THE CURRENT STATE OF DNA EVIDENCE

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I. INTRODUCTION

A new form of forensic testing harkens the day when science can say with near certainty whether a suspect was present at a crime scene. Promising as this new technology is, a scientific method of itself cannot guarantee justice. Indeed, as presently received, the current identification method carries with it the potential to impart a significant prejudicial impact, if not a grave injustice.

The introduction of DNA identification into the criminal justice system has been heralded as the “greatest boon to forensic medicine and law since fingerprinting.” Praise for this new technique includes the claim that “disputing the technology is like disputing the law of gravity.” Accolades such as this overlook serious criticisms regarding the hurried acceptance of DNA evidence. These issues can be significant, if not critical, in a death penalty case.

The current state of DNA forensics should be examined in light of several limitations. First, the techniques presently used in forensic testing do not identify the chemical structure of DNA. A detailed chemical analysis is possible, but at present is prohibitively expensive. Second, forensic DNA testing is subject to human error. Third, statistical interpretation of the results are based upon very limited testing of the populace. Last, procedural guidelines for testing have not been firmly established among testing facilities or widely recognized by the courts. Left unexplored, these factors can lead to prejudicial, or even erroneous, conclusions.

The apparent willingness of the American public to endure encroachment upon liberty and fairness in order to facilitate the fight against crime, particularly when drug related, has reached the proportion of a national obsession. Thus a cutting edge technology which promises to identify criminals with near certainty has found a very receptive market. DNA evidence has been accepted in many jurisdictions. Prosecutors and commercial laboratories have been able to push acceptance of DNA testing to the point that some courts take judicial notice of its reliability, has contributed to the premature acceptance of DNA testing.

This article will not challenge the technology; its foundation and potential are clear. This article will (1) summarize the prevailing DNA testing technique with the purpose of identifying possible sources of human error, (2) examine the validity of the “probability calculations” that are often given along with the test, (3) survey the law, particularly as it stands in Virginia, and (4) provide tactical advice for defense counsel. Further, this article will attempt to make clear that because the potential for the technology has not been reached in forensic application it may be harmful, if not lethal, for defense counsel’s client to let the judge and/or jury believe that such perfection currently exists.

II. THE MECHANICS OF THE TEST

II.1. A General Description of DNA

Deoxyribonucleic acid (DNA) holds the chemically encoded genetic information present in all living organisms. It exists in the nucleus of every major type of cell except mature red blood cells. Each DNA molecule is structured as a “double-helix,” a long threadlike molecule consisting of two threads that intertwine and coil.

The DNA molecule is often described as a “closed zipper,” the teeth of which are formed by the chemical bases adenine, guanine, thymine, and cytosine. These four nucleotides pair together such that adenine molecules always pair with thymine molecules and cytosine with guanine. A molecule of human DNA contains three billion of these base pairs.

The order in which the nucleotides pair is the key to the information carried by the DNA. A gene is a particular sequence of base pairs that provide the information for a specific structure, function or feature, such as the gene for blue eyes. Thus, at certain sites, or loci, the arrangement of base pairs may differ from person to person. An individual’s genetic constitution at one or more gene loci is often referred to as “genotype.” Alternate forms of a gene among the relevant population (species, race, ethnic group, etc.) are referred to as “alleles.”

Approximately three million base pairs vary in human DNA. These variations, known as “polymorphisms,” are the basis for DNA profiling. Polymorphisms may be compared with those from other samples as a means of identification. Although each person’s DNA is unique as a whole, no person has a unique DNA pattern at a given polymorphic site. Since it is presently impractical to compare all three million differing base pairs, the DNA profiling technique seeks to distinguish among individuals by focusing on several highly polymorphic or “hypervariable” sections of human DNA. The kind of polymorphism most often sought in forensics is known as a Variable Number of Tandem Repeat or VNTR. VNTRs are stretches of DNA in which a short nucleotide sequence is repeated tandemly 20 to 100 times.

II.2. The RFLP Process

The RFLP process breaks the DNA chain at specific points into smaller fragments. The results of an RFLP test represent a measurement of the length of these fragments. Thus, if tests performed on samples from the suspect and the crime scene identify segments of the same length, then a common source is suggested.

The RFLP process is not a simple test. There are many steps where error or inaccuracy can occur. The procedure can be divided into seven steps. Each of these steps and associated potential sources of error are discussed below.

Extraction of DNA

Sources of DNA at a crime scene are most often samples of tissue or bodily fluids dried onto solid material. This biological sample is treated with various chemicals in order to accomplish removal from the material it is on. The sample is then treated with enzymes and organic solvents in order to release and clean DNA from the cells of the source substance.
The quantity and quality of the sample present two possible sources of error. Success of the RFLP test requires a sample containing several hundred nanograms of intact DNA. This amount of DNA requires a blood stain the size of a quarter or a semen stain the size of a dime. In rape cases, where a semen stain is the only biological evidence, approximately half of all samples given to Lifecodes did not yield sufficient DNA to test. Generally, a reliability problem is not created with insufficient molecular weight because the bands produced on the DNA print will be too faint to read, thereby causing an inconclusive “blank” result.

A second possible problem at this stage of the procedure is the presence of environmental contaminants. Molecular biologists have utilized RFLP testing methods for over a decade, however the application of the technology to forensics is relatively new. While some cases have accepted the notion that the scientific community has generally accepted the technique, it is worth noting that most non-forensic experts have experience with the procedure in a laboratory setting using “clean” samples. Samples from a crime scene may contain any number of contaminants including bacterial, viral or other nonhuman DNA. Some experts believe that false or misleading bands can be produced by the presence of foreign DNA in the sample. Others do not.

Restriction Digestion

After extraction and cleaning, the DNA specimen is mixed with “restriction enzymes.” These enzymes act as biological scissors and separate the DNA at specific places leaving segments known as “restriction fragments.” Although some of the fragments contain polymorphic genes, most do not.

Restriction digestion is widely accepted and used, but it is still subject to error. The ability of a restriction enzyme to cut at a particular restriction site is referred to as its “specificity.” Changes in the specificity of a restriction enzyme will cause the enzyme to cut the DNA at the wrong sites and will change the position and number of bands in the DNA print. An alteration of specificity resulting in incomplete cleavage of the DNA is known as partial digestion; an alteration producing cuts at too many sites, is known as star activity. Alterations in specificity may arise from a variety of sources.

Other sources of contamination include organic solvents, detergents, and salt. These substances can also cause the restriction enzymes to cut the DNA at the wrong places resulting in an erroneous DNA print. Error at this stage is far more likely to result in diverse prints rather than a false match.

Gel Electrophoresis

After the DNA is broken down, the restriction fragments are placed on a slab of agarose gel. An electric current is passed through the gel in order to cause the fragments to move from the negative pole to the positive. The size of the fragments determine the speed with which they move, so that longer fragments will not move as far as shorter ones. The result is that the DNA fragments will align themselves in an orderly pattern of parallel lines.

An error can occur in this procedure if something causes the entire pattern to “shift” in the gel. A shift is usually caused by an imperfection in the gel. The result is that the DNA fragments will move further or less than their true length would normally dictate.

Lifecodes utilizes a calibration procedure where a DNA marker of known length is included with the sample. If, for example, the calibration marker does not move far enough, then it is assumed that all the fragments did not travel as far and the results are adjusted accordingly.

Uniformity between tests is also a problem because fragments derived from the crime scene are often run on different gels than the suspect’s DNA. The possibility of this difficulty arose in State of Georgia v. Caldwell. Experts testified that the fragment pattern derived from the suspect’s DNA had shifted, but that a match could still be determined because the shift was uniform. Ultimately, the Caldwell court accepted the DNA evidence, despite the “shift,” finding that a visual match of the DNA prints from the crime scene and the suspect was confirmed by a scientifically acceptable method.

Southern Transfer

The purpose of this step is to make a permanent copy of the pattern of the DNA fragments on the gel. First, a nylon membrane is placed on top of the gel. A reservoir of buffer is then placed beneath the gel, and absorbent paper is placed on top of the nylon membrane to pull the buffer through the gel, picking up the DNA fragments along the way. This absorption process causes the fragments to bind to the membrane in the same positions they occupied in the gel. The resulting copy is known as a “blot.”

The sample is also treated with a chemical which causes the DNA chain to “unzip,” a process which is analogous to cutting the rungs of a ladder. The purpose of this treatment is to prepare the DNA for the next step, hybridization with a genetic probe.

Assuming that this process is carefully done, there should be no reliability problems.

Hybridization

The next step locates portions of the DNA chain that are highly polymorphic or hypervariable. Specially selected pieces of DNA, known as probes, are “tagged” with a radioactive substance and applied to the nylon membrane. The probes attach to specific bases sequences on the DNA chain and act as a radioactive marker. Lifecodes and Cellmark use a single-lodge probe that locks onto a polymorphic segment that occurs only once in the DNA chain. Because all chromosomes are present in duplicate, the resulting DNA print generally has two bands, one inherited from the mother and one from the father. This polymorphic segment may comprise only a portion of a fragment derived through restriction digestion. This step in the testing process poses no significant reliability problem.

Autoradiography

This step is essentially a “picture” of the positions of the probes. The nylon membrane, containing the radioactively-tagged probe, is placed on a piece of X-ray film. The radioactive energy from the probes expose the film and produces a pattern of bands known as a DNA print. The position of each band on the DNA print indicates the position of the polymorphic segment on the blot. The location of each tagged segment on the blot, which mirrors the location achieved by corresponding restriction fragments to which the probe attached, indicates the length of the DNA fragment identified.

The position of the bands on a DNA print varies from one individual to the next because the length of their DNA fragments vary. This procedure is relatively simple and has been reliably used by molecular biologists for over fifteen years. Assuming it is done correctly, it does not cause a reliability problem.

Interpretation of the DNA Print

The final step in the RFLP process is a comparison of the DNA prints produced from the crime scene and the suspect. If these match, there is a high probability that the samples came from the same source. There are two steps to the procedure. First, the two DNA prints are juxtaposed and examined visually to determine if they exhibit the same total pattern. Second, the size of each band is measured with the assistance of a computer digitizing system. The results are measured in terms of kilobase pairs. A kilobase pair is 1,000 base pairs.
For two DNA prints to be considered a match, the two bands compared should not differ by more than three standard variations. The standard deviation for these DNA segment measurements is 0.6 percent. Thus, two bands match if their measurements do not differ by more than plus or minus 1.8 percent. For example, a band length of 1,000 kilobase pairs matches bands with lengths of 982 kilobase pairs or 1,018 kilobase pairs because 1.8 percent of 1,000 is 18.

The Lifecodes matching procedure involves several steps that may result in error. First, the visual comparison for pattern similarity is based solely on subjective impressions with no objective check. This portion of the interpretation can be made difficult by degraded or contaminated DNA samples. Some critics have suggested that commercial labs hired by the prosecution may be more inclined to declare a match based solely on subjective impressions with no objective check. This may in fact have a different chemical structure, and hence, may come from a different source. Be aware, however, that the prospect of a false match decline as more restriction fragments are isolated, measured and matched.

The Reliability of Band Measurements

It is uncommon for band length measurements derived from RFLP testing to match exactly. As previously mentioned, Lifecodes considers two bands differing by less than 1.8 percent to be a match. The frequency figure is determined by averaging the length of the known sample with the length of the crime scene specimen and then consulting the database.

For example, assume that a band from the suspect’s DNA print measured 2,000 kilobase pairs while the band from the crime scene DNA print measured 1,960 kilobase pairs; in this case, Lifecodes would use the frequency of a band measuring 1,980 kilobase pairs. One human geneticist has written that this calculation may cause an error on the order of 8,000 fold. In Caldwell, a defense expert recalculated the probability of a random match, without averaging, to be only one in 360.

A fundamental criticism queries whether the lengths of the DNA fragments can accurately determine that the samples came from a common source. While the RFLP test is designed to determine the number of kilobase pairs contained in a restriction fragment, it cannot determine if the restriction fragments contain the same base pairs. Thus, fragments of similar lengths that register as a match under the RFLP test may in fact have a different chemical structure, and hence, may come from a different source.

The Reliability of Band Frequencies

After computing the average of the two band lengths, Lifecodes looks at the frequency with which this band length will occur at its location in the DNA strain as compared to the general population.

Based upon DNA tests of 900 unrelated persons in the New York and Los Angeles areas, Lifecodes compiled a database of gene frequencies. This study provides Lifecodes with relative frequencies of various gene lengths at five loci on the human DNA chain. These figures are used to calculate the probability of a random match between samples.

The frequency figures used by Lifecodes have come under question. The most significant challenge is that the study is based upon only 900 people in only two cities. Some critics argue that deducing the frequency of fragment lengths from such a small and regional sample of the population is faulty.

The greatest flaw in the gene pool extrapolation may be variation among ethnic groups. The Lifecodes study was broken into three ethnic groups: U.S. Blacks, Caucasians and Hispanics. Significant differences were found in the pattern of distribution and relative frequencies of gene lengths among these three ethnic groups. For example, at D14S13 loci, U.S Blacks had frequencies four times more common than Caucasians and Hispanics for bands 3.4-5 kilobase pairs long. At the D2S44 loci, bands 6.7-9.3 kilobase pairs were found 2.7 times more frequently in U.S Blacks than in Caucasians. The greatest difference occurred among the most common genes. One conclusion from these results is that there are subgroups even within ethnic groups and that each subgroup could have a different genetic frequency distribution.

Another shortcoming of the Lifecodes study is that it does not encompass some ethnic groups, such as Asians, Jews and Native Americans. The lack of data from these groups will pose a reliability problem should a suspect belong to one of these classes. Equally problematic is the question of what to do when a suspect of mixed race is tested. Which gene frequency distribution should be used? What if a portion of the suspect’s ethnic makeup has not been studied? The differing results between the three ethnic groups tested thus far suggest that the untested ethnic groups would also have a different gene distribution. This potential for error should be recognized and warrants further study before these calculations are touted as reliable.

The Reliability of DNA Calculations

Law-enforcement agencies hold great hopes for DNA testing because of its potential for identification. The probability of a random match through blood typing may be as high as 1 in 2.36. Assuming that the test is done correctly and that the frequency calculations accurately
reflect the gene distribution in the population, the probability of a coincidental match between a suspect’s DNA and the sample taken from a crime scene can be as low as one in several hundred million. If the probability calculation is not of this order of magnitude, then counsel should seriously question the results. For example, a probability of 1 in 2,000 might suggest either that a different type of test was performed, or that one or more bands could not be used in the calculation.

As described above, the frequencies generated at each locus on the DNA chain are multiplied together to obtain a total frequency of occurrence for the entire DNA-print pattern. This number when stated as a reciprocal represents the probability of a random match.65

However, the use of the product rule will accurately predict the chance of multiple events only if each event is independent from the others.66 Independence means that the occurrence of one event does not affect the probability of a second event. Thus, the band length at each locus must be independent of both other potential bands at that location and the band lengths at other locations on the DNA chain.

Statistical independence within a locus is referred to as Hardy-Weinberg equilibrium (HW), while statistical independence across loci is called linkage equilibrium (LB).67 Linkage disequilibrium is considered unlikely when the restriction fragments are on different chromosomes.68 Lifecodes has reduced the possibility of linkage disequilibrium by using probes that sever the DNA chain at locations significantly distant from one another.69

The Hardy-Weinberg Law holds that gene frequencies will remain constant (“equilibrium” will be achieved) from generation to generation within a population unless outside forces act to change them, provided that mating remains random.70 Processes such as natural selection, inbreeding and population substructuring may cause deviations from the Hardy-Weinberg equilibrium.71 Population substructuring will result in a statistical phenomenon called the Wahlund effect. The Wahlund effect arises when genetic data from several genetically differentiated populations are collected and treated as if they have come from a single randomly mating population.72 It is arguable that the existence of ethnic or other subgroups may challenge the appropriateness of using the Hardy-Weinberg Law and the product rule.73

A further difficulty is that a sufficiently broad and diverse sampling size is required to determine if a population is in Hardy-Weinberg equilibrium. An assumption of equilibrium based upon a limited sampling may be erroneous. Some experts argue that statistical tests for Hardy-Weinberg equilibrium are not the proper method for determining whether genetic differentiation exists among subgroups in a population, and that the only way to discern genetic variation is through sampling of the subgroups.74 If assumption of a Hardy-Weinberg equilibrium is erroneous, for whatever reason, then the application of the product rule will not result in a correct assessment of the probability of a random match.

Presenting DNA Test Results to the Jury

Several aspects of the RFLP test and analysis are of questionable accuracy. Some experts argue that the probability calculation is the greatest source of imprecision.75 Further, the likelihood of a random match, couched in terms of one in several hundred million, can have an overpowering effect upon the jury. The prejudicial impact includes a mistaken belief by the jury that the odds represent the probability that the defendant is not guilty. The sheer magnitude of the ratio distracts the jury from other issues in the case, including the question of whether the DNA test itself was properly done.

In addition, few jurors have the background to evaluate the validity of the probability calculation in an independent fashion. They must rely on the testimony of the party offering the test. The results of a DNA printing test lend a false sense of scientific certainty when they are bolstered with a probability of error that sounds like the odds in a state lottery.

One response to this situation has become known as the “Kidd Rule.” Dr. Kidd, testifying on behalf of Lifecodes, stated that any

disequilibrium in the Lifecodes database would not reduce the identity power of the test by any more than a power of 10.76 The court in Wesley took his remark quite literally and reduced the Lifecodes identity power by exactly a power of 10.77 Dr. Kidd did not mean that this adjustment would make the probability calculation any more accurate, indeed this “rule” is not based upon any scientific or statistical theory.78

It is viable to argue that the probability calculation is not presently reliable enough to be admitted into court. In legal jargon, the probability calculation is not sufficiently probative to overcome the potential prejudicial impact against the defendant.

The best solution is to exclude all testimony regarding the probability of a coincidental match between DNA prints. The RFLP test is clearly a valuable and damming forensic tool. Its scientific basis cannot be seriously challenged. The only testimony that should be admitted is a statement that no two people have ever had identical DNA prints, with the exception of identical twins.

IV. ADMISSIBILITY OF DNA TESTING

As prosecutors began introducing DNA test evidence in criminal cases, the courts responded by looking to the evidentiary rules governing the admissibility of novel scientific techniques. Two rules have developed throughout the various jurisdictions: (1) the standard first introduced in Frye v. United States;79 and (2) the more permissive “relevancy” standard.80 The majority of jurisdictions apply the Frye rule.81 Virginia and the Fourth Circuit use the relevancy approach.82

Andrews and Wesley: The Fast Track to Judicial Acceptance Begins

One of the first judicial considerations of DNA profiling evidence came under a jurisdiction governed by the relevancy approach.83 In State v. Andrews,84 the defendant became the first American convicted on the basis of DNA testing evidence while still maintaining his innocence throughout his trials. His case also resulted in the first appellate decision on the admissibility of DNA testing.85

Another early indication of judicial reaction to DNA identification came from a jurisdiction subscribing to the Frye standard. The court in People v. Wesley,86 enthusiastically upheld the use of DNA testing and elaborated on the Frye standard by observing that it does not require a particular procedure be unanimously endorsed in the scientific community, rather that it only be “generally accepted as reliable.”87

In both Andrews and Wesley the prosecution was able to draw upon the expertise of the commercial laboratories marketing the test, and thus, put together testimony superior to that which the defense was able to present.88 While the courts had considered evidence concerning the implementation of the test, they had neither excluded evidence on this basis nor decided whether such evidence went to weight or admissibility.

Woodall and Spencer: High Courts Examine the Theory

During 1989 two decisions brought the issue of DNA evidence to a higher level of review. The first was State v. Woodall,89 which involved an inconclusive result from a DNA test. The issue before the court was whether evidence of inconclusiveness in the DNA test should be admissible. The West Virginia Supreme Court of Appeals declared that “the reliability of these tests is now generally accepted by geneticists, biochemists, and the like”90 and ruled that in the future West Virginia courts may dispense with Frye hearings and simply take judicial notice of the reliability of DNA profiling. The court provided that expert testimony was still admissible for the purpose of impeaching the specific procedures used, or for the results that were obtained; but such expert testimony generally goes to the weight of the evidence, and only in extreme cases will it go to admissibility itself.91
The second decision involved the twin cases of *Spencer v. Commonwealth.*92 These cases were the first incidence of a state high court affirming a conviction based upon DNA evidence. In fact, the DNA identification evidence was the only basis for convicting the defendant and for inflicting the death penalty. On the question of admissibility, the *Spencer* court did not state specifically which test should govern, however it did clearly reject the *Frye* test.93

*Spencer* and Woodall resembled Andrews and Wesley in that the treatment of the DNA identification issue revolved around the theory of the test, rather than the adequacy of the specific procedures employed in the case. The *Woodall* court seemed to agree with the suggestion in Wesley that questions regarding adequacy of procedure go primarily to weight rather than admissibility.94

**Castro and Schwartz: A Case Specific Threshold Inquiry**

Until the second half of 1989 the courts seemed to be on the fast track to judicial acceptance of DNA testing. This trend was challenged by *People v. Castro.*95 The Castro court quite accurately referred to its efforts as “the most comprehensive and extensive legal examination of DNA forensic identification tests held to date in the United States.”96

The defendant in *Castro* was accused of the murder of a pregnant woman and her young daughter. The defendant was arrested wearing a wrist watch with detectable blood stains on it. While he claimed that the blood was his own, the prosecution sought to introduce DNA evidence demonstrating that the blood was that of the adult victim.

The *Castro* court stated that it would follow the *Frye* rule in its consideration of the DNA evidence.97 The court then applied a three-prong analysis, which was described as follows:

- **Prong I:** Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?
- **Prong II:** 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?
- **Prong III:** Did the laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case?98

As a theory, DNA analysis passed the first prong of the *Castro* test. Indeed, the court found this to be the “sole area of unanimous agreement” among the scientists and lawyers in the case.99 The second prong was also met after an in-depth review of the components of the DNA testing process.100 The court found enough evidence to establish that the techniques utilized in the test were currently recognized in the relevant scientific community and hence capable of producing reliable results in forensic identification.101

The third prong was by far the most controversial aspect of the court’s analysis and the basis for the most significant part of the case. The court conceded that prior decisions were in disagreement over whether testing procedures, performed in their respective cases, should be part of the *Frye* inquiry. It opined that the *Frye* test too often focused only upon the general acceptance issue and thus overlooked problems involving performance of the test.102

The *Castro* court argued that “[t]he focus of this controversy must be shifted” and “centered around the resolution of the third prong.”103 The court then explained that the complexity of the DNA testing procedure and the potential impact it could have upon the jury necessitated such a shift. The court then concluded that this concern would be better addressed in a pre-trial hearing to determine whether the procedure and calculations performed in the particular case were reliable enough for presentation to the jury.104

As to the DNA evidence in question, the *Castro* court decided that it was admissible for purposes of excluding the defendant, but inadmissible for purposes of inculpating the defendant. This decision was based upon a finding that the testing laboratory had “failed in several major respects to use the generally accepted scientific techniques and experiments for obtaining reliable results.”105

Another recent case suggests that courts may be receptive to the *Castro* analysis. In *State v. Schwartz,*106 the Minnesota Supreme Court wrote that the question of admissibility under *Frye* “hinges” on “the laboratory’s compliance with appropriate standards and controls, and the availability of their testing data and results.”107 The Schwartz court, after considering both expert testimony on the laboratory’s testing procedures and on guidelines for DNA RFLP analysis established by the Technical Working Group on DNA Analysis Methods,108 found that the lab performing the test had failed minimum guidelines,109 and ruled that “the test results lack foundational adequacy and, without more, are thus inadmissible.”110

**Proposals for Improvement**

In addition to a more detailed analytical framework, the *Castro* court offered three procedural suggestions based upon its extensive study of the issue of DNA evidence. First, a party intending to use DNA identification should give prompt notice to the opposing side. Second, expanded discovery should be permitted.111 Third, the proponent of the DNA evidence should have the burden of establishing that the tests and calculations in the case were conducted properly.112

Another area in need of attention is quality control. Many of the most impressive claims regarding the accuracy and identification capabilities of DNA profiling are based upon laboratory research with “clean” samples. Biochemist Richard Roberts of Cold Spring Harbor Laboratory remarked that if a lab sample fell on the floor, he would throw it away and start over, “but [that] in forensics, all of the samples have been on the floor, so you don’t really know what you’ve got.”113

A very thorough and impressive law review note114 points out that “[t]he main criticism [of DNA testing] is not that it will never be reliable, but that the lack of uniform standards and quality controls allows the ambiguities and problems in the technique to go unnoticed.”115 The note urges the following controls and standards:

1) controls to ensure the accurate interpretation of results; 2) standards for declaring matches; 3) standards for the choice and number of polymorphic sites studied; 4) standards for determining the probability of a coincidental match and for determining the relevant population studies; 5) standards for record keeping; and 6) standards for proficiency testing and licensing.116 However, some observers caution against a premature attempt to standardize a rapidly evolving technology and advise full consideration of the potential ethical issues.117

**Recent Events**

The adequacy of the genetic databases is a matter of intense debate as of this printing. An article published in *Science* magazine taking issue with the assumptions underlying the probability calculation118 sparked so much controversy that it prompted an article supporting the current practice,119 an editorial “lead-in” article120 and disclaimer of impropriety by the editors121 all within the same issue! The following issue of *Science* included a study devoted to random matches in the Lifecodes and FBI databases concluding that the probability of a matching DNA profile between unrelated individuals to be vanishingly small.122

Several days after the controversial article in *Science* magazine, the FBI sent out a press release in support of DNA technology and the FBI’s methods.123 In the release it was stated that Drs. Hartl and
hired to perform DNA testing. Thus, all of the work in preparation for a test, as well as the actual result, is covered by the work product privilege unless and until, the witness is called to the stand.\textsuperscript{132} The jury should not be told that the defense has conducted a test, because to do so would require the jury to speculate about the result of the test. As a practical matter, the defense must usually make a tactical decision early in the case whether it will seek to have a DNA test performed, assuming the prosecution has not already initiated such testing. A defense request for evidence samples will force the prosecution to decide whether to conduct a test before the evidence leaves its custody. Therefore, there is always a calculated risk for the defense in moving for discovery of the evidence first, but it does have the advantage of forcing the prosecution to bear the cost.

The extent to which the defense will be granted discovery of any DNA test results obtained by the state may become an issue. The court may limit discovery to the reports alone, or it may allow discovery of all laboratory notes made during testing as well as permit access to physical evidence such as photographs, autoradiographs, and electrophoretic gels. Because DNA testing is often performed by private laboratories that compete with one another, the company conducting the test may assert a proprietary interest regarding some the information. The defense may get around this by requesting a protective order to avoid disclosure of trade secrets to a competing firm. If the company continues to resist, the defense may have to argue that the due process rights of the defendant outweigh the economic concerns of a private company.

V. ADVICE FOR DEFENSE COUNSEL

The issues of admissibility, statistical validity and procedural propriety have already been discussed. These issues may form the basis for an evidentiary challenge, but the prospects in a Virginia court do not appear to favor the defense.\textsuperscript{132} Several other tactics and preliminary matters deserve attention.

At present, the use of DNA identification technology is primarily a tool for prosecutors. However, there may be times when the state will not have the evidence tested. For example, there may be other evidence suggesting guilt or the defendant may not have an alibi. In such a situation, obtaining the biological evidence through discovery so that an expert retained by the defense can compare samples may be advisable. If there is not a match, then the defense will want to bring up the exclusion of the defendant at trial. If there is a match, the defense will seek to keep the evidence out of trial and will attempt to prevent the prosecution from acquiring discovery of the results. The defense should, through a motion in limine seek an order of the court prohibiting the prosecution from even mentioning at trial that the defense has done any DNA testing.

Under certain circumstances retesting may be warranted. If it appears that an adverse test result will be introduced at trial, then the defense may wish to obtain the sample through discovery in order to have it retested by an independent expert. This option may not be available if there is insufficient sample remaining from the initial test. While the RFLP test requires a significant quantity of biological material,\textsuperscript{133} there may be enough remaining for a PCR test.\textsuperscript{134} The preservation and reanalysis of biological evidence is likely to become a major concern for the defense bar if DNA testing is routinely accepted by the courts.

Defense attorneys must be prepared to deal with the possibility of DNA evidence at the early stages of a case if the evidence is to be preserved for exclusionary or retesting purposes. A recent United States Supreme Court case\textsuperscript{135} holds that the failure of police to preserve potentially useful evidence is not a denial of due process of law unless the defendant can show "bad faith" on the part of law enforcement personnel. Thus, if biological evidence exists and there is a substantial issue over the identity of the perpetrator, then the defense should submit a motion to require preservation of the evidence. A subsequent failure to preserve such evidence may meet the standard for "bad faith." Again, counsel will need to draft motions to accomplish this objective.\textsuperscript{136}

An agency relationship exists between the defense and an expert hired to perform DNA testing. Thus, all of the work in preparation for
possible from degraded DNA. In addition, the test is relatively easy to
be insufficient for RFLP testing. A second benefit is that testing is
PCR technology is that it permits testing of a sample that might otherwise
procedure reproduces certain gene sequences. The greatest benefit of
was developed by Cetus Corporation of Emeryville, California. This
iary of ICJ Americas, Inc., a corporation based in Great Britain. Cellmark's
Quantum Chemical Corporation. Lifecodes began forensic testing in
percent of these cases, the DNA test showed that the suspect's DNA did
lenging current technique, the FBI issued a press release on December
DNA evidence has been admitted in about 600 cases in all states except North
forensic services manager for Cellmark Diagnostics, as saying that DNA
this an issue. The article can be extremely helpful if an error or shortcoming in the DNA test is suspected.
A nanogram is a billionth of a gram. Kanter, Baird, Shaler &
Analysis of Restriction Fragment Length Polymorphisms in
DNA Fingerprinting: Possibilities and Pitfalls of a New
The FBI Laboratory has issued DNA test results in more than
30 percent of these cases, the DNA test showed that the suspect’s DNA did
match the DNA at the crime scene. FBI experts have testified over
250 times in federal, state and local courts in over 40 states.


Burk, DNA Fingerprinting: Possibilities and Pitfalls of a New
Technology, 28 Jurimetrics J. 455, 468-69, 469 n.65 (1988)("the name
"fingerprinting" may create unsubstantiated beliefs and expectations in the
minds of judges and jurors").
The most common type of DNA identification is an RFLP test. See
infra, note 14.
Remember that DNA is a twin helix.
Lifecodes Corporation of Valhalla, New York is a subsidiary of
Quantum Chemical Corporation. Lifecodes began forensic testing in
1987. It was the first U.S. firm to get DNA evidence into court and to
obtain a conviction based upon the evidence.
Cellmark Diagnostics of Germantown, Maryland is a subsidiary of
ICI Americas, Inc., a corporation based in Great Britain. Cellmark’s
technique was developed by Dr. Alec Jeffreys. The company opened in
1987 and obtained the first death penalty conviction in the United States
based on DNA evidence.
The FBI opened its DNA laboratory for business in December

Another test called Polymerase Chain Reaction (PCR) testing
was developed by Cetus Corporation of Emeryville, California. This
procedure reproduces certain gene sequences. The greatest benefit of
PCR technology is that it permits testing of a sample that might otherwise
be insufficient for RFLP testing. A second benefit is that testing is
possible from degraded DNA. In addition, the test is relatively easy to
perform and can be obtained in a relatively short period of time. The test
attempts to identify the “DQ-alpha genotype.” See Sensabaugh & von
Beroldingen, The Polymerase Chain Reaction: Application to the Analysis
of Biological Evidence, in Forensic DNA Technology 63 (Farley &

See also Spencer IV, 240 Va. 78, 393 S.E.2d 609 (1990); note
89 infra.

For a more thorough discussion of the RFLP test, see Thompson &
Ford, DNA Typing: Acceptance and Weight of the New Genetic
& Ford, DNA Typing: Acceptance and Weight).

Thompson & Ford, The Meaning of a Match: Sources of
Ambiguity in the Interpretation of DNA Prints, in Forensic DNA
Technology 93 (Farley & Harrington ed. 1991)(hereinafter Thompson
& Ford, Ambiguity in DNA Prints). This article is a very detailed account
of errors that can and have been made, as well as a listing of cases
where ambiguous DNA evidence was an issue. The article can be extremely
helpful if an error or shortcoming in the DNA test is suspected.

A nanogram is a billionth of a gram. Kanter, Baird, Shaler &
Analysis of Restriction Fragment Length Polymorphisms in
Deoxyribonucleic Acid (DNA) Recovered From Dried Bloodstains,

Sensabaugh, Forensic Biology - Is Recombinant DNA Tech-

Interview with Michael Baird (May 4, 1988), as reported in
Boeler & Wiebe, DNA Identification Tests and the Courts, 63 Wash. L.

People v. Wesley, 533 N.Y.S.2d 643, 652, 140 Misc.2d 306,
Laboratory and Dr. Kenneth Kidd of Yale University.

Id. at 649, 140 Misc.2d at 315.

Interview with Michael Baird, note 18 supra, wherein it is
reported that Lifecodes has observed erroneous bands produced by
bacterial DNA.

Budowle, Baechtel & Adams, Validation with Regard to Envi-
ronmental Insults of the RFLP Procedure for Forensic Purposes,
in Forensic DNA Technology 83 (Farley & Harrington ed. 1991).

Wesley, 533 N.Y.S.2d at 648, 140 Misc.2d at 315 (The court
accepted the claim that all of the steps in DNA testing utilize scientific
principles and technology that have gained general acceptance in the
scientific field in which they belong).

Fuchs & Blakesly, Guide to the Use of Type II Restriction
"troubleshooting guide" lists thirty-seven different possible causes of
problems that may be encountered during restriction digestion.

"Restriction digestion is regarded as a rather tricky pro-
cedure which can yield spurious results if performed in a manner which
departs even slightly from an exacting protocol." Thompson & Ford,
DNA Typing: Acceptance and Weight, note 14 supra, at 68.


Thompson & Ford, Ambiguity in DNA Prints, note 15 supra, at
120-28.
27 Fuchs & Blakesley, note 24 supra, at 5. According to Fuchs and Blakesley, the most important factors affecting the performance of restriction enzymes are: (a) the purity and physical characteristics of the substrate DNA; (b) the reagents used in the reaction; (c) the assay volume and associated errors; and (d) the time and temperature of incubation.

There are hundreds of different restriction enzymes available that recognize and cut at different sites. Brooks, Properties and Uses of Restriction Endonucleases, in Methods in Enzymology 152:113 (1987).


29 Wesley, 553 N.Y.S.2d at 649, 140 Misc.2d at 315-16.

30 Id.

31 Thompson & Ford, note 14 supra, at 70.


33 Id.

34 260 Ga. 278, 393 S.E.2d 436 (1990); Harvey & Berry, DNA Typing: Keeping the State Out of Your Client’s Genes, 8 Champion 19, 24 (1989).

35 Id. at 288, 393 S.E.2d at 443.

36 Id.


38 Thompson & Ford, note 14 supra, at 72. Multi-locus probes are also used, usually in paternity cases, which lock onto “families” of polymorphic DNA segments that occur at many locations on the human DNA chain. These multi-locus probes produce approximately fifteen interpretable bands.

39 Only one band will appear in cases where the maternal and paternal alleles are identical, for example when parents have the same blood type. Thompson & Ford, DNA Typing: Acceptance and Weight, note 14 supra, at 72.

40 Id. at 74.

41 Id.


43 Baird, note 32 supra, at 44.

44 Id. at 44-46.

45 The standard deviation is the average amount all band lengths differ in magnitude from the mean band length computed for that locus.


47 Baird, note 32 supra, at 46-47.

48 Moss, note 2 supra, at 67. A degraded or contaminated DNA sample can result in a print that is less clear or one that has too many bands.


51 Baird et al., note 46 supra, at 494.

52 Thompson & Ford, note 14 supra, at 81.


55 Baird, note 47 supra.

56 Quoted from Dr. Eric Lander, a human geneticist and mathematician at Whitehead Institute for Biomedical Research Cambridge, Mass., as reported in Harvey & Berry, note 27 supra.

57 Harvey & Berry, note 34 supra.

58 Balazs et al., note 53 supra, at 182.

59 Id.

60 Balazs et al., note 45 supra, at 187-88.

61 Id.

62 Id.


64 For example, Lifecodes will save a small portion of the crime scene sample for Polymerase Chain Reaction (PCR) testing which amplifies informative gene sequences.

65 The use of a reciprocal here results in the translation of a decimal figure to a fraction. For example, 0.03 can be stated as 3/100 or as a probability of 3 in 100.

66 Tribe, note 54 supra, at 1335-36.


68 Id.

69 Balazs et al., note 53 supra, at 185.

70 Vogel & Motulsky, Human Genetics 152 (2d ed. 1986).

71 Mueller, note 67 supra.
72Id. at 60-61.
73Id.; see also Lewontin & Hartl, Population Genetics in Forensic DNA Typing, 254 Science 1745 (1991).
74Lewontin & Hartl, note 73 supra.
75Id.
76Wesley, 533 N.Y.S.2d at 658.
77Id. at 659.
79293 F.2d 1013 (D.C. Cir. 1923).
Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and 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. Id. at 1014.
80Under the relevancy standard, the question of admissibility is evaluated by the logical relevancy of the evidence, such that exclusion is required when its probative value is outweighed by potential prejudice. McCormick on Evidence § 203, at 607 (E. Cleary 3d ed. 1984). One statement of the test urges scrutiny of:
(1) the soundness and reliability of the process or technique used in generating the evidence, (2) the possibility that admitting the evidence would overwhelm, confuse, or mislead the jury, and (3) the proper connection between the scientific research or test result to be presented, and particular disputed factual issues in the case. United States v. Downing, 753 F.2d 124, 1237 (3d Cir. 1985).
81See Giannelli & Imwinkelried, Scientific Evidence § 1-5, at 10-11 (1986)(describing Frye as the majority test); Thompson & Ford, note 14 supra, at 53.
83Florida has a history of receiving novel scientific evidence readily. See e.g., Coppolino v. State, 223 So.2d 68 ( Fla. Dist. Ct. App. 1968), cert. denied, 399 U.S. 427 (1970). In this highly publicized matter, a physician was prosecuted for the murder of his wife. The trial court accepted a forensic test indicating the presence of a particular poison in the victim’s body, even though the test was developed for use in the investigation. Dr. Coppolino’s appeal was denied, despite the able representation of F. Lee Bailey, and represented the first significant representation of F. Lee Bailey, and represented the first significant
84Andrews, No. 87-1659 (Fla. Cir. Ct. (Orange County) Nov. 1987); see also Nat’l L.J., January 18, 1988, at 42.
85Andrews v. State, 533 So.2d 841 (Fla. Dist. Ct. App. 1988). The court explicitly adopted the relevancy standard, and noted that the lower court had not definitively handled the issue.
87Id. at 309, 533 N.Y.S.2d at 645 (quoting People v. Middleton, 54 N.Y.2d 42, 49, 429 N.E.2d 100, 103, 444 N.Y.S.2d 581, 584 (1981)).
88See Thompson & Ford, DNA Typing: Acceptance and Weight, note 14 supra, at 104 (stating that “the defense in Wesley was hindered by its [inability] to present a witness who had experience working with the molecular biology techniques employed by the Lifecodes’ test”); Comment, DNA Printing: The Unexamined “Witness” in Criminal Trials, 77 Cal. L. Rev. 665, 691 (1989)(noting that although Andrew’s attorney contacted a number of university scientists and the FBI, the defense still could not find an expert witness willing to testify on its behalf).
90Id. at 260.
91Id.
Spencer III, 238 Va. 563, 385 S.E.2d 850 (1989), says little about the issue of DNA evidence other than a cursory statement that the test was performed correctly and that DNA testing is a reliable scientific technique. Spencer IV, 240 Va. 78, 393 S.E.2d 609 (1990), involved the same defendant but a different victim. An RFLP test in this case was unsuccessful, but an analysis was made using a process called PCR amplification which resulted in identification of the defendant’s “DQ-Alpha genotype.”
93Spencer I, 238 Va. at 290 n.10, 384 S.E.2d at 783 n.10 (citing O’Dell v. Commonwealth, 234 Va. 672, 695-96, 364 S.E.2d 491, 504, cert. denied, 109 S.Ct. 186 (1988)). The court did, however, note that “even if Frye were the test in Virginia, DNA printing would meet that test.” Id.
94Woodall, 385 S.E.2d at 260. However, the court did acknowledge that in some circumstances “[e]xpert testimony may be received to impeach the particular procedures employed in a specific test or the reliability of results obtained.” Id.
96Id. at 956-57, 545 N.Y.S.2d at 985. The court held a twelve week pre-trial hearing on the issue and generated a transcript of over five thousand pages. Id. at 957, 545 N.Y.S.2d at 986.
97Id. at 958, 545 N.Y.S.2d at 986-87.
98Id. at 959, 545 N.Y.S.2d at 987.
99Id. at 960, 545 N.Y.S.2d at 988.
100Id. at 964-73, 545 N.Y.S.2d 990-95.
101Id. at 973, 545 N.Y.S.2d at 995.
102Id. at 960, 545 N.Y.S.2d at 987-88.
103Id.
opposing the introduction of DNA evidence should strongly consider 

The prolific work by Janet Hoeffel borders on a treatise. Counsel 

Importance of Human Error as a Cause of Forensic Misanalysis, 

Cases Over the Foundation for the Admission of Scientific Evidence: The 

should bear the burden of proof, 

normally go to the weight of the evidence. Where, however, the proce- 

show (by a preponderance of evidence) that the tests or calculations should 

met, however, the ultimate burden of proof would shift to the adversary to 

Chain of custody documents. 

I) Copies of the autorads, with the opportunity to examine the 

II) The 

I2) Id. at 799, 545 N.Y.S.2d at 999. After such a burden has been 

met, however, the ultimate burden of proof would shift to the adversary to 

show (by a preponderance of evidence) that the tests or calculations should 

not be admitted or should be modified. If issues of fact were to arise at the 

pre-trial hearing relating to the reliability of a particular test used in the 

case, or the size or ratio of the population frequency calculated, they would 

normally go to the weight of the evidence. Where, however, the proce- 

dures reach the level of unreliability found in Castro, the results would be 

inadmissible as a matter of law. Id. 

For an interesting argument that the opponent of the evidence 

should bear the burden of evidence see Imwinkelreid, A Debate in the DNA 

Cases Over the Foundation for the Admission of Scientific Evidence: The 

Importance of Human Error as a Cause of Forensic Misanalysis, 69 Wash. 


Cooke, Standards Sought for DNA Testing, Newsday, June 15, 

1989, at 27. 


This prolific work by Janet Hoeffel borders on a treatise. Counsel opposing the introduction of DNA evidence should strongly consider reading it.

Id. at 479. 

Id.

120Sherman, note 126 supra.


132Counsel considering such a challenge to the admissibility of DNA evidence should read the following article: Hymer, DNA Testing in Criminal Cases: A Defense Perspective, in Forensic DNA Technology 181 (Farley and Harrington ed. 1991).

133See notes 16 and 17 supra.

134See note 13 supra.


136An excellent text providing useful case authority for such motions is Giannelli & Imwinkelreid, Scientific Evidence, The Michie Co. (1986).


DRUG FELONY CAPITAL MURDER IN VIRGINIA

BY: SHARRON LAMOREAUX

In 1990, Virginia amended its capital murder statute, Virginia Code § 18.2-31, by adding subdivision 9. The amendment provides that a killing during and for the purpose of furthering a drug transaction constitutes capital murder, punishable by the death penalty or life imprisonment. It is important for attorneys defending clients faced with murder and/or drug charges to be aware of the new provision and of its meaning. This article explores the structure and scope of § 18.2-31(9) and compares it to a somewhat similar federal statute.

Statutory Structure

The Virginia drug felony capital murder provision involves three separate code sections. Virginia Code § 18.2-31(9) establishes that capital murder includes a "willful, deliberate, and premeditated killing of any person in the commission of or attempted commission of a violation of § 18.2-248, involving a Schedule I or II controlled substance, when such killing is for the purpose of furthering the commission or attempted commission of such violation." Without § 18.2-31(9), a killing during a violation of § 18.2-248 could not be classified as capital murder solely because of that violation.

Section 18.2-248, violation of which is the felony predicate for § 18.2-31(9), addresses the distribution of drugs. Under this section, it is illegal to "manufacture, sell, give, distribute, or possess with intent to manufacture, sell, give or distribute a controlled substance or an imitation controlled substance" without authorization. Maximum punishments for violations vary with the nature of the substances involved. Trafficking in less serious drugs is a misdemeanor, punishable by jail time of not more than one year and/or a fine of not more than $2,500. A violation of § 18.2-248 involving more serious drugs is punishable by five to forty years for the first offense and as much as a life sentence for subsequent convictions.

Controlled substances are classified as to their degree of seriousness by five schedules in The Drug Control Act, codified at Virginia Code § 54.1-3400 et seq. Only substances in Schedules I and II are pertinent to the drug felony murder provision — murders involving substances from Schedules III, IV, and V are not provided for in § 18.2-31. Schedules I and II include substances that have a high potential for abuse, such as heroin, mescaline, methaqualone, morphine, and cocaine.5

Statutory Breadth: Picking the Correct Defendant

Determining the scope of § 18.2-31(9) requires examining several aspects of § 18.2-31(9) itself and of § 18.2-248. The role of The Drug Control Act in this determination, although important for purposes of knowing which substances are in Schedules I and II and which are not, is fairly straightforward and consequently will not be further considered in this article.

It should first be noted that first degree murder is necessary for § 18.2-31(9) to apply. As with the other subsections of the capital murder statute, subsection 9 requires a "willful, deliberate, and premeditated" killing. Although the usual rule that premeditation need not exist for any specified period of time prior to the killing applies,3 still the intent to kill must be formed before or at the time of the murder.4 An unintentional or grossly negligent or malicious killing that occurs during a drug transaction, therefore, would not be covered by the statute.

A second factor limiting the scope of the drug felony murder provision arises from § 18.2-248. Section 18.2-248 is a specific intent law — it requires manufacture, distribution, or possession of drugs or imitation drugs with intent to manufacture or distribute the same. Committing a prohibited act without having the prohibited intent is not a violation of this section and thus not a basis for a capital murder charge. For example, processing or transferring an illegal substance, thereby committing a prohibited act, without being aware of its illegality and thus not having the prohibited intent is not a violation. A murder to facilitate such an act would therefore not qualify as capital murder.

Furthermore, simple possession of a drug is also not encompassed by § 18.2-248. Although possession may violate another Virginia law,6 it is no violation of § 18.2-248 and thus again cannot be a basis for a capital murder charge. Apparently, then, a killing to further mere possession of a controlled substance, without intent to subsequently transfer the substance, is not chargeable as capital murder.

Finally, the last clause of § 18.2-31(9) is significant. The clause specifies that a murder during the commission or attempted commission of a § 18.2-248 violation must be "for the purpose of furthering the commission or attempted commission of such violation." This phrase on its face seems to narrow the applicability of § 18.2-31(9) to premeditated murders committed in the course of an illegal drug transaction expressly to advance that transaction. Premeditated murders committed during drug transactions but not to aid or advance the transactions would appear to be outside the capital murder provision. Because the requirement is "for the purpose of furthering," however, murders undertaken to aid the drug