Fourth Report of the Independent Investigator for the Houston Police Department Crime Laboratory and Property Room

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Executive Summary

This is the Fourth Report of the Independent Investigator for the Houston Police Department ("HPD") Crime Laboratory and Property Room. This report, like our previous reports, is intended to advise the City of Houston (the "City") and the public of our progress in fulfilling the mandate to conduct a comprehensive independent investigation of the Crime Lab and Property Room.[1]

The investigation is divided into two phases. In Phase I, which we completed with the issuance of our Third Report on June 30, 2005, we investigated the historical operations, practices, and management of the Crime Lab and Property Room as well as assessed the scope of the work to be performed during the second phase of the investigation. Phase II, which began with the Houston City Council's approval of our Phase II Plan on August 24, 2005, centers on the review of approximately 2,700 cases originally analyzed by Crime Lab forensic scientists in each of the six forensic science disciplines in which the Crime Lab historically performed work -- DNA/serology, trace evidence, controlled substances, firearms, toxicology, and questioned documents. Through the first week of December 2005, we have completed a total of over 1,100 case reviews across all of the sections of the Crime Lab, which is approximately 41% of the total number of case reviews we currently plan to perform during Phase II.[2] We also have conducted interviews of Crime Lab personnel to gather additional information and deepen our understanding of issues that have arisen during the case reviews.

In our Third Report, we highlighted several themes that had emerged in our efforts to determine the root causes of the severe problems that have afflicted the Crime Lab.

- <u>Lack of support for the Crime Lab within HPD and by the City</u>. During at least the 15 years preceding the closure of the DNA Section in December 2002, HPD and the City failed to provide the Crime Lab with adequate resources. In particular, the City and HPD failed to

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support the Crime Lab to ensure that the DNA/Serology Section was properly staffed and supervised and that its analysts were trained to perform high quality, reliable scientific work. One of the most glaring examples of how HPD and the City failed the Crime Lab was that there was no Criminalist III line supervisor over the DNA/Serology Section from August 1996 through December 2002.[3]

- Ineffective management within the Crime Lab. The Crime Lab also suffered from a lack of strong and effective leadership within the Lab. Senior managers in the Crime Lab, including in particular former director Donald Krueger and the former head of the DNA/Serology Section James Bolding, failed to make a strong case within the HPD chain of command for more resources, better training, and improvements in the Lab's facilities.

- Lack of adequate quality control and quality assurance. HPD closed the DNA Section in December 2002 almost immediately after an outside audit -- the first ever performed of the Crime Lab -- found that the DNA Section fell woefully short of the standards established by the Federal Bureau of Investigation's Quality Assurance Standards for Forensic DNA Testing Laboratories. Again, for a period of over six years, there was no line supervisor in the DNA Section to oversee and provide quality assurance for the DNA work performed by the Crime Lab.

- Isolation of the DNA/Serology Section. The DNA/Serology Section was never audited by anyone outside of the Crime Lab until December 2002, and the results of that review were, ultimately, closure of the section, a large-scale post-conviction re-testing program, and this investigation. The complete lack of outside scrutiny of the Crime Lab's operations, procedures, and reporting of results allowed serious deficiencies, particularly in the DNA/Serology Section, to become so egregious that analysts in the Lab simply had no perspective on how bad their practices were. The isolation of the Crime Lab also allowed

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[3] Criminalist I is the entry level position for personnel conducting forensic science analysis in the Crime Lab; Criminalist II is the more advanced position for a working analyst; Criminalist III is the title for first-line supervisors; and Criminalist IV is the top-level supervisory position, which generally involves the supervision of multiple sections of the Lab.

> deficient practices and poor scientific work to continue, as our case reviews are beginning to show, since at least the mid-1980s.

Our case reviews have demonstrated that problems with the Crime Lab's forensic scientific work and the reliability of the results reported by Lab in the areas of serology and DNA analysis are even more severe and pervasive than we anticipated when we began Phase II of this investigation. The case reviews highlight and underscore the consequences of the deep-rooted problems we identified in our earlier reports and demonstrate how these failures and problems are reflected in the quality of some of the casework performed in the Crime Lab, especially in the DNA/Serology Section. However, it is important to note that the problems we have seen are not spread uniformly throughout the Crime Lab; in fact, we have seen some very competent and high quality work, especially in the Firearms, Toxicology, and Questioned Documents Sections.

Below are summaries of our specific observations with respect to each of the sections of the Crime Lab based on the case reviews we have completed thus far in Phase II.

Serology

We have completed reviews of 80 serology cases worked by the Crime Lab. We identified major issues[4] in 18 of those cases, which is approximately 22.5% of the cases reviewed to date.[5] Our review has already revealed several pervasive and serious problems with the quality of scientific work performed by the serologists, as well as with the presentation of the results obtained. These problems are present in virtually every serology case we have reviewed, even those cases that we determined did not contain "major issues," as we have defined that term. Moreover, these very significant deficiencies are not the result of analytical or interpretive errors made by individual serologists. Rather, they are the product of inadequate procedures employed in the Serology Section throughout the relevant time period -- from 1987 through the early 1990s -- as

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[4] For purposes of our case reviews, we have defined "major issues" as deficiencies that raise significant doubt as to the reliability of the work performed, the validity of the Crime Lab's results, or the correctness of the analysts' conclusions.

[5] These figures are provided only to reflect the status of our Phase II review of serology cases. Because we have not completed the review of our entire sample of substantive serology cases, our results -- such as, specifically, the percentage of cases we have identified as containing major issues -- cannot be extrapolated to the total population of substantive serology cases analyzed by the Crime Lab during the relevant period.

well as the Crime Lab's systematic failure to adequately train and supervise its serologists.[6]

Although we have observed several other less severe problems with the serology work performed by the Crime Lab, the five most significant problems are:

- the absence in the serologists' reports of genetic profile frequency statistics or any discussion of the significance of the statement that a suspect could not be excluded as a potential donor of an evidence sample;
- the failure to use substrate, positive, and negative controls in connection with ABO typing, which directly affects the reliability of reported results;
- the routine and common failure to report the results of testing and probative findings;
- the lack of any documentation of administrative or technical reviews of the serologists' work; and
- the absence of generally accepted documentation and evidence control procedures -- such as assignment of unique identification numbers to items of evidence, descriptions of evidence, and preparation of complete tables of testing results -- as well as numerous errors by analysts in transferring their test results to worksheets.

We also have identified two cases in which the Crime Lab issued incorrect conclusions that were inconsistent with the results of the ABO testing performed by the analysts.

In the case of Dwight Harold Riser, James Bolding appears to have altered the results of blood typing work on the basis of a scientifically unjustifiable explanation, with the result that Mr. Riser was included within a very small pool of potential semen donors equaling, according to Mr. Bolding's trial testimony, approximately 2.5% of the male population. In fact, Mr. Bolding's original test results would have shown that *100%* of men who produce semen were within

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[6] The starting date for our examination of serology cases is 1987, which was established by HPD at the beginning of our investigation. Based on our serology case reviews to date, there is no reason to believe that the problems began at that time rather than many years earlier.

the population of potential donors. According to the transcript of Mr. Riser's jury trial, Mr. Bolding appears to have falsely stated his credentials -- claiming to have a Ph.D. in biochemistry from the University of Texas when, in fact, he does not -- and provided misleading testimony regarding the statistical significance of his reported conclusion that Mr. Riser could have contributed to the evidence tested.

In the case of Charles Eura Hodge, the testing performed by Crime Lab serologist Christy Kim excluded the suspect, based on his blood type, as a potential donor to the analyzed sample. Despite these test results, Ms. Kim reported that Mr. Hodge could have been a contributor.

DNA

We have completed reviews of 67 substantive DNA cases analyzed by the Crime Lab, including files and supporting raw data for all 18 of the death penalty cases in which DNA work performed by the Lab was involved. We have identified major issues in 27 of these cases (including in three death penalty cases), which is approximately 40% of the cases we have reviewed to date. The three death penalty cases relate to Franklin Dewayne Alix, Juan Carlos Alvarez, and Gilmar Alex Guevara, none of whom has been executed.[7] These death penalty cases and other illustrative cases are discussed below.

As with serology, we have observed pervasive problems with both the quality of the Lab's forensic DNA profiling work as well as with the Lab's practices with respect to the interpretation of its DNA results. Many of the problems we have seen in the Crime Lab's serology work -- including failure to report probative results, poor technical work, lack of controls, absence of technical reviews, and poor documentation -- carried over into the Lab's DNA work after the DNA Section became operational in the early 1990s. Many of the personnel who were involved with serology testing became the Crime Lab's DNA analysts. As discussed in our Third Report, Mr. Bolding, HPD's lead serologist, was instrumental in establishing the DNA capabilities of the Lab and became the Criminalist III supervisor once DNA analysis began in the Crime Lab.[8] The Crime Lab's history of inadequate training and supervision of its

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7 Our preliminary review also has indicated that there might be significant issues with the Crime Lab's serology work and its DNA analysis in the case of a fourth death row inmate, Derrick Jackson. Our review of the Crime Lab's work in Mr. Jackson's case is continuing.

8 Third Report at 16-18.

personnel continued into the DNA era. Indeed, as we discuss in detail in our Third Report, the DNA Section was without a Criminalist III line supervisor from 1996 through 2002 when the DNA Section was closed.[9]

Although we have observed many other less serious problems with the Crime Lab's DNA profiling work, the following are the most significant and pervasive issues we have identified through our case reviews so far:

- Failure to report typing results, including potentially exculpatory results.
- Prevalence of poor quality results, particularly with respect to PCR-based DQ Alpha, Polymarker, and D1S80 testing, likely attributable to some combination of poor technique on the part of the Crime Lab's DNA analysts and contamination.
- Misleading reporting of the statistical significance of the DNA profiling results, particularly in cases involving samples containing mixtures of bodily fluids from more than one person.
- Failure to use and to show proper regard for scientific controls, particularly negative controls in PCR testing and failure to compare typing results in STR testing.
- Failure to perform and document meaningful technical and administrative reviews of the work performed by DNA analysts.
- Failure to assign a unique identifier to evidence items so that evidence and specimens generated from evidence could be tracked from submission through analysis.

Two of the most troubling DNA cases we have reviewed involve Franklin Dewayne Alix,[10] who is a death row inmate, and Garland Davis.[11] In both of these cases, the Crime Lab failed to report potentially exculpatory DNA typing results. In each of these cases, the DNA Section obtained very clear RFLP results that did not reflect the presence of the suspect's profile in the evidence sample, and yet the Crime Lab called the RFLP results "inconclusive" in both cases.

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9 Id. at 21-26.

10 *Texas v. Alix*, Cause No. 772073 (Harris County, Tx.).

11 *Texas v. Davis*, Cause No. 666524 (Harris County, Tx.).

Moreover, PCR-based testing in both cases generated a mixture of DNA profiles in the evidence sample that were reported as including the suspect and at least one other person. Post-conviction re-testing of the evidence has failed to confirm the PCR-based typing results reported by the Crime Lab in either case.

The failure of the Crime Lab to report the potentially exculpatory RFLP results it obtained in the Alix case is especially troubling in light of questions we have with respect to the PCR typing results obtained and reported in that case by former DNA analyst Christy Kim. She identified Mr. Alix as a contributor to a DNA mixture found on the evidence. Although Ms. Kim indicated on her worksheets that she ran both positive and negative controls in conjunction with her PCR-based tests, photographs of these tests provide no evidence that she ran negative controls. The absence of documentation that negative controls were run calls into question the reliability of Ms. Kim's test results.[12]

Trace Evidence

Until October 2003, the Trace Evidence Section of the Crime Lab normally operated with a staff of two analysts and a Criminalist III supervisor. However, the Crime Lab stopped performing in-house trace evidence examiner after the section supervisor was appointed to the Lab's quality assurance position in the fall of 2003.

We have reviewed most of the trace evidence case files examined by the Crime Lab during the review period, and much of the Trace Evidence Section's work appears to have been done in a manner consistent with generally accepted forensic standards. However, we found that there were significant delays in the overall examination and reporting process as well as cases in which little or no effort was made to identify evidence that could have generated potentially significant investigative leads. Some cases involved an inexplicable lack of follow-up and communication between the Crime Lab and investigators. Because of these deficiencies, the potential investigative value of trace evidence

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[12] In the Alix case, Ms. Kim reported that "[t]he DNA type of Frank Alix can be expected to occur in 1 out of 81,000 people among the Black population." This information, although technically correct, is incomplete and thus misleading with respect to the strength of the DNA profile obtained from the gauze sample. Upon re-calculation using the alleles reported by Ms. Kim, we estimate the percentage of the population that could be considered possible contributors to the gauze sample to be about 9% of the African American population, 13% of the Caucasian population, and 9% of the Hispanic population.

was not being used to its full advantage by the HPD during 1998-2003, the period of our review.

Controlled Substances

The Controlled Substances Section processed the overwhelming majority of cases worked by the Crime Lab during the period of our review -- more than 97,000 cases between 1998 and 2004. After the release of our Second Report, which detailed four drylabbing incidents involving two analysts in the Controlled Substances Section,[13] the City requested that we expand the scope of our planned Phase II case reviews to specifically target cases analyzed by the criminalists involved in those drylabbing incidents, Vipul Patel and James Price. To date we have reviewed 150 cases from the general Controlled Substances Section sample, 200 cases analyzed by Mr. Patel, and 114 cases analyzed by Mr. Price.

Analysts in the Controlled Substances Section test substances in a variety of forms, including tablets, capsules, vegetative material, powder, chunks, residue, cigarettes, and liquids. Our preliminary review of the section's case files indicates that analytical work performed on commonly-encountered substances, such as cocaine and marijuana, was generally quite good and was performed in a manner consistent with generally accepted standards of forensic science applicable to the analysis of controlled substances during the period of our review, 1998-2004. However, when analysts encountered more complex and less common substances, we found more deficiencies in their analytic work.

We have identified several significant issues in the general Controlled Substances Section case file sample. The first issue involves the reporting of definitive identifications based on inconclusive findings. The second issue, which has been identified in three cases thus far, involves the issuance of reports containing quantitative findings when no quantitative analysis was actually performed. These all involve liquid codeine cough syrup, which Crime Lab analysts, as a matter of custom and practice, have assumed could not exceed a particular concentration. This assumption, though likely true in most cases, may not always be correct. More problematic is that the Crime Lab reported quantitative results as to liquid codeine, implying that quantitative tests were performed, when in fact they were not. A variety of documentation and

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[13] "Drylabbing" involves the fabrication of scientific evidence. These incidents are discussed at length in our second and third Phase I reports.

procedural deficiencies have also been identified in the Controlled Substances Section case files.

The Patel Sample

Four particularly troubling issues have been identified to date in the Patel sample. Most disturbing is the identification of another potential drylabbing incident. In that case, Mr. Patel's report indicates that he conducted infrared testing on a tablet, but test printouts in the case file are so similar that they can almost be superimposed on one another. This may indicate that the tablet was never tested and that a "library standard," which can be generated by the testing equipment, was simply printed twice and inserted in the case file. In another case, Mr. Patel reported negative findings when some of the test results indicated that additional testing was necessary.

The remaining deficiencies identified thus far in the Patel sample are traceable to Crime Lab policies and procedures that are scientifically unsound. One involves the identification of unknown tablets using only the Physician's Desk Reference ("PDR") and the Drug Enforcement Administration Logo Index ("Logo Index"). The Crime Lab's practice, which was followed by Mr. Patel in a number of cases we reviewed, was to report those findings as if the identity of the tablets had been confirmed through actual testing procedures. The physical identification of drugs using the PDR or the Logo Index is conditionally acceptable, but reporting such results without acknowledging that chemical analyses had not been performed is inconsistent with generally accepted forensic science standards.

The Price Sample

Several significant areas of concern have also been identified in the Price sample. The first involved the same PDR and Logo Index identification issues discussed above. The second deficiency involved the apparently inadvertent mix-up of quantitation results, which affected two separate cases. The results were close, but this mistake should have been caught during technical[14] or administrative reviews. Mr. Price also reported negative results in a case in which conflicting results were obtained. In this case, a number of tests did, in fact, yield negative results, but a test that yielded a positive report for cocaine

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14 A "technical review" is review by another qualified person of the examiner's notes, data, and other documents that formed the basis for the examiner's conclusions.

could have reflected either the actual presence of cocaine or a positive result caused by a contaminant. Because of the inconsistent results, additional testing should have been performed to resolve the inconsistency.

The fourth significant issue involved violation of a well-established Crime Lab policy regarding the modification of reports. Under the policy, an analyst must retain three items in the case file if a report is modified after it has been approved: the original report, the modification notice, and the amended report. This is necessary because the computer program used by HPD and the Crime Lab overwrites the original report whenever it is amended. Therefore, Crime Lab policy is to maintain a printed copy of both the original and amended reports in the case file. In a number of Mr. Price's cases, only the modification notice and a single report are in the file, which makes it impossible to determine whether the report is the original version or the amended version. In addition, we were unable to determine in certain cases why the report was amended or what was changed.

Firearms

We have reviewed 109 firearms cases during Phase II of the investigation. Overall, most cases in the Firearms Section were properly examined, reported in a timely manner, and generally reflect work performed consistent with generally accepted forensic science standards. The issues identified have all been minor, involving primarily documentation issues and deviations from Crime Lab policies. One potentially troubling issue identified in the Firearms Section, however, is a tendency to avoid reporting results as inconclusive, even when this would be the most appropriate conclusion. This occurred in cases where general rifling characteristics -- which are patterns of impressions that a firearms examiner can use to identify the possible make and model of the gun from which a bullet was fired -- suggested that a weapon or class of weapons could have created the characteristics observed on a bullet. We have not, however, found any cases in which the Crime Lab made an incorrect weapons identification or elimination.

Toxicology

As was discussed in greater detail in our Phase I reports, questions regarding the performance of the Toxicology Section were raised after the section supervisor failed a competency test in October 2003. This development ultimately led to the suspension of toxicology analysis by the Crime Lab in October 2003. In May 2005, the Crime Lab was accredited by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board to

perform blood alcohol testing, and its toxicology case work is now limited to this area.

We have reviewed a substantial number of toxicology case files and proficiency tests handled by the Toxicology Section. To date, we have identified only one toxicology case in which some question exists as to the reliability of the work performed. In that case, testing yielded an unlikely result in which heroin, but not morphine, was identified. This result was questionable because heroin is almost immediately metabolized into morphine when it enters the human body. The absence of morphine in conjunction with a positive test for heroin could indicate possible sample contamination. The analyst failed to perform a second confirmatory test, despite the doubtful results. This is also troubling because analysts from the Toxicology Section reported results that proved to be "false positives" in three different proficiency tests administered between 1998 and 2003.

Overall, however, there was obvious and demonstrable improvement in the analytical procedures and processes used by the Toxicology Section during the period of our review and the work performed was consistent with generally accepted forensic science standards. In most of the cases reviewed thus far the files are well organized, the reviews are properly documented, and, with the exception of the matter noted above, an appropriate range of analytical procedures was performed.

Questioned Documents

The Crime Lab did not perform questioned documents examinations until 2004. Questioned documents were previously examined by another division of HPD, the Identification Division. However, that division closed in the mid-1980s after a number of employee departures. HPD's sole document examiner finished three years of outside training in 1999, and the Questioned Documents Section re-opened at that time. Responsibility for questioned documents was subsequently transferred to the Crime Lab in 2004.

We have reviewed all 91 cases examined by the Questioned Documents Section between 1999 and 2004, and we were impressed with the document examiner's knowledge and the quality of his work. In general, the questioned documents analyses were consistent with generally accepted forensic science standards. Only minor issues were noted, mostly involving the issuance of reports and the performance of technical reviews. Because the Questioned Documents Section is essentially a one-person operation, obtaining outside

technical review of case files was sometimes a difficult process. We note, however, that the Crime Lab now has a formal review system in place.

Our second area of concern was that the Questioned Documents Section examiner sometimes does not issue reports, even when he performs work on cases and enters case numbers in the Crime Lab's logs. At times, these cases simply involve inquiries from investigators or from the District Attorney's Office, but, when technical advice has been given, the document examiner should track the evidence, take notes, and prepare a report on the case.

We were struck by the Questioned Documents Section's relatively small workload, with only 91 cases examined in approximately five years. A much larger number of questioned documents cases are typical for a city the size of Houston. It appears that HPD does not make the fullest possible use of the resources available through its very competent document examiner.

Conclusion

This report summarizes the case reviews we have conducted in Phase II of our investigation from September 2005 through the first week of December 2005. Thanks to the cooperation provided by HPD and the sustained hard work by members of our investigative team, we have completed over 1,100 substantive case reviews out of our sample of approximately 2,700. More specifically, over the past three months, we have completed a significant percentage of case reviews in DNA and serology for cases handled from 1987 through 2002 and in all of the other areas of forensic science in which the Crime Lab performed work during the period 1998 through 2004.

As revealed by the case reviews, and as described in great detail in the body of this report, the record is mixed. We have observed some excellent work performed by Crime Lab analysts and examiners, especially in the Toxicology, Firearms, and Questioned Documents Sections of the Crime Lab. In some sections, such as Controlled Substances and Trace Evidence, the record is more balanced: We have noted some fine work performed, but we have also identified a number of significant deficiencies.

Unfortunately, our review of cases involving serology and DNA analysis has shown a near total breakdown in the forensic science function in those sections for at least a 15-year period from 1987 through 2002. Already, we have seen a disturbing and pervasive pattern involving repeated failures to report results of scientific testing, including results that were exculpatory; the general failure to use appropriate scientific controls to ensure the reliability of reported

results; the failure to properly calculate and communicate the meaning of statistics in scientific reports and courtroom testimony in order to accurately convey the significance of test findings; and the absence of any meaningful internal or external oversight of the critical work performed by serology and DNA analysts. Our work to date in reviewing cases analyzed by these sections reflects a level of performance completely unacceptable in a forensic science laboratory providing critical support to the criminal justice system.

We still have considerable work to do in completing the case reviews as well as in conducting further interviews and gathering the additional information necessary to come to final conclusions about the problems we have identified to date. The remaining case reviews and additional investigative work will provide us with an even stronger foundation on which to base recommendations for the Crime Lab, which is a central element of our mandate. Once the case reviews and further investigation have been completed, we will not only have a full and accurate picture of the past problems in the Crime Lab -- their scope and their causes -- but also a detailed body of knowledge that can serve as the basis for improving the quality of the Lab's work and enhancing its contribution to the criminal justice system.

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Introduction

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[3] Criminalist I is the entry level position for personnel conducting forensic science analysis in the Crime Lab; Criminalist II is the more advanced position for a working analyst; Criminalist III is the title for first-line supervisors; and Criminalist IV is the top-level supervisory position, which generally involves the supervision of multiple sections of the Lab.

> deficient practices and poor scientific work to continue, as our case reviews are beginning to show, since at least the mid-1980s.

Our case reviews have demonstrated that problems with the Crime Lab's forensic scientific work and the reliability of the results reported by Lab in the areas of serology and DNA analysis are even more severe and pervasive than we anticipated when we began Phase II of this investigation. The case reviews highlight and underscore the consequences of the deep-rooted problems we identified in our earlier reports and demonstrate how these failures and problems are reflected in the quality of some of the casework performed in the Crime Lab, especially in the DNA/Serology Section. However, it is important to note that the problems we have seen are not spread uniformly throughout the Crime Lab; in fact, we have seen some very competent and high quality work, especially in the Firearms, Toxicology, and Questioned Documents Sections.

The Investigative Team

We have assembled a highly experienced team of lawyers and forensic scientists for the Crime Lab investigation. Our team is led by Michael R. Bromwich, who is a partner in the Washington, D.C. and New York offices of Fried, Frank, Harris, Shriver and Jacobson LLP ("Fried Frank") and heads the Firm's internal investigations, compliance, and monitoring practice group. Mr. Bromwich is a former federal prosecutor and, from 1994 to 1999, served as Inspector General of United States Department of Justice. Mr. Bromwich is supported by a team of Fried Frank lawyers and legal assistants.

Our Scientific Advisory Board, comprised of three renowned forensic scientists who are experienced crime laboratory managers, has worked closely on the investigation throughout Phases I and II.[4] Each member of the Scientific Advisory Board has visited the Crime Lab and Property Room, participated in interviews, and performed quality control and quality assurance reviews. In addition, throughout Phases I and II we have consulted -- and will continue to consult -- with the Scientific Advisory Board in order to discuss the status of the investigation and to receive the members' input and guidance. The members of the Scientific Advisory Board are:

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[4] The *curricula vitae* for each of the members of the Scientific Advisory Board and the forensic scientist members of our investigative team are posted on our Web site.

Margaret Kuo retired as Deputy Director of Forensic Science Services after 27 years with the Orange County Sheriff-Coroner's Office. Among other things, Ms. Kuo has participated in or led approximately 30 crime laboratory inspections or audits.

Douglas M. Lucas is the retired Director of the Centre of Forensic Sciences of the Province of Ontario, Canada. Among his many leadership positions in the forensic science community, Mr. Lucas is a past president of the American Society of Crime Laboratory Directors ("ASCLD") and has led approximately 13 accreditation inspections performed by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board ("ASCLD/LAB") as well as audits of 12 other crime laboratories.

Bruce W. Vander Kolk retired in 2001 as the Commander of the Illinois State Forensic Sciences Command, where he oversaw the operations of eight regional forensic science laboratories and a research and development laboratory. During his career, Mr. Vander Kolk has, among other things, served on the strategic planning committee as well as the Board of Directors of ASCLD.

Our team includes a Scientific Coordinator, **Roger J. Bolhouse**, who is responsible for overseeing and coordinating the case reviews performed by our forensic scientists. Mr. Bolhouse also is our primary expert in trace evidence examination. He was an officer with the Michigan State Police ("MSP") for 26 years, including 22 years in the MSP's crime laboratory system. He retired in 2000 as Director of the MSP's Grand Rapids Laboratory and currently is a forensic scientist with Speckin Forensic Laboratories in Okemos, Michigan.

The following forensic scientists involved with the investigation have been drawn from across North America and are experts in their respective fields. These scientists are responsible for conducting the case reviews that we are performing during Phase II of the investigation.

Jeanine M. Baisch, Ph.D. is the Director of the Research and Development Laboratory, Orchid Identity Genomics in Dallas, Texas.

Robert P. Bianchi is the former Director of the Drug Enforcement Administration Special Testing and Research Laboratory in McLean, Virginia.

Michael A. Evans, Ph.D. is the President and Chief Executive Officer of the American Institute of Toxicology Laboratories located in Indianapolis, Indiana.

Patricia P. Hamby has over 30 years of experience in forensic serology and has been a criminalist in several law enforcement crime laboratories.

Edward E. Hueske is a firearms and toolmark expert who retired as the Supervising Criminalist for the Arizona Department of Public Safety in 1996.

Karen L. Irish retired in 2003 as the Director of the Forensic Services Section of the Baltimore County Police Department.

Michael Sinke spent 20 years as a forensic scientist with the Michigan State Police Crime Laboratory and is a questioned documents examiner with Speckin Forensic Laboratories

Theresa F. Spear has over 25 years of experience as a criminalist and recently retired from the California Department of Justice, Bureau of Forensic Services, where, among other things, she was a supervisor in the California Criminalistics Institute's Biology Program.

Rick W. Staub, Ph.D has a doctorate in genetics and is a Senior Manager for Forensics and Laboratory Director at Orchid Cellmark.

Mark D. Stolorow is the Executive Director for Forensic Science at Orchid Cellmark and has been a forensic serologist for over 30 years.[5]

Status of the Investigation

Pursuant to our agreement with the City and HPD, our investigation into the management, operations, and performance of the Crime Lab and Property Room is divided into two phases.

During Phase I, we investigated the current and historical operations and practices of the Crime Lab and Property Room. Among other things, this phase of the investigation was designed to lead, in consultation with HPD, to the development of a detailed plan for the second phase of the investigation. We provided our Phase II Plan to HPD on July 6, 2005.[6]

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5 Rhonda K. Roby, who, among other things, is the founder and CEO of Identity Quest, LLC, will begin work on the investigation in January 2006.

6 The Phase II Plan is posted on our Web site.

The second phase of our investigation involves reviewing a sample of cases analyzed by the Crime Lab during defined time periods. The samples have been drawn from each of the forensic science disciplines applied in the Crime Lab -- DNA/serology, controlled substances, toxicology, trace evidence, questioned documents, and firearms. These cases are being reviewed by our team of forensic scientists and evaluated with reference to the Crime Lab's own standard operating procedures ("SOPs") in place at the time, as well as applicable standards and practices generally accepted within the forensic community during the time the Crime Lab conducted its examination of the cases.

During Phase I of the investigation, we reviewed the methodology by which HPD arrived at its suggested sample size of 1,966 cases, and we determined that it would be prudent to consult with expert statisticians to develop our own sample populations. After advising HPD and gaining the approval of the Stakeholders Committee, which is overseeing our investigation, we have retained and consulted with statisticians from PricewaterhouseCoopers LLP ("PwC"), including PwC partners Dr. Jessica Pollner and Arthur Baines. With PwC's guidance, we have developed appropriate sample sizes for the case reviews to be performed by our forensic scientists in each of the following forensic science disciplines:

- Serology
- DNA
- Trace Evidence
- Controlled substances
- Firearms
- Toxicology

For the last discipline, Questioned Documents, because of the relatively small number of cases examined, we decided to review all of HPD's questioned documents cases since 1998. We also selected separate statistically-based sample populations of the controlled substances cases analyzed by former HPD Criminalists Vipul Patel and James Price, both of whom were involved in instances of drylabbing in the Controlled Substances Section.

In order to cover the case reviews required under the Request for Proposals ("RFP"), as well as the targeted case reviews that HPD has requested with respect to the controlled substances cases analyzed by Mr. Patel and Mr. Price, we have defined a total of nine categories of cases for which we have developed, in consultation with PwC, appropriate sample sizes. Our progress in

the case reviews related to each of these nine categories is reflected in the following chart.

Category of Cases	Completed Reviews	Total Number of Cases	Percentage of Reviews Completed
DNA	67	325	21%
Serology	80	281	29%
Controlled Substances[7]	150	383	39%
James Price	114	342	33%
Vipul Patel	200	366	55%
Toxicology	94	308	31%
Trace Evidence	222	264	84%
Firearms	109	364	30%
Questioned Documents[8]	91	91	100%
Total Cases	1,127	2,724[9]	41%

The total number of DNA cases we will review includes the 18 death penalty cases involving DNA testing performed by the Crime Lab. We also currently are working to identify all of the death penalty cases in which forensic science work was performed by any other section of the Crime Lab. We intend to review each of those death penalty cases as well.

In addition to reviewing cases, we also have conducted several additional interviews of Crime Lab personnel as well as a second interview of former Chief

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7 In addition to the samples, we also have reviewed 43 "bulk" controlled substances cases in order to evaluate how the Crime Lab and Property Room handle bulk seizures of controlled substances. We intend to review an additional 7 "bulk" cases.

8 In our Phase II Plan, we estimated that the total number of Questioned Documents Section cases that we would review was approximately 200. This estimate was based on the total number of cases identified on the Questioned Documents Section case log. Once we began our case review, it became clear that only 91 of the cases on the Questioned Documents Section case log involved substantive work that we could review.

9 In our Phase II Plan, we estimated the total number of case reviews to be 2,799. Because only about half of the Questioned Documents Section case numbers related to reviewable cases and because we have slightly modified certain samples to address specific issues that have arisen in the case selection process, the total number of cases in our samples now is 2,724.

of Police C.O. Bradford. Interviews with Lab personnel who worked in the various sections of the Crime Lab during the relevant periods have been extremely helpful in providing information and context relevant to our case reviews. Since the start of Phase II, we have attempted to contact both Ms. Kim, to speak with her for the first time, and Mr. Krueger regarding a follow-up interview. Thus far, neither of these former employees has agreed to meet with us. We believe their cooperation with this phase of the investigation would be extremely helpful and that we would benefit from their views on some of the problems we have identified during our case reviews. We have discussed with the Stakeholders Committee potential alternatives for compelling such persons to be interviewed by us. It appears that, at least in some cases, such measures will prove necessary if we are to have the benefit of information from all relevant witnesses. Accordingly, we will continue our efforts to explore alternatives for compelling witnesses to be interviewed.

Results of Phase II Case Reviews: September through December 9, 2005

I. Process for Reviewing Cases

From the time we resumed our work in early September 2005, we have devoted substantial time and effort to the careful review of Crime Lab cases. To the greatest extent possible, members of our investigative team responsible for reviewing work in a specific forensic science discipline have conducted the case reviews in a collaborative manner while on site in the Crime Lab at HPD headquarters. We have scheduled our forensic scientists working in each discipline to be at HPD conducting case reviews at the same time in order to ensure efficiency and the greatest degree of collaboration possible so that we reach consensus on matters under review.

The members of our team have had access to all relevant documentary materials still maintained in the Crime Lab and have conferred with analysts and Lab supervisors to gain further understanding of how cases were handled and analyzed. Our reviews have been based primarily on documentation contained in the Crime Lab's paper files and associated raw data -- such as, for example, autoradiographs and photographs of test strips related to certain methods of DNA typing -- that the Lab maintains separately from the paper Lab files. Where

necessary and appropriate in order to assess the reasonableness of the original forensic science work, we have reviewed available underlying evidence.[10]

Lawyers and legal assistants from Fried Frank have worked extensively with the scientists during the Phase II case review. Among other things, the legal team has conducted interviews to gather information relevant to the case reviews; coordinated the selection of statistically valid samples and worked with our statistical experts to refine the various sample frames; gathered and reviewed information regarding the status of death penalty cases and post-conviction appeals; reviewed HPD investigative files and the trial testimony of Crime Lab analysts who testified in cases we have examined; evaluated and recorded results of case reviews; and managed the legal, technical, and administrative aspects of the review.

A. Definitions of Major and Minor Issues

Our case reviews are designed to determine whether the cases in our sample were analyzed in a manner consistent with the SOPs existing in the Crime Lab at the time the analysis was performed and consistent with the generally accepted forensic science standards prevailing at that time. The case reviews are not designed to evaluate the work of Crime Lab analysts against a standard of perfection, nor to use the forensic standards prevailing in 2005 to evaluate work done, in some cases, many years earlier.

We have devoted substantial effort to ensure that the case review process is managed effectively and efficiently and that the case reviews are conducted consistently regardless of the individual reviewer on our investigative team who perfomed the review. We have sought to be thorough, fair, objective, and consistent. To attain these goals, all members of the team apply the same written standards for evaluating case files. These standards were established in consultation with our Scientific Advisory Board and apply to each forensic science discipline under review.

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[10] Consistent with the scope of our mandate, we have not re-tested any evidence. We have reviewed underlying evidence only in cases where information and documentation in the Crime Lab file -- such as photographs, narrative descriptions of the evidence and the analyses conducted, and laboratory notes -- are inadequate to permit us to assess the reasonableness of the original forensic science work.

In order to advance the goals of clarity, consistency, and coherence in our case reviews, we have sought to draw appropriate distinctions among the various deficiencies we have identified during our case reviews. Our main tool for doing so has been to distinguish "major issues" from "minor issues," definitions for which we developed at the outset of the case review process in consultation with our team of forensic scientists. As described below, all matters that we tentatively identify as involving major or minor issues undergo a careful and thorough quality assurance process. Even so, it is important to note that the process of categorizing an issue involves a certain amount of judgment and discretion. In the sections below, we describe the types of deficiencies that fall into these two broad categories.

1. Major Issues

Major issues are matters that raise significant doubt as to the reliability of the work performed, the validity of the analytic results, or the correctness of the analyst's conclusions. We characterize an issue as "major" if, for example, it involves:

- significant errors in the testing, evaluation, or handling of evidence or in the reporting of results;
- serious omissions where an analyst failed to perform a critical examination or analysis; or
- analytic work that was undocumented or insufficiently documented to permit an outside reviewer to assess the basis of the analyst's conclusions.

Examples of major issues include failure to report probative findings, incorrectly reporting probative findings, reporting incorrect conclusions, reporting findings that are unsupported by documented testing, and failing to perform a critical examination or analysis.

2. Minor Issues

Minor issues are matters that involve deviations from generally accepted forensic science practices or from the Crime Lab's SOPs. However, minor issues are distinguished from major issues in that they do not appear to raise significant doubt as to the reliability of the work performed, the validity of the analytical results, or the correctness of the analyst's conclusions. Minor issues may include, for example:

- failure to provide sufficient or accurate documentation, but where the basis for the analyst's conclusions *can* nevertheless be determined and reviewed; and

- deficiency in the management of the case that includes, but is not limited to:

    - failure to perform the analysis within a reasonable period of time,

    - failure to provide adequate supervisory oversight and review, and

    - failure to reasonably organize the case file and case notes.

The distinctions between major and minor issues sometimes can be subtle and they frequently are case-specific. In some cases, we conclude that a case involves only minor issues even though we identified significant deficiencies in the Crime Lab's work because we found that the deficiencies ultimately did not cause us to have significant doubt about the reliability of the work performed or the correctness of the analyst's results and that the deficiencies would not have had a material impact on the results of the forensic scientific work in the case.

B. Quality Assurance Review

Members of our Scientific Advisory Board conduct quality assurance ("QA") reviews of the case evaluations performed by each of the forensic scientists on our team. The members of the Board review every case that has been preliminarily identified as having one or more major or minor issues, as we have defined those terms. The QA reviewers confer with us about every case raising a potential major or minor issue, and we reach a consensus before any final determinations are made on how to categorize an issue. The QA reviewers also evaluate randomly-selected files from the case sample to confirm that cases are being assessed consistently and in accordance with our review standards.

Douglas Lucas is the QA reviewer handling the evaluations of the Trace Evidence, Firearms, Questioned Documents, and Toxicology Sections. Margaret Kuo is performing QA review of work performed by experts evaluating the DNA/ Serology Section of the Crime Lab, and Bruce Vander Kolk is handling the QA review of work performed by the Controlled Substances Section case reviewers.

The following sections present the findings of our case reviews conducted over the last several months in the following order: (1) serology, (2) DNA,

(3) trace evidence, (4) controlled substances, (5) firearms, (6) toxicology, and (7) questioned documents.

II. Serology

The cases in our serology sample were drawn from cases analyzed in the Serology Section of the Crime Lab from 1987 through 1990. Based on our reviews, we have determined that the Crime Lab continued to perform serology into the early 1990s, even after the Lab had established its DNA analysis capability. We found that our original sample of serology cases, which was derived directly from the Crime Lab's roster of cases assigned to analysts in the DNA/Serology Section during the relevant time period, included a large number of administrative cases that did not involve substantive forensic science work by the Lab and, therefore, would not provide a basis to assess the serology performed in the Lab.[11] In order to identify cases involving substantive analytical work performed by the Crime Lab's serologists, we developed a database of cases derived from raw data records that the Lab preserved and then reconfigured our sample based on that database.[12] So far, we have identified a total of 281 "substantive" serology cases and have reviewed 80 of them, which is approximately 29% of the substantive serology cases we have identified.[13]

The term "serology" refers to the study of blood (or other bodily fluids), particularly blood group interactions, and derives its name from the liquid portion of blood known as "serum." At the beginning of the 20th century, Karl Landsteiner, an Austrian physician, discovered that not all human blood is the same and, in fact, can be grouped into distinct types.[14] Dr. Landsteiner's work

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11 For example, we found that the Crime Lab often would assign a Lab number and open a Lab file upon receiving evidence such as a sexual assault kit. However, if no suspect was identified or samples provided for comparison with the evidence in the sexual assault kit, the Crime Lab typically would not have analyzed the evidence.

12 To date, the Crime Lab has not been able to locate and provide us with raw data related to the work performed by all of the serologists employed by the Lab during the relevant period. We are continuing to work with the Crime Lab to locate raw data that might still exist.

13 The original sample size we estimated for serology in our Phase II Plan was 358. We will review additional substantive serology cases, including cases from the early 1990s, as we are able to identify them and include them in our database.

14 Dr. Landsteiner's discovery that blood from individuals is distinguishable by its type or group was one of the most significant medical and scientific breakthroughs of the last century. The identification of ABO blood groups made it possible for physicians to

Footnote continued

led to the development of the ABO blood typing system that formed the initial basis of forensic serology. The four nominal blood types are A, B, AB, and O. Until it was replaced by the growing use of DNA profiling technology in the early 1990s, serological typing was based on ABO type supplemented with other genetic markers. It was one of the most important techniques available to forensic scientists to link individuals to crime scenes.

Blood is a complex mixture of cells, enzymes, proteins, and other substances. The components of blood most relevant to forensic serology are red blood cells and blood serum. On the surface of each red blood cell are chemical structures called "antigens," which impart an individual's blood type characteristics. An antigen is a protein that stimulates the body to produce antibodies against it.[15] A person who is blood type A has type A antigens; a type B person has type B antigens; a type AB person's red blood cells have both A and B antigens; and a type O person has neither A nor B antigens. Serum is the second blood component important to ABO typing because it contains proteins known as antibodies, which destroy or inactivate specific antigens. Each antibody is named with the prefix "anti" followed by the antigen for which it is specific. Thus, anti-A is specific for A antigen and anti-B is specific for B antigen.

The fundamental principle of blood typing is that for every antigen, there exists a specific antibody. For example, if serum containing anti-A is added to red blood cells carrying the A antigen, the antibody will immediately attach to the cell carrying the antigen. This process results in the observable clumping of cells known as "agglutination." In summary, blood of type A will be agglutinated by anti-A serum; blood of type B will be agglutinated by anti-B serum; AB blood will be agglutinated by both anti-A and anti-B serums; and blood type of O will not be agglutinated by either anti-A or anti-B serum.[16]

Footnote continued from previous page

match the blood types of donors and recipients and paved the way for safe blood transfusions, which have saved countless lives. Dr. Landsteiner received the Nobel Prize for Medicine in 1930 in recognition of his discoveries related to the typing of blood.

15 Because blood type is related to the physiological response resulting in the production of antibodies, blood types are a characteristic of the body's immune system and blood typing is a form of immunological testing.

16 It is because red blood cells in blood type O carries neither A nor B antigens, and therefore will not be agglutinated by either anti-A or anti-B serum, that persons with

Footnote continued

Among other things, serology involves the use of various laboratory tests that use specific antigen and serum antibody reactions to identify the blood type factors contained in bodily fluid samples as well as in dried stains of them. These tests can be used to include or exclude persons as potential suspects based on an individual's known blood type characteristics.

ABO typing is not limited to blood samples. In many people, ABO factors also are present in other bodily fluids, such as semen, saliva, and vaginal secretions. The population is divided into two groups with respect to the presence or absence of ABO factors in bodily fluids. Approximately 80% of the population have detectable levels of their ABO type in their other bodily fluids and are known as ABO "secretors." The remaining 20% of the population lack normally detectable levels of their ABO factors in their secretions and are known as ABO "non-secretors." Although useful in the investigation of homicides and other crimes, ABO testing of bodily fluid secretions was historically particularly valuable in the analysis of biological evidence related to sexual assaults.

During the 1980s and early 1990s, forensic serology practiced in the Crime Lab primarily involved ABO typing. Although from the late 1960s on, forensic serology also included the identification of other biochemical genetic markers such as certain enzymes and proteins, it appears that the Crime Lab rarely used such enzyme testing results to associate or disassociate stains with particular individuals.[17] Although we found Crime Lab log books recording the results of electrophoretic runs associated with enzyme testing and have seen laboratory notes and worksheets in case files reflecting that enzyme testing was performed in certain cases, Lab serologists rarely reported results obtained through enzyme testing. Thus far, we have identified virtually no cases in which the Crime Lab

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blood type O are known as "universal donors" whose blood may be used in transfusions to persons of any of the four nominal blood types.

17 An enzyme is a type of protein that acts as a catalyst for certain specific biochemical reactions. Forensic scientists have historically been particularly interested in certain enzymes and other proteins found in blood -- such as PGM (phosphoglucomutase), EAP (erythrocyte acid phosphatase), EsD (esterase D1), Hp (haptoglobin), and others -- because those enzymes and proteins are "polymorphic," meaning they exist in different forms and, therefore, are useful in distinguishing between individuals. The various inherited forms of these polymorphic enzymes and proteins are called "alleles." The analysis of such enzymes and proteins involves the separation of the alleles through a process known as electrophoresis.

reported the results of enzyme testing for use in an investigation or prosecution. Accordingly, our discussion of the results of our serology case reviews relates almost entirely to ABO typing work performed in the Crime Lab.

A. Significant Problems Identified in Serology Cases

We have now completed reviews of 80 substantive serology cases worked by the Crime Lab. In 18 of these cases, or approximately 22.5% of the cases reviewed to date, we have identified major issues.[18] Our review has already revealed several pervasive and serious problems with the quality of work performed by serologists in the Crime Lab as well as with the presentation of the ABO grouping results obtained by Lab analysts using various serology testing methods.[19] These problems are present in virtually every serology case we have reviewed, even in those cases that we determined did not contain major issues. Moreover, these very significant deficiencies are not the result of mistakes or interpretive errors made by individual serologists. Rather, they are the product of defective procedures employed in the Serology Section throughout the relevant time period -- from 1987 through the early 1990s -- as well the Crime Lab's systematic failure to adequately train and supervise its serologists.

Although we have observed several other less serious problems with the serology work performed by the Crime Lab, the five most significant issues are:

- the absence in the serologists' reports of genetic profile frequency statistics or any discussion of the significance of the statement that a suspect could not be excluded as a potential donor of evidence samples;
- the failure of serologists to use substrate or positive and negative controls in their ABO typing;

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18 These figures are provided only to reflect the status of our Phase II review of serology cases to date. Because we have not completed the review of our entire sample of substantive serology cases, our results -- such as, specifically, the percentage of cases we have identified as containing major issues -- cannot be extrapolated to the total population of substantive serology cases analyzed by the Crime Lab during the relevant period. As with our uncompleted reviews of samples in all of the disciplines, the portion of the serology cases we have reviewed to date does not have statistical validity and does not yield the ability to extrapolate to the entire universe of substantive serology cases.

19 At Appendix B to this Report, we have included a technical discussion of the serology techniques commonly used in the Crime Lab.

- the routine and common failure to report the results of testing and probative findings;
- the lack of any documentation of administrative or technical reviews of the serologists' work; and
- the absence of generally accepted documentation and evidence control procedures -- such as assignment of unique identification numbers to items of evidence, descriptions of evidence, and preparation of complete tables of testing results -- and errors by analysts in transferring their test results to worksheets.

We also have identified two seriously troubling cases, described in detail below, in which the Crime Lab reported incorrect conclusions that were inconsistent with the actual ABO testing performed by the analysts.

In the case of Dwight Harold Riser, James Bolding appears to have altered the results of blood typing work on the basis of a scientifically unjustifiable explanation to include the suspect within a very small pool of potential semen donors -- which Mr. Bolding testified was approximately 2.5% of the male population -- despite the fact that his original results would have shown that *100%* of men who produce semen were within the population of potential donors. According to the transcript of Mr. Riser's jury trial, Mr. Bolding appears to have provided misleading testimony regarding the statistical significance of his reported conclusion that Mr. Riser could have contributed to the tested evidence. In addition, he appears to have falsely stated his credentials during testimony.

In the 1986 case of Charles Eura Hodge, the testing performed by serologist Christy Kim excluded Mr. Hodge as a potential donor to the analyzed sample from sexual assault kit vaginal and cervical swabs, based on his blood type. Ms. Kim, nevertheless, reported that Mr. Hodge could have been a contributor.

1. Failure to Provide the Statistical Significance of Inclusions in Blood Typing Cases

We have yet to review a report[20] issued by the Crime Lab that contained a statement regarding the statistical significance of an ABO typing result in which a suspect was reported to be a potential contributor to the evidentiary sample. Typically, the serology reports we have reviewed contain as conclusions statements such as "the defendant cannot be eliminated as the source of the human bloodstain" or "the defendant is included in the group of possible donors of the semen stain," without any explanation of the significance of such conclusions. While such conclusions, where supported by appropriate testing, may be technically accurate, they have the potential to be misleading when not accompanied by appropriate statistics.

As discussed above, ABO blood typing is used to associate or disassociate a suspect with biological evidence associated with a crime. Although probative, ABO blood typing (unlike modern DNA testing techniques) is not discriminating enough to develop individualized genetic profiles. At best, it can only provide information about the statistical probability that a suspect (or victim) could have contributed to a biological sample related to a crime.

The frequencies of the four nominal blood types -- A, B, AB, and O -- in the general population of the United States are reflected in the table below.[21]

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20 Throughout the time period covered by this investigation, the final "reports" issued by the Crime Lab actually are supplements to the HPD investigative police reports, and the serology reports usually contain only a few sentences. The supplements typically contain a general description of the evidence received by the Crime Lab, the bodily fluids identified on the evidence samples, and a statement of the ABO types detected. Frequently, not all typing results are presented, and sometimes the supplement does not indicate the item of evidence from which the ABO typing result was obtained. Occasionally, the report includes a statement as to whether the suspect could have contributed to the sample tested.

21 The distribution of blood type frequencies can vary depending on demographic factors of the population for which the frequencies are presented, such as race, ethnicity, and geographical location. The distribution reflected in the above chart is for the general population of the United States as reported at http://www.aabb.org/All_About_Blood/FAQs/aabb_faqs.htm by the American Association of Blood Banks.

O	A	B	AB
43-45%	40-42%	10-12%	3-5%

Thus, for example, the potential donors of an ABO type A blood sample (with no other genetic information about the sample) are any ABO type A individuals, who constitute approximately 40-42% of the general population.

To fully understand the probative value of serological evidence, several critical questions about bloodstains and bodily fluid stains must be answered. Such questions include:

- What is the size of the relevant pool of possible donors of the biological stain evidence in a particular case?
- Could the bloodstain, semen stain, or saliva stain have originated from the suspect or victim, or are they scientifically excluded as the source of that evidence based on their blood type?
- If the stains consist of a mixture of bodily fluids from more than one person, are there any factors present that are foreign to the victim that might include or exclude the suspect?
- If the suspect is included as a possible source of the stain evidence, what percentage of the relevant population might also have been the source of the stain?

Without the forensic serologist providing answers to those critically relevant questions, it is not possible to assign the appropriate weight to the serology evidence.

Moreover, while the forensic serologist must provide, when necessary, answers to these questions to the judge and jury in the form of courtroom testimony, it is equally important for written laboratory reports to explain the significance of results in clear, unambiguous language, including the proper use of statistics. There are two overlapping reasons that a laboratory report should always contain an explanation of the statistical significance of inculpatory or exculpatory genetic marker test results, such as ABO type. First, laboratory reports often are stipulated to in criminal proceedings, and, therefore, the written laboratory report must accurately and fully address the significance of genetic marker test results in the absence of testimony by the forensic serologist or by a defense expert. Second, a defendant and his counsel must receive sufficient

information to understand the significance of the genetic marker testing evidence.[22] In Harris County, where for various reasons defense counsel rarely had access to the worksheets, bench notes, and raw data underlying the conclusions stated in the Crime Lab reports, the need for the statistical significance of ABO results to be included in the police report supplements themselves was even greater.

We have encountered several cases in which the Crime Lab's failure to report statistical frequencies resulted in gross overstatements of the significance of the Lab's ABO typing results. For example, in a 1986 sexual assault case, Ms. Kim identified the victim as a type A secretor and reported the suspect as a type O secretor. Ms. Kim found that stains on a vaginal swab and from the victim's underpants demonstrated type A and type O activity. Ms. Kim concluded that "[b]y these results it was not possible to eliminate the suspect as a possible semen donor." While technically accurate, Ms. Kim's conclusion was misleading because it was not accompanied by statistical probabilities explaining its insignificance. Because no genetic markers foreign to the victim were detected on the vaginal swab or undergarments,[23] no potential semen donor can be excluded. In other words, Ms. Kim's conclusion that the suspect could not be excluded as a potential semen donor applied with equal weight to virtually *100%* of semen donors in the male population.[24]

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22 Unfortunately, in the 1980s and early 1990s, the Crime Lab was not alone among police agency laboratories in failing to consistently include statistics describing the significance of genetic marker test results. By the time of the first ASCLD/LAB accreditations in 1982, however, the trend among good forensic laboratories was toward inclusion of combined frequency of occurrence genetic marker test results in the body of the written laboratory report.

23 It is not uncommon for persons of ABO types A, B, or AB also to demonstrate O activity. Therefore, in this case, it could not be concluded that any of the ABO activity detected by Ms. Kim on the vaginal swab or the victim's undergarments was foreign to the victim.

24 In the cases we have reviewed, the failure to provide statistical frequencies has tended to lead to misleading impressions regarding the significance of evidence that may be prejudicial to the suspect. However, we also have reviewed cases in which the Crime Lab's mantra that "the suspect cannot be eliminated as a possible donor" understated the probative weight of genetic marker evidence developed by the Lab. In one case, a combination of ABO and enzyme testing performed by Crime Lab analysts was very discriminating and would have indicated a potential donor pool of less than 10% of the male population, which constitutes a very powerful serology result. The failure to provide statistics in that case significantly understated the probative value of the Crime Lab's serology results.

2. Failure to Use Substrate, Positive, and Negative Controls

We found no evidence in the cases reviewed so far that Lab analysts ran substrate controls in connection with the absorption elution ("AE") and absorption inhibition ("AI") tests for ABO activity.[25] This failure to run substrate controls is a very significant departure from generally accepted forensic science practices prevailing at the time the work was performed. For the reasons described in detail below, the absence of substrate controls diminishes the significance of any of the antigenic activity detected by Crime Lab serologists because it is possible that the ABO activity detected was present in the material on which the biological stain at issue was deposited, rather than being attributable to the questioned stain itself.

With all forms of ABO testing, it is critical to the reliability of the typing results that, whenever possible, the same ABO testing procedures used to test a stain also be applied to the unstained regions of the "substrate" material adjacent to or in close proximity to the stain.[26] A forensic serologist must use substrate controls to determine whether the ABO factors detected in the questioned stain were part of the background material -- *i.e.*, were contained in the substrate before the questioned stain was deposited on the substrate material -- rather than present in the bodily fluid evidence being tested. If background ABO factors are detected in the substrate control, the significance of the presence of those same factors in the questioned stain must be taken into consideration in the interpretation of the ABO factors detected.

For example, if a shirt has a semen stain that exhibits ABO type A activity and the substrate control test of a cutting of the shirt taken from a spot adjacent to the semen stain also exhibits ABO type A activity, the type A activity in the semen stain cannot be definitively attributed to the suspected semen donor. The reason is that, in this example, the wearer of the shirt might have been an ABO type A secretor and all of the type A activity could have originated from dried perspiration from the wearer of the shirt.

Although we found infrequent documentation of the use of positive and negative controls in connection with ABO testing, in the majority of ABO typing

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25 For a description of certain serology testing methods including AI and AE, see Appendix B.

26 Substrate material is the fabric or surface upon which the questioned stain was deposited.

cases we have reviewed there is no indication in the worksheets that Crime Lab serologists ran positive and negative controls alongside the evidentiary sample to detect possible contamination and to verify that the test procedures were functioning properly. For example, in AE testing, Crime Lab analysts should run a negative control of unstained cotton thread as well as positive controls of threads stained with known types A, B, and O samples. The absence of such controls, and of documentation reflecting that such controls were run, also is a very significant departure from generally accepted forensic science practices in the serology community in effect at the time the work in the Crime Lab was performed.

Finally, a very significant failure of the Serology Section was the absence of written SOPs establishing requirements and guidelines for serologists regarding, for example, the use of substrate and positive and negative controls, the interpretation of data and test results, the appropriate manner for resolving conflicting test results, the calculation of statistics, and proper standards for report writing. The only guidance Crime Lab serologists had in the late 1980s and early 1990s was method manuals obtained from an outside serological school and the Federal Bureau of Investigation ("FBI"). These manuals contained step-by-step descriptions of procedures for performing serology tests but did not establish standards and procedures to be followed by Crime Lab serologists in every case in the areas described above. The lack of such SOPs is a very serious departure from generally accepted forensic science practices and undoubtedly was a primary factor in the pervasive problems we have observed in the serology cases.

3. Failure to Report Test Results and Probative Findings

We have reviewed many cases in which testing performed by the Crime Lab generated probative -- and even potentially exculpatory -- results that either were not interpreted or were not presented in the Lab's final reports. In certain cases, the reporting of some ABO testing results might be unnecessary because the results either were cumulative or non-probative. Generally, Crime Lab serologists appeared to focus only on reporting test results that they viewed as relevant to the inclusion of a suspect. In many cases, though, it is impossible to determine the analysts' rationale for reporting the results of certain genetic marker tests while failing to report others.

One example of the Crime Lab's failure to report results and to explain the significance of the inclusion of a suspect in light of all of the analyst's results is the 1987 sexual assault case involving defendant Gordon Wayne Hairrell.

According to the worksheets prepared by Lab serologist Christy Kim, she used direct ABO testing and Lewis testing to determine that the complainant was a type A secretor and that Mr. Hairrell was a type O non-secretor.[27] Ms. Kim's testing of a semen stain on the victim's shorts identified A, B, and possible O activity in the stain. Based on this testing, Ms. Kim's report stated that "[b]y these results it was not possible to eliminate the suspect [Mr. Hairrell] as the possible semen donor." This statement, standing alone is quite misleading because Ms. Kim failed to explain that, as a non-secretor, Mr. Hairrell can *never* be excluded as a potential donor in any case where semen is present because his ABO type is not detectable in his semen.

Even more problematic, Ms. Kim failed to report that the B activity she detected in the semen stain on the victim's shorts was foreign both to the victim (who was type A) and to Mr. Hairrell (who was type O) and that, therefore, even if Mr. Harrell could not be excluded as a potential donor in light of the fact he was a non-secretor, he could not have been the *sole* donor of the semen stain.[28] In other words, Ms. Kim found strong evidence that someone other than the victim or Mr. Hairrell was associated with the semen stain on the victim's shorts, and yet Ms. Kim failed to report this finding and failed to explain the significance of the finding relative to her bald conclusion that Mr. Hairrell could not be excluded as a potential contributor to the stain.

4. Lack of Documentation of Technical and Administrative Reviews

During the late 1980s and early 1990s, Mr. Bolding was the Criminalist III supervisor over the Serology Section. The serology cases we have reviewed to date are devoid of any indication that Mr. Bolding or anyone else reviewed the work performed by the Crime Lab's serologists in order to identify technical issues related to testing and interpretation of results or for administrative purposes to ensure adequate and appropriate documentation of the work performed. Moreover, there is no documentation or other evidence showing that anyone performed technical or administrative reviews of the serology cases analyzed by Mr. Bolding. The failure of the Crime Lab to perform routine

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27 The Crime Lab report erroneously states that Mr. Hairrell was determined to be a type O secretor. The raw data reflected in the analyst's worksheets reflects that the results of Lewis testing determined that Mr. Hairrell was a non-secretor.

28 According to court records, the aggravated sexual assault charge against Mr. Hairrell was dismissed at the request of the complaining witness.

technical and administrative reviews of serology cases -- and, in cases where such reviews might have been performed, to document the reviews -- also is a very significant departure from generally accepted forensic science practices prevailing at the time.

5. Inadequate Documentation of Testing and Results

In many of the serology cases we have reviewed, we have observed confusing documentation regarding tracking of evidence specimens as they move through the Crime Lab's testing process. The same specimens may be described differently on submission forms, on various worksheets, and, finally, in the Crime Lab reports. This confusion could have been avoided by assigning unique laboratory specimen numbers to individual specimens and using those numbers throughout the case, consistent with generally accepted forensic science principles.

We also have observed pervasive problems with the documentation contained in the serology case files. Frequently, test results recorded in raw data logs were maintained separately from the case files, were not incorporated into individual case files, and were not transferred into the analysts' worksheets included with the case files. In cases where results from the raw data logs were transferred into the analysts' worksheets, transcription errors were not uncommon. Crime Lab serologists rarely prepared a master table showing the test results for all of the evidentiary items tested, which was a common practice in many serology laboratories. Such a master table enabled criminalists to keep track of all of the results achieved through genetic marker testing and to be able to interpret how results related to individual samples. To facilitate our reviews, we have spent a great deal of time preparing such tables in many cases in order to fully understand the work performed and results obtained in cases involving multiple biological specimens.

Finally, the serology files usually (but not always) lack drawings, diagrams, photographs, or written descriptions of evidentiary items examined to document the appearance, size, and location of stains identified. Such documentation often is crucial in assessing the significance and probative value of biological stains, and the failure to include these types of descriptions is inconsistent with generally accepted forensic science practices.

B. The Dwight H. Riser Case

The most troubling case we have reviewed to date involves ABO typing work that Mr. Bolding performed in 1988 and about which he testified in the September 1988 trial of Mr. Riser on charges of aggravated sexual assault and aggravated kidnapping.[29]

On July 30, 1987, the victim in this case reported to HPD that earlier in the day she had been kidnapped at gunpoint, taken to a house, and locked in a closet, from which she managed to escape. The following afternoon, a rape kit examination was performed. That evening, the victim told an HPD sex crimes investigator that, while she was held captive, she had been sexually assaulted twice. On December 14, 1987, Mr. Riser was arrested in Ruston, Louisiana. On August 29, 1988, hair, saliva, and blood samples were taken from him. The following day, these known samples from Mr. Riser were submitted to the Crime Lab where they were analyzed, along with a vaginal swab from the victim's rape kit and known blood and saliva samples from the victim.[30]

Mr. Bolding's report, dated September 14, 1988, states he determined the victim to be an ABO type A secretor and Mr. Riser to be an ABO type AB secretor.[31] According to the August 31, 1988 laboratory examination worksheet, Mr. Bolding used the AI method to obtain ABO typing results from the vaginal swab taken from the rape kit. AI is a "reverse" typing method; therefore, agglutination observed in the A, B, or H[32] test solution indicates an *absence* of that antigenic activity in the sample. Mr. Bolding initially recorded the results of the AI testing on the vaginal swab as follows:

A	B	H
--	+2	+3

29 *Texas v. Riser*, Cause Nos. 481105, 481106 (248th Dist. Ct. Harris County, Tx).

30 Mr. Bolding analyzed the blood and saliva samples. The hair samples were transferred to the Crime Lab's trace evidence examiner for examination.

31 The examination worksheet contained in the case file does not reflect any results of ABO typing on the victim's known blood sample. The worksheet reflects that AI testing performed by Mr. Bolding indicated A activity on the known saliva sample taken from the victim.

32 For reasons explained in footnote 8 of Appendix B, the H antigen has become synonymous with the O antigen in ABO testing.

These results indicate that Mr. Bolding initially observed strong agglutination with respect to the O factor and relatively intense agglutination in the B factor, which indicated *only* type A activity on the vaginal swab. These results are consistent with the victim, who was determined to be ABO type A secretor. Because Mr. Bolding's original test results failed to demonstrate the presence of any ABO factors foreign to the victim, *no* male semen donor can be eliminated as a possible source of the semen detected on the vaginal swab. As a result, the pool of potential donors in fact equals *100%* of male semen donors in the population.[33]

Mr. Bolding did not report his initial findings. In a handwritten note on the worksheet, Mr. Bolding states that the results he had originally obtained "changed after a 30 minute reading" and that agglutination he had originally observed in the B well disappeared. Mr. Bolding altered his original results to reflect the following observed agglutination in each of the ABO test wells:

A	B	H
--	--	+3

Mr. Bolding's explanation that the agglutination he had originally observed in the B well disappeared "after a 30 minute reading" is scientifically unsupportable. The AI process begins with cells that are free in a solution and that begin to agglutinate in reaction to the presence of known ABO antibodies depending on the ABO antigenic activity present in the sample. The degree of agglutination present in any of the test wells can be expected only to either remain constant or increase over time. Agglutination *does not* reverse and return to a negative state, which is the change Mr. Bolding reported observing "after a 30 minute reading."

This is the first serology case we have reviewed where the analytic results appear to have been altered without a reasonable explanation. The worksheets

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33 If there were a detectable level of ABO activity in the semen and vaginal secretion mixture on the vaginal swab, then the absence of ABO type B activity on the swab would have to eliminate Mr. Riser as a possible donor to the mixture (in light of his status as a type AB secretor). However, because the ABO type A activity on the swab could have originated entirely from the victim, no male can properly be excluded. Therefore, without further information, Mr. Bolding's original ABO typing did not eliminate Mr. Riser, but the results simply were not probative as to whether Mr. Riser -- as opposed to any other male semen donor -- contributed to the sample on the vaginal swab.

in this case reflect that Mr. Bolding appears to have altered the results of his own ABO typing work in a scientifically unsupportable manner. The effect was to include the suspect in a very small pool of potential semen donors -- which Mr. Bolding testified at trial was comprised of only 2.5% of the male population. In fact, Mr. Bolding's original test results supported the finding of a pool of potential donors equaling *100%* of male semen donors in the population.

The significance of Mr. Bolding's scientifically unsupportable alteration to the AI results for the vaginal swab is that the changed results now indicate the presence of both type A and type B ABO activity -- which means that there is now ABO activity foreign to the victim (the ABO type B activity) which could be attributable to Mr. Riser (who was type AB). Mr. Bolding reported only his altered results, stating in the Crime Lab report dated September 14, 1988 that "[t]he vaginal swab contained types 'A' and 'B' secretor activities." Mr. Bolding concluded in the Crime Lab report only that "we cannot eliminate the suspect Riser," and he provided no statistics regarding the significance of his conclusion (*i.e.*, the size of the population that, like Mr. Riser, cannot be excluded based on Mr. Bolding's ABO typing results).

On September 28, 1988, just a week after issuing his Crime Lab report containing the conclusion that Mr. Riser could not be eliminated, Mr. Bolding testified at the trial of Mr. Riser. According to the trial transcripts, Mr. Bolding testified under oath to his qualifications as a forensic scientist in the Crime Lab as follows:

> I have a BS degree an [sic] MS degree in biology and biochemistry from Texas Southern University. I have a Ph.D. in biochemistry from the University of Texas.[34]

Assuming the accuracy of the transcript, Mr. Bolding's testimony as to his educational background was false. According to the transcripts contained in his personnel file, Mr. Bolding received a B.S. degree in biology, with a minor in chemistry, from Texas Southern University in 1969 and an M.S. in biology from Texas Southern University in 1975.[35] He does not have a Ph.D. degree.[36]

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34 *Riser* Tr., at 105:3-5 (Sept. 28, 1988).

35 Mr. Bolding told us that he was enrolled in a Ph.D. program at the University of Texas School for Biomedical Sciences for one year. He dropped out of the program in 1977 or 1978 because he was having difficulty with the course work.

Mr. Bolding's altered AI results never were discussed at Mr. Riser's trial. He testified that the Crime Lab found "semen on the vaginal swab and the vaginal smear from [the victim's] sexual assault kit" and that "[w]e found that the blood group activity in the semen sample also contained both A and B groupings."[37]

The Crime Lab report in this case, consistent with all of the serology Lab reports we have reviewed so far, did not contain any statistics regarding the significance of Mr. Bolding's conclusion that, due to the reported finding of both type A and type B ABO activity on the vaginal swab, "suspect Riser" could not be eliminated. At trial, however, he provided misleading testimony as to the significance of the inclusion of Mr. Riser based on his finding of type "A" and type "B" activity on the vaginal swab.

Mr. Bolding testified correctly that Mr. Riser's ABO type AB is present in only 5% of the human population,[38] but then he overstated the statistical significance of inclusion of Mr. Riser as a potential contributor to the semen sample found to be present on the vaginal swab. Mr. Bolding narrowed the population that could have contributed to the semen reportedly present on samples from the rape kit to the male half of the population having ABO type AB -- or 2.5% of the overall population -- and included Mr. Riser within the 2.5% of the population that could have contributed the semen present on the vaginal swab:

> Q: Can you then pinpoint what you found in the semen sample found in 2.5 percent of the people walking out there in Harris County? [sic]

Footnote continued from previous page

36 In 2003, the District Attorney's Office investigated allegations that Mr. Bolding falsely testified that he had a Ph.D. during trial testimony in another case. According to Mr. Bolding's attorney, the District Attorney's Office reviewed transcripts from numerous cases in which Mr. Bolding testified before deciding not to charge him with misrepresenting his educational credentials in sworn testimony. We do not know whether Mr. Bolding's testimony in the trial of Mr. Riser was among the transcripts reviewed by the District Attorney's Office, but it seems unlikely given that Mr. Riser's trial happened 15 years before the investigation of Mr. Bolding.

37 *Riser* Tr. at 119:12-13 (Sept. 28, 1988).

38 *Id.* at 122:1-4.

A: That's correct.

Q: And it just so happens, does it not, Mr. Bolding, that the Defendant falls within that 2.5 percent?

A: Yes, ma'am, he does.[39]

This testimony as to the probability that Mr. Riser contributed to the type A and type B ABO activity Mr. Bolding reported that he found on the vaginal swab is misleading for two reasons. First, there is no support in the testimony or in the Crime Lab report for the assumption upon which the 2.5% statistic is premised -- namely, that the type A and type B activity Mr. Bolding reported as present on the vaginal swab is associated with seminal material present on the swab. Second, Mr. Bolding's 2.5% statistical figure assumes, without basis, that the type A and type B activity he found on the swab is attributable to a single donor with the ABO type AB. The 2.5% figure fails to account for the possibility that the ABO activity Mr. Bolding reports having detected on the vaginal swab was attributable to separate type A and type B donors (the victim, for example, was determined to be an ABO type A secretor and could have contributed to the ABO activity present on the vaginal swab). Mr. Bolding conceded on cross examination that, for this reason, the population of potential contributors was greater than the 2.5% of the population he testified to on direct examination.[40]

At the conclusion of the trial, Mr. Riser was convicted of aggravated kidnapping and aggravated sexual assault. He was sentenced to 75 years in prison.[41] The Court of Appeals of the State of Texas affirmed Mr. Riser's convictions in November 1989.

C. The Charles E. Hodge Case

In the Crime Lab case involving Charles E. Hodge, Ms. Kim failed to report the exculpatory results of her ABO testing. Ms. Kim should have reported

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39 *Id.* at 123:11-17.

40 *Id.* at 125:7-11.

41 Our discussion of the Riser case, as with all of the cases we address in this report, is limited only to our review of the forensic science work performed by the Crime Lab and, if available, the trial testimony of Lab analysts. We have not reviewed and make no assessments with respect to other evidence in individual cases.

that Mr. Hodge was eliminated as a possible contributor to the biological sample she tested. She failed to do so.

This case involved an alleged sexual assault that occurred on November 12, 1986. Following the assault, a sexual assault examination of the victim was performed that included the collection of vaginal and cervical swabs. On March 11, 1987, Ms. Kim found semen present on both the vaginal and cervical swabs contained in the rape kit and through AI testing found ABO type B activity on both swabs. On August 7, 1987, Ms. Kim tested known blood and saliva reference samples from both the victim and Mr. Hodge. In her report dated September 25, 1987, Ms. Kim accurately reported the results of her ABO testing -- the complainant was determined to be an ABO type B non-secretor and Mr. Hodge was determined to be an ABO type AB secretor.

Based on these results, Mr. Hodge -- an ABO type AB secretor whose ABO activity would be detectable in his semen -- could not have contributed to the semen sample found on the vaginal and cervical swabs tested by Ms. Kim, which demonstrated *only* type B activity and *not* type A activity.[42] Nevertheless, Ms. Kim stated in the Crime Lab report that "[b]y these findings the defendant could have contributed semen on the vaginal and cervical swabs." Ms. Kim's ABO testing actually supported the opposite conclusion -- that Mr. Hodge should have been eliminated as a possible contributor of the samples obtained from the vaginal and cervical swabs.

On August 10, 1987, Mr. Hodge pleaded guilty to one count of aggravated sexual assault and *nolo contendre* to two other counts of aggravated sexual assault.[43] He was sentenced to 35 years in prison.

III. DNA

During the late 1980s, DNA typing tests were developed as a new and extremely powerful identification tool for forensic scientists. Forensic DNA profiling was pioneered by Alec Jeffreys, a professor at Leicester University in

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42 Moreover, because the victim was an ABO type B *non-secretor*, the ABO type B activity Ms. Kim detected on the vaginal and cervical swabs was foreign to the victim. Therefore, Mr. Hodge can be eliminated as a potential donor of the samples on the swabs.

43 *Texas v. Hodge*, Cause Nos. 463510, 463511, 463534 (Harris County, Tx.). A robbery charge was dismissed at the time of Mr. Hodge's guilty plea.

England.[44] Professor Jeffreys' DNA profiling technique was first employed in connection with a criminal investigation in the famous Colin Pitchfork case, in which DNA analysis was used to exonerate a wrongly accused young man (who had actually confessed) and to identify and help convict the murderer of two 15-year-old girls in 1988. In the almost twenty years that have passed since that first application of DNA testing to forensic evidence, DNA profiling has become an extremely sophisticated and effective scientific tool in criminal investigations and is now a fundamental discipline in most crime laboratories.

The nucleus of each of the 60 trillion nucleated cells in the human body contains strands of genetic material called chromosomes. Chromosomes are made up of deoxyribonucleic acid (DNA) and carry genes that determine the physical characteristics of all living organisms. Most human DNA (99.9%) is the same for everyone. Therefore, because forensic scientists are interested in the individualization of samples containing DNA -- *e.g.* blood, semen, and saliva -- they focus only on the relatively few chromosomal locations that vary widely among individuals. Moreover, a DNA analyst only needs to examine enough locations ("loci") on the DNA strand to render negligible the statistical probability that two people could have the same DNA profile purely by chance. Under current DNA standards in the United States, a complete DNA profile for an individual is generally considered to be one which consists of the alleles present at 13 specified loci. Generally speaking, there is less than a 1 in 200 billion chance that two unrelated persons will have the same 13-loci DNA (the total population of the world is only about 6.4 billion persons).

Similar to the serology techniques that preceded it, forensic DNA profiling of evidence samples involves the analysis of genetic markers to ascertain associations among suspects, victims, and crime scenes. The uniqueness, abundance, and durability of DNA make it ideal for use by forensic scientists. DNA profiling, therefore, has many advantages over earlier conventional serology procedures. In addition to the markedly improved discrimination capability of DNA profiling, the DNA molecule itself is a particularly robust test target compared to the more labile genetic markers involved with serology. Another significant advantage of DNA testing compared with serology is the ability to use a technique called differential extraction by which the sperm (male) components of a mixture can be separated from the female components.

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[44] Professor Jeffreys was knighted by Queen Elizabeth II in recognition of his work in the development of forensic DNA profiling.

Differential extraction is, therefore, extremely useful in typing DNA evidence in sexual assault cases.

A. Overview of DNA Profiling and Techniques

The first step in DNA analysis is to determine whether DNA is present on evidence items. Forensic scientists perform preliminary screening to determine whether certain bodily fluids that might contain DNA are present. After a sample is determined to potentially contain DNA, several techniques may be used to attempt to extract DNA from the evidentiary sample. With mixed specimens such as those typically examined in sexual assault cases, a differential extraction procedure, described above, is used to separate the "male" and "female" components of the mixture, which are then purified and analyzed separately.

DNA analysis techniques have evolved rapidly and become much more sophisticated since Professor Jeffreys' original work. From the beginning, forensic scientists have focused on regions of chromosomes that contain DNA sequences arranged in a repeating fashion.[45] These regions are known as "tandem repeats." Tandem repeats are useful in profiling because, while all humans have these repeats, there is enormous variation -- or "polymorphism" -- in the number of repeats among individuals.

RFLP typing, commonly used until the mid-1990s, involved the analysis of tandem repeat segments known as restriction fragment length polymorphisms ("RFLP"). Restriction enzymes are used to cut DNA at precise points, producing a collection of DNA fragments of precisely defined length. The RFLP analysis process, while very discriminating, is time consuming and requires a relatively large amount of non-degraded, high molecular weight DNA.

DNA profiling technology made a major advance in the late 1980s with the development of a technique known as polymerase chain reaction ("PCR"), which is an amplification process designed to copy or multiply specific segments of DNA. Development of the PCR process gave forensic scientists the ability to analyze much smaller quantities of DNA and made DNA profiling possible in

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45 DNA is composed of four building blocks called "bases." These are adenine ("A"), cytosine ("C"), guanine ("G"), and thymine ("T"). These bases pair with each other (C with G and A with T) to form base pairs. It is the sequence and numbers of these base pairs that are determined in profiling.

some cases involving sample amounts too small or too degraded for effective RFLP analysis. The early PCR-based methods used in the Crime Lab were known as DQ Alpha, Polymarker, and D1S80.

The most common form of DNA typing used today is a form of PCR-based typing known as STR (for "short tandem repeats") analysis, which was developed in the early 1990s and for which commercial kits became available in the mid- to late-1990s. STRs are regions on the chromosome (loci) containing a series of short repeated units. The forensic science community in the United States has standardized DNA typing based on 13 STR loci for entry into the national DNA profiling database known as the Combined DNA Index System ("CODIS"),[46] which is managed by the FBI.

DNA profiles obtained from the biological evidence samples can inculpate the donor of that biological evidence with a high degree of scientific certainty. The statistical meaning of comparisons between DNA profiles developed from known reference samples and the DNA test results developed from evidence items must, of course, be properly calculated and routinely reported in the laboratory reports prepared by DNA analysts. The true significance of a DNA "match" cannot be properly conveyed without the frequency of occurrence of the DNA profile from the evidence sample being presented accurately and clearly by the DNA analyst.

In order to provide some background information helpful to understanding the discussion of the results of our DNA case reviews to date, at Appendix C to this report we briefly describe each of the DNA analysis techniques used in the DNA Section of the Crime Lab from the establishment of the Lab's DNA analysis capability in the early 1990s through the closure of the DNA Section in December 2002.

B. Significant Problems Identified in DNA Cases

The cases in our DNA sample were drawn from cases analyzed in the Crime Lab from 1991 through the closure of the DNA Section in 2002. Similar to

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[46] CODIS is a system that "enables federal, state, and local crime labs to exchange and compare DNA profiles electronically, thereby linking crimes to each other and to convicted offenders." CODIS is a hierarchical database with three tiers -- the National DNA Index System (NDIS) is the highest tier, with state (SDIS) and local (LDIS) databases flowing into it. *See* www.fbi.gov/hq/lab/codis/brochure.pdf.

serology, we found that our original sample of DNA cases, which was derived directly from the Crime Lab's roster of cases assigned to analysts in the DNA/Serology Section, included a large number of administrative cases that did not involve substantive forensic scientific work by the Lab and, therefore, would not provide a basis to assess the DNA analysis performed in the Lab. In order to identify cases involving substantive analytical work, we developed a database of cases derived from raw data records maintained by the Lab, and then with the assistance of PwC, we modified our sample based on that database. Through this process, we identified a total of 1,288 "substantive" serology cases. PwC developed a sample comprised of 296 substantive DNA cases from this database.[47] We also are reviewing all 18 death penalty cases that involved DNA analysis by the Crime Lab as well as cases that have not yet been confirmed through the post-conviction re-testing process.[48] Therefore, the universe of DNA cases to be reviewed during Phase II is 325. We have now completed reviews of 67 of these cases, which includes reviews of the Crime Lab files and supporting raw data for all 18 of the DNA death penalty cases and the files for all of the cases the results of which have not yet been confirmed by the post-conviction re-testing program. Accordingly, we have completed approximately 21% of our planned DNA case reviews.

We have identified major issues in 27 of these cases -- including 3 death penalty cases -- which is approximately 40% of the DNA cases we have reviewed to date. The three death penalty cases involving major issues relate to death row inmates Franklin Dewayne Alix, Juan Carlos Alvarez, and Gilmar Alex Guevara.[49] None of these inmates has been executed. Each of these cases -- as well as other illustrative cases -- is discussed below.

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47 As described in the Phase II Plan, the original sample size PwC developed for DNA cases (which was derived from a population including both substantive and administrative cases) totaled 358 DNA cases.

48 In early 2003, the District Attorney's Office and HPD began a process with the goal of re-testing all cases that resulted in a conviction -- whether at trial or through a guilty plea -- in which DNA evidence analyzed by the Crime Lab may have played a role. The central purpose of the re-testing program has been to identify any cases in which the results of DNA analysis performed by the Crime Lab cannot be confirmed. As of December 22, 2005, re-testing has been ordered for 416 cases.

49 Our preliminary review also has indicated that there might be significant issues with both the Crime Lab's serology and DNA work performed in the case of a fourth death row inmate, Derrick Jackson. Our review of the Crime Lab's work in Mr. Jackson's case is continuing.

As with the serology work performed by the Crime Lab, we have observed pervasive problems with both the quality of the Lab's forensic DNA profiling work as well with the Lab's practices with respect to the interpretation of its DNA testing results. It is not surprising that many of the significant and pervasive problems we have observed in the Crime Lab's serology work -- including failure to report probative results, poor technical work, lack of controls, absence of technical reviews, and poor documentation -- carried over into the Lab's DNA work after the DNA Section became operational in the early 1990s. Many of the same personnel who were involved with serology testing became the Crime Lab's DNA analysts. As discussed in our Third Report, Mr. Bolding, the lead serologist in the Crime Lab, was instrumental in establishing the DNA capabilities of the Crime Lab and became the Criminalist III supervisor once DNA came on line.[50] The Crime Lab's history of poor training and inadequate supervision of its personnel responsible for the analysis of biological evidence continued into the DNA era. Indeed, as we discussed in detail in our Third Report, the DNA Section was without a Criminalist III line supervisor from 1996 through 2002 when the DNA Section was closed.[51]

Although we have observed various problems with the Crime Lab's DNA profiling work, we have determined the following to be the most significant and pervasive issues we have identified so far through our case reviews:

- Failure to report typing results, including potentially exculpatory results.

- Prevalence of low quality analytic results, particularly with respect to PCR-based DQ Alpha, Polymarker, and D1S80 testing, likely attributable to some combination of poor technique on the part of the Crime Lab's DNA analysts and contamination.

- Misleading reporting of the statistical significance of the Lab's DNA profiling results, particularly in cases involving mixture evidence.

- Failure to use and show proper regard for scientific controls, particularly negative controls in PCR testing and failure to compare typing results at

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50 Third Report at 16-18.

51 Id. at 21-26.

the redundant loci when two STR reagent kits were used to type the same evidence samples.

- Failure to perform and document meaningful technical and administrative reviews of the work performed by DNA analysts as well as the absence of a system assigning a unique identifier to track evidence samples from submission through analysis.

1. Failure to Report DNA Results

As with serology, we have observed a number of cases in which DNA testing performed by the Crime Lab generated interpretable, probative, and even potentially exculpatory genetic typing results that the Lab failed to report. In certain of these cases, the Crime Lab reported results based on PCR testing that were less conclusive than conflicting results from more definitive RFLP testing. With DNA, as in serology, we found that the Crime Lab analysts sometimes characterized as "inconclusive" relatively clear-cut typing data that did not reflect a DNA profile consistent with the DNA profile obtained from the suspect's known reference sample. Rather than reporting those results, Crime Lab analysts generated profiles implicating multiple contributors and then interpreted the results as including the suspect, victim, and one or more unknown contributors to the DNA mixture sample.

We have identified two significant cases in which the DNA Section obtained very clear RFLP results that do not reflect the presence of the suspect's profile, and yet the RFLP results were reported as inconclusive in both cases. In each of these cases, PCR-based testing generated a mixture of DNA profiles that were reported as including the suspect and at least one other person. These cases involve Franklin Dewayne Alix[52], who is a death row inmate, and Garland Davis.[53]

a. The Franklin Dewayne Alix Case

Eric Bridgeford was the victim of a homicide that occurred on January 3, 1998. Just over a week later, on January 11, 1998, HPD officers arrested Mr. Alix on suspicion that the murder of Mr. Bridgeford was the culmination of a six-month brutally violent crime spree by Mr. Alix that involved multiple

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52 *Texas v. Alix*, Cause No. 772073 (Harris County, Tx.).

53 *Texas v. Davis*, Cause No. 666524 (Harris County, Tx.).

killings, rapes, and robberies. HPD suspected that Mr. Alix also had been involved in the killing of Gregorio Ramirez. On February 10, 1998, Ms. Kim, a DNA analyst in the Crime Lab, received what she described in a Crime Lab evidence transfer form as "one white gauze" related to the Ramirez homicide. A telephone log in the Crime Lab file related to the testing of the gauze reflects that, on February 9, 1998, an HPD officer advised the Lab that he was "very positive that the blood on the gauze belongs to the suspect [Mr. Alix], but he will check with the morgue for the blood of the complain[ant]." On February 11, 1998, Ms. Kim received an autopsy blood stain card taken from Mr. Ramirez. The Crime Lab also had received a known reference sample from Mr. Alix for comparison.

Ms. Kim extracted DNA from the bloodstain present on the gauze and obtained a relatively large amount of high molecular weight DNA. On February 16 and 19, 1998, Ms. Kim typed this DNA using DQ Alpha, Polymarker, and D1S80 tests. Based on the results of those tests, Ms. Kim concluded that "the DNA patterns detected from the gauze are consistent with a mixture of DNA patterns from Gregorio Ramirez, Frank Alix and one other donor." The Crime Lab report reflects that, on February 23, 1998, Ms. Kim transferred "the remaining DNA" from the known reference samples of Mr. Alix and Mr. Ramirez and the evidence sample from the gauze to a second DNA analyst, Raynard Cockrell, for RFLP analysis.

The report issued by Ms. Kim states that "no DNA pattern was detected from the gauze" as a result of Mr. Cockrell's RFLP analysis. Our review of the original RFLP autoradiographs ("autorads"), contained in binders maintained by the Lab separately from the paper Lab file, determined that, contrary to this statement in the Lab report, the RFLP tests Mr. Cockrell completed in March 1998 contained very clear typing results, using multiple probes, for the three reference and evidence samples. With the exception of one or possibly two faint extraneous bands on the autorads, all of the bands on the autorads related to the gauze sample correspond with the bands associated with the victim's reference sample.[54] In other words, none of the high quality RFLP results from the gauze

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54 While it is possible that these faint bands might indicate that Mr. Cockrell's RFLP testing detected the presence of one or two alleles consistent with Mr. Alix in the gauze DNA sample, a more likely explanation is that the faint bands reflect carryover resulting from poor RFLP technique. The RFLP autorads reflect that Mr. Cockrell placed the gauze sample and Mr. Alix's known reference directly adjacent to each other in the gel without an empty lane separating the samples. This improper technique raises the possibility that

Footnote continued

shows reliable evidence of Mr. Alix's DNA profile. Despite these clear results, a Post-It note attached to the RFLP analytical worksheet indicates "Inconclusive Results," and the final Crime Lab report wrongly states that no results were obtained from the RFLP testing. In sum, the Crime Lab failed to report (and, in fact, mischaracterized) the clearly probative, and potentially exculpatory, RFLP typing results it had obtained.

On August 26, 1998, Mr. Alix was convicted of capital murder in connection with the killing of Mr. Bridgeford. During the penalty phase of Mr. Alix's trial, the State introduced evidence of other crimes attributed to Mr. Alix, including the murder of Mr. Ramirez. Ms. Kim testified during the penalty phase of the trial that, based on her PCR testing:

> A: . . . My conclusion is that the DNA patterns detected from the gauze are consistent with a mixture of DNA patterns from Mr. Ramirez, Franklin Alix, and one other donor.
>
> Q: What does that mean?
>
> A: Meaning that not only did I find Franklin Alix's DNA and Mr. Ramirez's DNA, there's another person who bled on the gauze.[55]

The results of Mr. Cockrell's RFLP testing were not disclosed during the penalty phase of the trail. Ms. Kim testified that the DNA evidence obtained from the gauze "wasn't highly degraded. However, we determined that it was not high quality for us to carry out the RFLP."[56]

The failure of the Crime Lab to report the potentially exculpatory RFLP results it obtained is all the more troubling in light of questions we have regarding Ms. Kim's reported PCR typing results, which identified Mr. Alix as a contributor to a DNA mixture found on the gauze. Although Ms. Kim indicated

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Footnote continued from previous page

DNA from Mr. Alix's reference sample carried over into the adjacent lane occupied by the gauze DNA sample.

55 *Alix* Tr., Vol. 22, at 196:10-17, 197:1.

56 *Id.* at 189:13-15.

on her worksheets that she ran both positive and negative controls in conjunction with her DQ Alpha, Polymarker, and D1S80 tests, photographs of the assays related to these tests do not reflect evidence of such negative controls.[57] We reviewed photographs taken of the typing strips produced in other cases by Ms. Kim both before and after the testing in the Alix case. In all of the other cases, we found the negative control typing strips in the photographic record. The absence of photographic evidence that negative controls were in fact run calls into question the reliability of Ms. Kim's test results.[58]

In connection with the re-testing process that HPD and the Harris County District Attorney's Office initiated in early 2003 following the closure of the DNA Section, an outside laboratory re-tested the bloodstain found on the gauze. On November 5, 2003, the outside laboratory, which used contemporary STR profiling technology, reported only Mr. Ramirez's DNA profile in the gauze bloodstain and that "Franklin Alix . . . is excluded as a possible source of this DNA." A second re-test by another outside laboratory was performed on the unstained portion under the theory that, if the suspect used the gauze as a mask during the killing of Mr. Ramirez, there might be contact DNA present in the unstained areas of the gauze. On December 30, 2004, the second outside laboratory reported that "there was an insufficient amount of DNA obtained from . . . scrapings of the gauze . . . to obtain a profile."

In sum, the DNA re-tests of the gauze referred to in the penalty phase of Mr. Alix's trial are consistent with the Crime Lab's unreported RFLP results that only Mr. Ramirez's DNA profile is present on the gauze and are not consistent with Ms. Kim's reported PCR results finding a mixture of DNA profiles in the

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57 If a negative control was not included in the assay, the results would be invalid. If a negative control was included in the assay and indicated the presence of DNA, affected samples in the assay should not be interpreted. Despite the absence of the negative controls in the photographs, Ms. Kim testified that she ran both positive and negative controls in conjunction with her DNA typing and that the "[n]egative control did not show any DNA types." *Id.* at 198:21-23.

58 Ms. Kim reported that "[t]he DNA type of Frank Alix can be expected to occur in 1 out of 81,000 people among the Black population." This information, although technically correct, is misleading with respect to the strength of the DNA profile obtained from the gauze sample. Upon re-calculation using the alleles reported by Ms. Kim, we estimate the percentage of the population who could be considered possible contributors to the gauze profile to be about 9% of the African American population, 13% of the Caucasian population, and 9% of the Hispanic population.

bloodstain on the gauze that included profiles related to Mr. Ramirez, Mr. Alix, and an unknown donor.

On September 2, 1998, the court sentenced Mr. Alix to death and he currently is on death row.[59]

b. The Garland Davis Case

The Garland Davis case is another example of the Crime Lab failing to report probative, reliable, and potentially exculpatory RFLP results that did not detect the suspect's profile in the evidentiary DNA sample. Mr. Davis was arrested as one of five suspects in the brutal gang rape of a woman that occurred on June 10, 1993. In this case, the Crime Lab performed both RFLP testing and DQ Alpha testing in order to assess whether DNA testing could associate Mr. Davis with semen from a rape kit vaginal swab, rectal swab, and a stain located on the rear waistband of shorts worn by the victim.[60]

Similar to the Alix case, the Crime Lab obtained strong RFLP results on three probes used by Crime Lab analyst Mary Childs-Henry. The first probe detected the same non-victim DNA profile in both the male fraction of the stain on the waistband from the victim's shorts and in the male fraction of the stain on the vaginal swab, neither of which originated from Mr. Davis or a second suspect tested in this case. The second and third probes also excluded Mr. Davis and the second suspect as contributors to the male fraction on the vaginal swab. Even though the RFLP results from each of the probes were strong and none of the

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[59] The information discussed here relating to the Alix case only involves testimony during the penalty phase; it does not address any of the evidence submitted against Mr. Alix in the guilt phase, which related to the killing of Mr. Bridgeford rather than the killing of Mr. Ramirez. Thus, our discussion of the analytic work testified to by Ms. Kim does not impeach or taint the verdict in the guilt phase to any degree.

In general, with respect to the prosecutions of any individual discussed in this report, our investigation is limited to reviews of the forensic scientific work performed by the Crime Lab and the presentation of analysts' findings in any related criminal proceedings. We have not reviewed or considered other evidence, such as eye-witness testimony or confessions, that might be available in such cases. We also make no assessment as to the likely guilt or innocence of any of the suspects or defendants, or the appropriateness of any punishment, discussed in this report.

[60] RFLP testing was performed on biological samples extracted from both the vaginal swab and the victim's shorts. The Crime Lab supplement reported only PCR testing on the vaginal swab.

three probes detected Mr. Davis's profile in the samples, the Crime Lab reported that the RFLP "results in this case are inconclusive because no conclusive patterns due to male (sperm) DNA could be developed."[61] Moreover, the Crime Lab failed to report the unknown non-victim pattern identified through RFLP testing on the male fraction of the vaginal swab and the sample from the victim's shorts. There is no indication that the unknown DNA profile was compared against known reference samples from any of the other three men suspected to have been involved in the sexual assault.

Again similar to what we observed in the Alix case, the Crime Lab failed to report its probative -- and potentially exculpatory -- RFLP results, while it did report the results of DQ Alpha testing performed by DNA analyst Joseph Chu that found a DNA profile consistent with Mr. Davis on the male fraction of the vaginal swab. The Crime Lab report stated its DQ Alpha test conclusions as follows: "The DNA type detected on the vaginal swab does match the DNA from Garland Davis (based on more than one semen donor)." In addition, a frequency calculation of 6.5% is included in the Crime Lab report, which is based on Mr. Davis's DQ Alpha type of 1.2. This information, although technically correct, is misleading with respect to the strength of the DNA profile obtained from the male fraction of the vaginal swab. Given that the victim also has the only DQ Alpha allele (1.2) that could be directly associated with Mr. Davis (and, therefore, the victim could have been the source of the 1.2 allele in the evidence sample), these should not have been considered inculpatory typing results.

Finally, as in the Alix case, re-testing of DNA evidence by an outside laboratory has failed to confirm the Crime Lab's reported findings. In a report dated March 4, 2004, the outside laboratory reported that it had analyzed cuttings from several forensic evidence items, including a cutting from the rear of the victim's shorts near the waistband. Mr. Davis was excluded from all of the samples tested by the outside laboratory, including the victim's shorts. In addition, the outside laboratory developed a profile of the semen donor which was never compared with a known suspect profile. These findings are consistent with the Crime Lab's unreported RFLP results. According to an e-mail dated August 25, 2004 between the outside laboratory and HPD, the outside laboratory tested a processed vaginal swab and obtained no DNA profile. E-mails among the outside laboratory, HPD, and the District Attorney's Office in February 2005

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61 The meaning of the Crime Lab's stated explanation of the supposed inconclusive nature of the RFLP results -- "because no conclusive pattern due to male (sperm) DNA could be developed" -- is unclear.

reflect that the outside laboratory's tests had excluded Mr. Davis. Despite these re-testing results, this case has been designated for further testing on additional available extracted samples.

On December 5, 1994, Mr. Davis pleaded guilty to two counts of aggravated sexual assault and one count of aggravated kidnapping. Accordingly, no analysts from the Crime Lab testified in this case. Mr. Davis was sentenced to 18 years in prison.

2. Poor Quality DNA Profiling Results

We have reviewed many cases, including the Alix case discussed above, in which PCR-based testing performed by the Crime Lab generated multiple DNA profiles which were matched to a suspect, a victim, and one or more unknown donors. The frequency with which the Crime Lab's PCR-based work showed an abundance of alleles implicating multiple donors raises significant concerns regarding the quality of the DNA work performed. This situation was exacerbated by the absence of a quality assurance system to detect and remedy technical problems.[62]

Critical features of both DQ Alpha and Polymarker are the inclusion of control dots appearing on the test strips (the "C" dot in the case of DQ Alpha and "S" dot in the case of Polymarker). A DNA analyst must be very cautious about "calling" any dots that appear fainter than the control dot on the test strip. Appropriate positive and negative controls must be run with each test or the PCR test results may be invalid. Ms. Kim's PCR-based results in the Alix case -- which generated a profile consistent with multiple donors -- were not replicated by either the Crime Lab's RFLP testing or by the re-tests performed by an outside laboratory. Ms. Kim's typing results in the Alix case are highly questionable due

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[62] Although the cases we describe in this section involve the early forms of PCR-based testing -- DQ Alpha, Polymarker, and D1S80 -- we also have observed problems with analysts' technical proficiency and use of controls in RFLP and STR testing. For example, in our Third Report, we discussed the reputation within the Crime Lab of Dr. Baldev Sharma, a former Criminalist III supervisor in the DNA Section, for having difficulty obtaining RFLP results because his technique tended to produce weak or diffuse bands that made interpretations difficult. *See* Third Report at 18. We have reviewed at least one case that confirmed Dr. Sharma's reputation for being unable to obtain RFLP results from a sample that contained a relatively large amount of high molecular weight DNA. Later in this report, we discuss problems we have identified in the Lab's failure to use the D3/D7 control in STR testing.

to the absence of evidence that she ran negative control strips in connection with her PCR-based tests.

The DNA testing performed by Ms. Kim in connection with the capital case of Juan Carlos Alvarez provides another example of conclusions drawn based on weak results. In the Alvarez case, Ms. Kim performed DQ Alpha, Polymarker, and D1S80 testing on DNA extracted from separate bloodstains located on firearms evidence -- on the stock of a rifle, on the barrel of a rifle, and on a shotgun. The only reference samples that Ms. Kim ran were those of two victims, Jose Varel and Hugo Perez. No known suspect DNA reference sample was run. Ms. Kim reported that the "DNA patterns detected on the rifle and shot gun are consistent with those of [Jose Varel] and one other donor."[63] This mixture finding was based on Ms. Kim's decision to call the "C" allele of the GC locus in Polymarker for one evidence sample and the "24" allele of the D1S80 typing system for three of the evidence samples. Our review found that these allele calls were weak and that Ms. Kim's decision to report a mixture containing the profiles of Mr. Varel and an unknown person was questionable. On April 8, 2003, the outside laboratory that re-tested samples extracted from the rifle and shotgun determined, through STR testing, that only Mr. Varel's DNA profile was present in the evidence samples.

We are concerned that the multitude of alleles that HPD Crime Lab analysts often identified through their PCR testing might, in some cases, be attributable not only to poor techniques but also to possible contamination. Generally accepted practices applicable during this period required forensic laboratories to maintain a database of profiles of each member of the laboratory for every method employed by the laboratory. At our request, the Crime Lab recently provided us with a list of employee DNA profiles. This list of profiles does not include typing information related to the Polymarker or D1S80 systems. We also have found no evidence that the Crime Lab staff used this information when reviewing DNA typing data as a check against possible contamination.

Finally, we have found that the Crime Lab's DNA analysts rarely conducted re-testing of samples that produced questionable results. Rather than re-test such samples, the Lab's analysts tended to ignore some questionable signal bands, dots, and peaks and to interpret other similarly questionable signals as alleles originating from multiple donors. The ambiguity of the DNA

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63 Ms. Kim concluded that Mr. Perez's DNA profile was not present in any of the DNA samples extracted from stains on the rifle and the shotgun.

analysts' results in mixture cases was masked by the Crime Lab's practice of reporting probability statistics based on known reference samples rather than on the mixture results. In many cases, this grossly exaggerated the significance of the DNA profiles reported by the Crime Lab.

3. Misreporting of Statistics

The purpose of forensic DNA testing is to develop scientific information regarding the source of biological evidence recovered from crime scenes or from the victims of crimes. The role of the forensic DNA analyst is to answer the following questions: Could the biological evidence have originated from a particular suspect, or is he or she excluded as the donor of that evidence? If a particular suspect is included as a possible source of the evidence sample, how strong is the association between the suspect and the evidence?

Unlike serology testing, DNA testing is very discriminating and is capable of providing scientific evidence with a high degree of certainty that a particular individual is the source of an evidence sample. Forensic DNA analysts express the strength of the association of an individual with a specific sample of biological evidence through the calculation of a frequency estimate called a "random match probability." That estimate quantifies the possibility that a person randomly drawn from the population could be the source of the genetic profile found in the evidence sample. The random match probability associated with an evidence sample can also be understood as the probability with which two unrelated people could share a series of DNA alleles. Probabilities of a random match at a single locus are combined into an estimate of the probability of a random match over an entire DNA profile. This estimate is interpreted as the probability that a person selected at random could have a DNA profile that matches the DNA profile obtained from biological evidence found, for example, at a crime scene. Therefore, such random match probabilities are critical to understanding the significance of "matching" a suspect's DNA profile to the DNA profile of crime scene evidence.[64]

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[64] Because frequency estimates are central to understanding the significance of associations based on forensic DNA evidence, the "Quality Assurance Standards for Forensic DNA Testing Laboratories and Convicted Offender DNA Databasing Laboratories" issued by the FBI specifically require that technical leaders and analysts in DNA laboratories have specific education and training in statistics.

DNA profiles developed from biological evidence samples may indicate that there is a single source for the evidence, that the evidence contains a mixture of DNA profiles contributed by more than one person, or that the evidence contains only a partial profile -- *i.e.*, not all of the alleles necessary to develop a complete DNA profile for the evidence sample are present or detectable in it.

In cases where the evidence stain contains only a single DNA profile, the results of the DNA testing are somewhat easier to interpret and the calculation of the random match probability is relatively simple and straightforward. Evidence samples containing only a single DNA profile provide the most discriminating information about whether a particular individual could be the source of the biological evidence. In fact, random match probabilities from single source profiles often become so astronomically small -- *e.g.,* only one in billions (or often numbers significantly smaller than one in billions) -- that it becomes unreasonable to conceive that another person in the world has this same profile. In these cases, the DNA testing data provide extremely powerful evidence that biological evidence at a crime scene could have come from only one person.

However, when a DNA profile contains DNA from more than one person or only reflects some of the DNA alleles (*e.g*., a partial DNA profile), it is much more difficult to provide compelling statistical evidence that a particular person's DNA was found in an evidence sample. Random match probabilities related to mixture or partial DNA profiles may result in frequency estimates that indicate that a relatively large proportion of the human population could have contributed to the biological evidence.

Therefore, it is critical that forensic DNA scientists provide an accurate and relevant frequency estimate when they discuss the interpretation and meaning of DNA evidence. A frequency estimate based on a DNA profile obtained from a suspect's known reference sample is completely irrelevant to the strength of the DNA evidence when the DNA profile is a mixture or a partial profile. If the frequency estimate of the suspect's known reference sample is presented, in a laboratory report or during testimony, juxtaposed with information from such a mixture or partial evidence profile, it can seriously overstate the strength of the evidence and be extremely misleading.

We have found that the Crime Lab virtually always calculated its reported frequency estimates on the DNA profile developed from the suspect's known reference sample rather than from the DNA profile obtained from evidence samples. It is clear that DNA analysts in the Crime Lab, including Mr. Bolding, did not fully understand the scientific basis of calculating frequency estimates

from DNA profiles obtained from evidence samples and that they were not trained in the methods of properly calculating statistics associated with DNA mixture profiles and partial DNA profiles.

This failure to properly calculate frequency estimates exacerbated the poor quality of the Crime Lab's technical work in developing DNA profiles from evidence samples. As discussed above, Crime Lab analysts often developed and reported multiple DNA profiles, which frequently were reported as including the suspect and one or more unknown donors. In many cases, the Crime Lab then went on to grossly exaggerate the significance of finding the suspect's DNA profile among the one or more other DNA profiles reported to be in the mixture by calculating and reporting the random match probability based on the suspect's known reference sample. In some cases, the improper calculation of statistics from mixture samples masked the poor technical work of the DNA Section that sometimes resulted in the Crime Lab finding a mixture of DNA profiles in an evidence sample where re-testing has shown that no mixture was present, such as in the Alix case discussed above.

We observed another example of the Crime Lab's improper calculation of random match probabilities based on the suspect's known reference sample in mixture cases in the case of Marshall Ware. This case, analyzed by the Crime Lab in 1995, involved a sexual assault in which the forensic evidence included a bodily fluid stain on the shorts worn by the victim. DNA analysts Joseph Chu and Maurita Carrejo performed DQ Alpha, Polymarker, and D1S80 testing on the sample extracted from the stain on the victim's shorts. The Crime Lab concluded that "the DNA type detected on the shorts is consistent with a mixture of DNA from [the victim] and at least three semen donors." The Crime Lab reported that "the DNA detected on the shorts match the DNA type of Marshall Ware" and that a second suspect, Johnny Johnson, "cannot be eliminated as having contributed to the mixture on shorts."

The Crime Lab also reported that "the DNA type of Johnny Johnson can be expected to occur in 1 out of 900,000 people among the Black population" and that "the DNA type of Marshall Ware can be expected to occur in 1 out of 2,900,000 people among the American Black population." These statistics are merely the frequencies with which the suspects' known DNA profiles are expected to appear in the African American population in general and, therefore, are misleading and irrelevant to the question of whether DNA from Mr. Ware or Mr. Johnson was present on the victim's shorts. Based on the alleles that Mr. Chu and Ms. Carrejo found through their PCR testing of the victims shorts, we calculated random match probabilities of 22% for the African American

population, 7.7% for the Caucasian population, and 5.9% for the Hispanic population.

4. Lack of Proper Controls in STR Analysis

In our case reviews to date, we have observed in several cases the failure by Crime Lab DNA analysts performing STR analysis to compare typing results obtained from the COfiler and Profiler Plus reagent kits at the redundant D3, D7, and amelogenin loci. The presence of these redundant loci in the COfiler and Profiler Plus reagent kits is a built-in quality control measure designed to detect possible sample mix-up in STR testing. This feature also serves as a tool to ensure that both assays are working properly. If the alleles detected with COfiler for D3, D7, and amelogenin are not in concordance with those detected with Prolifer Plus, this suggests that there is a problem, including the possibility of a sample switch or that the sample is of poor quality. If the allele calls at the redundant loci are not the same for the same samples, the problem must be resolved by re-analyzing the original samples. The Crime Lab's SOPs specifically require that the D3 and D7 loci for the COfiler and Profiler Plus systems must agree in each sample run through the STR process.[65]

We have identified several cases in which DNA analysts failed to take appropriate action to resolve potential problems with the accuracy and reliability of DNA typing results obtained from STR tests in which the D3 and D7 loci results generated from the COfiler and Profiler Plus reagent kits were not in concordance. One such case is the death penalty case of Gilmar A. Guevara.[66]

The Guevara case involved the June 2, 2000 murders of two convenience store clerks during an attempted robbery by suspects wearing masks. On June 10, 2000, Mr. Guevara was arrested, and police found blue and black ski masks and a Halloween mask in the trunk of his car. Mr. Chu performed STR testing on all three masks. In his Crime Lab report dated May 4, 2001, Mr. Chu reported that "a mixture of DNA consistent with Gilmar Guevara and [co-defendant] Jose Luis Hernandez was detected on the blue ski mask" and "a

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65 The Crime Lab's SOPs, however, provide no guidance as to what procedures the DNA analyst should follow with respect to sample tests where the D3 and D7 loci are not in concordance.

66 *Texas v. Guevara*, Cause No. 847121 (Harris County, Tx).

mixture DNA type consistent with Jose Luis Hernandez and at least one unknown donor was detected on the black ski mask."[67]

Our review of the electropherograms contained in the Crime Lab file for this case found that, with respect to the STR testing on the blue ski mask, the alleles detected using COfiler and Profiler Plus reagents were in discordance at both the D3 and D7 loci. With respect to the black ski mask, the COfiler and Profiler Plus reagents were in discordance at the D3 locus. In light of these inconsistencies, the typing results obtained by Mr. Chu with respect to the blue and black ski masks should have been considered questionable or inconclusive, and the samples should have been re-tested.

During a trial that lasted less than two days, Mr. Chu testified about his DNA typing results on the blue and black ski masks. Mr. Guevara was found guilty of capital murder on May 30, 2001 and then sentenced to death. He is currently on death row.

On August 18, 2003, an outside laboratory reported that re-testing of the blue ski mask did not yield a DNA profile. On October 14, 2003, the same outside laboratory reported that DNA testing could not be performed on an extract from the black ski mask because there was an insufficient amount of remaining DNA extract. Thus, re-testing by an outside laboratory has not confirmed the Crime Lab's findings. On February 16, 2005, the District Attorney's Office requested that a case review by an outside laboratory be performed. To date, that review has not been completed.[68]

Finally, in our initial reviews of cases involving STR testing, we have observed that the negative control profiles in some cases appear to be out of the ordinary on the electropherogram printouts that are present in the case files.

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[67] The Crime Lab found that DNA was present on the third mask -- a Halloween mask -- but it was not able to obtain any DNA typing results for the samples extracted from that mask.

[68] Another serious case we have reviewed in which the Crime Lab reported STR results despite discordance between COfiler and Profiler at the D3 and D7 loci is that of Robert Cantrell, in which STR testing was performed by Ms. Kim. *Texas v. Cantrell*, Cause No. 906221 (Harris County, Tx). We observed the additional problem in the Cantrell case that it is difficult to tell which alleles reflected on the STR electropherograms were called by Ms. Kim. Although the Crime Lab's SOPs require that an allele must exhibit an intensity of 150 relative fluorescent units ("rfus") in order to be included in typing results, in this case it appears that Ms. Kim may have called alleles with peaks lower than 150 rfus.

Specifically, on the negative control printouts, there is no peak height scale (rfu) on the Y-axis that reflects the quantity of DNA in a given sample and there is no evidence of the slightest amount of signal (or readings) reflected on the electropherogram. In other words, it appears that there is none of the typical "baseline" signal that normally appears in an electropherogram printout of a negative control. In addition, there may or may not be issues with the negative control samples in those cases. We are continuing to work with HPD and the Crime Lab to obtain raw electronic data files related to STR tests in order to review the negative control profiles in greater detail.

5. Lack of Technical and Administrative Reviews and Poor Documentation

We have observed no documentation in the DNA case files we have reviewed reflecting that a supervisor in the DNA Section performed a technical review of the DNA analysts' work. This is a very disturbing and significant departure from generally accepted forensic science principles. As discussed in our Third Report, until 1996 Dr. Sharma was the Criminalist III supervisor over the DNA Section. In 1996, Dr. Sharma was removed as the line supervisor over the DNA Section in the wake of the Lynn Jones case.[69] No one ever replaced Dr. Sharma as the Criminalist III supervisor for the DNA Section, which remained without a line supervisor through December 2002 when the DNA Section was closed. Although the then-head of the Crime Lab, Donald Krueger, created a Quality Assurance/Quality Control position to which to move Dr. Sharma after the Lynn Jones debacle, Dr. Sharma did very little to fulfill his role as the quality control manager for the entire Lab.[70]

This left Mr. Bolding, already the Criminalist IV over both the DNA and Trace Evidence Sections, as the sole supervisor overseeing the Crime Lab's DNA work. Analysts who worked in the DNA Section during that period told us that they would submit their case files to Mr. Bolding for review, but it was unclear to them whether he performed a technical review of their work. The case files themselves contain no documentation reflecting that Mr. Bolding or any other supervisor performed such a review, and the DNA analysts with whom we have

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[69] Third Report at 21.

[70] As discussed in our Third Report, Dr. Sharma made almost no meaningful contribution in the QA/QC position. By February 2001, Mr. Krueger had assigned Dr. Sharma to assist the Controlled Substances Section by analyzing marijuana cases. *See* Third Report at 30.

spoken did not recall receiving regular feedback from Mr. Bolding regarding the technical aspects of their casework. Moreover, in light of the pervasive problems we have identified related to the quality of the DNA Section's work, if Mr. Bolding did perform undocumented technical reviews of the cases analyzed by the DNA Section, such reviews were ineffective.[71]

It appears that administrative reviews -- *i.e.*, reviews focused on the documentation contained in case files and the organization of the Crime Lab files -- were performed occasionally in the DNA Section. Again, however, to the extent such reviews were conducted, they were not effective. For example, as with many serology cases, we have observed that in DNA cases Crime Lab analysts failed to assign unique identification numbers to specimens extracted from items of evidence to establish with clarity what testing procedures were performed and what results were obtained with respect to which specimens. For example, in one case, an evidence sample from a piece of clothing was referred to alternatively as "blue jacket" and "shirt." In this same case, several pairs of "jeans" were screened for the presence of DNA, but it was not clearly documented which pair of "jeans" evidence was actually tested.

Moreover, the Crime Lab's DNA files generally do not contain drawings or descriptions specifying from what part of an item of evidence biological stains were detected and removed for analysis. The lack of information in laboratory notes to adequately describe the presence and location of important biological evidence is inconsistent with generally accepted forensic science practices.

Finally, DNA analysts rarely prepared allele tables charting the alleles that they identified through their DNA testing. This failure to prepare allele tables is particularly problematic in those STR cases with many items of evidence or where the STR electropherograms reflect a number of weak readings near or below the Crime Lab's 150 rfu threshold. Without an allele chart, it is very difficult to discern which alleles the DNA analyst might have interpreted as present in the sample.

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71 There certainly appears to have been an appetite among analysts in the DNA Section for technical assistance. We have seen documents from as early as August 1994 reflecting concerns among members of the DNA Section about the lack of standardized SOPs and training in PCR. *See* Third Report at 19.

C. The Post-Conviction DNA Re-testing Program

In early 2003, following closure of the DNA Section, the District Attorney's Office and HPD launched a re-testing program whose objective was to re-test evidence in all cases that resulted in a conviction -- whether at trial or through a guilty plea -- in which DNA evidence analyzed by the Crime Lab may have played a role. The central purpose of the re-testing program has been to identify all cases in which the results of DNA analysis performed by the Crime Lab cannot be confirmed.

As of December 22, 2005, re-testing has been ordered for 416 cases.[72] As of August 26, 2005, the Crime Lab's findings were confirmed in a total of 335 of the post-conviction re-test cases. So far, HPD and the District Attorney's Office have concluded that the Crime Lab's findings were reversed by the outside laboratory in 5 cases.[73] The post-conviction DNA re-testing program has been ongoing for nearly three years, however, and 56 of the cases on the re-test list are still pending additional testing or case review by an outside laboratory.[74]

During the first months of Phase II, we have reviewed 13 cases -- including the Alix, Davis, and Guevara cases -- that HPD identifies as pending additional testing or case reviews where the initial round of re-testing failed to confirm the Crime Lab's original DNA test results. We have found that in several cases that the initial round of re-testing conducted by outside laboratories has failed to confirm the Crime Lab's reported results. The District Attorney's Office has advised us that the defendant and counsel for the defendant, in cases in which the defendant is currently represented, are notified of re-testing results soon after the results are received from the outside laboratory, including those cases where the District Attorney's Office and HPD believe additional testing or a paper case review should be performed.

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72 By the conclusion of Phase I of this investigation on June 30, 2005, the District Attorney's Office and HPD had identified 403 DNA cases for post-conviction re-testing. On December 22, 2005, HPD advised us that an additional 13 DNA cases have been identified for re-testing, bringing the total number of DNA cases to be re-tested to 416.

73 Three of these 5 reversal cases involve co-defendants in a related case that was originally analyzed by the DNA/Serology Section under a single Crime Lab number.

74 The remaining 20 cases have not yet undergone any re-testing because either the case was only recently identified for re-testing or HPD has not been able to locate evidence to be re-tested.

In some of the cases we have reviewed, it appears that additional rounds of re-testing likely will prove unsuccessful in confirming the results originally reported by the Crime Lab. For example, in Mr. Alix's case, raw cuttings from bloodstained gauze as well as scrapings from the unstained portions of the gauze have failed to confirm the Crime Lab's reported finding of Mr. Alix's DNA profile on the gauze. Moreover, the Crime Lab's original, unreported RFLP results related to the gauze are consistent with the re-testing results that found only the victim's profile on the gauze. The chances that additional testing of remaining extract samples, followed possibly by a paper case review, would confirm the Crime Lab's reported results -- that the gauze contained a mixture of DNA patterns from Mr. Alix, the victim, and a third donor -- are extremely low.

IV. Trace Evidence

Trace evidence can play a critical role in generating investigative leads, identifying potential suspects, determining how crimes were committed, and corroborating other evidence developed during an investigation. Forensic examination of trace evidence involves the search for and analysis of hairs, fibers, paint, glass, arson debris, bodily fluids, and many other substances and items. This evidence is examined with three primary objectives:

- identifying the physical and chemical properties of the material(s);
- comparing the evidence being analyzed with known samples in order to determine whether they could share a common origin; and
- providing investigative leads when suspects are unknown.[75]

If comparative analysis of suspect evidence and a known sample suggests a common origin, the forensic scientist can help determine the likelihood that the evidence came from the same source. The cumulative effect of physical evidence, including trace evidence, can be quite powerful. When numerous pieces of evidence link a suspect to a crime scene, the probability of the suspect's involvement with the crime increases significantly. Conversely, the lack of a match in trace evidence can serve the critical function of excluding or exonerating an individual suspect.

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[75] For example, trace evidence might be used to identify the year, make, and model of a "hit and run" car based on paint particles recovered from the victim's clothing.

Until October 2003, the Trace Evidence Section generally operated with a staff of two analysts and a supervisor.[76] However, the Crime Lab stopped performing in-house trace evidence examinations after the section's supervisor, Reidun Hilleman, was appointed the Quality Assurance/Quality Control Leader for the entire Lab in the fall of 2003. Trace evidence collected by HPD is now examined by the Texas Department of Public Safety ("DPS") Crime Lab when deemed necessary.

Approximately 220 trace evidence cases were opened by the Crime Lab during the relevant period.[77] Our statistical experts from PwC originally selected a sample size of 141 trace evidence files for review, but we found that many of the cases selected involved no substantive trace evidence examination. This was true for several reasons:

- Some cases involved material that was merely processed, rather than examined, by a trace evidence examiner. Criminalists in the Trace Evidence Section often received crime scene materials (*e.g.*, latent fingerprints) that were then transferred to other sections of the Crime Lab or elsewhere in HPD for examination.

- Some trace evidence (for example, hairs) was forwarded to outside laboratories, including Identigene, Reliagene, Orchid-Cellmark, and the DPS laboratory.

- Finally, some case files involved trace evidence (particularly hair) that was merely inventoried and stored and that never underwent in-depth forensic examination by the Crime Lab or any other laboratory. This category of cases is discussed in additional detail below.

Because the total number of trace evidence cases is relatively small, and because many did not involve substantive work, we will review all of the 264 cases we have identified in which examination of trace evidence was involved, including serology and DNA cases in which there was a trace evidence component. We have made substantial progress in this area, completing our

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76 During the relevant period, Mr. Bolding was the Criminalist IV supervisor over both the Trace Evidence and DNA/Serology Sections.

77 Although arson cases constituted a large proportion of the Crime Lab's trace evidence cases, they were not included in our review because HPD no longer performs these examinations and has no plans to do so in the future.

reviews of 222 (84%) of these cases. The majority of these cases were examined by the Criminalist III supervisor for the Trace Evidence Section, Ms. Hilleman. So far, we have reviewed five trace evidence cases in which we identified a major issue.

Additionally, we reviewed a total of 18 trace evidence proficiency tests, which were used to evaluate the reliability of examiners' performance between 1987 and 2002. We found the examiners' performance on the proficiency tests to be generally satisfactory.[78] Nevertheless, we have identified a number of areas of concern relating to the performance of the Trace Evidence Section between 1998 and 2004.

A. Lengthy Delays and Lack of Follow-up

As the examples below indicate, excessively lengthy and inexplicable delays sometimes occurred at several points in the Crime Lab's trace evidence examination process. In some cases weeks, months, or even years elapsed before any examination was performed or a report was issued.

For example, in a "hit and run" case that occurred on December 28, 2002, hairs from the suspect vehicle were submitted to the Crime Lab on January 9, 2003 and examined the same day. Some of the hairs were described in the examiner's notes as human head hairs, and several were described as suitable for DNA analysis. These hairs were retained in a freezer in the Crime Lab. However, no report was issued until more than two years later, on April 15, 2005, and there is no record of any communication between a trace evidence examiner and the investigator. The report states: "If further analysis is required in this case, please make an additional request." A request for more information in fact was made on April 18, 2005, when the investigator asked if the hairs were human or animal. This information was already available in the examiner's notes, but there is no record in the file of the finding ever having been communicated to the investigator.

In another hit-and-run case, skin tissue from the bumper of a suspect vehicle was submitted to the Crime Lab on November 15, 2002. On December 4, 2002, the Crime Lab was asked to compare the victim's blood and hair to the

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[78] We found that an examiner's performance on one 1989 proficiency test was unsatisfactory, but Crime Lab records indicated that this test was performed by an unidentified trainee.

evidence collected from the suspect vehicle. The trace evidence examiner did not begin examining the evidence until January 4, 2004, and "possible skin tissue" was then transferred to an outside DNA laboratory (Identigene) for analysis. The prolonged delay in processing this evidence was not consistent with good forensic laboratory practices, although we note that this case occurred during a tumultuous time in the Crime Lab when the DNA Section was being shut down and alternative arrangements for the analysis of biological evidence were just beginning to be developed.

Delay and inadequate documentation issues are also evident in the trace evidence files relating to a 2001 homicide case. The offense occurred on September 28, 2001; evidence was submitted to the Crime Lab on November 26 and December 17, 2002. Although the evidence was initially examined on December 12, 2002 and on January 16, 2003, the only report in the case file is dated July 19, 2004. The report states that "[a] supplement will follow that will document the examinations performed on the above items." However, there is no such report in the file and no explanation for its absence. Generally accepted forensic science practices require that a report always be prepared to summarize the examinations performed and results obtained, even if, for well-documented reasons, the report need not be issued.

Significant delays in the examination of evidence, such as in the cases described above, lead to "cold" information that is, for obvious reasons, not as valuable to investigators as more timely reports would be. The lack of follow-up we observed in some Trace Evidence Section cases may be attributable in part to a lack of communication with investigators or the District Attorney's Office. When communication between investigators, prosecutors, and crime laboratory staff is lacking, examiners might not recognize the significance of a particular piece of evidence or might not be in a position to articulate the significance of their findings for investigators.

B. Minimal Attempts to Generate Investigative Leads

The potential value of trace evidence examinations was not being fully utilized during the period of our review. In some cases, either minimal or no attempts were made to examine evidence that could have generated important investigative leads. For example, fibrous insulation material collected from a crime scene and from two suspects was submitted to the Crime Lab on October 28, 1998. The items were not examined until more than eight months later, on June 30, 1999. The examination notes describe each of the three items as

consisting of "various fibers (cotton, wool and some synthetic, various colors) dust particles."

Because this evidence involved a number of different fiber types and colors, it would have provided very strong associative evidence if a more detailed examination had been conducted and reported. Although the file notes that were recorded are informative, the actual Crime Lab report states only that the three items "consist of assorted compressed fibers and other dust particles." As a result, the report in this case does not communicate to the investigators the true potential value of this evidence. Moreover, the report is dated August 2, 1999, which was over nine months after the evidence was submitted to the Crime Lab and likely too late to be of much use to the investigators.

C. Adherence to Generally Accepted Laboratory Procedures

Generally accepted forensic science procedures require that controls be used and recorded in laboratory notes to assure the reliability of results in trace evidence testing. For example, "reagent blanks" are used to ensure that test results are not influenced by variations or inconsistencies in the reagents themselves. The use of these and other controls is especially important in connection with chemical tests for the presence of saliva, blood, and semen. However, there is often no reflection in the case files that appropriate controls were used or recorded by the Trace Evidence Section.

D. Documentation

Documentation is sparse in many of the trace evidence files. The files rarely contain the notes or telephone logs that are commonly used in forensic laboratories to document communications with investigators and prosecutors. Similarly, there is often no documentation in the files explaining the reasons certain evidence was not examined. Some of the case files could have been greatly enhanced by the use of sketches or photomicrography, which would aid the analyst or reviewer in reconstructing the case (*e.g.,* when called upon to testify at trial or in connection with legal appeals).

Based on the case files we have reviewed to date, we found that the quality of the examinations that were actually performed in the Trace Evidence Section was generally good. However, in many cases, nothing of evidentiary significance was developed because of a lack of adequate reference samples or adequate information from investigators about the circumstances surrounding a case to provide context for the examinations. There is no indication that the

Crime Lab vigorously pursued with investigators the need for comparison samples. As a result, HPD did not take full advantage of the potential value of trace evidence.

V. Controlled Substances

The Controlled Substances Section analyzed the vast majority of cases processed by the Crime Lab -- over 97,000 cases between 1998 and 2004. More analysts were employed in the Controlled Substances Section than in any other section of the Crime Lab. For example, in December 2005, the Crime Lab employed a total of 40 criminalists, 15 of whom were in the Controlled Substances Section. The next largest section was the DNA/Serology Section with 8 analysts, followed by the Firearms Section with 7 examiners.

In response to the discussion contained in our Second Report related to drylabbing incidents in the Controlled Substances Section involving Vipul Patel and James Price, HPD requested that during Phase II we perform reviews specifically targeting cases processed by those two analysts, in addition to the overall sample of Controlled Substances Section cases.[79] Therefore, our Phase II case reviews of controlled substances cases consists of three separate samples -- a general controlled substances sample, a sample of Mr. Patel's cases, and a sample of Mr. Price's cases. To date, we have reviewed 150 of the 383 (39%) cases in the general controlled substances sample; 200 of 366 (55%) cases in the Patel sample; and 114 of the 342 (33%) cases in the Price sample.

We have reviewed these controlled substances cases with reference to the SOPs in existence in the Crime Lab when an analysis was performed, standards and practices generally accepted within the forensic science community at the time of the analysis, and standard administrative and documentation practices. We also reviewed proficiency tests taken by Crime Lab analysts, compared case files to documentation in various logbooks and manuals, and conferred with two analysts from the Controlled Substances Section.

A. Techniques Used to Identify Controlled Substances

In the context of a forensic lab, controlled substances are found in a number of different forms, including powder, cigarette, chunk, residue, liquid,

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79 "Drylabbing" involves the fabrication of scientific evidence. These incidents are discussed at length in our second and third Phase I reports.

and vegetative. Drug analysts also identify licit and illicit pharmaceutical products in tablet, capsule, and liquid form. Depending on the laws of a jurisdiction and the type of substance, analysts may also be called upon to determine the quantity and purity of a controlled substance, which can ultimately affect a defendant's sentence.

Drug analysts use a wide range of techniques and instruments to identify controlled substances, including color tests, microcrystalline tests, gas chromatography ("GC"), mass spectrometry ("MS"), infrared and ultraviolet spectrophotometry, and both microscopic and macroscopic examinations. A few of the many controlled substances that can be identified by such analyses include marijuana, Phencyclidine ("PCP"), heroin, codeine, methamphetamine, cocaine, and Gamma Hydroxybutyrate ("GHB").

Some tests used by drug analysts are simply screening tests that indicate the general type of drug being analyzed. For example, analysts use color tests to presumptively identify a drug by looking at a color change, which is the result of a chemical reaction between the substance and an added reagent. Another presumptive identification testing method, chromatography, separates active ingredients within a drug mixture and provides a tentative identification of a drug. If an analyst uses a screening test to narrow the field of possible drugs and presumptively identify a substance, more testing is necessary to definitively determine the identity of a substance. For instance, an analyst can definitively identify marijuana by conducting a color test and then looking at the botanical features, such as cystolithic hairs, under a microscope.

On the other hand, certain tests can definitively identify the substance.[80] Mass spectrometry uses high-energy electrons to break an unknown substance into fragments and then measures and plots the masses of the small fragments. Mass spectrometry can provide a virtually definitive identification of a drug because the fragmentation pattern that is produced is unique for a vast majority of substances.[81] A second definitive drug identification technique is infrared

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80 Under generally accepted forensic science practices, however, analysts use at least two techniques, based on different principles and two independent samplings, to determine the identity of a drug in a sample.

81 Another instrument commonly used in forensic labs is a gas chromatograph/mass spectrometer. In gas chromatography, the sample being analyzed is injected into a heated chamber and then carried by a constant stream of a carrier gas (usually nitrogen or helium). The carrier gas moves the sample into a column containing a thin film of liquid. In this column, the components of the sample move at different speeds and thus

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spectrophotometry. An infrared spectrophotometer measures the wavelengths of infrared light that a particular substance absorbs and produces a spectrum that is unique for many substances.[82]

No matter which test or combination of tests is used, the governing principle behind controlled substances analysis is to compare the analytical results obtained from analyzing an unknown substance with the results obtained from known substances. For example, an infrared spectrum can be compared with the unique peaks on a spectrum of a known substance. Some laboratory instruments provide a library of standards, which are analytical results of known substances. An analyst compares the results of the unknown sample with the standards in the reference library and decides whether there is sufficient similarity to determine that the unknown substance matches the known controlled substance.[83]

B. Results of the General Controlled Substances Case Reviews

We have reviewed 150 cases from the general controlled substances sample. Initially, most cases in the sample involved basic marijuana or cocaine identifications, so the sample was adjusted to capture cases involving more complex and challenging analyses.[84] Of the 150 cases we have reviewed thus far, 4 have been identified as involving major issues. Based on our preliminary

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are separated and carried to a detector, which generates an electrical signal that is recorded as a series of peaks in graph format. The time it takes for a substance to travel from the injection point through the column is referred to as the substance's retention time. Analysts can identify the nature and quantity of substances in a sample by comparing retention times and column peaks on the chromatogram to those of known substances. Although gas chromatography alone is not a definitive test, a drug identification made by GC/MS testing can be definitive.

[82] An analyst usually must purify the sample before infrared spectrophotometry analysis can be completed. One of the benefits of the combined GC/MS analysis is that a pure sample is not needed because gas chromatography separates the components of the mixture and mass spectrometry is then used to identify each component.

[83] Some laboratory instruments conduct a library search and provide a list of results for the standard that most closely matches that of the unknown substance.

[84] We have also been reviewing certain "bulky cases," which, as the term suggests, involve large quantities of drugs. These cases were not included in the general Controlled Substances Section sample, and results of this review will be reported after we have completed our work in this area.

review, it appears that analytical work performed on substances frequently encountered in the Crime Lab, such as cocaine and marijuana, was generally of a high quality. It is also important to note that the section's work improved over time. However, when substances that were more complex or rarer were examined by the Crime Lab, more analytical deficiencies were identified.

In one case an analyst identified cocaine even though gas chromatography results were inconclusive. This finding was based on one microcrystalline test and three color tests. However, when combined with an inconclusive GC test, the results of the microcrystalline and color tests did not provide a definitive identification.[85]

In three cases, analysts reported quantitative results for a substance, even though quantitative analyses were not performed. It appears to have been a customary Crime Lab practice to presume that liquid codeine cough syrup could not have a concentration greater than 200 mg of codeine per 100 mL of liquid. While this will likely be true in most cases, higher concentrations of codeine could be present. More problematic is the fact that the reports gave quantitative results, implying that quantitative analyses had been performed. At the very least, the reports should have clearly stated that the quantitative report was based on Crime Lab protocol and presumption, not on actual analysis.[86]

We found that controlled substances analysts frequently failed to follow the Crime Lab's SOPs. Between 1998 and 2004, written guidelines were not maintained in one central resource but, rather, were scattered among a number of different SOPs, training guides, and other documents. Some of these documents were undated, and some were not clearly written.[87] Additionally, controlled substances analysts relied to a large extent on oral instructions received in training or from informal advice provided by supervisors. This

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85 This matter did not involve a defendant.

86 It is our understanding that the Crime Lab may still follow this policy when reporting quantitative results for certain substances, such as codeine or hydrocodone. However, the Crime Lab's current SOPs rarely require an analyst to report quantitative results.

87 For example, some of the SOPs used the term "should," which could have led analysts to believe certain practices were optional, rather than mandatory.

process may have made it unnecessarily difficult for analysts to identify and follow Crime Lab policies and procedures.[88]

Many of the failures to adhere to the Crime Lab's SOPs that we have observed involved inadequate documentation, including the following issues relating to analysts' worksheets:

- information regarding sample preparation was omitted from case files;
- copies of the relevant portions of the Logo Index) and specific citations to the PDR[89] were not included in case files when those sources were used to physically identify a capsule or tablet;
- reports were not properly initialed by analysts or peer reviewers;
- documentation of blank instrument runs was not maintained;[90] and
- analytical instrument printouts were not maintained.

In a large number of cases, documentation problems in the analysts' worksheets made it difficult to determine the steps taken by Crime Lab analysts. A properly documented case file should allow an independent reviewer to logically follow the steps taken to reach a scientific conclusion.[91] The poor

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88 The preferred system for disseminating laboratory policies is to have clearly written procedures that are easily accessible and thoroughly understood by laboratory staff. All policies should be written, dated, authorized, and contained in one location that is readily accessible to the entire staff. Additionally, a staff member with the necessary training, experience, and writing skills should be responsible for maintaining, updating, and distributing lab policies and procedures.

89 These resources can assist in the physical identification of drugs based on the appearance of a specimen. For example, the color, shape, size, and logo of dosage forms produced by a particular pharmaceutical manufacturer can be found in the PDR.

90 "Blanks" are used for quality control purposes. Blanks consist of the solvents or reagents used to prepare the sample for analysis and are used to assure that no background substances or contaminants affect the accuracy of test results.

91 Because of poor documentation in certain cases, we were unable to determine the following: (1) which items were the ones analyzed, when a case included numerous similar items, (2) how the items examined by the analysts correlated with the items described on the police officer's submission form, (3) which reagent was used for

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documentation identified in many cases raises troubling questions about the ability of Crime Lab supervisors to perform adequate technical reviews of those cases.

Another issue identified in our review is that analysts sometimes did not perform all of the analyses that were required by the SOPs. Ultimately, these issues -- and the documentation issues discussed above -- do not raise significant doubts about the validity of the analysts' conclusions. This is so because other analyses that were completed and sufficiently documented in the case files support the reported conclusions. For example, in a number of cases, analysts did not document whether they performed the SOP-required macroscopic examination on marijuana evidence, but the substances were still definitively identified by a combination of microscopic examination and color testing.

In addition to the deficiencies noted above, we also identified a number of cases in which analysts did not comply with generally accepted forensic science practices. For example, in three cases, analysts retained custody of evidence for months at a time. In two other situations, analysts identified a controlled substance through the use of chromatography but ignored "extra" peaks that indicated the presence of another substance.

C. Results of the Patel Case Reviews

We have also made significant progress in reviewing cases analyzed by Mr. Patel, with 200 of the 366 cases (55%) having been reviewed so far. To date, we have found that 14 of Mr. Patel's cases that we have reviewed involved major issues.

Most troubling is the identification of another potential drylabbing incident. In a case involving multiple tablets, Mr. Patel used the Logo Index to physically identify one of the tablets as Carisoprodol, a non-controlled, dangerous substance. Mr. Patel's report also indicates that he conducted an infrared analysis on a tablet. However, we noted that the library standard and the infrared spectrum supposedly produced from the tablet were virtually identical. The two printouts are so similar that they can almost be superimposed on one another. Because it is highly unlikely that spectra from two different

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microcrystalline tests, (4) who marked and/or made changes on worksheets and instrument printouts, and (5) how the samples were prepared for instrumental analysis.

sources would be so closely matched, this may indicate that the tablet was never tested. Rather, it may be that the library standard was simply printed twice and one of the spectra relabeled as being from the test sample.

To investigate this issue further, we inspected the tablet that was purportedly tested by Mr. Patel. A small portion (approximately one to two milligrams of material) had been scraped from an edge in a manner that is consistent with the handling of samples actually being subjected to infrared analysis.[92] However, we also compared the infrared spectra from Mr. Patel's case to those obtained from other cases recently handled by the Controlled Substances Section. In those cases, the spectra were similar enough to identify a match, but many minor differences were apparent between the spectra produced from the known and tested samples. This is what an analyst would normally expect to find. The almost perfect match of the sample and standard spectra from Mr. Patel's case casts doubt on whether the sample was actually tested.

Other concerns identified in the Patel sample relate to historical policies and procedures of the Crime Lab that are scientifically unsound. One involves the identification of unknown tablets using the PDR or the Logo Index, as described above. In a number of cases we reviewed, Mr. Patel followed the general Crime Lab practice and then reported those findings as if the identity of the tablets had been confirmed through actual analysis. The physical identification of drugs with a PDR or the Logo Index is conditionally acceptable, but reporting such results without acknowledging that laboratory analytical procedures were not used to identify the sample is generally viewed as improper. If the reports had stated that the items were "physically identified as X," the practice would have been acceptable. Another major issue identified in the Patel sample involved the previously discussed codeine syrup quantitation issue, described above. Mr. Patel followed the Crime Lab's deficient quantitation practices in a number of his cases.[93]

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92 As is described in our Third Report, the samples at issue in another case of apparent drylabbing by Mr. Patel were scraped in a similar manner.

93 With regard to the codeine quantification issue and the PDR/Logo Index identification issue, it is important to note that forensic science laboratories are responsible for reporting scientific conclusions based upon acceptable scientific testing. While visual identification, comparison to various references and labels, and experience from previous testing of other samples with similar physical characteristics may potentially identify a substance and serve as a presumptive step, they do not constitute acceptable scientific analysis for confirmatory purposes and could not effectively be defended in a court

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In another case, Mr. Patel's own analytical skills (rather than unsound Crime Lab policies) appeared to cause the problem. In that case, Mr. Patel reported that capsules were "negative" after getting seven negative color test results, one color test result indicating the possible existence of an identifiable substance, and conflicting ultraviolet ("UV") spectrophotometry results. Mr. Patel's first UV run for this case was a run of the capsule, which produced a peak. After performing an acid/base extraction on the capsule, Mr. Patel ran another UV test, which did not show a peak. Rather than stopping at that point and reporting the capsules as "negative" for identifiable substances, as Mr. Patel did, he should have run another analysis, such as GC/MS, in order to determine if the capsule was truly negative or if it contained an identifiable substance.

We also noted a number of minor issues when evaluating Mr. Patel's cases. For example, he departed from generally accepted forensic science practices in the following ways:

- identifying cocaine when GC peaks were less than 10% of the full-scale deflection;[94]
- failing to initial his corrections on reports;
- identifying acetaminophen by using only an UV analysis;
- reporting a cigar as negative for controlled substances after testing only for marijuana and not testing for other controlled substances, such as PCP or codeine; and
- not attempting to scientifically identify tablets that he visually identified as ibuprofen through the use of the Logo Index.

As was true in some files reviewed from the general controlled substances sample, Mr. Patel's worksheets did not always indicate that the SOP-required macroscopic examination was performed on vegetative substances, such as marijuana. However, Mr. Patel appeared to have completed other tests that

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proceeding. Additionally, the frequency with which results were reported based only upon presumptive tests renders that work scientifically unacceptable.

94 For maximum accuracy when making a comparison between an unknown substance and a standard, peaks should be closer to 50%.

definitively identified the sample. In a number of other cases, Mr. Patel's work did not comply with the SOPs for the Controlled Substances Section. For example, we found that in some cases Mr. Patel failed to:

- identify the source of tablet identification;
- have his report initialed when (or if) another analyst verified his crystal test results;
- include a photocopy of a chromatography plate in the case file; and
- have a supervisor review and initial photographs and weight results.

In one of Mr. Patel's cases, he included documents from a different case in the case file, which is only one of many documentation issues found in Mr. Patel's cases. At times, we found it difficult to determine the analytical processes used by Mr. Patel because of the documentation deficiencies described above.

D. Results of the Price Case Reviews

From the sample of 342 Price cases, we have reviewed 114 (33%) of the cases to date. Seven of the Price cases we have reviewed involved major issues.

Like Mr. Patel and other Crime Lab analysts, Mr. Price visually identified tablets by using the PDR or Logo Index, and reported those results as if the substance had been identified by actual analyses. In two cases, Mr. Price reported incorrect quantitative results. He performed GC analyses in two different cases, but it appears that he inadvertently placed the instrument results for those two cases in the wrong case files. His quantitative results were therefore swapped between the cases but were, fortunately, close in value. Still, this mistake should have been caught during the technical or administrative reviews these cases by Controlled Substances Section supervisors.[95]

Another deficiency involved reporting a dark chunk substance with white specks as "negative" after negative results were obtained in five color tests, one

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95 We identified this mistake because a case number is entered into the gas chromatograph when a sample is being run through the instrument. That case number is printed with the results, and we noticed in these cases that the number on the printouts did not match the number of the cases being reviewed.

UV test, and two microcrystalline tests. However, Mr. Price also conducted a GC/MS analysis that was positive for cocaine. Because of the inconsistent results, Mr. Price should have performed additional testing to determine whether the cocaine identified by GC/MS was due to the presence of cocaine in the substance or caused by some sort of contamination.

Another very problematic issue raised in our review of Mr. Price's cases involves violations of well-established Crime Lab SOP requirements regarding the modification of reports. Under the SOPs, an analyst must retain three items in the case file if a report is modified after it has been approved: the original report, the modification notice, and the amended report. This policy is necessary because the computer program used by HPD and the Crime Lab overwrites the original report whenever it is amended. Therefore, Crime Lab policy is to maintain a printed copy of the original report in the case file.

In a number of Mr. Price's cases, the modification notice and only one report were located in the file, without any clear evidence of whether the retained report is the original or the amended report. In more than one case, we were unable to determine why the report was amended or what was changed in it.[96] In addition, when an amended report is created, HPD's computer program does not allow an analyst to change the date on the report, so an amended report has the same date as the original report. It is also problematic that in these cases the section supervisors appear not have detected the problem or enforced this important SOP requirement.

Minor issues already discussed elsewhere in this report were also evident in our review of Mr. Price's case files. In a few cases, he did not comply with the Crime Lab's SOPs. In one case, Mr. Price received negative results from the screening test performed on a cigarette, but he did not conduct the SOP-required UV analysis that might have identified a substance that the screening test could have missed. In two other cases, he did not document the reagents used to perform microcrystalline tests. Other documentation deficiencies were also

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[96] We also found documentation problems in the Crime Lab reports. For example, in one case, the analyst tested different substances but then combined the weight of all of the substances under one broad classification called "dangerous drugs." In other cases we reviewed, the analyst listed and named each dangerous drug and the individual weight of each drug. This is just one example of the lack of consistency in the Controlled Substances Section's reporting protocol.

noted, changes made in reports were often not initialed, and the incorrect date appeared on more than one of Mr. Price's instrument printouts.[97]

In another of Mr. Price's cases, one of the Controlled Substances Section supervisors reanalyzed the substance before giving testimony when Mr. Price was not available to testify. However, rather than properly generating a separate worksheet and explaining why the case was reanalyzed, this supervisor simply wrote checkmarks and new weight values on Mr. Price's worksheet. Similarly, in two of Mr. Price's other cases we reviewed, it was apparent that someone in the Crime Lab reanalyzed evidence, but the worksheets and reports do not reflect why the evidence was reanalyzed.

E. Proficiency Tests

Proficiency testing is a critical component of a laboratory's quality assurance program. Laboratories are provided with samples containing a substance (or usually multiple substances) known only to the test provider. Analysts test the samples and submit their results to the test provider. Participating laboratories are later given a report, which lists results obtained by the lab, substances actually present in the sample, and results obtained by other labs participating in the test.

Proficiency tests may not be completely reliable indicators of the quality of routine case work performed by an analyst because they know they are being tested and may perform differently under these circumstances. On the other hand, proficiency tests often present more challenging analyses, sometimes involving obscure drugs or drugs not normally reviewed in the forensic science context.

In two proficiency tests administered to analysts in the Controlled Substances Section, the substance analyzed was GHB (commonly known as a "date rape" drug) in water. In their notes, the analysts recorded that Fourier Transform Infrared Spectroscopy ("FTIR") results were positive for GHB and sodium chloride. The sodium chloride did not originate from the unknown

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[97] Mr. Price's date mistakes can be partly attributed to a malfunctioning GC/MS instrument, which consistently printed the incorrect year. Analysts often had to correct the mistakes and initial the changes. It is troubling that the date error continued for an extended period.

substance being tested but, rather, was the medium used to prepare the samples for FTIR scanning.

In the results section of the test worksheet, Crime Lab analysts correctly reported finding only GHB. However, the Crime Lab supervisor who reviewed the analysts' work and submitted the results to the test provider for review changed the analysts' report to reflect the identification of sodium chloride. The analysts apparently recognized that the sodium chloride was the FTIR preparatory medium and, accordingly, should not be reported. The supervisor's action, however, suggests that the supervisor may not have understood the basic procedure for preparing samples for FTIR analysis.

Some of the issues identified above are directly related to poorly conceived and implemented laboratory procedures. As a result, these issues might not necessarily reflect the quality of an individual analyst's skills. Concerns remain, however, regarding the judgment and skills of those in leadership positions who were responsible for creating and implementing Crime Lab SOPs in effect during the period of our review. Deficiencies in the Controlled Substances Section's SOPs caused some of the problems we have observed in controlled substances cases to be pervasive and common.

VI. Firearms

Forensic examination of firearms-related evidence typically involves microscopic comparison of markings on bullets, cartridge casings, and shot shells; test firing of firearms to evaluate proper function; trigger pull determinations; serial number restorations; and muzzle-to-target distance determinations. Fired ammunition components can be matched to the weapon that fired them, link different crimes committed with the same weapon, and, thanks to nationwide tracking programs, such as the National Integrated Ballistics Information Network ("NIBIN"), provide leads for investigators and useful data for laboratories across the country.

We have reviewed 109 firearms cases since Phase II of our investigation began, which constitutes 30% of our sample. These cases were reviewed using standards based on generally accepted forensic science practices applicable at the time the examinations took place, as well as SOPs that were in place when the examinations were originally performed. We compared the Crime Lab's techniques to generally accepted practices at that time and noted any divergence. We also noted where a divergence raised questions regarding an examiner's conclusion.

A. Method Related to Firearms Examinations

The examinations required in firearms cases vary greatly depending upon the types of evidence involved. Fired bullets, cartridge casings, and shot shells are examined with a comparison microscope, which enables the examiner to view side-by-side images of the ammunition components. Proper use of the comparison microscope requires a great deal of time, patience, and experience.

Markings on fired cartridge casings and shot shells may include firing pin and breech face impressions, as well as chamber, ejector, and extractor markings. Bullets are engraved with markings produced by the interior surfaces of the gun barrel. Markings on a bullet include General Rifling Characteristics ("GRCs"), which are a pattern of "land" and "groove" impressions that can identify the possible make and model of the gun from which a bullet was fired. Other markings on a bullet are microscopic striations unique to the gun that fired it. Markings on cartridge casings, shot shells, and bullets can be extremely faint and require a careful, trained eye to locate and identify.

Where documentation in the Crime Lab's case files was not sufficient to permit us to evaluate the reported conclusions, we have reviewed the original evidence in order to assess the reasonableness of the original work performed by the Lab's firearms examiners. This has been particularly true in comparison and identification cases because, prior to 2004, the Crime Lab's SOPs did not require firearms examiners to take photographs, make drawings, or otherwise document their observations that form the basis for their conclusions in such cases. Some of the cases we reviewed contained multiple bullets or cartridge casings, and thus a single case involving fired ammunition components may take considerable time to review. Other cases -- such as trigger pull examinations, serial number restorations, and test fires -- generally can be reviewed based on the documentation contained in the Crime Lab file and, therefore, are less time consuming.

To date, our review of firearms cases has progressed smoothly and we have identified no major issues in our case reviews. The minor issues we have identified include insufficient documentation, failing to report results as "inconclusive" when that was the appropriate conclusion, and inefficient or inappropriate deviations from generally accepted laboratory practices.

B. Documentation Issues

We found that Firearms Section examiners did not consistently document all of the necessary information required by generally accepted laboratory protocols. It was often clear from other material recorded in the case files that the examiners had obtained the information but simply failed to record it. For example, many pre-2004 case files do not include bullet base diameter measurements. The Crime Lab examiners reported calibers of firearms analyzed, which implies that they measured and evaluated the bullet base diameters, but they failed to record these measurements. The Firearms Section worksheet includes a space to record the bullet base diameter, indicating that the failure to do so was an individual, as opposed to systematic, failure. The Firearms Section recently adopted an ASCLD/LAB recommendation on this issue, and all bullet base diameters should therefore be recorded in cases analyzed in 2005 and forward.

To track previous ownership of a firearm, Crime Lab examiners occasionally perform serial number restorations on firearms when the number has been altered or obliterated. Most members of the forensic science community document serial number restorations photographically in order to create a record of what may be a transitory restoration. It is currently not the policy of the Firearms Section to make a photographic record of serial number restorations.

Other omissions that we noted were minor and infrequent. In a very small number of cases, the second of two examiners evaluating a set of evidence failed to sign the final report as required by the Crime Lab SOPs. We also noted that at least one examiner failed to mention cylinder flares. The pattern of the cylinder flares, which are deposits of soot and lead residue found on the cylinder face of revolvers, can help identify the most recently fired chamber.

Before the Crime Lab's SOPs were updated in 2004, minimal notes were maintained in case files. Information not recorded included the number of test fires performed with a firearm and the source of ammunition used. The Firearms Section was not accredited before 2004, and the Crime Lab examiners' notes were consistent with the SOPs in place at that time. The Firearms Section's current SOPs require more thorough documentation.

C. Statement of the Examiner's Results

Our review of several case files suggested that Firearms Section examiners were inclined to state a definitive conclusion in certain cases where it would have been more appropriate to report an inconclusive result. It is important to note that all of these instances were limited to cases involving possible weapon suggestions based upon GRCs and did not involve cases where the Crime Lab made identifications or eliminations. While an examiner should perform the examinations necessary to extract as much information as possible from a piece of evidence, care must also be taken not to overstate the results.

For example, in two cases, firearms examiners reported the "twist" on a bullet, whereas we found that the "twist" could not be determined with a sufficient degree of certainty.[98] In the process of striking an object, bullets often shatter, and it is not uncommon for the evidence from a crime involving a firearm to include bullet fragments. Where a bullet fragment is small, an examiner may not be able to reliably determine the "twist." In such cases, examiners should report an "indeterminate twist." Erroneously concluding that the twist is in a particular direction could lead to the errant exclusion or inclusion of a firearm. Thus, in these two cases, we found that the evidence did not support a conclusion regarding "twist," and the Crime Lab examiners should have reported an indeterminate twist.

D. Other Issues

We have identified several departures from generally accepted laboratory procedures and documentation practices. These departures included:

- using correction fluid or tape on worksheets;
- not examining cartridge casings and shot shells found inside the chambers of submitted weapons; and
- performing a trigger pull examination on every firearm submitted to the Crime Lab for examination.

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98 "Twist" is a type of GRC and is impressed on a bullet as it is propelled out of the barrel of a firearm. Depending upon the construction of the firearm, a bullet will exit the barrel spinning in a left-hand or a right-hand direction. This direction is known as left or right "twist."

The generally accepted laboratory practice is to mark through errors in work notes with the single stroke of a pen, write the correct information to the side, and initial the correction. We observed two instances in which correction fluid was used over entries made on a worksheet in the space related to bullet weight. We found no indication, however, of any improper motive for these changes. Only one of these incidents occurred after 1999, and the Firearms Section's current SOPs related to documentation specify that correction fluid should not be used. We also noted some delays in reporting results of firearms examinations. While the SOPs required that requests for analysis be performed in a "timely fashion," some case files revealed that thirty to sixty days passed between the completion of the examination and the date that a report was issued, with no reason for the delay documented.

The Crime Lab has had a long-standing policy of not examining ammunition components that are contained in the chambers of submitted firearms. The policy is apparently based on the assumption that the cartridge casing or shot shell found in a submitted weapon must have been fired from that weapon. While typically this assumption is correct, not examining ammunition components in such instances prevents the Crime Lab from detecting staged events in which, for example, ammunition from another weapon is placed in a weapon at a crime scene. This possibility may appear remote, but most laboratories would examine these cartridge casings and shot shells for markings that might help identify bullets fired from the same firearm. Although examining more cartridge casings and shot shells obviously requires the examiner to spend additional time on a case, doing so may lead to useful evidence and is in keeping with standard laboratory practice.

HPD firearms examiners did not perform muzzle-to-target distance determinations in any of the cases that we reviewed. This type of information can be extremely useful in reconstructing the circumstances of a shooting. Muzzle-to-target distance determination is based on the pattern and density of partially burned and unburned gunpowder particles on a target using a chemical test for nitrites, which are products of gunpowder combustion. Additional testing for the presence of vaporized lead, which originates from the bullet or the priming mixture, may further refine the distance determination. We are concerned that such testing has not been encouraged in the Crime Lab and believe that examiners should ensure that investigators are aware of the value of such examination. Moreover, the Crime Lab does not perform gun shot residue ("GSR") testing of subjects. This testing can provide indications as to whether a

person has recently fired a gun. This service is currently provided by the Harris County Medical Examiner's Lab.[99]

We also noted that the Firearms Section performed trigger pull determinations on every firearm submitted to the Crime Lab. The time spent on these determinations would, in our view, be better used comparing ammunition components received within the chambers of submitted firearms and, where appropriate, performing muzzle-to-target distance determinations. Where there is no issue regarding unintentional firing, an examiner does not gain useful data by conducting a trigger pull examination. Furthermore, in the course of test firing, an examiner can readily recognize weapons that appear to have extremely light trigger pulls. We believe that examiners' time would be better spent if trigger pull examinations are performed only where there is a question regarding unintentional firing or where the test firing identifies a light trigger pull.

Overall, most cases in the Firearms Section were properly examined and reported in a timely manner. Although our review has not uncovered any major issues in this section, we note that failing to strictly follow generally accepted laboratory practices creates a risk for potentially serious errors. We include in this category failing to document thoroughly each step of an examination, allocate time in a manner that yields the most useful information, and report inconclusive findings when the results merit.

VII. Toxicology

Forensic toxicology involves the detection, quantitation, and identification of potential toxins, including drugs and alcohol, in bodily fluids and tissues. Two basic steps are normally involved: (1) initial screening tests and (2) confirmatory tests. During the screening step, lab analysts test for the presence of a wide range of drugs or other toxins. Screening tests are not necessarily specific for a particular toxin; thus, until initial results are confirmed, they are viewed as tentative at best. Confirmatory tests reduce the risk of false positive test results, which can occasionally occur when a substance's chemical structure is similar to that of another substance or when a contaminant has been introduced. At the Crime Lab, screening tests have been commonly performed

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[99] The examiners in the Firearms Section also do not currently perform toolmark examinations, which, among other things, involve comparisons of pry marks, hammer head impressions, and other evidence related to crimes such as burglaries. This is a service commonly provided by forensic firearms laboratories.

using fluorescence polarization immunoassay ("FPIA") techniques and thin-layer chromatography ("TLC"). GC/MS testing was normally used by the Toxicology Section as a confirmatory test.

Until October 2003, most of the toxicology analyses performed at the Crime Lab involved the analysis of blood and urine samples. Blood and, more frequently, urine was typically analyzed for alcohol and other drugs of abuse. These specimens were usually collected from individuals suspected of driving under the influence of alcohol and other drugs. Quantitation was not performed, except for cases involving alcohol.

As was discussed in greater detail in our Phase I reports, questions regarding the performance of the Toxicology Section were raised after the Criminalist IV supervisor of the section, Pauline Louie, failed a competency test in October 2003. This development ultimately led to the suspension of toxicology analysis by the Crime Lab in October 2003.

In May 2005, the Crime Lab was accredited by ASCLD/LAB to perform blood alcohol analysis, and its toxicology case work is now limited to this area. Three analysts currently perform blood alcohol analysis.[100] These three analysts are also responsible for calibrating and maintaining HPD breath alcohol analysis equipment. Analysts in the Crime Lab do not administer breath tests to suspects but do provide training to the HPD officers who do.

A. Testing Procedures Used by the Toxicology Section

The same fundamental antigen-antibody reactions that apply in serology can be used for detecting drugs in blood and urine. The Toxicology Section used an FDA-approved FPIA technique as a screening test. FPIA involves the use of a drug antigen that is created with a fluorescent "label." When these antibodies are added to a blood or urine specimen containing the drug antigens, the antigens in the sample move to attach themselves to the antibodies. The sample is exposed to light, and this movement creates measurable changes in the intensity of the light. The changes are proportional to the quantity of drug antigen present in the specimen being tested. Again, chemically similar substances can create false positive results when immunoassay techniques are used, so confirmatory tests are required.

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100 A supervisory position for the Toxicology Section is currently unfilled, and there are no immediate plans to fill it.

Like many other forensic and clinical laboratories, the Crime Lab used a commercially available thin-layer chromatography ("TLC") system to test urine samples for drugs. TLC is used to separate components of a mixture and to tentatively identify those components. The varying colors, shapes, and *Rf* values[101] observed on the resulting chromatogram are compared with patterns produced by known compounds to make a tentative identification of substances present in the sample.

B. Proficiency Testing

The preliminary results of our Phase I investigation indicated that no toxicology proficiency testing was performed between 1995 and 1999. Since then, we have received additional proficiency test files indicating that the toxicology proficiency testing hiatus was for a slightly shorter period -- between late 1995 and early 1998. In addition, the Crime Lab's subscription to a bi-annual Department of Transportation blood alcohol proficiency testing program lapsed at some point during this time, and we have seen no blood alcohol proficiency test results since then. Aside from the period noted, drug proficiency testing was performed at the rate of five to six times per year. Thirty-three proficiency tests performed by Toxicology Section analysts between 1998 and 2003 have been identified and reviewed.

Test results were generally good and sometimes excellent. Most of the tests were examined by more than one analyst and were then reviewed by the section supervisor. However, three tests performed during the review period yielded false positive results, *i.e.,* the Crime Lab analysts incorrectly reported drugs that were not actually present in the test sample. In one case, three analysts noted "indications" of methamphetamine in their work notes, but none of the analysts attempted to confirm the identification. The sample did contain a drug with a chemical structure similar to methamphetamine. In another test, two analysts incorrectly reported the presence of methorphan (a codeine-based cough suppressant), but failed to identify cimetidine that was present in the sample.[102]

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[101] *Rf* value is expressed in terms of a ratio, in which the distance traveled by the substance being tested is compared with the distance traveled by the transporting solvent.

[102] Cimetidine is commonly prescribed for the treatment of gastric reflux disease. It is not a drug of abuse and, therefore, is not the type of drug typically tested for in DUI cases.

A third false positive involved the identification of a narcotic metabolite by the section supervisor. For a period of time beginning around 2000, the Crime Lab experienced a high rate of turnover and was understaffed. As a result, Ms. Louie, the Criminalist IV supervisor over both the Toxicology and Controlled Substances Sections, returned to bench work in toxicology after a relatively long absence from bench case work. This work was in addition to her many supervisory duties and frequent court appearances. Because of her dual role as analyst and supervisor, there was no meaningful oversight of Ms. Louie's own performance on proficiency tests during this time. Nevertheless, to her credit, she rated her own performance on this proficiency test as unsatisfactory.[103]

In a number of other tests, Toxicology Section analysts failed to identify substances that actually were present in the sample. One was a cannabinoid commonly encountered in forensic toxicology. For no apparent reason, the analysts simply did not perform tests that would have identified it. In another proficiency test, the analysts correctly identified cannabinoids, but did so based on a positive FPIA and inadequate GC/MS test results.[104]

C. Results of Toxicology Case Reviews

Toxicology case files have been selected from a total universe of 1,555 toxicology cases handled by the Crime Lab between 1998 and 2004. We recalibrated our original toxicology sample after we discovered a significant number of the cases in the sample actually involved analysis by other sections in the Crime Lab, particularly the Controlled Substances Section. The recalibrated toxicology sample includes 308 cases, 94 (31%) of which we have reviewed.

To date, we have identified only one toxicology case as potentially involving a major issue relating to the reliability of the work performed. In that case the analyst concluded -- on the basis of GC/MS testing alone -- that a blood

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103 Additionally, a fourth false positive test result occurred in a proficiency test administered in 1997 (outside the 1998-2004 period of our formal review). Toxicology Section analysts identified the presence of cocaine in the sample. The sample did contain a cocaine metabolite, but the test provider firmly denied that the sample contained any cocaine, and most labs participating in the test did not report it. The Crime Lab's analytical data clearly shows cocaine, and the most reasonable explanation for this is sample contamination at some stage in the examination process.

104 In that same test, the analysts failed to identify the presence of erythromycin, a drug that, similar to cimetidine, is not typically tested for in DUI cases.

sample was positive for heroin, cocaine, and PCP. The GC/MS data were, in our view, interpreted correctly. However, no morphine was identified by the analyst. Because heroin is almost immediately metabolized into morphine when it enters the human body, a positive heroin test without the presence of morphine is an unlikely pharmacological result and could indicate possible sample contamination. In light of the pharmacologically questionable result and the absence of a second test, we consider the work in this case to be inconsistent with generally accepted forensic science practices.

A number of other case files reviewed thus far involved drug identifications that were based on a single test, usually GC/MS. In some, the analytical data were not interpreted as rigorously as they might have been. For example, mass spectrometer "matches" were identified by the analysts but were not, in our view, strong matches. It appears that analysts may have treated the GC retention time in a GC/MS run as a second, confirmatory test, even though it is not an independent test. Another common issue in many of these cases was the lack of technical review by a qualified person other than the analyst who had performed the work. This typically occurred when the section supervisor was the only person performing toxicological analysis at the Crime Lab.

We observed deficiencies in the identification of some drugs and metabolites in some toxicology cases. However, in each of these cases, other drugs and metabolites were properly identified and correctly reported. As a result, because other controlled substances were detected in the samples, we concluded that the failure to identify the additional drugs or metabolites in the sample probably did not have any effect on the outcome of the case.

D. Blood and Urine Alcohol Testing

There were no significant issues identified in the blood and urine alcohol cases reviewed thus far. Moreover, our preliminary review of the Toxicology Section's work indicates that there has been continual improvement in procedures and documentation in this area. As of 2004, the procedures used by the Crime Lab were state of the art.

The files reviewed to date indicate that, with a few exceptions, the work performed by the Toxicology Section has been satisfactory. Between 1998 and 2004, there was an obvious and demonstrable improvement in the analytical procedures and processes used by the section. Toxicology case files are well organized, the reviews are properly documented (except as noted above), and an

appropriate range of analytical procedures has been performed in most of the cases reviewed.

VIII. Questioned Documents

In the forensic context, document examination serves the goal of determining how or by whom a document was generated. Document examiners attempt to establish the date, source, history, preparation, authenticity, and relationship of documents. Their work involves any or all of the following:

- identifying or eliminating the source of handwriting by comparison of unknowns with knowns;
- identifying or eliminating the source of typewriting and the output of other mechanical or electronic imaging devices;
- comparing or identifying inks and papers;
- visualizing indented marks; and
- restoring altered, damaged, and erased writing or text.

To perform that work, document examiners must have the skills necessary to successfully conduct macroscopic and microscopic examinations, spectral analysis with infrared/UV instrumentation, and electrostatic imaging of latent impressions, supplemented by the knowledge and experience necessary to properly interpret the results. In addition, document examiners must be able to write reports, explain the testing process and their findings to investigators, and testify in hearings and trials.

One example of document examination is the identification or elimination of a person as the source of handwriting on documents in many different types of cases. Results of such comparisons may range from positive identification of the writer to definite elimination, with differing intermediate probabilities including inability to identify or eliminate.

To identify someone as the source of handwriting, a document examiner needs contemporaneous samples of known writing from the suspected writer to compare with the questioned writing. When comparing the two writings, the examiner looks at a variety of characteristics including such things as the formation and proportions of the letter and letter combinations, strokes, pen pressure variations, and pen lifts in order to find repetitive handwriting habits in

both writings. The examiner also looks for significant differences that could possibly eliminate the suspect as the source of the writing.

A. Overview of the Questioned Documents Section

Document examination work was conducted in HPD's Identification Division until the mid-1980s. Following a number of employee departures, the Questioned Documents Section was closed. It did not re-open until the current examiner, Randy Carodine, finished his three-year training with outside experts in 1999. Re-establishing the Questioned Documents Section was a challenging task. To meet that challenge, Mr. Carodine solicited advice from a qualified document examiner in Houston. To develop interest among HPD investigators, he distributed a circular within HPD and visited each division in HPD to distribute pamphlets that detailed the Questioned Documents Section's capabilities and described how to submit evidence properly for examination.

In 2004, when the Crime Lab began its accreditation application process, the Questioned Documents Section was transferred from the Identification Division and became part of the Crime Lab. This transfer was completed in anticipation of a Texas state law that became effective in 2005, which provides that forensic science evidence can be admitted in courts only if the lab is accredited. Although Mr. Carodine tried for some time to implement formalized procedures within the Questioned Documents Section, he did not receive authorization to enact those procedures until the section was transferred to the Crime Lab. The Questioned Documents Section was then finally able to develop and implement detailed SOPs.

Based on the register of cases handled by the questioned documents examiner, we originally estimated that we would review about 200 cases, encompassing all of the questioned documents cases from 1998 through 2004. After we began reviewing the case files, however, we determined that only 91 of these cases actually involved work performed by the questioned documents examiner. We have completed our review of all 91 of these cases, and we have identified none as involving a major issue.

Overall, we were impressed with Mr. Carodine's knowledge and the quality of his work. In fact, the vast majority of cases were well documented, with impressive notes that supported the conclusions reported. We did not disagree with any of the results or opinions expressed by Mr. Carodine. We did note some minor issues, which mainly revolved around two aspects of the

Questioned Documents Section's work -- the issuance of reports and the performance of technical reviews.

Most of the minor issues we noted occurred before the implementation of more detailed and specific SOPs in 2004. Before those SOPs were adopted, the Questioned Documents Section relied on a four-page SOP. Although it was not specific in most areas, the pre-2004 SOPs did require that a report be issued for all cases. At times, Mr. Carodine placed case numbers in a log but did not create reports documenting his work on those cases. Whenever Mr. Carodine gave advice or an investigative lead to an investigator over the telephone, he established a case number in the log. For example, when investigators and district attorneys telephoned to ask Mr. Carodine what was necessary to submit a case for examination or whether a particular examination was possible, he logged those inquiries to document the fact that he gave out technical advice. However, Mr. Carodine did not create a report documenting his advice. We believe that when a case number is established -- especially if any work is performed on a case -- questioned document examiners should track the evidence, prepare notes, and prepare a report on that case.

We also observed that some of the Questioned Documents Section's casework had not undergone a technical review, which is a review by another qualified person of the examiner's notes, data, and other documentation supporting the examiner's conclusions. Since the Lab's Questioned Documents Section has had only one examiner since its re-opening in 1999, that examiner was forced to develop a technical review network for his examinations. Even though none of Mr. Carodine's supervisors within the Identification Division required a technical review of his work, he believed it was necessary and took the initiative to ask experts outside HPD to perform such reviews. In most of the cases where definitive opinions, such as the elimination or identification of a source of writing, were given, Mr. Carodine had his work independently reviewed.

Mr. Carodine told us, however, that he did not usually seek verifications on less-definitive results (when, for example, he could not come to a conclusion or only reported an indication). At other times when he did have his work reviewed, he did not document this in the case file because the independent reviewer did not wish to risk a possible subpoena and, hence, did not want to be identified in the Crime Lab's case file. Because the Questioned Documents Section is a one-person unit, special and sometimes cumbersome arrangements had to be made for technical reviews. Since 2004, the section has had a formalized technical review process in place.

B. The Questioned Document Section's Workload

We were somewhat surprised by the Questioned Documents Section's relatively small workload -- 91 cases in about five years. In light of the size of the City of Houston and the HPD, we would have expected the Questioned Documents Section's workload to be much greater. The examiner's efforts to promote the re-opened Questioned Documents Section did initially result in more cases being submitted, but the section has been continuously underutilized for a number of years.[105]

There are a few possible explanations for the underutilization of the Questioned Documents Section. One may be that investigators are unaware that the Crime Lab has an operating Questioned Documents Section. Another possibility may be that they are unaware of how document examination can assist their investigations. Yet another possibility is that investigators have become discouraged after submitting evidence to the section and receiving inconclusive results.[106] Whatever the reasons, HPD is not fully utilizing its highly competent document examiner.

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[105] In fact, Mr. Carodine was given additional tasks from the Identification Division in order to fill his time during the 1998-2004 period.

[106] This is a common (and misguided) complaint by investigators about document examination. Questioned documents examiners will often be unable to make a conclusive determination because inadequate specimens are submitted for examination. For example, the examiner cannot make a conclusive finding when he is working with a bad photocopy of a document.

Conclusion

This report summarizes the case reviews we have conducted in Phase II of our investigation from September 2005 through the first week of December 2005. Thanks to the cooperation provided by HPD and the sustained hard work by members of our investigative team, we have completed over 1,100 substantive case reviews out of our sample of approximately 2,700. More specifically, over the past three months, we have completed a significant percentage of case reviews in DNA and serology for cases handled from 1987 through 2002 and in all of the other areas of forensic science in which the Crime Lab performed work during the period 1998 through 2004.

As revealed by the case reviews, and as described in great detail in the body of this report, the record is mixed. We have observed some excellent work performed by Crime Lab analysts and examiners, especially in the Toxicology, Firearms, and Questioned Documents Sections of the Crime Lab. In some sections, such as Controlled Substances and Trace Evidence, the record is more balanced: We have noted some fine work performed, but we have also identified a number of significant deficiencies.

Unfortunately, our reviews of cases involving serology and DNA analysis have shown a near total breakdown in the forensic science function in those two important sections for at least a 15-year period from 1987 through 2002. Already, we have seen a disturbing and pervasive pattern involving repeated failures to report results of scientific testing, including results that were exculpatory of the suspect; the general failure to use appropriate scientific controls to ensure the reliability of reported results; the failure to properly calculate and communicate the meaning of statistics in scientific reports and courtroom testimony in order to accurately convey the significance of test findings; and the absence of any meaningful internal or external oversight of the critical work performed by serology and DNA analysts. Our work to date in reviewing cases analyzed by these sections reflects a level of performance completely unacceptable in a forensic science laboratory providing critical support to the criminal justice system.

We still have considerable work to do in completing the case reviews as well as in conducting further interviews and gathering the additional information necessary to come to final conclusions about the problems we have identified to date. The remaining case reviews and additional investigative work will provide us with an even stronger foundation on which to base

recommendations for the Crime Lab, which is a central element of our mandate. Once the case reviews and further investigation have been completed, we will not only have a full and accurate picture of the past problems in the Crime Lab -- their scope and their causes -- but also a detailed body of knowledge that can serve as the basis for improving the quality of the Crime Lab's work and enhancing its contribution to the criminal justice system.

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January 4, 2006

Appendix A

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Appendix B

Discussion of Serology Techniques Used by the Crime Lab

During the 1980s and early 1990s, forensic serology practiced in the Crime Lab primarily involved ABO typing. The discipline of forensic serology at the time also included procedures for the identification of biochemical genetic markers in blood such as certain enzymes and proteins, but it appears that the Crime Lab rarely used such testing results to associate or disassociate stains with particular individuals.[1] Although we found Crime Lab log books recording the results of electrophoretic runs associated with enzyme testing and have seen Lab notes and worksheets in case files reflecting that enzyme testing was performed in certain cases, Lab serologists rarely reported results obtained through enzyme testing. Thus far, we have identified virtually no cases in which the Crime Lab reported the results of enzyme testing for use in an investigation or prosecution. Accordingly, this discussion provides an overview only of techniques related to ABO testing commonly used by serologists in the Crime Lab.

I. ABO and Lewis Testing of Known Reference Standards

"Known reference standards" are samples of blood and saliva collected from persons potentially associated with evidence stains. For example, known reference samples are used to compare a suspect's genetic characteristics, such as blood type, with the genetic characteristics of blood or secretion stains recovered from a crime scene. This process is followed in order to develop evidence tending to show that the suspect is included -- or excluded -- as a possible source of biological evidence. Known reference standards are most commonly collected from suspects in the form of a tube of blood drawn from the arm and saliva collected by a swabbing of the lining of the cheek with cotton.

Crime laboratories typically subject known blood reference standards to both ABO testing, in order to determine the suspect's ABO blood type, and

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1 An enzyme is a type of protein that acts as a catalyst for certain specific biochemical reactions. Historically, forensic scientists have been particularly interested in certain enzymes and other proteins found in blood -- such as PGM (phosphoglucomutase), EAP (erythrocyte acid phosphatase), EsD (esterase D1), Hp (haptoglobin), and others -- because those enzymes and proteins are "polymorphic," meaning they exist in different forms and, therefore, are useful in distinguishing between individuals. The various inherited forms of these polymorphic enzymes and proteins are called "alleles." The analysis of such enzymes and proteins involves the separation of the alleles through a process known as electrophoresis.

"Lewis" testing, which is helpful to predict or confirm whether the suspect can be expected to be a secretor whose ABO type can be detected in other bodily fluids such as semen. ABO and Lewis testing of the known reference blood samples are normally conducted by testing the antigens on the red blood cells in the reference samples with commercially-available "antisera."[2] This is commonly referred to as "direct" testing because the subject's red cells are tested directly by combining known antibodies with the red cells in a test well and observing the test result. A positive test result is manifested by agglutination (clumping) of the cells caused by the binding of the red cell antigens to the antibodies in the test reagent.[3] Such agglutination is clearly observable with the naked eye or under low magnification, and the absence of clumping indicates the absence of the antigen being tested for. Thus, for example, if agglutination is observed in the test well containing anti-A antibodies, then the serologist would record a positive result for the presence of type A activity.

Known reference saliva standards typically are collected from a suspect on sterile cotton swabs or sterile gauze and allowed to air dry to preserve the sample from mold or decomposition caused by bacteria. The purpose of the collection of a known reference saliva standard is to enable the forensic serologist to determine the subject's ABO secretor status. The method used for testing the dried reference saliva standard is called ABO absorption inhibition ("AI"), and is the same method that is used for testing for ABO factors present in secretion stain evidence. The AI testing technique is described briefly below.

II. ABO Testing of Bloodstains by Absorption Elution

Absorption elution ("AE") is the generally accepted forensic serology testing method for determining the ABO factors located in bloodstain evidence. AE is also considered to be a type of "direct" testing. AE involves testing the ABO antigens in bloodstains directly by adding commercially-available known ABO antibodies to the bloodstained material, permitting the antibodies to bind to the ABO antigens in the bloodstain, and then eluting those antibodies from the

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[2] Anitsera are solutions containing specific antibodies.

[3] A "reagent" is a substance used in a chemical reaction to examine or produce other substances. In the context of ABO testing, for example, it is the solution containing antigens or antibodies the reaction of which the scientist is observing in order make a blood type determination.

bloodstains.[4] The ABO typing is then performed by adding red cells of known ABO type into test wells containing the eluted ABO antibodies obtained from the bloodstain and observing the agglutination that signals a positive test result for the presence of the corresponding ABO antigens.

Occasionally, blood crusts or evidence items with bloodstains on hard surfaces are submitted to a crime lab for testing. When that occurs, a serologist transfers the bloodstain to clean cotton threads by dissolving the bloodstain and then allowing the concentrated solution of blood to dry onto the cotton threads. AE can then be conducted on the cotton threads bearing the transferred bloodstains.[5]

III. ABO Testing of Secretion Stains by Absorption Inhibition

AI is the generally accepted forensic testing method for determining the ABO factors present in stains related to bodily fluids such as semen, saliva, vaginal secretions, perspiration, tears, nasal mucous, or mixtures of these fluids. The same AI method is also used to test the known reference saliva standards obtained from a suspect to determine whether he or she is a "secretor" -- *i.e.,* a person whose ABO type is expressed in his or her bodily fluid secretions. [6]

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4 The term "elution" refers to the immunological process of freeing (*i.e.,* eluting) bound antibodies contained in bloodstain evidence from the bloodstains by applying heat to break the antigen-antibody bonds.

5 Sometimes AE testing of bloodstains was conducted in conjunction with a form of "reverse" blood typing called the "Lattes Crust" test, named after Leon Lattes who developed this technique. Forensic serology laboratories commonly used Lattes testing to obtain ABO typing results from scrapings of dried blood crust collected from hard surfaces, such as glass or a weapon (hence the term "Lattes Crust" test). The Lattes Crust test, however, is less sensitive than AE. Consequently, more bloodstain material must be consumed to conduct a Lattes Crust test than the amount of bloodstain material needed for AE. After other genetic marker systems (polymorphic enzymes and proteins) became available to forensic serologists in the early to mid-1970s, the use of Lattes Crust testing as an adjunct to AE for ABO typing of bloodstains competed with the other genetic markers for the consumption of limited amounts of bloodstain material and generally fell out of favor in crime laboratories. AE was sufficiently sensitive and accurate to be relied upon for good quality ABO typing of bloodstains without the parallel use of Lattes Crust testing.

6 Bloodstains are not tested by the AI method because, among other things, the concentration of ABO factors in bloodstains is significantly less than the concentration of ABO factors found in secretion stains. Consequently, the forensic serologists typically use the direct AE method, which is more sensitive than AI, to test bloodstains.

AI is an "indirect" ABO test method, meaning that the presence of an ABO factor in a secretion evidence stain is determined by observation of a diminished level or absence of agglutination in the test solution.[7] Cuttings from secretion stains (such as from stained underwear, a vaginal swab obtained from a rape kit, or saliva stained cigarette filter paper) are placed into three separate tubes. A small volume of test reagent containing a pre-determined dilution of the appropriate antibody is added to each tube to enable the antibody to incubate with the secretion stain. Each tube contains one of three antibody dilutions -- either anti-A, anti-B, or "anti-O."[8]

If the corresponding antigen is present in the questioned stain, the strength of the antibody remaining in the solution will be diminished as the antibody becomes bound to the corresponding antigen by forming an antigen-antibody complex. The serologist then removes the residual antibody solution from each tube and places these residual solutions on a glass plate or glass slide, which is tested with a freshly prepared suspension of the corresponding commercially-available, known ABO cells. The three residual solutions are mixed with known ABO type A cells, type B cells, and type O cells. Because AI is a form of "reverse" testing, the presence of agglutination in the test slide for a particular antigen indicates that the corresponding ABO factor is *not* present in the secretion stain being tested. For example, the absence of agglutination in the antibody solution mixed with A cells indicates the presence of type A activity in the secretion sample.

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7 By contrast, presence of a specific ABO factor as a result of a "direct" testing method such as AE is indicated by observation of agglutination in a test well.

8 Because there is no common human antibody against ABO type O blood cells, scientists use an extract from gorse seeds, *Ulex Europeus*, to cause type O cells to agglutinate. The seed extract, called "lectin," agglutinates the H antigen found on all ABO cells, but the agglutination occurs in much higher concentration in the presence of type O cells. Thus, the term "anti-H" seed lectin has become synonymous with "anti-O" for purposes of ABO testing.

Appendix C

Discussion of DNA Profiling Technology and Techniques Used by the Crime Lab

I. RFLP Testing

Testing of restriction fragment length polymorphisms ("RFLP") involves the analysis of DNA fragments that are produced by using restriction enzymes, which act like scissors to cut DNA into fragments at specific locations along the chromosome. These DNA fragments of different lengths, also known as alleles, are distinguishable from each other in human populations. Hence, the genetic variation that RFLP identifies is known as "length polymorphism."[1]

Once DNA molecules have been cut into pieces by restriction enzymes, the resulting fragment lengths are separated through a process known as gel electrophoresis.[2] During the electrophoretic process, DNA fragments migrate through a gel, with the smaller DNA fragments moving at a faster rate than the larger DNA fragments. It is the results of this migration process that enable the forensic DNA analyst to distinguish between fragment sizes of DNA.

In order to generate reliable RFLP test results, the loading of DNA samples into the electrophoresis gel must be performed correctly. The DNA analyst must deliver the solution containing DNA samples into the appropriate hole (or well) located on the gel-coated plate. To accomplish this, the tip of the pipette containing the DNA sample must be lowered into the buffer solution in which the gel is submerged and the DNA sample must be ejected above the well in order to permit the DNA extract to flow into the well. Because each well has a limited capacity, the DNA analyst must take care not to overfill it. This precise process of loading of DNA samples requires training, patience, and skill to avoid contamination as a result of crossover of the DNA extract into one or more adjacent wells.

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1 Another form of forensic DNA testing that involves the identification of genetic variation attributable to length polymorphism is the testing for short tandem repeats ("STRs") of DNA markers. By contrast, other types of DNA testing are used to detect differences in individual nucleotides or base pairs, rather than DNA fragment length, which is a form of genetic variation known as "single-nucleotide polymorphism" or "SNP." PCR-based DQ-alpha and Polymarker testing, discussed below, are examples of SNPs that have been used in forensic applications.

2 Electrophoresis is a technique that separates molecules based on their size and electrical charge.

In order to avoid the potential for such contamination, which might cause a false positive typing result, the DNA analyst must avoid placing DNA extracted from evidence in a well immediately adjacent to a DNA sample extracted from a known reference sample taken from a victim or a suspect. To reduce the risk of crossover contamination and the potential for a false positive resulting from a mistake in the gel-loading process, the best practice is for the analyst to leave an empty well between a questioned sample and a known reference sample. In this way, any appearance of a DNA profile in the empty lane (or control lane) between a question sample and the reference sample will signal that contamination has occurred and that the analyst must take appropriate remedial action.

Once the electrophoretic process is complete, the DNA analyst transfers the separated DNA fragments from the electrophoresis gel to a permeable nylon membrane through a technique known as "Southern blotting." The DNA fragments are then chemically bound to the membrane to allow the results of the electrophoretic separation of the fragments to be visualized through a radioactive or chemiluminescent process.

To visualize the patterns generated by the electrophoresis process, DNA fragments bound to the nylon membrane are made radioactive or chemically active through the use of commercially-available "probes," a process known as "hybridization."[3] The membranes are then placed in close contact with x-ray film, which is exposed at very cold temperatures for periods ranging from hours to weeks. The analyst then develops the x-ray film in order to reveal the images of the radioactive or chemically labeled DNA allele fragments. These x-ray film images, known as "autoradiographs" or "autorads," appear as clear films with dark bands on them. The DNA analyst determines the size of each band by comparison with known sizing standards. The size of the evidence fragments are compared to those in the known reference samples.

Sometimes the banding patterns can appear too faintly for reliable interpretation of the RFLP alleles. When that occurs, the analyst must to take steps to try to enhance those results. The best practice for enhancing results is to

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[3] These radioactively or chemically labeled probes are fragments of DNA of known molecular structure and contain a base sequence complementary to the RFLPs being identified.

expose a second film for a longer period of time. This allows the analyst to interpret faint bands with higher confidence.[4]

II. Early PCR-Based Testing

The PCR process, developed by Dr. Kerry Mullis in the mid-1980s, revolutionized molecular biology by providing scientists the ability to replicate (or amplify) extremely small amounts of DNA up to a billion-fold. PCR's impact on forensic DNA analysis was particularly significant because it enabled forensic scientists to obtain meaningful results from evidentiary samples of DNA that would have been previously too degraded or too low in quantity for successful RFLP testing. PCR-based testing also has the advantage of providing a much faster turnaround time than RFLP testing. A forensic DNA laboratory can complete most PCR testing in a matter of days -- a significant improvement over the weeks or months it could take to complete RFLP testing.

One drawback of forensic PCR technology is that it is extremely susceptible to contamination by DNA from other sources, including other items of evidence, the investigators who collected the evidence, and the forensic DNA analysts themselves. Although the use of proper standards and controls can usually signal any contamination that occurs in the laboratory, proper training, compliance with strict quality control procedures, and diligence are required to avoid contamination during the analysis of forensic samples. This underscores the importance of strict compliance with proper standard operating procedures, adequate training, close supervision, and mandatory standards and controls in order to obtain accurate and reliable DNA test results.

PCR technology is a patented process that is very closely regulated through licenses from the patent holders. Consequently, virtually all of the test reagent kits used in crime laboratories are sold by a limited number of vendors that confer the licensing rights to use PCR for forensic applications with the purchase of the kits. The advantage is that high quality kits with consistently high performance characteristics are available to all forensic laboratories. This allows standardization of the loci, the kits, and the procedures across the entire forensic DNA testing community.

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[4] It is important to note that stripping the membrane of probes and re-hybridizing with fresh probes eventually will lead to a reduction in the amount of DNA bound to the membrane.

A. DQ Alpha

DQ Alpha (also know as "DQα" and later "DQA1") refers to a gene located in the human leukocyte antigen ("HLA") complex on the short arm of the sixth chromosome in humans. In the late 1980s, the AmpliType™ HLA DQα Forensic DNA Amplification and Typing Kit was introduced to forensic laboratories. The kit distinguished six alleles or genetic variants at the DQA1 locus, which defined a total of 21 different genotypes. The kit format was known as "reverse dot blot" that came in the form of a probe strip containing a series of test dots. The actual DQα typing test procedure involves three stages:

(1) DNA extraction;

(2) DNA amplification through the PCR process; and

(3) DNA typing, which includes de-naturation of the amplified DQα product, hybridization of the evidentiary and known reference DNA samples to probe strips, stringent washing of the probe strips in solution, and, finally, interpretation of the color development appearing in the dots contained on the test strip.

Specifically, DNA probes are immobilized onto a nylon typing strip in a pattern of a series of dots. During the hybridization step, amplified DQα DNA from the test samples is captured by these probes and retained on the typing strip. During the stringent washing stage of the process, only those DQα alleles that are sufficiently well matched to the DNA sequences contained on the probes will remain attached to the probe strip. The amplified DQα DNA retained on the strip is then visualized by color development in the dots contained on the DQ Alpha test strip. The DNA analyst interprets the DQ Alpha test results by reading the pattern of blue dots on the probe strips in order to determine which DQα alleles are present in the DNA sample being tested.[5]

An important feature of the DQ Alpha typing kit is the control (or "C") dot placed on the probe strip. The C dot serves two functions. First, the C dot indicates whether adequate amplification and typing of the DQα alleles has been achieved in a given test. Second, the C dot guides the DNA analyst in the typing

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5 DNA analysts should interpret DQ Alpha results by reading the freshly developed test strip. The analyst should also take photographs that are of large enough size and sufficient clarity to be examined for subsequent interpretation and maintain such photographs as a permanent part of the case file.

of DNA samples potentially complicated by a mixture of DNA from more than one donor or containing DQα subtypes not identified by the test strip. The manufacturer of the DQ Alpha testing kit designed the C dot to be the weakest spot on the strip in terms of visualization, thereby providing a threshold for the interpretation of the allelic dots on the DQ Alpha test strip. If, after the washing process the C dot is not visible, then no results on the test strip should be interpreted and typed because the results obtained on the allelic dots are below the threshold for reliable interpretation. Moreover, the DNA analyst should interpret those dots exhibiting a signal intensity that is less than the C dot with caution because this might indicate the presence of a mixed DNA sample, a procedural error such as improper washing, cross-hybridization, or contamination of the DNA sample.

In addition, controls such as a reagent blank, a negative DNA control, and a positive control must be included with each assay of the DQ Alpha test strips. The reagent blank is a check for possible contamination of the sample preparation reagents by other human DNA or by amplified DQα DNA. The reagent blank is performed by carrying out the DNA extraction in a tube containing no sample. This reagent blank extract is then amplified and typed along with the test samples. The negative control is a check for contamination during the set up of the PCR reaction. If typing signals appear in the negative control, every effort should be made to locate the possible sources of contamination. Under no circumstances should the reagent blank control or the negative control show a positive signal. If these controls happen to show a positive signal, the affected samples must be re-tested. Finally, a positive control is provided as part of the DQ Alpha test kit and should be used with each amplification and hybridization to demonstrate that the kit is performing properly. If the DQ Alpha type of the positive control is not correct, the DNA analyst should re-test all of the affected case samples. As a last step, the DNA analyst should take photographs of all wet strips of all samples tested, including the reagent blank, negative control, and positive control. These photographs should be maintained as a permanent part of each case file.

B. Polymarker

Following the release of the DQ Alpha typing kit, the AmpliType PM PCR Amplification and Typing Kit, also known as "Polymarker," was developed and released. The Polymarker test kit allows for the simultaneous amplification of five specific loci: Low Density Lipoprotein Receptor (LDLR), Glycophorin A (GYPA), Hemoglobin G Gammaglobin (HBGG), D7S8, and Group Specific

Component (GC).[6] The Polymarker kit contained detection reagents and DNA test strips for typing the LDLR, GYPA, HBGG, D7S8, and GC loci by using the same reverse dot blot format and process as the DQ Alpha test process -- *i.e.,* PCR amplification, hybridization, washing, visualization, and interpretation.

Under appropriate hybridization conditions, amplified DNA products containing the alleles designated on the test strip will bind specifically to a particular dot on the Polymarker test strip. The AmpliType PM test system includes a standard probe dot (the "S" dot) that serves the identical quality control functions as the C dot on DQ Alpha typing strips. In reading a Polymarker test strip, a DNA analyst should not type any of the five loci on the test strip if the S dot is not visible and should interpret any dots on the test strip that are lighter in color than the S dot with caution.

C. D1S80

The D1S80 locus is found in the non-coding region of the first chromosome.[7] Since it was first described in 1988, the D1S80 locus has been used in forensic analysis because it shows a very high degree of polymorphism. Most individuals have alleles at the D1S80 locus containing between 14 and 40 tandem repeats. The observed variability in the combination of alleles ("heterozygosity") at this locus has been reported to be as high as 87.6%. Due to the large number of alleles associated with the D1S80 typing system, it is highly discriminating and is frequently a more effective system for the analysis of mixed samples than the DQ Alpha or Polymarker systems.

A DNA analyst tests the number of tandem repeats possessed by an individual at the D1S80 locus by running PCR-amplified DNA products in a gel using an electrophoretic process. D1S80 allelic bands are then visualized and photographed. Similar to the RFLP process, larger fragments of DNA (those containing more tandem repeats) run slower through the gel and can be observed toward the top of the gel, while smaller fragments (those containing fewer tandem repeats) run more quickly through the gel. Sizing ladders are run

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6 These genetic markers, as well DQα, are inherited independently, thus allowing the genotype frequencies to be multiplied in order to determine the frequency of occurrence for a particular genetic profile in a specific population of humans.

7 More than 30% of the human genome is composed of repeating segments of DNA that seem to act as fillers or spacers between the coding regions of DNA on chromosomes. These repeating segments of DNA appear not to control any genetic function, they nevertheless they are an inherited component of an individual's genetic makeup.

on the gel to determine the alleles present in each sample. D1S80 alleles are expressed as the number of repeats in each DNA fragment. For example, one individual might be typed for D1S80 as 18,24 (18 repeats and 24 repeats) and another person as D1S80 type 22,31.

III. STRs

Short tandem repeats (STRs) are the genetic markers most widely used at the present time by crime laboratories to type biological evidence samples. STR technology is fast, sensitive, and highly discriminating.

In principle, STR markers are very similar to the DNA markers used in RFLP and D1S80 typing; they are DNA fragments composed of a number of DNA repeats that vary in fragment size from one person to the next. STR markers are particularly useful in typing biological samples that are old or degraded because the DNA fragments used in STR typing are relatively small compared with the DNA fragments analyzed in RFLP or D1S80 testing. STR typing incorporates the use of PCR amplification and, therefore, is very sensitive and capable of producing DNA typing results from small amounts of biological evidence.

During the PCR amplification process, fluorescent dyes are incorporated into the DNA fragments. After the PCR process, DNA fragments are transferred to a gel matrix and separated by size using electrophoresis. This electrophoretic step can be conducted on a variety of scientific instruments, such as a DNA sequencer. These instruments detect the DNA fragments through the use of the fluorescent dyes attached to the DNA fragments. The advantage of this fluorescent dye detection strategy is that it allows "multiplexing," which is a technique that simultaneously detects multiple STR loci in a single analysis. Because multiplexing allows for several STR loci to be analyzed in a single tube, STR technology is considered a relatively fast method that delivers very discriminating results.

As the DNA fragments migrate through the gel matrix and into the instrument's detection window, the fluorescent tags attached to the fragments give off a signal that is captured by the instrument as a "peak" detected at a particular point in time in the analysis. Through the application of sophisticated software, the instrument is capable of converting the time the DNA peak was detected into first a fragment size and then a DNA type. This typing information can be recorded on a printout known as an "electropherogram." Similar to the results generated by D1S80 testing, allelic types developed through STR analysis typically are expressed as numbers. For example, at the "D3" STR locus, an

individual's DNA sample could be typed as a D3 type "16,18." The analyst then compiles all of the allelic typing information developed at multiple STR loci to produce a complete STR profile of known reference samples as well as the evidence samples.

Because STR typing is based upon a PCR platform, it is essential that DNA analysts handle all biological samples appropriately so that the chance of sample mix-up or contamination is minimized and that reliable and accurate STR results are obtained. In part, this means that appropriate positive and negative controls must be used throughout the STR typing process. DNA analysts must monitor the performance of all controls to minimize the chance of error and to assess the testing process. In addition to the use of positive and negative controls, the analyst should take advantage of features that are engineered into the STR reagent kits. For example, when used in conjunction with each other, the Profiler Plus and COfiler reagent kits used by forensic laboratories have a built-in redundancy at three loci -- D3S1358 ("D3"), D7S820 ("D7"), and amelogenin.[8] The presence of these redundant STR loci is a control to detect possible sample switches or poor sample quality. If the typing results at the three redundant loci obtained by both the "Profiler Plus" and "Cofiler" kits are not concordant, the analyst should be alerted to a problem that must be resolved.

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[8] The COfiler and Profiler Plus STR kits are proprietary products of Applied Biosystems.

Appendix D

Acronyms

AE	absorption elution
AI	absorption inhibition
ASCLD	American Society of Crime Laboratory Directors
ASCLD/LAB	American Society of Crime Laboratory Directors/Laboratory Accreditation Board
City	The City of Houston, Texas
CODIS	Combined DNA Index System
DNA	deoxyribonucleic acid
DPS	Department of Public Safety
FBI	Federal Bureau of Investigation
FPIA	fluorescence polarization immunoassay
FTIR	Fourier Transform Infrared
GC	gas chromatography
GHB	Gamma Hydroxybutyrate
GRC	General Rifling Characteristic
GSR	gun shot residue
HLA	human leukocyte antigen
HPD	Houston Police Department
MS	mass spectrometery
MSP	Michigan State Police
NIBIN	National Integrated Ballistics Information Network
PCP	Phencyclidine
PCR	polymerase chain reaction
PDR	Physician's Desk Reference
PwC	PricewaterhouseCoopers LLP
QA/QC	quality assurance/quality control
RFLP	restriction fragment length polymorphisms
RFP	Request for Proposals
SOP	standard operating procedure
STR	short tandem repeats
TLC	thin-layer chromatography
UV	ultraviolet