if any) to that request. It may decide that, even where an accused fails to testify, the chances of a random match still leave open reasonable explanations consistent with innocence. But the importance of there being a case to answer is that the failure of the accused to provide an answer becomes evidence for the jury's inductive consideration. In particular, it may be taken into account to discount any reasonable explanations peculiarly within the accused's knowledge.

The Right to Remain Silent at Trial

An important assumption of the above discussion is that, just as any explanation and evidence an accused gives may be taken into account in determining whether the DNA match is proved, so may the failure of the accused to explain be taken into account. The question is whether permitting this is inconsistent with the accused's right to remain silent at trial and to call no other evidence by way of defence.

The content of this right in Australia, both at common law and under the uniform evidence legislation, is determined in two High Court decisions, *Weissensteiner v The Queen*[77] and *Azzopardi v The Queen*.[78] These decisions permit a jury to be directed, once a case to answer has been made out, that it may take into account the failure of an accused to testify to a matter that is peculiarly within the accused's knowledge in deciding whether it has any remaining reasonable doubts about the accused's guilt. Otherwise, the jury must be directed to draw no adverse inference from the failure of the accused to testify or

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[77]   (1993) 178 CLR 217.
[78]   (2001) 205 CLR 50.

otherwise call evidence to meet the prosecution case. The limit to an inference is that the matter should not just be a matter within the accused's knowledge, but peculiarly so. If it is not peculiarly so it seems the prosecution is obliged to call other witnesses in order to have evidence capable of eliminating that doubt and. the jury cannot be directed to use the failure of the accused to testify as evidence to eliminate that doubt.[79]

Just as the failure to explain can in some circumstances be taken into account, so may any explanations given by the accused. But an accused must be careful not to provide an explanation that is disbelieved by the jury for, as in *Forbes*, this disbelief can be taken into account and, provided appropriate directions are given, may be used by the jury to find an implicating consciousness of guilt.[80]

Conclusions

The question whether DNA evidence alone is sufficient to convict raises two main issues. The first questions the very reliability of DNA evidence, not only the reliability of the very theory that underlies it but also the reliability of those many human actions that isolate and then analyse biological material to produce evidence of the match and the chances of a random match. The second questions whether, assuming this reliability, the statistical conclusions alone can support conviction of an accused beyond reasonable doubt. It is the second question that was raised by *Forbes* and that is the subject of this article.

The answer turns on the very nature of criminal proof. If it was simply a statistical exercise, then a numerical standard of proof could be specified and the necessary calculations made. However, empirical evidence, most notably the very practice of the criminal courts, shows that human beings do not generally reason in this way. Criminal proof is regarded by the law as an inductive exercise, aspiring to certainty, demanding that a trier of fact, after considering all the evidence before the court, be convinced beyond reasonable doubt of the hypothesis supporting guilt before finding an accused guilty. Essential to this inductive exercise is the exclusion of any other possible innocent hypotheses that might explain away the evidence before the court.

As a consequence, DNA evidence must be considered as part of this inductive process. In the first place, the nature of a case turning on DNA evidence alone must be considered. The issue in the case will be identification of the accused through a DNA sample associated with the crime. At a bare minimum, there will be evidence of the crime alleged

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[79]   See further Ligertwood and Edmond, above n 14, particularly [123]–[124].
[80]   See further above n 14.

and the finding of the sample together with expert evidence of the DNA match and of the chances of a random match. But if, as is argued above, this is sufficient to make out a case to answer against an accused, there will also be evidence of the accused's response, if any, to this prima facie case. If there is a response, its credibility must be determined. If rejected, at a minimum this will exclude that innocent explanation of the DNA evidence and in some cases may give rise to an inference of consciousness of guilt supporting the prosecution case. If there is no response, that failure may be taken into account in determining the reasonable possibility of innocent explanations that may be within the peculiar knowledge of the accused.

The place of the DNA evidence in this inductive process is to provide evidential support for the prosecution case. But the overall support required for conviction is beyond reasonable doubt and the DNA evidence assists in this determination by producing evidence of a match and evidence of the chances of random match. While the match supports the prosecution case, the chances of a random match determine the evidential weight of that match through showing the possibility of there being matches with others, and hence an innocent explanation for the evidence of the match with the accused. To ensure the DNA evidence is considered rigorously within this inductive process, it is argued that the evidence should be presented not in terms of a likelihood ratio or as a mere percentage most suited to calculating the statistical chances of guilt, but in terms of a simple frequency that encourages the trier of fact to consider how many other persons within the suspect population might have matching DNA, and whose possible involvement in the crime must be excluded before the accused can be convicted. Empirical evidence also shows a frequency presentation most conducive to this inductive process that demands consideration of other scenarios that might explain away a match with the DNA of the accused.

This approach does nothing to undermine the weight of DNA evidence. Where there is some chance of there being other matches within the suspect population, the reasonable possibility of another person having committed the crime must be carefully considered and excluded before the DNA evidence 'alone' can convict.[81] The reality is, however, that through increasing the number of loci at which alleles are identified, the chances of finding a random match are now in many

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[81] Generally in such cases the prosecution will have other evidence that excludes these possibilities. In *Carroll* [2010] SASC 156 (28 May 2010), a case where the chances of a random match were as small as one in 122 million, having regard to that figure Sulan J was prepared to convict given that the accused lived in the vicinity of the crime, concluding (at [59]) that 'the possibility of some person other than the accused [with matching DNA] living in the area close to the Colonnades Shopping Centre is so remote that I can discount it as reasonably possible'. See also Kourakis J in *Marticanaj* [2010] SASCFC 82 (23 December 2010) [100].

cases so 'mind-bogglingly' remote that it becomes unlikely that there will even be another match within the suspect population. This being so, assuming the reliability of the DNA evidence, and in the absence of any evidence raising the reasonable possibility of an innocent explanation, the DNA evidence 'alone' may constitute proof beyond reasonable doubt.

Of course the question of the reliability of the DNA evidence remains. In particular, investigatory and analytical processes are required to minimise, as far as is possible, the human errors that can occur in the collection and analysis of DNA evidence, and processes are needed to ensure that the reliability of DNA evidence can, where necessary to protect the innocent, be effectively challenged at trial.[82] Undiscovered laboratory errors and contaminated samples can result in serious miscarriages of justice.[83]

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[82] For a discussion of processes to safeguard the reliability of forensic evidence more generally, see Edmond and Roberts, 'Principles of Evidence Law and Their Implications for Forensic Science and Medicine', (2011) 33 *Sydney Law Review* 359; and National Research Council of the National Academies, *Strengthening Forensic Science in the United States: A Path Forward* (National Academies Press, 2009).

[83] As occurred recently in Victoria in the case of *Jama* where contamination produced a matching DNA sample, the case leading to a governmental inquiry into DNA processes relied upon by prosecutors in Victoria: see F Vincent, *Report: Inquiry Into the Circumstances That Led to the Conviction of Mr Farah Abdulkadir Jama* (Vincent Report) (Victorian Government Printer, May 2010) <http://www.justice.vic.gov.au/wps/wcm/connect/5a103e804263c8da810e832b0760 a79a/VincentReportFinal6May2010.pdf?MOD=AJPERES>.