DNA Profiling: Forensic Science under the Microscope[1]

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Forensic scientists and crime investigators have long dreamed of being able to identify the origin of blood and other body fluids with certainty. The currently developing techniques of DNA profiling promise a degree of accuracy greater even than current methods of fingerprinting suspects.

DNA profiling allows examination of human biological material at its most fundamental level - the deoxyribonucleic acid (DNA) molecule. This molecule, which is found in every living cell within the body, carries the genetic information that makes one individual separate and distinct from every other individual. The DNA profiling process involves extracting the DNA from a specimen such as semen, blood or tissue and chemically dividing the DNA into fragments. Because of the naturally occurring variations in the DNA molecule from one person to another, the sequence of fragments forms a pattern, similar to a bar code found on items in supermarkets, that is to all intents and purposes unique to the individual (Phillips 1988, p. 551; Thompson & Ford 1989). The different forms of DNA testing use different numbers of various sensitive probes and differ in their percentage of result certainty. DNA testing, however, is distinguished by its particularly low false positive rate. So long as stringently developed laboratory procedures are painstakingly adhered to, DNA profiling evidence should be as reliable as any form of scientific evidence that is brought before the courts.

Many claims have been made by the competing scientific houses marketing their versions of DNA profiling for the accuracy rates of their form of DNA testing. It is clear, though, that DNA profiling represents a dramatic step forward in the capacity of science to tell us whether two body samples obtained at different times come from the same individual. This paper identifies the relevance of the techniques for the legal system, especially in light of the *Castro* (Unreported. Supreme Court of the State of New York County of Bronx, 14 August 1989) decision in the United States, focusses on matters likely to be contentious for lawyers, and queries the civil liberties issues that accompany the development of DNA profiling techniques.

Relevance for the Law

DNA profiling has particular application to the criminal law because of the possibility that it offers of determining whether blood or semen deposits located at the scene of a

crime come from a person suspected of having committed the crime. This is especially useful in investigations into sexual offences. The critical advantage of DNA profiling over more traditional serological tests is that the DNA profile obtained from a vaginal swab or a sample of blood can be matched with the sample of a suspect tested with near certainty. It is much more specific than traditional tests for typing blood such as ABO typing, HLA (human leucocyte antigen) typing or typing of red cell enzymes and serum proteins. If a combination of vaginal and seminal material is present, this can usually be seen and is susceptible of interpretation as a mixture in the vast majority of cases (Thompson & Ford 1988, p. 64). This was not so with traditional methods where the danger of contamination was significant.

Whenever an assailant is injured or leaves any form of body sample at the scene of a crime (such as hair roots, saliva, blood, semen, etc.), the DNA profile has the potential to identify the person from his or her own deposit of biological evidence. It can also exculpate the suspect. DNA profiling provides the possibility of identifying victims of `anonymous crimes' such as hit-run accidents. As well, it can give a clear indication whether the same person is responsible for a series of crimes, such as serial rapes.

DNA profiling has been used extensively overseas for paternity testing because of its capacity to determine to a high degree of certainty whether claims to be a child's parents or grandparents are valid. The application of such information is wide, varying from intrafamilial disputes, to resolving the fatherhood of a child for rape victims, to rights to social security benefits, to issues of inheritance. It is also of major significance to governments seeking to confine immigration to family reunion categories (Jeffreys, Brookfield & Semeneoff 1986; Freckelton forthcoming(a)) and is being used extensively in Britain for this purpose. This context also provided the first encounter for the Australian legal system with DNA technology during 1988 when DNA testing showed conclusively that a young man seeking to migrate to Australia was in fact the son of a refugee already living in Victoria.

No Panacea

Limited application

Although DNA profiling has been claimed to be likely to have a very significant impact on the legal system should authorities have power to take intimate body samples without subjects' consent, these claims have been significantly exaggerated. The greatest application of the new techniques is in relation to paternity determination - in the family dispute and immigration areas. Division 8 of the *Family Law Act 1975* (*Cwlth*) and *Family Law Regulations 21A - 21G* already deal with the uncooperative test subject, allowing the magistrate or judge to draw appropriate conclusions about obligations to pay maintenance, etc. should the subject refuse to comply with parentage tests ordered by the court.

In the criminal arena, DNA profiling will have a more limited impact. It is rare that the perpetrator of a serious crime leaves body samples amenable even to this new form of testing at the scene of the crime. In the area where DNA testing has its greatest criminal investigative application - allegations of sexual assault - its real utility can be overstated. Most victims do not, and are unlikely to begin, reporting to police. Many of these who do report do so too late for DNA profiling to be an option. Of those who do report in time, the occurrence of sexual intercourse is often not an issue in dispute. The existence or non-existence of consent will be the critical matter. DNA profiling can offer nothing to resolve this problem. However, in the case of serial rapes or where there is a real doubt about the identity of the assailant, DNA profiling potentially has a great deal to offer.

Cost and time

However, DNA profiling is neither quick nor cheap. The testing process takes, on current estimates, between 9 and 18 days per sample. Depending on the system used, the cost will vary but Dr Gutowski of the Victorian State Forensic Science Laboratory has publicly estimated employment of the Lifecodes System at between $100 and $150 per test for materials alone. Some estimates are higher. This factor will tend to limit the employment of DNA technology to those occasions when it is genuinely thought that testing is likely to yield useful results. DNA extravaganzas such as that seen in the `Pitchfork Rapist' case in England, where an entire township was tested, are unlikely to be repeated in times of economic restraint.

Quantity of samples

DNA technology also requires significant amounts of samples, unless polymerase chain reaction procedures are employed to amplify quantities of testable body tissue. Such techniques reduce the accuracy of DNA profiling significantly. While this is likely in due course to change, current technology requires at least 50 _L of blood, 10 _L of semen or at least 10 hair roots for testing. This is a significant limiting factor for the feasibility of DNA testing.

Fallibility

Moreover, DNA profiling is not infallible. It has recently been the subject of serious challenge in a United States court (*The People v. Castro*, Unreported decision 14 August 1989; *see also* Lander 1989; Thompson & Ford 1988; Thompson & Ford 1989; Beeler & Wiebe 1988) and has to be acknowledged as carrying with it some risk on the basis of subjectivity of interpretation. This is not to maintain that it is an unreliable testing procedure - quite the contrary - but rather to acknowledge that it is not as infallible as early claims by its commercial entrepreneurs suggested. The 1989 *Castro* decision, which is discussed in detail below, usefully details a series of laboratory procedures that have the potential to render unreliable the results of DNA profiling tests.

Limited police powers

A significant impediment in many jurisdictions to the employment of DNA technology is the absence of police powers to compel suspects to provide a body tissue sample (usually blood) for analysis.

In England, where the technology was first developed, `intimate body samples' can only be taken from a person in police detention if the person acquiesces and if a police officer of at least the rank of superintendent authorises it. The officer can only do so if he or she has `reasonable grounds' for suspecting the involvement of the person in a serious arrestable offence and for believing that the sample will tend to confirm or disprove the suspect's involvement. Where consent is adjudged by a court to have been refused `without good cause' (undefined), a judge or jury may draw adverse inference from the refusal if they wish (s. 62, *Police and Criminal Evidence Act* (UK)).

In Australia the Victoria Police Force is alone in having no power to compel the provision of body samples. New South Wales, Queensland, Western Australian and South Australian legislation allows a police member of or above the rank of sergeant to compel a medical examination of a person in custody for an offence if the member has reasonable grounds for believing that such an examination will afford evidence as to

the commission of the offence (s. 353A(2) *Crimes Act 1900 (*NSW*)*; s. 259 *Criminal Code 1899 (*Qld; s. 236 *Criminal Code 1899 (*WA*)*; s. 81(2) *Police Offences Act 1953* (SA)). The Tasmanian legislation differentiates between intimate body sampling in relation to the offence with which the person in custody has been charged and in relation to other offences with which the police believe him or her to have been involved (ss. 6 and 7 *Criminal Process (Identification and Search Procedures) Act 1976 (*Tas.)). With respect to the former, the legislation is similar to that of most states, but with respect to the latter, the consent of a magistrate is required (s. 145, Northern Territory*h respect to the latter, the co*h resh respect to the latter, the consent of a magistrate is required (s. 145, Northern Territory Police Administration Act 1979 giveh respect to the latter, the consent of a magistrate is required (s. 145, Northern Territory Police Administration Act 1979 giveh respect to the latter, the consent of a magistrate is required (s. 145, Northern Territory Police Administration Act 1979 giveh respect to the latter, the conseh respect to the latter, the consent of a magistrate is required (s. 145, Northern Territory Pprofiling. The 1966 case of *Schmerber v. California* 384 United States 757 [1966] ruled on the constitutionality of a doctor's extraction of blood, at police direction, from a person suspected of having been intoxicated at the time of an accident, contrary to his expressed wishes. The Supreme Court rejected the driver's Fourth Amendment claim that extraction of blood against his will was an unreasonable search and seizure. It also denied that it represented a violation of the driver's Fifth Amendment privilege against self-incrimination basing its decision on the distinction between testimonial or communicative evidence, and acts which it classified as noncommunicative in nature. Finally, the court denied that such a procedure was a violation of the Fourteenth Amendment right to due process.

It has, however, been argued that: `Permitting the government to force suspects to give blood samples raises a spectre of coercion which should not be tolerated under the Constitution' (*The People v. Castro* p. 28ff). It has been suggested that the likely frequent use of DNA profiling against the will of suspects may infringe against the Fifth and Fourteenth Amendments' due process clauses (*The People v. Castro* p. 28 ff).

The court may make an order directing a relevant suspect to give a sample of his or her blood if the court is satisfied that:

a) there are reasonable grounds to believe that the relevant suspect has committed the offence in respect of which the application is made; and

b) material reasonably believed to be from the body of a person who committed the offence has been found -

   i) at the scene of the offence; or

   ii) on the victim of the offence or on anything reasonably believed to have been worn or carried by the victim when the offence was committed; or

   iii) on an object reasonably believed to have been used in or in connection with the commission of the offence; and

c) there are reasonable grounds to believe that the taking of the sample of blood from the relevant suspect would tend to confirm or disprove his or her involvement in the commission of the offence; and

d) in all the circumstances, the making of the order is justified.

Notably, the court is not obliged to make the order. However, its grounds for failing to do so are not usefully explicated. Moreover, the meaning of subsection (d) is entirely unclear and the section can only be described as the provision of the widest possible, but unguided discretion to the court. It is not possible to predict at this stage what arguments could be properly put to address the issue of when the order would not be `justified'. The amendments, however, do provide for a system for destruction of samples if a person is not charged within 6 months of the time of the taking of the sample or if the person is acquitted of the charges. There are criminal penalties for breach of this regime. At the time of writing, the draft bill had received strong support from police and related organisations but had been criticised by legal and medical groups. The government is expected to introduce the bill, or a variant on it, into State Parliament by early 1990.

Civil Liberties Issues

Those with a concern about civil liberties (Cuthbert 1989; Freckelton 1989b) will be uneasy on a number of grounds with the granting of powers to the police to take intimate body samples without the subject's consent.

Self-incrimination

Our legal system has traditionally eschewed forcing people to incriminate themselves by becoming the instruments of their own downfall. That principle has suffered a number of encroachments in recent years. Thus, drivers pulled over by police or involved in accidents can be forced to provide a breath or blood sample and defendants intending to claim an alibi as a defence are now required to provide advance notice to the prosecution. In some jurisdictions medical reports have to be exchanged. Other than that, our legal system has insisted upon the primacy of the privilege against self-incrimination and has orchestrated a balance between defence and prosecution with this as its basis. The prosecution has to prove its case without assistance from the accused person.

As a matter of principle, if we are to provide police with the power to insist upon the provision of intimate body samples for DNA analysis under any circumstances, even utilising recourse of some kind to a magistrate's order, we must recognise the significance of our decision and re-assess the balance of the criminal justice system accordingly. DNA profiling will inevitably be a boon primarily to the prosecuting authorities. The issue in the self-incrimination context is whether the advantage given to the prosecution by being able to force the suspect to self-incriminate in this way will operate unfairly.

The accuracy and reliability of DNA profiling properly conducted in well-functioning, independent laboratories is of a very high order. Thus, if such conditions existed, there would be little danger of false-positive or incorrect findings were intimate body samples to be extracted from suspected persons under compulsion. So far as the privilege against self-incrimination is concerned, the issue for Australians is whether a meaningful distinction exists between evidence that is compelled in the form of words and evidence that is actually tangible.

Accountability of police

Many important issues revolve around the means by which samples are obtained from suspects and how the information derived from those samples is placed before tribunals of fact. A prerequisite for giving the police the extra powers that they seek to take intimate body samples should be our preparedness to trust them to adhere to proper

procedures and to police their own abuses adequately. There is ample and recently documented reason for believing that the present system for investigating complaints against police, depending as it does on an unsatisfactorily performing Internal Investigation Department (IID) of the Victoria Police, is an inadequate check on police abuses (Selby 1988; Freckelton & Selby 1989). Until that is remedied by the proven success of Ombudsmen, Police Complaints Authorities or by governments in implementing independent Criminal Justice Commissions (as recommended by Commissioner Fitzgerald) with sufficient powers to investigate police impropriety, further powers should not be given to police.

A no-win situation

Although police do not presently have the powers that they would wish to compel provision of intimate body samples, it is significant that they have been singularly successful in obtaining fingerprints, photographs and intimate samples from suspects when they want them. In England the police were able to prevail on approximately 5,000 individuals to cooperate with their inquiries by providing such samples in one case. Concerns have already been raised about the processes by which some of those samples were obtained. Recently in New Zealand, in the Teresa Cormack case media pressure was extreme in `encouraging' the few suspects who had not `cooperated' to provide the samples sought by the prosecuting authorities. This process left a great deal to be desired with a form of media involvement in the criminal investigation process that should not be repeated. The imposition of pressure on individuals to cooperate with police wishes that they have their photographs taken or their fingerprints recorded has been and continues to be a fertile source of complaints against police conduct. Unsuccessful bids by defence counsel have not infrequently been made to have such improperly obtained information declared inadmissible on public policy grounds. Considerable distress has also been caused to people when they have not been charged, or have been acquitted or not convicted of criminal charges, but have met with no satisfaction in having such records stricken from police data banks.

The problem arises in two ways. First, if legislation does not empower police under certain circumstances to take intimate body samples without the suspect's consent, there is an incentive for police to exert unacceptable pressure on suspects to agree to provide such samples. There is every reason to believe that similar problems or perhaps more serious ones will be experienced if the present situation continues in which police have to rely on their powers of `persuasion' to obtain evidence which could be highly probative in the courtroom.

Secondly, the alternative mooted by the draft Victorian legislation and that existing in many other jurisdictions, permits police, through the aegis of a cooperating medical practitioner, to use all reasonable force to subdue an objecting individual and by intrusive means take from him or her an intimate body sample. The use of any form of coercion or force in police stations should be denounced by all concerned with civil liberties in our community. There are also real difficulties with the notion that medical practitioners be suborned into, or in any way involved in such a process.

Informed consent

The taking of intimate body samples from an unwilling subject, usually by blood sample, is inevitably an intrusive procedure. Doctors, nurses and dentists in Victoria and elsewhere have all expressed concern about such a procedure without the informed consent of the patient. The Victorian Council for Civil Liberties and the Victorian Criminal Bar Association (in 1989 submissions to the Attorney-General's Department) have argued that such a procedure represents an act of violence that is incompatible

with proper behaviour in police stations and with modern notions of defensible medical practice.

Targeting of the suspect

A problem with the Victorian legislation is the fact that it is the rights of `the suspect' which are under threat. It is not necessarily the person who has been arrested and charged with the offence, in respect of which it is desired by investigating authorities to extract an intimate body sample, who is the target of the mooted legislation. It is merely the `relevant suspect' of a serious crime.

It is this writer's view that because of the legitimate concerns about:

- the abrogation of the privilege against self-incrimination;
- the continuing lack of accountability for abuse of existing police powers;
- the accountability of many forensic laboratories to police commands;
- the inappropriateness of the use of force in police stations;
- the inappropriateness of coercive, medically intrusive measures being performed without informed consent;
- the inappropriateness of targeting of `suspected persons'; and
- the fact that DNA profiling has limited application to the overall quality of criminal justice

the approach proposed by the Victorian Attorney-General should not be accepted by government. Although the English legislation has the conceptual and not insignificant problem that it allows adverse inferences to be drawn from the legitimate exercise of a right to refuse to undergo a testing procedure, in this writer's view it is preferable to the approach being proposed by the McCutcheon Bill.

Admissibility of DNA Evidence

British and Australian courts have not had occasion as yet to determine definitively what should be the criteria for receiving evidence of new scientific techniques or theories. The approach has generally been a laissez-faire one, allowing the evidence to be put before the tribunal of fact, so long as it is relevant and does not offend one of the long cherished rules of evidence.[2] This has left the responsibility with the judge or jury to decide how much weight should be given to the expert testimony to which they have been exposed.

However, there are increasingly strong indications that the 1923 United States decision of *Frye v. United States* 293 F1013, 1014 [1923] is at the least being absorbed into the law of Australia. It was held in that case that:

> Just when a principle crosses the line between the experimental and the demonstrable stages is difficult to define. Somewhere in this twilight zone, the evidential force of the principle must be recognised, and while the courts will go a long way in admitting expert testimony deduced from a well recognised scientific principle or discovery, the thing from which the deduction is made must be

> sufficiently established to have gained general acceptance in the particular field in which it belongs.

In 1977 the New South Wales Court of Appeal in *R v. Gilmore* [1977] 2 NSWLR 935 went some way towards introducing into Australia the *Frye* test, citing the United States case, adopting its language of `field of expertise' and using it in the context of voice identification evidence. *Gilmore* was followed in 1983 by the same court in *R v. McHardie and Danielson* [1983] 2 NSWLR 733. A hint of a similar approach had come in 1976 in Queensland when the Full Court of the Queensland Supreme Court had confronted difficulties in relation to the expertness of a witness called to testify as an expert upon the effect of wearing seat-belts. Justice Dunn focussed on the need for the judge to find as a fact that `there exists relevant technical or scientific knowledge' not possessed by the fact-finder and a need for that knowledge. He held that:

> The state of the evidence was such that, in my opinion, whilst there may be some room for difference of opinion upon the matter, it has not been shown that the learned trial judge was wrong in the relevant sense in his conclusion that `the study of seat-belts' has become a recognised field of specialist knowledge (*R v. McHardie and Danielson*).

In November 1985 the Queensland Court of Criminal Appeal rejected expert odontology evidence upon the identity of bite marks found on the body of a victim. Justice Kneipp held that there was:

> A body of eminent opinion which holds that valid identifications cannot be made by reference only to bruise marks or they should be referred to only for the purpose of excluding suspects and not from (sic) positive identification (*Carroll* [1985] 19 A Crim R 410).

Similar evidence relating to bite marks upon a victim and their similarity to the dentition of the accused person fell to be considered by the Northern Territory Court of Criminal Appeal in 1987 in the case of *Lewis* [1987] 29 A Crim R 267. Justice Maurice specifically referred to the previous Queensland odontology case and the passage cited above. Neither he nor his brother judges dissented from it. However, they stopped short of explicitly adopting the *Frye* test. Justice Maurice held that

> the jury should (not) have been permitted to place any reliance on the dentists' opinions. It really matters not whether that conclusion is supported by saying the evidence was strictly inadmissible, or its prejudicial effect far outweighed any probative value it may have had, or simply that it would be unwise to place any reliance on it (*Lewis* [1987] 29 A Crim R 267, p. 274).

Justice Muirhead noted pointedly that there was `no established universal view' as to the reliability of the technique in identifying, as opposed to excluding, a suspect.[3]

It is unclear, therefore, whether a superior court in Britain or Australia, if pressed, will unequivocally adopt the *Frye* criteria for determining whether a technique such as DNA profiling should be admitted into the courtroom. It does appear likely, though, at the very least that in formulating such criteria, judges may well borrow *Frye* language and focus upon the degree of dissension about any new technique within the scientific community.

Within the United States, the *Frye* test has been subjected to considerable and at times stringent criticism. It has been said that it is unduly difficult to determine what

constitutes `general acceptance' within the scientific community, what the relevant scientific community should be regarded as being at any one time (Williams 1987-88; p. 14), and how one determines the `scienticity' of a theory or technique in the first place. Some judges have departed absolutely from the *Frye* test, the court in *United States v. Williams* 583 F 2d 1194,1198 (1978), for example, asserting that

> the established considerations applicable to admissibility of evidence come into play and the probativeness, materiality, and reliability of the evidence on the one side, and any tendency to mislead, prejudice, or confuse the jury on the other, must be the focal points of inquiry.

The *Kelly* court (*The People v. Kelly* 17 Cal 3d 24; 546 P 2d 1240; 130 Cal Rptr 144 (1976)), by contrast, adopted what has become the majority stance and maintained that the essentially conservative standard of the *Frye* test shielded the jury from the unwarranted impact that a new scientific discovery could exert upon their otherwise reasoned considerations.

Generally speaking, the critics of the *Frye* test have maintained that it lacks clarity, is unduly rigid, sweeps too broadly, and is inconsistent with the traditional judicial prerogative to decide the accuracy and reliability of expert testimony (McCormick 1981; Saltzburg 1975; Gianelli 1980). The cases have evidenced patchy, but apparently increasing application of the *Frye* test in the United States to determine whether, pursuant to Rule 702 of the Federal Rules of Evidence, expert scientific evidence would be `helpful' to the tribunal of fact (659 F 2d 750 1981; Freckelton 1987b). The most recent criticism of the *Frye* test has come from a consensus statement issued by prosecution and defence employed scientists in the leading case on DNA evidence:

> All experts have agreed that the *Frye* test and the setting of the adversary system may not be the most appropriate method for reaching scientific consensus . . . The *Frye* hearing is not the appropriate time to begin the process of peer review of the data. Initiating peer review at this time wastes a great deal of the courts' and experts' time. The setting also discourages many experts from agreeing to participate in the careful scientific review of the data (Lewin 1989a; Freckelton 1987a).

During the 1980s United States courts strove to resolve some of the uncertainty surrounding the implementation of the *Frye* test. Thus in 1984 it was stressed that the *Frye* test only applied to novel scientific techniques and methodologies, as against opinion testimony which, while controversial in its conclusions, is based on `well-founded methodologies' (*Ferebee v. Chevron Chemical Co* 736 F 2d 1529, 1535 (1984)). Even in the case of novel scientific evidence, the opinion expressed need not be generally accepted but the methods by which it was reached must be methods upon which other scientists in the field would reasonably rely to reach their own conclusions, even though those may possibly be different (*Osburn v. Anohor Laboratories* 825 F 2d 908, 915 (1987)). The party offering the novel scientific evidence has the burden of demonstrating that it has been accepted as reliable among impartial and disinterested experts within the scientific community (*Kluck v. Borland* 413 NW 2d 90, 91 (1984) re thermography evidence). Such impartial experts' livelihood must not be intimately connected with the new technique (*The People v. Young* 418 Mich 1; 340 NW 2d 805 (1983) re electrophoresis of evidentiary bloodstains). Courts will look at papers written by scientists in the field or like fields (*United States v. Kozminski* 821 F 2d 1186), whether any trade organisation has recognised a test (*United States v. Kozminski; United States v. Distler* 671 F 2d p. 962) and the statistical reliability of a test (*United States v. Distler; United States v. Williams* 443 F Supp p. 272).

Implications of *Frye* for DNA Evidence

As a result of traditional judicial mistrust of scientific evidence (Best 1911; *Whitehouse v. Jordan* (1981) 1 All ER 267; *Lord Arbinger v. Ashton* (1873) 17 LR Eq 358; *Thorn v. Worthing Skating Rink Co* (1877) 6 Ch D 415), concern within the legal fraternity about the reliability of novel scientific evidence in the wake of the concerning cases, and the moves toward greater use of the *Frye* test in Australia, it is inevitable that DNA evidence will be scrutinised particularly carefully at first by the courts. These factors take on added weight after the problems exposed with the Lifecodes testing systems by the August 1989 decision of *The People v. Castro* (infra). Judges are likely to focus upon the parameters of DNA profiling's claimed accuracy, the possibility of human error during its testing processes, subjectivity in interpretation of results and any likelihood of bias in its reliability factors as a result of degradation or particular racial provenance of samples. Because of its probative value, the techniques have high prejudical potential should any of the claims made on their behalf be flawed. Thus, the onus is on the prosecution to satisfy the courts that the likelihood of error in employing DNA technology is so minimal as not to represent any significant danger of false correlation of samples.

An early question that must be answered is whether the courts will classify DNA profiling techniques as `novel'. In this they have little guidance by way of precedent outside the United States. However, because of DNA profiling's reliance upon techniques with which courts are for the most part as yet unfamiliar, it is likely that DNA profiling evidence will be regarded as novel. This established, it is probable that the *Frye* test will be applied as this so far has been the approach in the United States (*The People v. Castro;* Beeler & Wiebe 1988; Thompson & Ford 1989). However, it should be recognised that many constituent parts of some of the techniques are known and recognised by the courts. HLA testing and electrophoresis, for example, are not novel. As well, bar code-like patterns have been employed for decades in analysis of electrophoretic patterns of serum protein and enzyme polymorphisms. Where these `classical' approaches employed protein stains, DNA profiling employs enzyme-substrate colour change systems or autoradiography if radiolabelled probes are utilised. It can cogently be contended that the practice of pattern analysis of step-ladder like fragments is little different to longstanding protein polymorphism analysis.

Assuming the *Frye* test to apply, attention will focus on determining whether scientists within the relevant scientific community regard the methodology by which the DNA experts express their opinions as reliable. Experts will need to be sought whose livelihood does not depend intimately upon DNA technology. They will need to be prepared to depose that the methodology is well-known and regarded as dependable, accurate and mainstream by most scientists with acquaintance of it.

Evidence will then need to be given by experts concerned with the testing procedure about its different stages, the possibilities of contamination of samples and the likelihood of false results being reached. They will need to be thoroughly conversant with the laboratory's procedures and able to explain and defend them. Particular scientists with expertise, in the calculation of statistics may need to be called. Attention will need to be paid to explanation of any parts of the interpretation of results that could be regarded as subjective, to analysis of the procedures for exclusion of false positives and to the application of quality control mechanisms. Because the testing process is a long and complex one, trial judges will wish to be satisfied that the scope for human error has been minimised by adherence to appropriate protocols and adherence to standard laboratory procedures to safeguard against confusion of samples. Finally, the continuity of the evidence in the particular

case must be able to be guaranteed by reference to careful logging of the processes undergone by samples at all relevant times.

New Developments

The admissibility of DNA profiling evidence is not an open and shut issue. The August 16 decision of *The People v. Castro* (Unreported. New York Supreme Court, County of Bronx, Indictment 1508/87 1989) is the leading authority on the admissibility of DNA profiling evidence.

A woman and her two-year-old daughter were stabbed to death in their Bronx apartment. Acting on information, detectives interrogated a neighbourhood handyman, Joseph Castro. They noticed on his watch a small bloodstain, which was sent for analysis to Lifecodes scientists who extracted about 0.5 _g of DNA. This was compared to DNA from the two victims:

> The DNA was digested with the restriction enzyme Pst1, a size-fractionated on an agarose gel, and transferred onto a Southern blot. The blot was then hybridised with probes for three RFLP loci; DXYS14, D2S44 and D17S79, as well as a probe for a Y-chromosone locus to identify sex . . . On 22 July 1987, Lifecodes issued a formal report to the district attorney stating that the DNA patterns on the watch and the mother matched, and reporting the frequency of the pattern to be about 1 in 100,000,000 in the Hispanic population. The report indicated no difficulties or ambiguities (Lander 1989).

The case of *The People v. Castro* provided the first opportunity on which the DNA profiling techniques have been put under the forensic microscope.[4] It has been described by New York attorney, Peter Neufeld, as `unprecedented in the annals of the law' (Lewin 1989b). So concerned were the scientists for the prosecution and the defence about the possibility that the court might be misled by the evidence that had been put before it, that they convened a mini-scientific conference to thrash out some of the difficulties that had emerged in the application of the Lifecodes system of DNA profiling during evidence given in the case. This all occurred during the currency of the case! The result of the gathering was a `consensus statement' that:

> Overall, the DNA data in this case are not scientifically reliable enough (to reach a reliable conclusion) . . . If this data were submitted to a peer review journal in support of a conclusion, it would not be accepted (Lewin 1989b).

Acting Justice Sheindlin of the New York Supreme Court chose to approach the admissibility questions by a three-pronged analysis:

- Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?
- Are there techniques or experiments that currently exist that are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community?
- Did the laboratory perform the accepted scientific techniques in analysing the forensic samples of this particular case?

It was held that there was `unanimity amongst all the scientists and lawyers as well as that DNA identification is capable of procuring reliable results' (Unreported judgment, p. 8). Acting Justice Sheindlin noted that it was the areas of interpretation of autoradiograph results that presented `special problems' but held that DNA forensic identification tests to determine inclusion and exclusion are reliable and meet the *Frye* standard of admissibility (Unreported judgment, pp. 26, 28). So far as the performance of the Lifecodes laboratory was concerned, `the defence was successful in demonstrating . . . that the testing laboratory failed in its responsibility to perform the accepted scientific techniques and experiments in several major respects.' It was found that the DNA tests could be used to show that blood found on the suspect's wristwatch was not his, but could not be used to show the blood was that of the victim. Thus, the testing laboratory performed sufficiently reliable tests of exclusion, but not inclusion, within a reasonable degree of scientific certainty.

The *Castro* case has raised a number of disturbing problems, not so much with DNA technology but more with its application and with laboratory standards, procedures and safeguards. Dr Lander, subpoenaed by the defence, has taken the lead in expressing concerns. (Lifecodes tendered to the court a formal reply to Dr Lander's criticisms). Some were the subject of explicit ruling by the *Castro* judgment. They may be reduced to the following broad areas:

Discrepancies between forensic report and laboratory findings

The only autoradiogram involving the probe DXYS14 showed five bands in one of the lanes examined and only three in the other. Lander has pointed out that this was contrary to the formal Lifecodes' report to the district attorney. The explanation given in court by Dr Baird, Lifecodes' director of paternity and forensics, was that the two non-matching bands could be discounted as being contaminants `of a non-human origin that we have not been able to identify' (Lander 1989, p. 502). At the least, there should have been some account of this situation in the formal report. Acting Justice Shiendlin went further, holding that the existence of the extra two bands was of critical importance `in determining whether the forensic DNA testing performed in this case demonstrates these bands to be human DNA or non-human DNA . . . Further testing was required' (Unreported judgment, p. 32). The result of this finding was the ruling that:

> the credible testimony having clearly established that the testing laboratory failed to conduct the necessary and scientifically accepted tests, the evidence demonstrating an inclusion is inadmissible as a matter of law.

Deficient laboratory records

Dr Baird was called upon to give evidence of controls employed in relation to a finding of sex. Initially, evidence was given that the control DNA came from the female-derived HeLa cell line. Subsequently, it was suggested by the same witness that the control came from a male scientist with a short Y chromosome. After evidence was given by the defence about the likelihood of this being the case, Dr Baird told the court that no precise record had been kept of which DNA preparation had been used but it was apparent that the control DNA came from a female technician (cf. *Morling Report* pp. 103, 105). Such inconsistency and absence of record-keeping does not conduce to confidence in the professionalism of a forensic laboratory.

The use of controls

The confusion over the identity of the donor of the control DNA highlighted the issue of whether a sex test should be considered reliable without a demonstrable control on the autoradiogram to prove that the experiment had worked correctly. On this scientific opinions expressed during the course of the *Castro* case differed (Lander 1989 p. 503; *see also Morling Report* pp. 76, 86; *Shannon Report*, p. 51). The judge's response was to declare that in the absence of both male and female controls, `it is difficult to determine whether the probe hybridised correctly. The failure to include both controls renders the experiment uninterpretable' (Unreported judgment, p. 31).

Identification and matching of bands

There is room for believing that the Lifecodes' report in *Castro* fell into the approach so vigorously condemned by the South Australian *Shannon Report* (1984) in that the approach adopted by the investigating scientists was one of looking for similarities in samples rather than focussing on dissimilarities. Lander is particularly critical of Lifecodes' preparedness to make direct comparisons between lanes containing different DNA samples, rather than considering each lane in its own right:

> Personally, I do not understand how the presence of matches at D17S79 and DXYS14 has any bearing on the determination of a match at D2S44: each test must be evaluated independently, especially as the individual probabilities of a match for each locus are multiplied together at the end (Lander 1989, p. 503).

He also points out that the stated Lifecodes' matching rule, that two fragments are said to match when their positions differ by less than three standard deviations, was breached in the *Castro* results. That should have led to an adjudication of no match. His view is that the subjective process of visual matching may have taken over to the detriment of the integrity of the matching process (Lander 1989, pp. 502-3). Lifecodes in its reply to Dr Lander's evidence acknowledged the rule but sought to confine its operation to `comparison of like samples', maintaining that it could not be extended to the analysis of forensic samples `because contamination and degradation effects on evidence must be taken to account when the gels are evaluated' (Reply p. 3).

The impact of degradation of DNA samples

The small quantity of DNA present on the watch which was examined by the Lifecodes' scientists was to a degree degraded (Macalister 1989), a problem which was compounded by the fact that the suspect was a member of the Hispanic population. The danger was that the sample on the watch was a heterozygote with a relatively high band (above 10.25 kb) undetected because of degradation. Opinions differed as to the possibility of obtaining the necessary high reading, but it is clear that the problem existed to some degree.

The impact of probe contamination

Various artefacts were discovered in the results. Lifecodes sought to explain these by the unsatisfactory occurrence of contamination of probes. Dr Lander reports that Dr Baird testified that Lifecodes `continued to use probes even after learning that they were contaminated, while apparently keeping no precise records of when such probes had been used' (Lander 1989, p. 503). He has pointed out that this would make calculation of the likelihood of false matchings impossible because samples may also

be contaminated. Presumably, however, this could be cured by appropriate use of controls in the testing process. Acting Judge Shiendlin held that `the use of a contaminated probe is unscientific and unacceptable. Immediately upon discovering a contaminated probe its use should have been discontinued' (Unreported judgment, p. 29).

Calculation of matching probabilities

Lander colourfully maintained that the Lifecodes process of calculation of matching probabilities is `like catching a match with a 10 foot wide butterfly net' (Lander 1989, p. 504) as it failed to take account of the actual threshhold used for declaring matches. He also criticised the account taken by Lifecodes of heterogeneity of particular populations, maintaining that this led the company seriously to miscalculate its statistics. Acting Justice Shiendlin held that:

> The rule for declaring a measured match must be the same rule which is used for declaring a match between the measurements and the data pool. This was not done in this case. Because of this error, the population frequencies reported by Lifecodes in this case are not generally accepted by the scientific community' (Unreported judgment, p. 34).

Acting Justice Shiendlin's solution to the complex problems presented by the *Castro* case was to suggest the holding of a routine pre-trial conference in relation to DNA evidence and a practice whereby the proponent of the evidence would be obliged to give discovery of a variety of matters:

- Copies of the autoradiographs, with the opportunity to examine the originals;
- Copies of laboratory books;
- Copies of reports by the testing laboratory;
- A written report by the testing laboratory setting forth the method used to declare a match or non-match, with all relevant criteria;
- A statement by the laboratory setting out the method used to calculate the allele frequency in the relevant population;
- A copy of the data pool for each locus examined;
- A certification by the testing laboratory that the same rule used to declare a match was used to determine the allele frequency in the population;
- A statement setting forth observed contaminants, the reasons for them, and tests performed to determine their origin and the results of the tests;
- If the sample is degraded, a statement of tests performed and the reasons for them;
- A statement setting forth any other observed defects or laboratory errors, the reasons for them and their results; and
- A chain of custody of the documents.

Such a procedure has a great deal of merit. Although such a procedure is unlikely to be insisted upon by Australian courts, such a list provides an excellent checklist of steps for forensic scientists in the area. For trial lawyers, the list provides a most useful set of criteria to ensure scientific accountability.

Concluding Remarks

DNA techniques have made their first foray into the courts and tribunals of the United States, Britain and Australia. Until the *Castro* case they had not been the subject of substantial objection by either defence or prosecution counsel. As a result of that case, and particularly as a result of the concerns expressed by experts involved in the case, it can confidently be forecast that DNA profiling will henceforth receive a baptism of fire in the courts.

Castro notwithstanding, the techniques are likely in due course to be regarded as satisfying the criteria of the *Frye* test. However, for this to be so, a number of preconditions will need to be met. The fact is that novel scientific evidence has always been met with mistrust by judges. After 17 August 1989, this mistrust will be amplified. Judges are concerned that techniques will make their way before juries before the reliability of those techniques can be adequately assured. They are worried that judges and juries may be duped by very prejudicial material that may be deceptive in its quality. The *Castro* experience has called into question the professionalism of some of the laboratories employing forensic DNA technology in the same way that the Shannon and Morling Royal Commissions in Australia caused concern about forensic scientists' professionalism.

For DNA techniques to be admissible in the courtroom, the procedures adhered to by laboratories using them need to be standardised and scientifically stringent. The following are necessary:

- Professional laboratory practices need to be adhered to;
- Uniformity in testing and reporting procedures, so far as possible, needs to be secured (*see* Atchison & Cordner paper in this volume);
- Unimpugnable records must be kept;
- Cross-checks should be done on testing materials;
- Control tests on samples should be conducted, with particular emphasis on samples that may in any way be denatured or degraded;
- Measurements should be as objective and verifiable as available technology permits;
- Possibilities of contamination should be excluded to the highest possible degree;
- Opportunities for human error should be procedurally guarded against;
- Procedures should always be directed toward discovery of non-matches rather than matches of samples;
- Results of findings should never be overstated;

- Supervision of laboratory personnel should be stringent; and

- Routine checks of results and procedures should be done on traditional quality assurance principles.

Further, the acceptability of the technology will depend upon the articulateness of those testifying about it and their effectiveness as communicators. This entails preparation for presentation of its steps in the courtroom by overheads, graphics and diagrams, where appropriate, and preparedness on the part of the experts to make only those claims for DNA technology of which they can be completely confident (Malone 1988, p. 49; also inference chart concept, of Magnusson in E. Magnusson and B. Selinger, `DNA Profile Evidence and the Inference Chart Concept', this Proceedings).

However, there are enough aspects of DNA profiling that remain controversial and subject to human error and misinterpretation for trial lawyers to have a responsibility to test DNA evidence in the courtroom. It is likely that they will focus upon laboratory conditions and procedures and upon the propriety of each of the investigative steps followed in each particular case. Chiefly, this will mean examination of the extraction of the DNA, restriction digestion, gel electrophoresis, the process of hybridation and especially the interpretation of the results of the autoradiography (Thompson & Ford 1989). The well prepared forensic scientist from a well functioning laboratory should be able to meet such questions more than adequately with straightforward explanations.

The problems raised by *Castro* will be resolved. The stakes are too high for them not to be. DNA technology promises to provide a form of evidence to judges and juries upon whose accuracy and reliability they will be able to rely with a confidence that they can rarely experience. It has an already demonstrated potential to result in increased conviction of the innocent. At present, though, the utility of DNA profiling in the criminal context is dependent in many jurisdictions upon the success of the police in `persuading' suspects to provide intimate body samples. The challenge facing our legislators, assisted by those whose responsibility it is to draft proposals for law reform, is to determine the powers that should be given to our investigative agencies to demand intimate body samples.

Footnotes

1. For a fuller discussion of the issue canvassed in this paper, see I. Freckelton, `DNA Profiling - A Legal Perspective' in A. Ross, J. Robertson & J. Burgoyne (eds), *DNA Technology*, Ellis and Horwood (forthcoming).

2. In *R v. Murray* (1982) 7 A Crim R 48, for example, expert evidence in relation to polygraph examinations was ruled inadmissible by a District Court Judge because the evidence was hearsay and self-serving.

3. This was the substance also of the approach adopted by Acting Judge Shiendlin in *Castro*.

4. Of the few reported cases on the issue of DNA identification, none prior to *Castro* had held such evidence inadmissible. It had scarcely been challenged at all. In New York 3 cases had dealt with it: *The People v. Wesley*, 140 Misc 2d 306 (Sup Ct. Albany County 1988); *The People v. Lopez*, NYLJ (Jan 6 1989) p. 29 col. 1 (Sup Ct Queens County 1988); *Baby Girl S*, 140 Misc 2d 299 (Sup Ct NY Co 1988), the first dealing with the issue on the basis of *Frye* and the other two deeming the evidence admissible. One appellate court had found the evidence admissible under the relevancy and *Frye* standards (*Andrews v. State*, 533 So 2d 841 (Fla App 5 Dist 1988)) while by August 1989 at least 9 states had admitted DNA evidence at trial.

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Forensic Science. Analyzing clues such as fingerprints and DNA and using them to help solve a crime. Forensic science is a discipline that applies scientific analysis to the justice system. Three figerprint patterns. The loop, arch, and swirl.Â What instrument can detect gunshot residue? A microscope. Who won the Nobel Prize for classifying human blood groups? Karl Landsteiner. Sherlock Holmes of France. Edmond Locard. In what year did the FBI set up its own forensic laboratory? 1932. By the close of the 20th century, what did forensic scientists have? A wealth of high tech tools, including digital fingerprinting techniques with computer search capabilities. You might also like DNA (Deoxyribonucleic acid) is the molecule that contains within it all the instructions and information about an organism. This is to say that DNA contains information regarding how the organism will develop, how it lives and reproduces etc. Therefore, the DNA may be described as the blueprint of a living organism. Given that DNA molecules are found inside the cells, they are too small to be seen with the naked eye.Â The nucleic acid is applied to the grids and immersed in the staining solution for between 10 minutes and 4 hours. Rinse the grids using redistilled water at a pH of 6.0 three times and view under the microscope. In the event that the stained grid will not be viewed immediately, then they can be stored in an evacuated desiccators over phosphate P205. Observation.