Use Of Dna As Evidence In Court System With Current Perspective In India

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Abstract

Scientific and technical implementation along with the change in social standards of environment have made new challenges to the criminal justice system. With the change of thinking in society and technology, there has been an increase in the crime percentage. DNA provides the scientific evidence beyond the doubt and thus contributes in criminal as well as civil investigations.

DNA has opened new areas as extensive aid in the resolution of civil and criminal disputes.

In our country, DNA technology was introduced first time in a paternity matter in 1989. In July 2019, the DNA Technology bill 2019 was introduced in the Indian parliament.

Keywords: Criminal justice system, Forensics, IPC, Legal Investigation and DNA technology.

Introduction: DNA

Deoxyribonucleic acid [1] **DNA** is a polymer composed of two polynucleotide chains that coil around each other to form a double helix. The polymer carries genetic instructions for the development, functioning and reproduction of all known organisms and viruses. DNA are nucleic acids.

The two DNA strands are known as polynucleotides as they are composed of simpler monomeric units called nucleotides.[2][3] Each nucleotide is composed of one of four nitrogen-containing nucleobases (cytosine [C], guanine [G], adenine [A] or thymine [T]), a sugar called deoxyribose, and a phosphate group. The

nucleotides are joined to one another in a chain by covalent bonds (known as the phosphodiester linkage) between the sugar of one nucleotide and the phosphate of the next, resulting in an alternating sugar-phosphate backbone. The nitrogenous bases of the two separate polynucleotide strands are bound together, according to base pairing rules (A with T and C with G), with hydrogen bonds to make double-stranded DNA. The complementary nitrogenous bases are divided into two groups, the single-ringed pyrimidines and the double-ringed purines. In DNA, the pyrimidines are thymine and cytosine; the purines are adenine and guanine.

Both strands of double-stranded DNA store the same biological information. This information is replicated when the two strands separate. A large part of DNA (more than 98% for humans) is non-coding, meaning that these sections do not serve as patterns for protein sequences. The two strands of DNA run in opposite directions to each other and are thus anti parallel. Attached to each sugar is one of four types of nucleobases (or bases). It is the sequence of these four nucleobases along the backbone that encodes genetic information. RNA strands are created using DNA strands as a template in a process called transcription, where DNA bases are exchanged for their corresponding bases except in the case of thymine (T), for which RNA substitutes uracil (U).[4] Under the genetic code, these RNA strands specify the sequence of amino acids within proteins in a process called translation.

Eukaryotic organisms (animals, plants, fungi and protists) store most of their DNA inside the cell nucleus as nuclear DNA, and some in the mitochondria as mitochondrial DNA or in chloroplasts as chloroplast DNA.[5] These compacting structures guide the interactions between DNA and other proteins, helping control which parts of the DNA are transcribed.

Properties

DNA is a long polymer made from repeating units called nucleotides.[6][7] The structure of DNA is dynamic along its length, being capable of coiling into tight loops and other shapes.[8] Both chains are coiled around the same axis, and have the same pitch of 34 ångströms (3.4 nm). The pair of chains have a radius of 10 Å (1.0 nm).[9] According to another study, when measured in a

different solution, the DNA chain measured 22–26 Å (2.2–2.6 nm) wide, and one nucleotide unit measured 3.3 Å (0.33 nm) long.[10] The buoyant density of most DNA is 1.7g/cm^3.[11]

DNA does not usually exist as a single strand, but instead as a pair of strands that are held tightly together.[9][12] A biopolymer comprising multiple linked nucleotides (as in DNA) is called a polynucleotide.[13]

The backbone of the DNA strand is made from alternating phosphate and sugar groups.[14] These are known as the 3'-end (three prime end), and 5'-end (five prime end) carbons, the prime symbol being used to distinguish these carbon atoms from those of the base to which the deoxyribose forms a glycosidic bond.[12]

One major difference between DNA and RNA is the sugar, with the 2-deoxyribose in DNA being replaced by the related pentose sugar ribose in RNA.[12]

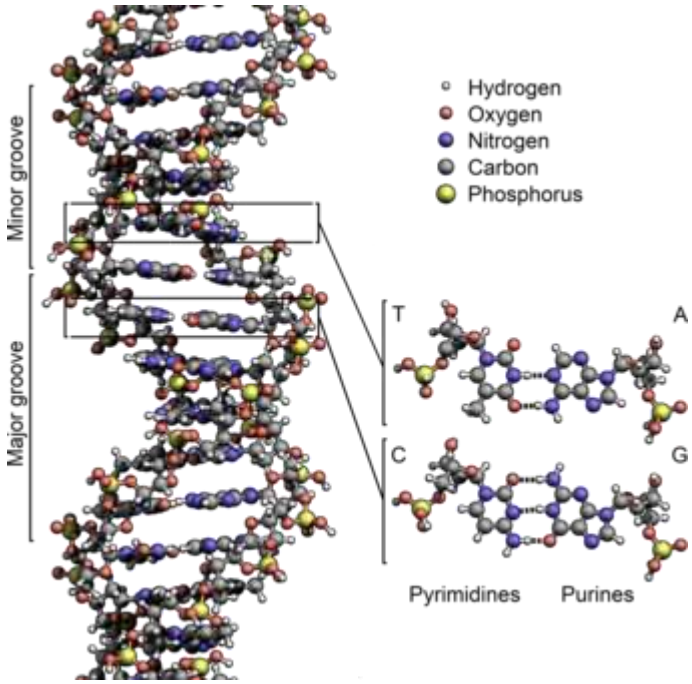

Figure 1 The structure of the DNA double helix (type B-DNA). The atoms in the structure are colour-coded by element and the detailed structures of two base pairs are shown in the bottom right.

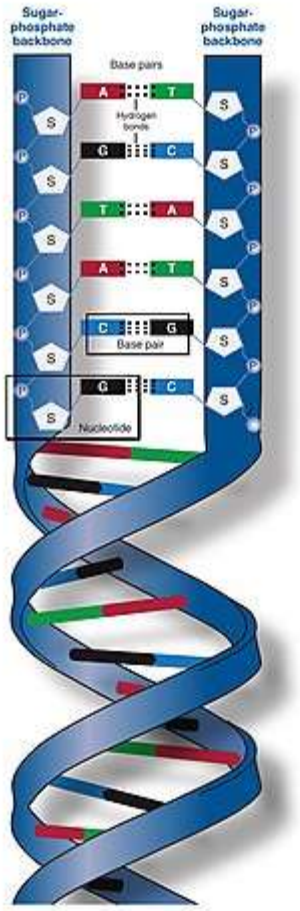

Figure 2 Classified Diagram

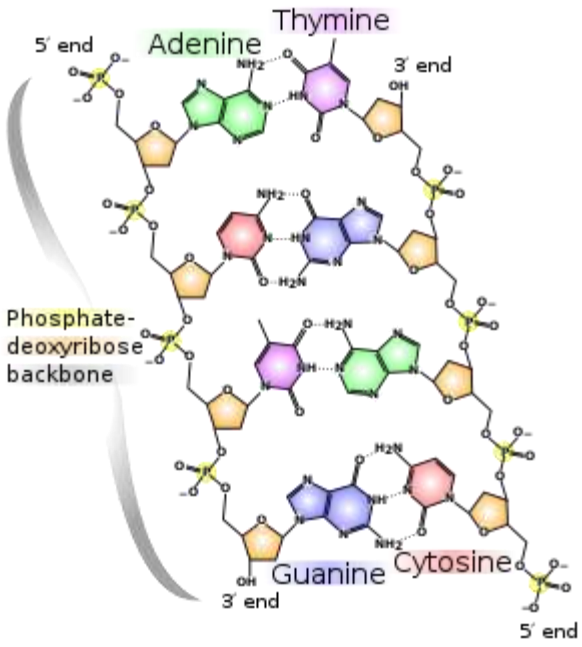

Figure 3 Chemical structure of DNA

DNA use in technology

Genetic Engineering

Various methods have been implemented to purify DNA from organisms, such as phenol-chloroform extraction. Modern science makes extreme use of these techniques in DNA technology. They can be transformed into organisms in the form of plasmids by using a viral vector.[15] The modified organisms produced can be used to produce recombinant proteins, used in medical research,[16] and in agriculture.[17][18]

Profiling of DNA

Scientists use DNA in blood, semen, skin, saliva or hair in a crime scene to find a matching DNA of a person.[19] This process is termed as DNA profiling. In DNA profiling, the lengths of variable sections of repetitive DNA, such as short tandem repeats and mini satellites, are compared between people. This process is an extremely reliable technique for identifying a matching DNA.[20] Identification can be complicated if the scene is contaminated with DNA from various people.[21] DNA profiling was developed in 1984

by British geneticist Sir Alec Jeffreys,[22] and first used in forensic science to convict Colin Pitchfork in the 1988 End murders case.[23]

DNA profiling is also used to positively identify victims of mass casualty incidents.[24] Normal DNA sequencing methods happen after birth, but there are new methods to test paternity while a mother is pregnant.[25]

DNA uses as evidence

DNA has contributed to the justice in various civil and criminal cases. The immigration case in the UK was the first civil dispute solved with DNA evidence. In the famous Colin Pitchfork case, DNA identified the offender and also saved an innocent. The role of DNA evidence in various civil and criminal cases has established it as "Genetic eyewitness". Robert Melia case, case of Ghanaian boy (immigration case in the UK), Andrew v. Florida2, etc. are some flagship cases in the history of forensic genetics (Bureau of Justice Statistics 1991).

With the exception of identical twins, no two individuals have the same DNA blueprint. DNA analysis, or DNA profiling, examines DNA found in physical evidence such as blood, hair, and semen, and determines whether it can be matched to DNA taken from specific individuals.

It is applicable in civil litigation, particularly in cases involving the determination of Paternity of identity. The Supreme Court of the United States in Maryland v King[26] stated that-
The advent of DNA technology is one of the most significant scientific advancements of our era. The full potential for use of genetic markers in medicine and science is still being explored, but the utility of DNA identification in the criminal justice system is already undisputed. since the first use of forensic DNA analysis to catch a rapist and murderer.

DNA use by the Court

The basic issue that come forth to the judiciary while ordering for the DNA testing is that it may affect privacy and bodily integrity of a person resulting in compromising with the Rights to life with dignity. Hence, the Supreme Court of India, in Selvi v State of Karnataka[27] has made it mandatory to take consent from the

court prior to conducting of forensic techniques like Narco Analysis as the statements of the subject are recorded under the influence of the drug administered to them, taking them to a trans-state for allegedly recording compulsive testimony. Thus, it is important for the court to maintain a balance between society and interest of justice.

In **Rudresh @ Rudrachari v State of Karnataka**[28] the issue was related to section 53A of Criminal Procedure Code where accused is being examined by the Medical Practitioner on the request of the police officer not below the rank of Sub-inspector. the question was whether the court can issue the order for conduction of scientific test like DNA under section 53 A crpc or is it strictly adhere to the request of the Police officer. On this question the High Court of Karnataka observed that- **The primary duty of the court is to ascertain the truth. Thus it is not correct to say that court or magistrate cannot direct or order the accused for medical examination as contemplated under Section 53 and 54 of the Code.**

Drawing of the blood sample for the purpose of civil proceedings without the consent of the party is not desirable but drawing of the blood sample for detection of the offence of rape wherein the investigating agency has to establish its case beyond reasonable doubt cannot be termed as violative of Article 20(3) of the Constitution[29]. The law under the section 53 CrPC empowers the criminal courts to use reasonably necessary force to conduct forensic examination. Further, to prove innocence, Section 54 CrPC provides an opportunity to the accused to offer medical examination. In civil disputes, free and informed consent has greater relevance. In Rohit Shekhar v. Narayan Dutt Tiwari[30] the court ordered for the use of appropriate force to take the sample of blood as per the norms.

DNA evidence in criminal cases for victim identification

In criminal matters, DNA profiling has not only helped in cracking cold cases and linking crimes with criminals but also aids in identification of victims in many cases. In many cases, the victims are being murdered with a general perspective of hiding the identity of the criminal and due to long lasting investigation procedures it becomes difficult to connect recovered body remains with the victim.

In such situations, DNA profiling proves to be a bane. it also assists in further proving the guilt or innocence of the accused but tempering with the DNA evidence may lead the case in wrong direction as a result of which courts are left with no other option except to give the benefit of doubt to the accused. An excellent instance for this was Santosh Kumar Singh v State through CBI[31] also known as **Priyadarshini Mattoo case.**

The tampering of evidence along with the shoddy investigation was the biggest hurdle faced by the prosecution in the trial. The clincher was that the DNA test proved rape but again that was being tampered during the investigation which creates a benefit of doubt situation for the accused. Despite many evidences favouring the Prosecution, the Trial Court acquitted the accused stating that CBI had failed on several counts namely concealing from the court that the evidences collected by it, were fabricated on behalf of the accused.

The courts cannot afford to award the judgments based on ethical and moral grounds, rather basis should be purely legal in character which certainly lose its originality once being tampered, as a result of which justice remains incomplete.

Limitations of DNA Profiling

The introduction of DNA profiling has posed some serious challenges to the legal rights of an individual such as Right to Privacy and Right against self-incrimination which is why its been declined as evidence by the Courts sometimes. Also, the admissibility of the DNA evidence before the court always depends on its accurate and proper collection, preservation and documentation which can satisfy the court that the evidence which has been put in front it is reliable.

There is no specific legislation present in India that can provide certain guidelines to the investigating agencies and the court, and the procedure to be adopted in the cases involving DNA as its evidence. However, some provisions allow examination of person accused of rape by medical practitioner and the medical examination of the rape victim respectively but the admissibility of these evidences has remained doubtful as the opinion of the

Supreme Court and various High Courts in various decisions remained conflicting.

Judges do not deny the scientific accuracy and conclusiveness of DNA testing, but in some cases they do not admit these evidences on the ground of legal or constitutional prohibition and sometimes the public policy.

The Patna high court, in **Rajiv Singh v. The State of Bihar**[32] referred to OJ Simpson case[33] and noted the possible errors at various stages involved in DNA procedure and observed:

One of the lasting effects of the OJ Simpson case will likely be greater scrutiny by defence lawyers of the prosecution's forensic DNA evidence presented in criminal cases. In the Simpson case, the defence, in essence, put the crime laboratory on trial.

There is no substantial dispute about the underlying scientific principles in DNA profiling, however, the adequacy of laboratory procedures and the competence of the experts who testify should remain open to inquiry. Although, there is a common consensus within the scientific community that DNA profiling can yield results with a very high probability, the complex procedure of DNA profiling is not without problems. At every phase of the seven-step procedure just described, mistakes and improper handling of the DNA-probe can produce false results which in some cases can lead to a life sentence or even death penalty judgement.

Therefore, the adequacy of laboratory procedures and the competence of the experts who testify should remain open to inquiry. The collection of biological evidence remains of utmost importance in forensic analysis. The manipulations or contamination of sample whether volunteer or negligently may vitiate the expert report.

Use of DNA Information in the Legal System

This chapter provides an overview of how DNA evidence might be used in the investigation and prosecution of crimes and in civil litigation. The DNA typing discussed in this chapter is mainly standard single-locus RFLP typing on Southern blots without apparent band shifting; i.e., it is the technique most often considered by the courts to date. We begin with a discussion of the

investigation stage, but devote most of our attention to admissibility. In that context, we review some of the rapidly growing number of cases involving admissibility. Discussion of case law is intended mainly to highlight specific issues and is not intended to be comprehensive. Finally, we make a series of practical recommendations, with judges especially in mind.

To produce biological evidence that is admissible in court in criminal cases, forensic investigators must be well trained in the collection and handling of biological samples for DNA analysis. They should take care to minimize the risk of contamination and ensure that possible sources of DNA are well preserved and properly identified. As in any forensic work, they must attend to the essentials of preserving specimens, labeling, and the chain of custody and to any constitutional or statutory requirements that regulate the collection and handling of samples. The Fourth Amendment provides much of the legal framework for the gathering of DNA samples from suspects or private places, and court orders are sometimes needed in this connection.

Wherever possible, a preserved sample should be large enough to enable the defense to obtain an independent RFLP analysis, but there should almost always be enough at least for PCR analysis, a technique likely to be widely used in forensics in the near future for amplification of the DNA in the evidentiary sample. All materials relied on by prosecution experts must be available to defense experts, and vice versa. The laboratories used for analysis must be reliable and should be willing to meet recognized standards of disclosure.

In civil (noncriminal) cases—such as paternity, custody, and proof-of-death cases—the standards for admissibility must also be high, because DNA evidence might be dispositive. The relevant federal rules (403, 702-706) and most state rules of evidence do not distinguish between civil and criminal cases in determining the admissibility of scientific data. In a civil case, however, if the results of a DNA analysis are not conclusive, it will usually be possible to obtain new samples for study. As in criminal cases, laboratories and other interested parties must treat evidence according to established protocols.

The advent of DNA typing technology raises two key issues for judges: determining admissibility and explaining to jurors the

appropriate standards for weighing evidence. A host of subsidiary questions with respect to how expert evidence should be handled before and during a trial to ensure prompt and effective adjudication apply to all evidence and all experts and are not dealt with in this chapter.

In the United States, there are two main tests for admissibility of scientific information from experts. One is the Frye test, enunciated in Frye v. United States.1 The other is a "helpfulness" standard found in the Federal Rules of Evidence and many of its state counterparts. In addition, several states have recently enacted laws that essentially mandate the admission of DNA typing evidence.

The Frye Test

The test for the admissibility of novel scientific evidence enunciated in Frye v. United States has been the most frequently invoked one in American case law. A majority of states profess adherence to the Frye rule, although a growing number have adopted variations on the helpfulness standard suggested by the Federal Rules of Evidence.

Frye predicates the admissibility of novel scientific evidence on its general acceptance in a particular scientific field: "While courts will go a long way in admitting expert testimony deduced from a well-recognized 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."2 Thus, admissibility depends on the quality of the science underlying the evidence, as determined by scientists themselves. Theoretically, the court's role in this preliminary determination is quite limited: it should conduct a hearing to determine whether the scientific theory underlying the evidence is generally accepted in the relevant scientific community and to determine that the specific techniques used are reliable for their intended purpose.

In practice, the court is much more involved. The court must determine which scientific fields experts should be drawn from. Complexities arise with DNA typing, because the full typing process rests on theories and findings that pertain to various scientific fields. For example, the underlying theory of detecting

polymorphisms is accepted by human geneticists and molecular biologists, but population geneticists and statisticians might differ as to the appropriate method for determining the population frequency of a genotype in the general population or in a particular geographic, ethnic, or other group. The courts often let experts on a process, such as DNA typing, testify to the various scientific theories and assumptions on which the process rests, even though the experts' knowledge of some of the underlying theories is likely to be at best that of a generalist, rather than a specialist.

When a process is new and complex, a court should recognize that the expertise of more than one discipline might be necessary to explain it. That is the case when the admissibility of DNA evidence is judged as a matter of first impression. Among the issues raised is the validity of the assumptions that except for identical twins, each person's DNA is unique, the technique used allows one to determine whether two DNA samples show the same patterns at particular loci, and the statistical methods used and the available population databanks allow one to assess the probability that two DNA samples from different persons would by chance have the same patterns at the loci studied. Even if those assumptions are accepted, there is the important question of whether the laboratory's procedures and analyses in the case in question were performed in accordance with accepted standards and provide reliable estimates of the probability of a match.

Assumption 1—that, with the exception of identical twins, each person's DNA is unique—is so well established in human molecular genetics that a court is justified in judicially noticing it, even in the context of a Frye hearing.

Assumption 2—concerns the validity of procedures for extracting DNA from samples of blood, semen, and other materials and analyzing it for the presence and size of polymorphisms. With regard to application in scientific research, the validity is sufficiently well established in the case of RFLP analysis with Southern blots that judicial notice is also appropriate. With regard to the application in forensic science, however, additional questions of reliability are raised. For example, forensic DNA analysis frequently involves the use of small, possibly contaminated samples of unknown origin, such as a dried blood stain on a piece of clothing. Some experts have questioned the reliability of DNA analysis of samples subjected to "crime scene"

conditions. In addition, the details of the particular techniques used to perform DNA typing and to resolve ambiguities evoke a host of methodological questions. It is usually appropriate to evaluate these matters case by case in accordance with the standards and cautions contained in earlier portions of this report, rather than generally excluding DNA evidence. Of particular importance once such a system of quality assurance is established would be a demonstration that the involved laboratory is appropriately accredited and its personnel certified. Some aspects (such as the validity of the theory underlying RFLP analysis) might be so well established that judicial notice is warranted. Others (such as quantitative correction of band shifting with a single monomorphic fragment) might not be sufficiently well established to justify admissibility.

Assumption 3—related to the adequacy of statistical databanks used to calculate match probabilities—rests on unproven foundations. Many experts question the adequacy of current databanks for making probability estimates, and the use of multiplicative modes of combining probabilities are also open to serious question. The solution, however, is not to bar DNA evidence, but to ensure that estimates of the probability that a match between a person's DNA and evidence DNA could occur by chance are appropriately conservative The validity of assumption 4—that the analytical work done for a particular trial comports with proper procedure—can be resolved only case by case and is always open to question, even if the general reliability of DNA typing is fully accepted in the scientific community. The DNA evidence should not be admissible if the proper procedures were not followed. Moreover, even if a court finds DNA evidence admissible because proper procedures were followed, the probative force of the evidence will depend on the quality of the laboratory work. More control can be exercised by the court in deciding whether the general practices in the laboratory or the theories that a laboratory uses accord with acceptable scientific standards. Even if the general scientific principles and techniques are accepted by experts in the field, the same experts could testify that the work done in a particular case was so flawed that the court should decide that, under Frye, the jury should not hear the evidence.

The Frye test sometimes prevents scientific evidence from being presented to a jury unless it has sufficient history to be accepted by some subspecialty of science. Under Frye, potentially helpful evidence may be excluded until consensus has developed By 1991, DNA evidence had been considered in hundreds of Frye hearings involving felony prosecutions in more than 40 states. The overwhelming majority of trial courts ruled that such evidence was admissible; there have been some important exceptions, however.

The first scientifically thorough Frye hearing concerning DNA typing was conducted in People v. Castro, in which a New York trial court concluded that the theory underlying DNA typing is generally accepted by scientists in genetics and related fields, that forensic DNA typing has also been accepted and is reliable, but that the technique as applied in the particular case was so flawed that evidence of a match was inadmissible. The Castro court stated that the focus of the Frye test as applied to DNA typing must include its application to the particular case. It held that flaws in the application are not simply questions as to the weight to be given the evidence by the jury, but go to admissibility as determined by the judge.5 Castro determined that there were serious flaws in the laboratory's declaration of a match between two samples, for a number of reasons, including the presence of several anomalous bands. The court did not credit the laboratory's explanation of the reasons for the anomalies and criticized its failure to perform adequate follow-up testing. In addition, the court concluded that the laboratory's population-frequency databank could not provide an accurate estimate of the likelihood that the defendant was the source of the DNA. The court's analysis and findings were careful, and they have generally been approved by experts in the field.

In November 1989, the Supreme Court of Minnesota, deciding State v. Schwartz became the first appellate court to reject the use of DNA evidence analyzed by a forensic laboratory. In answering a certified question, the court noted that "DNA typing has gained general acceptance in the scientific community." Nevertheless, the court went on to hold that admissibility of specific test results in a particular case hinges on the laboratory's compliance with appropriate standards and controls and on the availability of its testing data and results. It held that, "because the laboratory in this case did not comport with these guidelines, the test results lack foundational adequacy and, without more, are thus

inadmissible." One matter that troubled the court was the failure of the testing laboratory to reveal underlying population data and testing methods. The court noted that the reliability of a test implies that it could be subjected to an independent scientific assessment of the methods, including replication of the test. Because such independent assessment had not occurred and could not take place, owing to the laboratory's secrecy, the court held that the results were inadmissible. In addition, the court was concerned that the testing laboratory had admitted having falsely identified two of 44 samples as coming from the sample subject during a proficiency test performed by the California Association of Crime Laboratory Directors and had not satisfied relevant validation protocols used by the FBI. In that regard, Schwartz makes a good case for requiring laboratories to meet particular standards before they may provide analysis of evidence to juries. Schwartz also held that the use of population-frequency statistics must be limited, because "there is a real danger that the jury will use the evidence as a measure of the probability of the defendant's guilt or innocence, and the evidence will thereby undermine the presumption of innocence, erode the values served by the reasonable double standard, and dehumanize our system of justice."The decision in Schwartz was influenced by Minnesota's unique position in limiting the use of probability estimates in trials.

A new Minnesota statute not considered in Schwartz specifically requires judges to admit population-frequency data generated by DNA testing. Thus, it is not clear how influential Schwartz will be in its home state. Nevertheless, the Minnesota judges' skepticism about statistical analysis is shared by other judges. Particularly in regard to DNA typing, the manner in which probabilities should be calculated requires great care.

In Cobey v. State the Maryland Court of Special Appeals reached a conclusion opposite to Schwartz, holding that evidence of DNA analysis from the same laboratory that figured in Schwartz was admissible and finding that the laboratory's databank was sound. The Cobey court was impressed by the absence of expert testimony contradicting that in favor of admissibility. It did caution, however, that "we are not, at this juncture, holding that DNA fingerprinting is now admissible willy-nilly in all criminal trials." In 1989, Maryland became one of a growing number of states to enact a law recognizing the admissibility of DNA evidence.

Admissibility According to the Helpfulness Standard

The Federal Rules of Evidence, without specifically repudiating the Frye rule, adopt a more flexible approach. Rule 702 states that, if scientific, technical or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.

Rule 702 should be read with Rule 403, which requires the court to determine the admissibility of evidence by balancing its probative force against its potential for misapplication by the jury. In determining admissibility, the court should consider the soundness and reliability of the process or technique used in generating evidence; the possibility that admitting the evidence would overwhelm, confuse, or mislead the jury; and the proffered connection between the scientific research or test result to be presented and particular disputed factual issues in the case.

The federal rule, as interpreted by some courts, encompasses Frye by making general acceptance of scientific principles by experts a factor, and in some cases a decisive factor, in determining probative force. A court can also consider the qualifications of experts testifying about the new scientific principle, the use to which the new technique has been put, the technique's potential for error, the existence of specialized literature discussing the technique, and its novelty.

With the helpfulness approach, the court should also consider factors that might prejudice the jury. One of the most serious concerns about scientific evidence, novel or not, is that it possesses an aura of infallibility that could overwhelm a jury's critical faculties. The likelihood that the jury would abdicate its role as critical fact-finder is believed by some to be greater if the science underlying an expert's conclusion is beyond its intellectual grasp. The jury might feel compelled to accept or reject a conclusion absolutely or to ignore evidence altogether. However, some experience indicates that jurors tend not to be overwhelmed by scientific proof and that they prefer experiential data based on traditional forms of evidence. Moreover, the presence of opposing experts might prevent a jury from being unduly impressed with one expert or the other. Conversely, the absence of an opposing

expert might cause a jury to give too much weight to expert testimony, on the grounds that, if the science were truly controversial, it would have heard the opposing view. Other possible difficulties with the presentation of DNA expert evidence include the possibility of jury confusion and an inordinate consumption of trial time. Nevertheless, if the scientific evidence is valid, the solution to those possible problems is not to exclude the evidence, but to ensure through instructions and testimony that the jury is equipped to consider rationally whatever evidence is presented.

In determining admissibility with the helpfulness approach, the court should consider a number of factors in addition to reliability. The first is the significance of the issue to which the evidence is directed. If the issue is tangential to the case, the court should be more reluctant to allow a time-consuming presentation of scientific evidence that might confuse the jury. Second, the availability and sufficiency of other evidence might make expert testimony about DNA superfluous. And third, the court should be mindful of the need to instruct and advise the jury to eliminate the risk of prejudice.

As with the Frye rule, courts applying the federal rules or conforming state rules must consider whether the particular techniques used in a particular case pass scientific muster. Three federal courts have now conducted thorough hearings on the admissibility of DNA evidence, with two courts finding it admissible and one ruling it inadmissible.

The U.S. District Court for the District of Vermont conducted a detailed analysis in United States v. Jakobetz. It reviewed the literature and FBI practices. Despite a strong attack from the defense and its experts, the court found that the DNA evidence was "highly reliable" and that its probative value outweighed the potential for prejudice. Strict application of the Frye test was rejected in accordance with Second Circuit standards.

After a thorough hearing that focused on FBI protocols, the U.S. magistrate for the Southern District of Ohio in United States v. Yee also wrote a detailed analysis with conclusions essentially tracking those in the Vermont case. Interestingly, an Arizona trial court considering the admissibility of DNA typing in State v. Despain carefully studied the transcript of Yee, but reached a conclusion

opposite to it. That might have been because it also reviewed the transcript of another hearing in which four additional defense experts challenged FBI protocols. Finding that there was a legitimate scientific controversy as to the validity of DNA testing and that it had not gained general acceptance, the court in Despain refused to admit evidence analyzed by the FBI laboratory.

Most recently, the Superior Court for the District of Columbia reached the opposite conclusion and held DNA typing inadmissible. In U.S. v. Porter, the court ruled that the technical reliability of DNA typing was generally accepted, but that the FBI's method for calculating the probability of a coincidental match was not. The court ruled that the scientific foundation of these probability calculations bears on the admissibility of the evidence. Applying the Frye standard, the court found that "there is a controversy within the scientific community [on this issue] which has generated further study, the results of which will soon be available for scrutiny. It is after these studies and others when the court should be called upon to admit DNA evidence."

In addition, a number of state courts that apply analogues of the federal rules have considered the admissibility of DNA evidence. In Andrews v. State, a Florida court of appeals determined that the relevance approach was applicable under the Florida evidence code that tracks the federal rules. The court admitted the evidence presented by the plaintiff's three scientific experts, two of whom worked for a private testing laboratory; the defense called no experts. The court concluded that the DNA typing evidence offered by the plaintiff was clearly helpful to the jury. With respect to the possibility of prejudice, the court found that DNA typing is not particularly "novel," in that it had been used in non forensic applications for 10 years. The issue of differences between scientific applications and forensic applications were not raised by the defense. The court also noted the existence of specialized literature about the technique. As for the possibility of erroneous test results, the court credited testimony that an error in the testing process would mean that there would be no result, rather than a false-positive or false-negative result. The court also credited the efficacy of the laboratory's control runs and approved the use of statistical data to determine the probability of a match.

In Spencer v. Commonwealth,[26] the Supreme Court of Virginia affirmed a trial court's finding that evidence derived from RFLP

analysis was sufficiently reliable to be admitted. The trial court heard testimony from three experts for the prosecution in molecular biology and genetics. The defense called no expert witnesses. The trial court credited testimony that there is no risk of false positives, that the testing techniques are reliable and generally accepted in the scientific community, and that the particular test was conducted in a reliable manner.

At a later proceeding involving the same defendant, the Supreme Court of Virginia held that evidence based on a sample analysis that used a PCR technology was admissible. In discussing the standard for admitting novel scientific evidence, it rejected the Frye test, asserting instead that the court should make a ''threshold finding of fact with respect to the reliability of the scientific method offered." Without discussing the details of the experts' testimony, the court concluded that the evidence supporting admissibility was credible.[27]

A Delaware trial court held in State v. Pennell[28] that DNA evidence was admissible under a state statute similar to the federal rules, but refused to admit probability statistics. There was no dispute about the underlying theory of DNA typing or its general application in the particular case. The defendant challenged the laboratory's claims that the population databank it used was in Hardy-Weinberg equilibrium and that its "binning process" was valid. The defense held that the state's experts' assessment of the probability of declaring a match was overstated. The court accepted some of the defense contentions and faulted the laboratory for its procedure. The state later introduced new evidence based on the laboratory's revised procedure and a new databank. The court agreed to allow the new evidence if the state would provide the raw data to the defendant, but the state did not do so. The court expressed concern over testimony that the measurements of allele size can depend on who is doing the measuring, and it concluded that the state's evidence did not sufficiently support the probability calculation.

Recent Appellate Opinions

As of February 1991, one federal and 10 state appeals from decisions to admit DNA evidence had been decided. Eight of the state appellate courts upheld trial courts' decisions to admit; the other two approved the scientific theory underlying DNA typing,

but one excluded the work of a particular laboratory because of process unreliability, and one found that there was sufficient controversy about the methods for assigning statistical weight so that they could not be considered generally accepted. In the sole federal appellate ruling, the Eighth Circuit Court of Appeals reversed a federal trial court's decision to admit DNA typing evidence and directed the lower court to hold a full hearing on admissibility.29 In the spring and summer of 1990, an intermediate-level appellate court in Texas30 and the supreme courts of South Carolina,31 Georgia,32 North Carolina,33 and Massachusetts34 were among the courts that considered the admissibility of DNA evidence. These opinions are of particular interest, because they were issued after sustained debate in the legal and scientific communities about possible flaws in DNA typing technology and possible inadequacies in the population databanks. The courts in Texas, South Carolina, Georgia, and North Carolina upheld the admissibility of DNA evidence; Massachusetts rejected it because of concerns about the adequacy of population genetic interpretation.

In Kelly v. Texas, the defendant appealed from a murder conviction, challenging as error the trial court's admission of evidence that compared a semen sample from the crime scene to a blood sample of the suspect. The defendant did not challenge the principles of DNA typing or the general qualifications of the state's five experts. He did attack the methods of the testing laboratory and the statistical expertise of the witnesses. The appellate court was informed that outside experts had twice verified the laboratory's procedures and results. In upholding the trial court's decision to admit the evidence, the appellate court specifically acknowledged the "validity" of the laboratory's techniques.

In July 1990, the Supreme Court of Georgia decided Caldwell v. State, a death-penalty case. The appeal grew out of a trial court's decision after a Frye hearing to admit DNA evidence. Both at the Frye hearing and on the appeal, no challenge was made to the scientific principles or general techniques used by the forensic laboratory. The focus was on how the laboratory declared a match between samples, the validity of its probability calculations, and its procedures to ensure quality control. In deciding the appeal, the court first considered whether it was appropriate for the trial court to use a Frye hearing to determine whether the laboratory had

performed its test with reliable techniques and in an acceptable manner. It concluded that, because of the complexity of the issues and a lack of national standards, the inquiry was appropriate. Although noting that errors, including false positives, could occur, the court ruled that the laboratory's protocol was "adequate to meet these concerns."

The court addressed how the laboratory had conducted a band shift analysis and calculated the power of identity. Despite band shifting, the laboratory had originally decided a match by visual examination. During the course of the trial, as a result of criticism of that technique, it reanalyzed the samples with a mono morphic probe. Such a probe provides an arguably invariant reference point to analyze band shifts across samples. After review of the testimony concerning the reanalysis, the appellate court concluded that this approach to the problem of band shifting was acceptable.

The appellant in Caldwell also attacked the calculations that led the testing laboratory to conclude that the chance that a randomly selected person would have the same DNA pattern as that of the sample source and the suspect was 1 in 24,000,000. Only one of the 10 experts had actually examined the laboratory's population databank, and he, a defense witness, insisted that it was not in Hardy-Weinberg equilibrium. The court ruled that, in the absence of supporting testimony, the probability statement generated by the laboratory assumptions could not be accepted. But the court did accept the concept of appropriate statistical calculations, which it erroneously thought did not depend on population theory.

In January 1991, the Supreme Judicial Court of Massachusetts, in Commonwealth v. Curnin became the second state supreme court to refuse to admit DNA typing evidence. After being convicted of rape, in part on the basis of DNA typing evidence, the defendant appealed, arguing that there was no general agreement concerning test methods, use of control samples, or the need for a testing laboratory to meet external performance standards. The high court did not address those arguments, focusing instead on the "lack of inherent rationality" of the process by which the testing laboratory concluded that 1 Caucasian in 59,000,000 would have the DNA pattern represented by the semen stain and the defendant's blood. The court was particularly impressed by the testimony of an expert for the defense who criticized the product

rule as unsupported by the laboratory's reference databank, raised the possibility of calculation errors due to ignorance of population substructure, and explained why no assumption would be made as to whether the relevant population was in Hardy-Weinberg equilibrium. Despite its decision to reverse the trial court, the high court made clear that it would not be surprised if the prosecution could correct the weaknesses of its testimony. In the court's words, "it may even be that, by the time of the retrial of this case the prosecution can support the admissibility of evidence of the probability of the alleles disclosed by the DNA test being found elsewhere in the human population. …"

Admissibility Statutes

Since 1987, the admissibility of DNA typing evidence was raised repeatedly in the courts, largely in the context of Frye hearings. Challenges to admissibility have become more sophisticated over the last 2 years. State legislatures have recently begun to address the matter. Several states have enacted laws that declare that appropriately performed DNA tests are admissible. Although they do not specify what an appropriate test is, the statutes must have been passed with single-locus RFLP analyses by Southern blotting in mind. Arguably, some of them should not be interpreted as applying to technologies that were not in general use and therefore could not have been evaluated by the legislatures that passed the statutes. Such technologies could be validated by amended statutes or by courts in Frye or Rule 702 hearings. For most purposes, states with such laws have statutorily resolved disagreements over the scientific reliability of DNA testing, although the questions of whether tests were performed properly in a given case and of the adequacy of statistical calculations based on test results probably remain subject to challenge.

The state laws are of two types. A number of states—including Arkansas, Connecticut, Michigan, Montana, and New Mexico—now specifically admit DNA evidence to assist in the resolution of paternity—noncriminal—cases (and, by inference, probably other disputes concerning biological relationships).35 Louisiana, Maryland, Minnesota, Virginia, and Washington have enacted laws that recognize the admissibility of DNA evidence in criminal cases.36

Maryland requires that the DNA report be delivered to the defendant 2 weeks before the criminal proceeding and specifies that the defendant may require a witness who analyzed the sample to testify as to the chain of custody. The Minnesota statute states that in any civil or criminal trial or hearing DNA evidence is admissible without "antecedent expert testimony that DNA analysis provides a trustworthy and reliable method of identifying characteristics in an individual's genetic material upon a showing that the offered testimony meets the standards for admissibility set forth in the Rules of Evidence" a companion provision specifically permits the admission of "statistical population frequency evidence to demonstrate the fraction of the population that would have the same combination of genetic markers as was found in a specific human biological specimen." Louisiana provides that "evidence of deoxyribonucleic acid profiles, genetic markers of the blood, and secretor status of the saliva offered to establish the identity of the offender of any crime is relevant as proof in conformity with the Louisiana Code of Evidence.''

Legislative interest in DNA evidence remains active, and it is likely that other states will enact laws generally favorable to its admissibility.

Despite the scientific debate concerning some aspects of DNA typing technology, by late 1990 at least 11 states had implicitly acknowledged its potential value in forensic science by statutorily creating DNA databanks on convicted felons. In general, the laws require that a person convicted of a felony involving a sexual assault submit to phlebotomy before parole; the blood sample is to be subjected to DNA typing and stored under the control of authorities. The California law calls for the testing of felons convicted of murder and other nonsexual felonies involving violence to a person. The Iowa law does not make clear who will be tested. The Virginia law provides for testing of all convicted felons.

Those laws were enacted because of the high rate of repeat felonious behavior by convicted persons. For example, available data on Virginia offenders shows that 36.3% of persons convicted of rape and 32.8% of persons convicted of aggravated assault are convicted of another crime within 5 years. The laws are premised on the fact that criminals sometimes leave biological evidence at the crime scene and that the comparison of the results of DNA

typing of such samples with profiles stored in the forensic laboratory might lead law-enforcement officials quickly to a prime suspect.

The creation of felon DNA databanks raises a number of challenging constitutional questions, e.g., whether extracting blood for DNA analysis in anticipation of future conduct is an unreasonable search or seizure under the Fourth Amendment and whether the creation of such banks violates a privacy right of the first-degree relatives of persons whose DNA samples are stored. This committee is not prepared to recommend how these important questions should be resolved, but recognizes that they deserve careful scrutiny. So far, one federal district court has heard a challenge to the constitutionality of a felon DNA databank. Its order for summary judgment favored the Virginia law.

The committee did not conduct a detailed study of DNA databanks for law-enforcement purposes. However, the committee does recognize that, as scientific and technical concerns about DNA typing are resolved, it is highly likely that databanks will proliferate, interconnect, and communicate. There is clearly a need to conduct further studies on the issue. It will be important to measure the perceived benefits of such databanks against possible harm. We must explore, among other questions, the permissible purposes of such banks, how to minimize invasion of legitimate privacy interests, and how to determine the appropriate response when such interests are violated.

Assessing The Admissibility Of Evidence Based On Results Of Further Advances In DNA Technology

It is important to remember that "DNA typing" is a catch-all phrase for an array of quite different technologies for measuring DNA variations among persons. For some DNA typing methods, the technical basis is well accepted. For others, important scientific questions must be resolved before they are appropriate to use in court.

New developments in DNA technology probably will, and at first should, be the subject of in limine hearings, as has been the case in recent instances when present technology has been tested. As a general rule, generation of evidence with such new technology should be encouraged if it is adequately supported in court

hearings. It is highly desirable that experts in molecular genetics and statistical analysis review new developments and pass on them at a variety of conferences and through published papers. Until there is some consensus in this field, results of using new techniques may not be admitted; a testing period for the new techniques will be needed to determine whether there are unforeseen errors or difficulties, and it will take time to compile the necessary databanks. Otherwise, the normal rules with respect to new developments can be relied on. In fact, new developments should present less difficulty than has been posed by present DNA typing technology, because much of the theory will have already been tested and accepted by the courts.

The issue for courts will be to discern when a technology is so different as to require a full admissibility hearing. Admissibility hearings might be required to evaluate the underlying principle of a scientific method of identification, the particular method for applying the principle, and the performance of a test in a particular case. Regarding the underlying principles, there is, as we have noted, no longer any question concerning the principle that DNA can be used to obtain identification information; admissibility hearings need no longer address the question. Regarding the particular method for applying the principle, the inquiry will depend on the new method or technology. For example, use of a previously unused DNA probe in the context of the basic RFLP technique might require an admissibility hearing on whether the properties of the particular probe (e.g., pattern, sensitivity, or population genetics) are scientifically accepted. Methods of correcting for shifted DNA patterns might require an admissibility hearing concerning whether the correction procedure has gained scientific acceptance, inasmuch as this substantially changes the method of declaring a match. The use of PCR amplification for sample preparation might require a pretrial hearing on the properties of the technique, because it introduces a novel issue considered by only a few courts thus far the synthesis of evidence by amplification. And the use of various detection technologies for PCR products might require a pretrial hearing about the characteristics of the detection method and its sensitivity to artifacts. In each case, the court can properly limit inquiry to the substantially novel aspects of the technology, focusing on whether the method is accepted for scientific applications and whether it has been validated for forensic identification. Minor changes in

protocols will typically not require pretrial hearings, unless they are likely to affect key issues (such as the matching rule).

Suggestions

Whatever statute or rule of evidence is applicable, some standards for admissibility seem sound to the committee. In view of the importance of DNA typing in both civil and criminal cases, the judge should determine, before allowing DNA evidence to be introduced, that appropriate standards have been followed, that tests were adequately performed by a reliable laboratory, and that the appropriate protocols for DNA typing and formulation of an opinion were fully complied with. In states without relevant statutes, the committee recommends that the court judicially notice the appropriateness of the theoretical basis of DNA typing by using this report, similar reports, and case law. As new methods are used, the courts will have to assure themselves of their validity.

The problem that a court will have to focus on when a standard testing approach is used is not general scientific theory, but actual application. In limine hearings can be shortened considerably by stipulations, exchange of data by the parties, and pretrial hearings to avoid unnecessary delay in trials. In the absence of specific objections to laboratory procedures, a court may rely on evidence of accreditation and certifications, a history of adequacy of testing by the laboratory, and other assurances of careful practice. It is not necessary, at this stage of development of DNA typing, to hold extensive admissibility hearings on the general validity of the scientific techniques, although cases will still arise in which the procedures used to report a match will be questioned.

It also might be necessary in a particular case to decide in advance whether an expert will be permitted to characterize the probability of a match in mathematical terms. At present, courts should take a conservative approach concerning the assumptions underlying the use of the product rule. A considerable degree of discretion and control by the courts in these cases is recommended.

As a general matter, so long as the safeguards we discuss in this report are followed, admissibility of DNA typing should be encouraged. There is no substantial dispute about the underlying scientific principles. However, the adequacy of laboratory procedures and of the competence of the experts who testify

should remain open to inquiry. Ultimately, DNA typing evidence should be used without any greater inconvenience than traditional fingerprint evidence.

DNA evidence and the various parties in the legal system

Because a jury might overvalue or undervalue scientific evidence, it is appropriate where permitted for the judge to question DNA experts with an eye to aiding the jury. The judge can explain to the jury the role of experts and the role of the jury in evaluating the experts' opinions.

When probability statements are admissible, the judge should not be expected to instruct the jury in detail on how probabilities are computed or how probabilities available from an analysis of DNA material should be combined with probability estimates based on more traditional testimony and other evidence. Those matters are better left to the experts and to the lawyers on summation. The court should encourage the use of charts, written reports, and duplicates of materials that are relied on by the experts, so that the jury can be as well educated as possible in the evaluation of DNA typing evidence. To that end, the court should insist that technical terms be reduced to understandable lay language and that scientific information be presented to the jury in the least confusing form possible.

Special forms of charges are not required. DNA typing may be assessed within the framework of normal forensic laboratory work and can be readily handled with the present rules and forms of charges.

The Prosecutor

The prosecutor will work closely with the investigators and will normally have access to adequately staffed and organized forensic laboratories. The prosecutor should carefully supervise the investigation activities to ensure that DNA typing evidence will be admissible, if it proves relevant.

The prosecutor has a strong responsibility to reveal fully to defense counsel and experts retained by the defendant all material that might be necessary in evaluating the evidence. That includes information on tests that proved inconclusive, on retesting, and on the testing of other persons. Adoption of rules or statutes that

require the prosecutor to involve the defense in analysis of DNA samples at the earliest possible moment is highly recommended.

The committee recommends going beyond what is required by the federal rules of criminal procedure and of civil procedure in regard to disclosures concerning DNA evidence. For example, data sheets and other materials obtained from experts who are not designated to testify should be available freely without the need for separate motions, because such materials are important for the evaluation of the scientific evidence in the case of DNA typing. Such free exchange of information, including access to databanks and to samples of evidence DNA, should apply to defense and prosecution experts in both criminal and civil cases.

The Defense

Defense counsel must have access to adequate expert assistance, even when the admissibility of the results of analytical techniques is not in question, because there is still a need to review the quality of the laboratory work and the interpretation of the results. When the prosecutor proposes to use DNA typing evidence or when it has been used in the investigation of the case, an expert should be routinely available to the defendant. If necessary, he or she should be able to apply for funds early in the discovery stages to retain experts without a showing of relevance that might reveal trial strategy. Whenever possible, a portion of the DNA sample should be preserved for independent analysis by the defense.

The prosecutor should promptly reveal to defense counsel that DNA was involved in the investigation and might be available for analysis at the trial. Normally, the criminal-justice system will not provide for the appointment of counsel for the defendant or for payment for experts until the defendant has been arrested or charged. Where a sample of the defendant's tissue is sought for DNA typing, application to the court for DNA experts should be possible even before an arrest has been made.

In our judicial system, jurors are relatively independent. Nevertheless, through limitations on the admissibility of evidence and on the form of its presentation and through the use of a variety of instructions, the court exercises considerable influence. DNA evidence, like other scientific and statistical evidence, can pose special problems of jury comprehension. Courts and attorneys

should cooperate to facilitate jury understanding. Innovative techniques, such as allowing jurors to take notes or ask questions, might be considered. Jargon should be avoided, and information should be presented simply, clearly, and fairly. Unless limited by law or court rules, judges should be free to pose questions to witnesses when they feel that the answers might clarify the testimony. Reports and relevant materials should be admitted into evidence so that they can be studied by courts at their leisure. Finally, a judge would not be amiss in pointing out to attorneys the wisdom of including jurors who are found to have a background that enhances their ability to understand the expert testimony.

Testing Laboratories

Other chapters have indicated appropriate standards for the operation of testing laboratories and the collection and analysis of DNA samples. Uniformity in reporting, completeness of reporting (including laboratory protocols and written criteria for interpretation), and stringent quality assurance of laboratories are essential. The court and the jury should have no reason to doubt the accuracy of the processing of information. Laboratories and experts have a particular responsibility to ensure that they are open and candid with the courts. Any reservations about inadequacies or errors should be promptly revealed, and failure to do that should be dealt with seriously. The court should not hesitate to exercise contempt powers and exclude experts who have misled deliberately in the past. Private trade associations and other appropriate groups should also apply pressure to ensure accuracy and candor.

Protective Orders

Protective orders should not be used to prevent experts on either side from obtaining all relevant information, which can include original materials, data sheets, software protocols, and information about unpublished databanks. A protective order might be appropriate to limit disclosures by attorneys and experts to third parties about proprietary information acquired in the course of a particular case; but as a general rule, any scientific information used in a case should be open to widespread scientific scrutiny. One exception might be when the expert is involved in a current or recently completed study on which he or she does not directly rely to develop an opinion. That will ensure that the expert

does not lose his or her opportunity to publish as a consequence of testifying. Protective orders to prevent unnecessary intrusion into the privacy of such persons as those who have been cleared after investigation or who are juveniles are appropriate.

Availability And Cost Of Experts

Wide use of forensic DNA typing will have considerable costs. Laboratories will be required to be funded by many states and the federal government. The Commonwealth of Virginia, for example, has committed several million dollars to its DNA forensic activities. Costs will be associated with upgrading the databanks when new procedures replace old ones. Increased costs will also be associated with the control, licensing, and oversight of laboratories and technicians. Many experts will need to be available. The defense cost will be substantially increased. Moreover, as DNA typing becomes more generally available, jurors might expect it in situations where it is impossible to produce. A failure to introduce DNA typing evidence could lead to an inference of spoliation, i.e., the destruction or alteration of evidence.

Of course, the early exclusion of suspects who have been cleared by DNA typing evidence will reduce other costs to the judicial system. DNA evidence might also obviate trials in some cases by proving identity fairly conclusively. In general, however, the costs of the criminal-justice system will be increased.

We cannot now accurately estimate the cost of the widespread use of DNA typing, but it can be expected to run into the tens of millions of dollars a year. However, relative to the cost of operating the entire system, the cost of using DNA evidence is minuscule. The quality of justice will be increased by full use of DNA typing. In general, we believe that the expenditures are warranted by the advantages to be expected.

Summary of recommendations

Having carefully reviewed the issues, the committee offers the following recommendations:

Courts should take judicial notice of three scientific underpinnings of DNA typing:

— The study of DNA polymorphisms can, in principle, provide a reliable method for comparing samples.

— Each person's DNA is unique (with the exception of identical twins), although the actual discriminatory power of any particular DNA test will depend on the sites of DNA variation examined.

— The current laboratory procedure for detecting DNA variation (specifically, single-locus probes analyzed on Southern blots without evidence of band shifting) is fundamentally sound, although the validity of any particular implementation of the basic procedure will depend on proper characterization of the reproducibility of the system (e.g., measurement variation) and the inclusion of all necessary scientific controls.

The adequacy of the method used to acquire and analyze samples in a given case bears on the admissibility of the evidence and should, unless stipulated, be adjudicated case by case. In this adjudication, the accreditation and certification status of the laboratory performing the analysis should be taken into account.

Because of the potential power of DNA evidence, authorities must make funds available to pay for expert witnesses, and the appropriate parties must be informed of the use of DNA evidence as soon as possible.

DNA samples (and evidence likely to contain DNA) should be preserved whenever that is possible.

All data and laboratory records generated by analysis of DNA samples should be made freely available to all parties. Such access is essential for evaluating the analysis.

Protective orders should be used only to protect the privacy of the persons involved.

Conclusions

The development of DNA technology has provided a great help in investigation of criminal cases. To satisfy the legal areas, limitations, and applications of DNA technology in connection with the change in social and economical concerns of Indian society, specific arbitration and legal reforms are required. The government of India has enacted the DNA bill. The committees constituted for comments mainly propagated that the DNA profile

contains sensitive genetic information that can be misused. This will definitely prove to be an important key in the practice of DNA testing and addressing the current legal issues by creating a balance between legal values, human rights, and many scientific improvements.

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