

Observations on LCN DNA analysis¹

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The view from Northern Ireland

The acquittals in *R v Hoey* [2007] NICC 49 (20 December 2007) made international news, as the accused had faced 58 charges of murder, conspiracy to murder, causing explosions, conspiracy to cause explosions and possession of explosive substances with intent to endanger life or cause serious damage to property. These arose from “thirteen bomb and mortar attacks, attempts at such attacks and the finding of unexploded devices that began on 24 March 1998 and included the infamous car bomb explosion that destroyed much of the shopping centre of Omagh on the afternoon of Saturday, 15 August 1998 with the appalling consequence that twenty-nine members of the public, including a lady pregnant with twins which did not survive, were killed and hundreds of others were injured, many gravely, leaving permanent and widespread physical and psychological scars. The town centre was destroyed. This huge explosion was among the very worst of the numerous terrible events of that recent thirty-year violent period of Northern Ireland history sometimes euphemistically referred to as “the Troubles”.” (para 1)

Weir J found various aspects of the prosecution case unsatisfactory. Of particular interest here is his rejection of expert evidence concerning the analysis of DNA by what is called the LCN DNA technique. LCN means low copy number. It is of use where the crime scene yields a sample of material that contains a quantity of DNA that is too small to be analysed by what have become more traditional techniques. Instead of simply analysing what is there, this method has a stage where such DNA as is present is multiplied until there are enough copies of it to be analysed.

The LCN DNA technique is controversial in the scientific community.² Weir J said, para 62:

¹ For updates to this draft paper, check www.nzcriminallaw.blogspot.com and go to the link on the left of the page to “Selected papers available here”.

² The opposite conclusion was reached in *R v Murdoch* [2005] NTSC 76 (15 December 2005). I am grateful to Dr Jeremy Gans, Associate Professor at Melbourne Law School, for drawing my attention to this case. In *Murdoch* the trial judge, Martin (BR) CJ, accepted that the evidence of the expert (the same Dr Whitaker involved in *Hoey* and *Lepper*, below) on the LCN DNA technique was admissible.

“ ... I was concerned at the wide variance in expert opinions, not only as between the Prosecution and Defence but also between the two experts called for the Prosecution. The central plank in the attack made on the evidential value and reliability of this system by the Defence witnesses, Dr Krane and Professor Jamison, was that the LCN system which had been invented by Dr Gill of Birmingham FSS and whose use for evidential purposes is being promoted by him and a colleague at that laboratory, Dr Whitaker, has not been "validated" by the international scientific community.”

He listed ten points of concern raised by defence experts, and the first of these was “That LCN has only been adopted for evidential purposes in two other countries in the world, the Netherlands and New Zealand.”

Has something gone wrong in New Zealand?³

LCN DNA analysis in New Zealand

Although it was not cited or discussed by Weir J, the New Zealand case is *R v Lepper* [2005] NZCA 259 (1 November 2005). This decision of the divisional court (ie one permanent member of the Court of Appeal sat with two Judges of the court below, called the High Court) has remained unreported but is available online. It did not involve a determination as to whether evidence of the results of LCN DNA analysis qualified as expert evidence. This point was not decided, because it had not been raised at or prior to the trial, and the Court of Appeal held, para 30:

“...it is not part of the function of a Judge in a criminal trial in New Zealand to initiate a voir dire as contended for by [counsel for the appellant]. If the appellant wished to challenge Dr Whittaker’s evidence, he could have indicated that to the Crown and the Crown

³ According to the National Library of New Zealand, at <http://www.natlib.govt.nz/collections/online-exhibitions/contemporary-scientists/forensic-science>, “In 1996, New Zealand became the second country in the world to set up a National DNA Databank, in a joint venture between the Institute of Environmental Science and Research (ESR) and the New Zealand Police. This new crime-fighting tool is a database of DNA profiles from blood or mouth swabs taken from convicted offenders and volunteers. They can then be matched against DNA profiles from unsolved crimes in an attempt to link individuals to the scene or the crime. In 2005, ESR processed nearly 24,000 forensic DNA samples and linked one individual to 14 different crimes through the DNA databank. ... LCN began as a joint venture between John Buckelton from ESR and the UK Forensic Science Services. It uses increased numbers of PCR cycles compared to standard DNA profiling and is capable of detecting as little as one DNA molecule.”

would doubtless have made an application under s 344A of the Crimes Act in the usual way. There was no such application.”

I doubt, with respect, that such a complacent approach to the admissibility of evidence is correct. It would not be proper for an appellate court to ignore admissibility issues that may have been overlooked by counsel: see *Charles v R* (Saint Vincent and the Grenadines) [2007] UKPC 47 at para 17:

“...It is the duty of an appellate court to advert to any such matter which may appear to it to be significant and possibly determinative of an appeal in favour of the accused.”

It would be odd if a trial judge could be less vigilant in this regard than an appellate court.

In any event, it seems that at trial in *R v Lepper* there was no, or perhaps very little, challenge to the reliability of the LCN technique, as the Court of Appeal said, para 31:

“... the appellant had a full opportunity to question Dr Whittaker [the Dr Whittaker, spelt here with two ts, is the same person referred to by Weir J in *R v Hoey*] about the reliability of profiling using the LCN technique, and about the extent to which evidence about DNA profiles obtained using the LCN had been admitted in criminal Courts in Britain. In evidence Dr Whittaker said that he had made about 60 Court appearances to give evidence about LCN results.”

The Crown case in *R v Lepper* was that the accused had raped the victim, and that his identity was proved by DNA that he left at the scene on the ground, some of which had transferred to the complainant’s underwear and to one of her shoes. His defence was that it was not he who did it, that it was not his DNA on the victim’s clothing, but that if it was his, it got there because he had previously had consensual intercourse with someone else at that location.

The LCN DNA technique had been used in Birmingham to establish a DNA profile from the small amounts of DNA on the underwear and shoe. Once that profile was ascertained it was possible to match it in Auckland with DNA found in semen obtained from the ground where the rape occurred, and with a DNA profile that was on record from the accused.

One can see from this way of looking at the case that it may well not have seemed essential to defence counsel to cast doubt on the fact that it was the accused's DNA that was on the victim's clothing, since he was offering an explanation for its presence. This may be why no great effort seems to have been made at trial to discredit the LCN DNA technique. If this was indeed a case where it was not crucial to challenge the technique, it cannot be said that it establishes that, as far as the law of New Zealand is concerned, the LCN DNA technique is recognised as an acceptable basis for expert opinion.

What should have been the real focus of the dispute in *R v Lepper* was the risk of contamination of the DNA sample from the victim's clothing by a sample of the accused's DNA that was present in the laboratory at the same time.⁴ One of the shortcomings of the LCN technique is that, since it multiplies DNA from a very small sample, as small as that contained in a single cell, that sample can easily be contaminated by DNA in cells from persons other than the actual offender, so that it may not be the offender's DNA that is multiplied and analysed.⁵

⁴ Issues that should be taken into account are the probability of a random match in the test results (this can occur when, according to the method of DNA analysis that is used, samples from two different people produce the same DNA profile), and also the probability of a false positive result in the comparison of samples (which might occur due to error in the collection or handling of samples, misinterpretation of test results, or incorrect reporting of test results). The experts may have little or no information about the latter of those values, the focus of their evidence being on a version of the random match probability, but both are still logically relevant and may have a significant effect on the estimate of the likelihood that the samples do in reality match. See further, William C Thompson, Franco Tarone and Colin GG Aitken, "How the Probability of a False Positive Affects the Value of DNA Evidence" *J. Forensic Sci.*, January 2003, vol 48, No 1, and available at

http://www.bioforensics.com/conference04/Actual_Innocence/JFS%20False%20Pos.pdf . I am grateful to Dr Thompson for bringing this paper to my attention. See also Professor Allan Jamieson , <http://www.journalonline.co.uk/article/1003857.aspx> , who concludes "The scientific issue is the degree of confidence that can be placed in the results and the consequent opinion. The legal issue is whether the destructive techniques meet the requirements of physical evidence acceptable in court".

The importance of independent evidence against the accused to establish prior probabilities, is recognised in the following comment from the Secretary of State for the Home Department in the House of Commons, 17 May 2006 (Hansard col 1035W): "There is no known case of an innocent passer-by being wrongly convicted solely on the basis of their DNA being found at a crime scene. A match between DNA taken from an individual and that from a crime scene is intelligence, indicating that the individual has been present at the scene. The police and Crown Prosecution Service take account of the fact that there may be an innocent explanation for this. Home Office Circular 58/2004 to chief officers states that there should be further supporting evidence, in addition to the match, before someone is charged. This is also reflected in guidance issued by the Association of Chief Police Officers, and additionally the Crown Prosecution Service make it very clear that in every case involving a DNA profile, there must also be appropriate supporting evidence before a case can proceed."

⁵ See Fournay, DesRoches and Buckle, "Recent Progress in Processing Biological Evidence and Forensic DNA Profiling – A Review 2004 – 2007" in *15th International Forensic Science Symposium Interpol - Lyon 23-26 October 2007 Review Papers*, at p 676: "Several recent studies highlight our lack of understanding regarding the potential for casual contact DNA being present at the crime scene. Although experiments on LCN represent difficult control challenges (absence of DNA), [a study has] ...

The need to handle samples carefully was mentioned by Weir J in *Hoey*, para 46:

“...The Defence submit, correctly in my judgment, that it is for the prosecution to establish the integrity and freedom from possible contamination of each item throughout the entirety of the period between seizure and any examination relied upon. They contend, and I accept the contention, that the court must be satisfied by the prosecution witnesses and supporting documents that all dealings with each relevant exhibit have been satisfactorily accounted for from the moment of its seizure until the moment when any evidential sample relied upon by the prosecution is taken from it and that by a method and in conditions that are shown to have been reliable. This means that each person who has dealt with the item in the intervening period must be ascertainable and be able to demonstrate by reference to some proper system of bagging, labelling, and recording that the item has been preserved at every stage free from the suspicion of interference or contamination. For this purpose they must be able to demonstrate how and when and under what conditions and with what object and by what means and in whose presence he or she examined the item. Only if all these requirements have been satisfactorily vouched can a tribunal have confidence in the reliability of any forensic findings said to have been derived from any examination of the item.”

The prosecutor’s fallacy

Aside from not focusing on the question of contamination, to the extent that there was any issue about whether the accused’s DNA was present on the complainant’s clothing, there is another unsatisfactory aspect to the decision in *R v Lepper*. This arose out of a submission, unsoundly based in my view, that the Auckland scientist’s reporting of the identification of the DNA as coming from the accused, involved the prosecutor’s fallacy. But all the scientist – the one in Auckland - was saying was that there was extremely strong scientific support, arising from the DNA analysis, partly done in Birmingham and partly in Auckland, for the conclusion that the DNA at the scene came from the accused. That is just a report of the laboratory results. It did not purport to be an

demonstrated that a person speaking less than 30 seconds from a distance ranging between 69-115 cm can deposit sufficient amounts of DNA that the speaker can be identified from objects or persons directly in front of them.” Other sources of contamination such as fingerprint brushes, laboratory plastic ware and water have been recognised.

indication of how likely it was that the accused was guilty, which is a hallmark of the prosecutor's fallacy.⁶

The error of reasoning called the prosecutor's fallacy can occur when the issue of the likelihood of the accused being guilty is considered. That likelihood obviously requires assessment of more than simply the fact that the accused's DNA was there. In particular, it requires consideration of the likelihood that it got there innocently. I have discussed the prosecutor's fallacy in a draft paper.⁷ Unfortunately the references in *Lepper* to the prosecutor's fallacy lack clarity, as does the treatment of the same topic relied on by counsel for the appellant and quoted at para 14 of *Lepper*, in *Pringle v The Queen* [2003] UKPC 9 at paras 18 – 20. There, Lord Hope, delivering the judgment of the Privy Council, uses a rather ineptly described example, and identifies what the prosecutor's fallacy is, but then suggests that it would be wrong for the scientist to say it was the accused's DNA (while at the same time being alright for the scientist to say what the likelihood of that was).

The correct proposition is that the scientist may say what the likelihood of the DNA being from the accused is (numerically, eg in *Lepper* a likelihood of 20,000,000,000 to one that it was from the accused, or verbally, eg "very strong scientific support for the proposition that the DNA came from the accused"), and I suggest, the scientist should be able to say that in her opinion the DNA was from the accused, much as a fingerprint expert may say that in his opinion the prints from the scene and the accused are identical; but the scientist may not, in order to avoid the prosecutor's fallacy, say that this means that it is very likely (in the same, or any, numerical or verbal terms) that the accused is guilty of the crime charged.

⁶ My usage of the term "prosecutor's fallacy" here differs slightly from that employed in the academic community. Practising lawyers tend to differentiate between counsel and witnesses, and the term "prosecutor's" suggests that prosecuting counsel is being referred to. The prosecutor will be arguing for a finding of guilt, and the corresponding probability in Bayes' Theorem is the probability of guilt. Witnesses, however, can make the same error of logic, which is either or both of a transposition of the conditional and an ignoring of the priors. The term "prosecutor's fallacy", coined by William C Thompson and Edward L Schumann in "Interpretation of Statistical Evidence in Criminal Trials – The Prosecutor's Fallacy and the Defense Attorney's Fallacy" in *Law and Human Behaviour* Vol 11, No 3 (1987) 167, at 171, is applied to both witnesses and counsel (notwithstanding the narrower suggestion in their title). Accordingly, the witness who reports her laboratory results could make the logical error of transposing the conditionals, not to suggest that the accused is guilty, but to falsely equate the likelihood of getting the test results if the accused was the source of the sample of DNA, with the likelihood that the accused provided the sample, given the test results. I am grateful to Dr William C Thompson for his helpful comments on my references to the prosecutor's fallacy.

⁷ Available at <http://www.geocities.com/veneziophile/Propen.pdf>.

Interestingly, the ESR currently defines the likelihood ratio as “a statistical term that measures the value of a piece of evidence. Equal to the probability of seeing a piece of evidence given the prosecutor's hypothesis, divided by probability of seeing a piece of evidence given the defence hypothesis.”⁸ This definition could lead the fact-finder into accepting the prosecutor's fallacy. If the expert witness talks about the prosecution hypothesis, this could suggest the hypothesis that the accused is guilty, and comparing it with the probability of the defence hypothesis, that the accused is innocent,⁹ sets the scene for the fallacious conclusion that this is the ratio of the probability of guilt to probability of innocence. This form of the prosecutor's fallacy involves, in Bayesian terms, ignoring the priors. All the scientist is concerned with is the probability of obtaining the result of the analysis given that the sample came from the suspect, divided by the probability of obtaining the same result given that the sample did not come from the suspect. That ratio is the scientist's likelihood ratio, and is properly offered by an expert witness.

The risk of contamination

What should have been the focus of the appeal in *Lepper* is the evidence of the likelihood of the accused's DNA being at the scene innocently, and being innocently transferred to the complainant's clothing. There was apparently some evidence about this at the trial, as the Court of Appeal referred, at para 36, to the directions by the trial judge, Miller J, to the jury:

⁸ See <http://www.esr.cri.nz/competencies/forensicscience/dna/DNAglossary.htm> . There is some elaboration of this at <http://www.esr.cri.nz/competencies/forensicscience/dna/interpretation.htm> but there is also a repetition of a flawed description of the Bayesian method: this “is a statistical method that combines a likelihood ratio with additional information to produce an overall estimate of the strength of a piece of evidence.” The error here is in saying that combining the likelihood ratio with other information (which must mean the priors) produces an overall estimate of the strength of a piece of evidence: the correct proposition is that the combination actually produces another ratio (called the posterior ratio) - the probability of guilt divided by the probability of innocence; the strength of the “piece of evidence” (ie the DNA sample from the crime scene), to the extent that “strength” has any meaning here, is indicated by the likelihood ratio itself, not by the posterior. The “overall” strength of the evidence is a different concept and is appropriately confined, forensically, to the fact-finder's domain; the jury might, for example, think that the accused's DNA sample was planted at the crime scene by the police, in which case the overall strength of the DNA evidence would be zero. The ESR site does not give much attention to LCN DNA analysis. It defines LCN, as “Low Copy Number. Refers to a relatively new method of DNA analysis that uses increased PCR cycle numbers to detect extremely small amounts of DNA”, but does not appear to mention LCN analysis further. It does not mention problems with validation. A point of comparison is the reference on the site to mitochondrial DNA (defined as “a relatively new method of DNA analysis that examines the DNA in mitochondria, which are small organelles responsible for producing the energy in cells. Mitochondrial DNA techniques are not as discriminating as traditional methods, but because mitochondria are resistant to degradation, it can be very useful in identifying badly burnt or decomposed samples”) and adds “The forensic analysis of mitochondrial DNA is a relatively new technique that is in the process of being validated for use at ESR [dated Wednesday, 14 September 2005].”

⁹ Of course the defence hypothesis need not be that the accused is actually innocent, instead it could be, and in practice often is, that there is a reasonable doubt.

“He directed the jury that the defence case was an acceptance by the appellant that his semen had been found on the ground in the little park, because he had had unprotected, consensual sex with another woman there not long before the complainant was raped. His DNA had been transferred from the ground to the complainant’s clothing and shoe during a rape by another man who was wearing a condom. Miller J also reminded the jury about the evidence as to rainfall in Palmerston North over the days preceding the rape, and the expert evidence as to the likelihood that the appellant’s DNA could have remained on the ground in the park for a number of days.”

The Court found no inadequacy in the trial judge’s summing up on this aspect of the case.

It did not appear to the Court in *Lepper* that the LCN DNA analysis technique was controversial. Not only did it have the evidence of Dr Whittaker, but there was also some English case law, referred to as follows in para 32:

“[Counsel for the appellant] referred to a discussion about LCN DNA analysis in *R v Bamber* [2002] EWCA Crim 2912. From our own researches we can add references to profiling using the LCN technique in *R v Shirley* [2003] EWCA Crim 1976; *R v King* [2001] EWCA Crim 1980 and *R v Mitchell* [2004] EWCA Crim 1928. These cases indicate that evidence of DNA profiling resulting from the LCN technique now has general acceptance in British criminal Courts.”

Only the first of these cases, *R v Bamber*, is currently publicly available online (see in particular para 503 of that case, where dangers in interpreting the results are referred to). These cases are not cited in *R v Hoey*.

How not to be an expert witness

As to Dr Whittaker, his evidence had less impact in *R v Hoey*. After referring to criticisms made of the LCN DNA technique, Weir J said, at para 63:

“I was concerned about the manner and content of the response of Dr Whitaker to these criticisms. He was most unwilling to accept

that the continuing absence of international agreement on validation of LCN (unlike SGM+) or the variations in the way in which it was being implemented in different countries should be any impediment to the ready acceptance by any court of the Birmingham approach. I found him inappropriately combative as an expert witness and his unwillingness to debate constructively the various matters put to him was unhelpful in the extreme. By contrast, his colleague Dr Gill, while understandably concerned to endorse the views of Dr Whitaker where he properly could, was willing to carefully consider the propositions put to him by Mr Pownall QC and, where appropriate, to disagree with his colleague on important issues both general and specific to the case. In my view it was extremely fortunate that the prosecution decided late in the day to call Dr Gill as his evidence greatly helped to inform and bring some objectivity to the debate."

Dr Whitaker had, in contrast, impressed the judge in *Murdoch*,¹⁰ who said:

"[34] Dr Whitaker impressed me as a careful and reliable witness. There is no evidence to contradict the evidence of Dr Whitaker. Although reference was made to published articles for specific purposes, no article was put to Dr Whitaker challenging the reliability of LCN or Dr Whitaker's evidence generally and on specific issues."

On the other hand, in *Murdoch*, a defence scientist was less impressive:

"[46] It is unnecessary to canvass the evidence of Dr Both in detail except to observe that her evidence did not shake my confidence in the evidence of Dr Whitaker. Dr Both has had very little practical experience with the LCN methodology and her knowledge of LCN is derived primarily from reading publications. In certain respects Dr Both displayed an unfortunate intransigence."

There are lessons here for those who would be expert witnesses.

¹⁰ Above, note 2. Interestingly, it was thought to be significant in *Murdoch* that publication of a paper on LCN DNA analysis did not generate criticism; this was taken to be a sign of acceptance of the validity of the technique. In principle, this must, with respect, be wrong. It places the onus on laboratories that may not be as well financially supported as the proponent organisation to divert resources to work they may not be set up to do. Silence, in science, is not the same as validation.

Balance and acknowledgment of limitations

An italicised caution is included in a report by Dr Whitaker in *R v Foreman* (No 12):¹¹

“The relevance of these results require [sic] careful consideration in the context of this case given the sensitivity of the tests employed and the possibility that the DNA tested is unconnected with the offence under investigation. Although a DNA profile has been obtained, it is not possible to identify the type of cells from which the DNA has originated, neither is it possible to state when the cells were deposited.” (his emphasis)

An issue in this case was whether the accused’s DNA was on cartridges that had held the bullets that killed the victim. Dr Whitaker’s report was considered by the prosecution to be too tentative to have sufficient evidential value to be admissible. The defence obtained the opinion of another scientist who had gained some expertise with the LCN technique (but now called the LNC technique), and she concluded that if Dr Whitaker’s results were combined with the accused’s DNA profile, the accused would be excluded as a contributor to the DNA on the cartridges. Therefore, the defence wanted Dr Whitaker’s report introduced into evidence. There were objections to this based on hearsay, but they need not concern us here.

What qualifies as “expert” testimony?

In *R v Hoey*, Weir J concluded with the following observation on the need for some form of safeguard against unreliable evidence being admitted as expert testimony:

“[64] I have devoted a little space to this subject because of my concern about the present state of the validation of the science and methodology associated with LCN DNA and, in consequence, its reliability as an evidential tool. The House of Commons Science and Technology Committee published on 25 July 2005 the Government's response to the Committee's Report "Forensic Science on Trial" which had been published on 29 March 2005. At paragraph 55 the Committee's comments on validation are

¹¹ 19/5/08, Simon France J, HC Napier CRI-2006-041-1363.

repeated together with the Government's response. Both merit reproduction here:

'55. The absence of an agreed protocol for the validation of scientific techniques prior to their being admitted in court is entirely unsatisfactory. Judges are not well placed to determine scientific validity without input from scientists. We recommend that one of the first tasks of the Forensic Science Advisory Council be to develop a "gate-keeping" test for expert evidence. This should be done in partnership with judges, scientists and other key players in the criminal justice system, and should build on the US *Daubert* test.'

"The Government responded:

'....the Home Office, ACPO and APA are planning to consult with stakeholders on the issue of quality regulation in forensic science. The establishment of a regulator is one of the options to be considered, as is how the courts can be supported in appropriately weighing scientific evidence.'

"When Dr Gill was asked about this in the course of his evidence he said that he did not know whether anything had yet been done by government to further the plan.^[12] If it has not then I consider that the evidence given in this case by the FSS witnesses reinforces in the clearest way possible the need for urgent attention to this task for I am not satisfied that the publishing of two journal articles describing a process invented by the authors can be regarded without more as having "validated" that process for the purpose of its being confidently used for evidential purposes."

Under s 25 of the Evidence Act 2006[NZ] the opinion of an expert must be substantially helpful to the fact-finder in understanding other evidence in the proceeding or in ascertaining any fact that is of consequence to the determination of the proceeding. The intention of the Law Commission in drafting this provision was that the courts should be free to use the United States developments of the common law in *Daubert v Merrell Dow Pharmaceuticals Inc*

¹² We may observe here that in *Murdoch*, above, note 2, the court may have had the impression that the LCN DNA procedure did have the accreditation of an official regulator: see para 24 – 26.

509 US 579 (1993), promoting the judicial gatekeeping function. For similar developments in Canada, see *R v J (JL)* (2000) 148 CCC (3d) 487 (SCC). This may not necessarily mean that a discipline must be subject to scientific rigour (*R v Luttrell* [2004] 2 Cr App R 31 (CA)), and it may not even be necessary that the method on which the opinion is based have been accepted in the scientific community: *R v Calder* 12/4/95, Tipping J, HC Christchurch T154/94. Instances of this sort of slippage, if that is indeed what it is, might be avoided if an independent body was established to create guideline criteria for determining when an opinion can qualify as that of an expert.

And so, back in Europe ...

A review conducted at the request of the prosecution service has concluded that this form of DNA analysis can be of sufficient reliability for forensic use, but this view has been criticised.¹³

Germany recently had, on the basis of DNA evidence, a thrilling serial killer on the loose, “the Phantom of Heilbronn” aka “the Woman Without a Face”, but eventually doubts were cast on this linking of the murders. This was because the DNA at 40 crime scenes came from contaminated cotton swabs. It was considered possible that the DNA came from the person who packed the cotton swabs in the factory before they were supplied to the police.¹⁴ This would illustrate the ease with which DNA can be left on an object if the factory worker was not wearing gloves. Testing of several hundred unused cotton swabs for contamination did not reveal any evidence of rogue DNA, so factory conditions are usually adequate.

“Investigators now suspect that certain batches of cotton swabs were contaminated before delivery, which could have happened during the production process or when the cotton was picked. They are currently looking into how the cotton swabs are made to see how the DNA might have snuck in.”

The report notes the opinions of experts that cells from skin or sweat can survive the sterilisation process.

¹³ See the comments of Professor Allan Jamieson:

http://www.freepressreleases.co.uk/Press_Releases/Legal_and_Law/LCN_DNA_2008041516946/

¹⁴ See the online edition of *Spiegel*, 27 March 2009:

<http://www.spiegel.de/international/germany/0,1518,615608,00.html> .