

STATE OF SOUTH CAROLINA
IN THE SUPREME COURT

Appeal from Horry County
The Honorable Benjamin H. Culbertson, Circuit Court Judge

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Court of Common Pleas Case No. 2011-CP-26-3907
(Capital PCR Action)
Appellate Case No. 2014-000904

S.C. Supreme Court

LOUIS MICHAEL WINKLER, JR.,

Respondent/Petitioner,

vs.

STATE OF SOUTH CAROLINA,

Petitioner/Respondent.

SUPPLEMENTAL APPENDIX

EMILY C. PAAVOLA, ESQ.
Death Penalty Resource & Defense Center
900 Elmwood Avenue, Suite #101
Columbia, South Carolina 29201

JOHN R. MILLS, ESQ.
The Law Offices of John R. Mills
3145 Geary Blvd, Unit #213
San Francisco, California 94118

ALAN WILSON
Attorney General

JOHN W. McINTOSH
Chief Deputy Attorney General

DONALD J. ZELENKA
Senior Assistant Deputy Attorney
General
No. 4425

J. ANTHONY MABRY
Assistant Attorney General

ALPHONSO SIMON, JR.
Assistant Attorney General

Post Office Box 11549
Columbia, South Carolina 29211
(803) 734-6305

ATTORNEYS FOR
RESPONDENT/PETITIONER

ATTORNEYS FOR
PETITIONER/RESPONDENT

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tions are difficult or impossible.^{135,136} Workshops teach the fundamentals of basic pattern formation and are not a substitute for experience and experimentation when applying knowledge to crime reconstruction.¹³⁷ Such workshops are more aptly applicable for the investigator who needs to recognize the importance of these patterns so that he or she may enlist the services of a qualified expert. These courses also are helpful for attorneys who encounter these patterns in the course of preparing a case or when preparing to present testimony in court.

Although there is a professional society of bloodstain pattern analysts, the two organizations that have or recommend qualifications are the IAI and the Scientific Working Group on Bloodstain Pattern Analysis (SWGSTAIN). SWGSTAIN's suggested requirements for practicing bloodstain pattern analysis are outwardly impressive, as are IAI's 240 hours of course instruction. But the IAI has no educational requirements for certification in bloodstain pattern analysis.¹³⁸ This emphasis on experience over scientific foundations seems misguided, given the importance of rigorous and objective hypothesis testing and the complex nature of fluid dynamics. In general, the opinions of bloodstain pattern analysts are more subjective than scientific. In addition, many bloodstain pattern analysis cases are prosecution driven or defense driven, with targeted requests that can lead to context bias.

Summary Assessment

Scientific studies support some aspects of bloodstain pattern analysis. One can tell, for example, if the blood spattered quickly or slowly, but some experts extrapolate far beyond what can be supported. Although the trajectories of bullets are linear, the damage that they cause in soft tissue and the complex patterns that fluids make when exiting wounds are highly variable. For such situations, many experiments must be conducted to determine what characteristics of a bloodstain pattern are caused by particular actions during a crime and to inform the interpretation of those causal links and

¹³⁵ H.L. MacDonell. 1997. *Bloodstain Patterns*. Corning, NY: Laboratory of Forensic Science; S. James. 1998. *Scientific and Legal Applications of Bloodstain Pattern Interpretation*. Boca Raton, FL: CRC Press; P. Pizzola, S. Roth, and P. DeForest. 1986. Blood drop dynamics—II. *Journal of Forensic Sciences* 31(1): 36-49.

¹³⁶ Ibid.; R.M. Gardner. 2004. *Practical Crime Scene Processing and Investigation*. Boca Raton, FL: CRC Press; H.C. Lee; T. Palmbach and M.T. Miller. 2005. *Henry Lee's Crime Scene Handbook*. Burlington, MA: Elsevier Academic Press, pp. 281-298.

¹³⁷ W.J. Chisum and B.E. Turvey. 2007. *Crime Reconstruction*. Burlington, MA: Elsevier Academic Press.

¹³⁸ See "Bloodstain Pattern Examiner Certification Requirements." Available at theiai.org/certifications/bloodstain/requirements.php.

their variabilities. For these same reasons, extra care must be given to the way in which the analyses are presented in court. The uncertainties associated with bloodstain pattern analysis are enormous.

AN EMERGING FORENSIC SCIENCE DISCIPLINE: DIGITAL AND MULTIMEDIA ANALYSIS

The analysis of digital evidence deals with gathering, processing, and interpreting digital evidence, such as electronic documents, lists of phone numbers and call logs, records of a device's location at a given time, e-mails, photographs, and more. In addition to traditional desktop and laptop computers, digital devices that store data of possible value in criminal investigations include cell phones, GPS devices, digital cameras, personal digital assistants (PDAs), large servers and storage devices (e.g., RAIDS and SANS), video game consoles (e.g., PlayStation and Xbox), and portable media players (e.g., iPods). The storage media associated with these devices currently fall into three broad categories. The first, magnetic memory, includes hard drives, floppy discs, and tapes. The second, optical memory, includes compact discs (CDs), and digital versatile discs (DVDs). The third, electrical storage, includes USB flash drives, some memory cards, and some microchips. These items are the most commonly encountered in criminal and counterintelligence matters, but laboratories have been asked to examine such items as scuba dive watches in death investigations and black boxes in aircraft mishaps.

The proliferation of computers and related devices over the past 30 years has led to significant changes in and the expansion of the types of criminal activities that generate digital evidence. Initially, computers were either the weapon or the object of the crime. In the early days, most computer crime involved manipulating computer programs of large businesses in order to steal money or other resources. As computers became more popular, they became storage containers for evidence. Drug dealers, book makers, and white collar criminals began to keep computerized spreadsheets detailing their transactions. Digital cameras and the Internet have made child pornography increasingly available, and computers act as a digital file cabinet to hold this contraband material. Finally, digital media have become witnesses to daily activities. Many individuals have two cell phones with text messaging and/or e-mail capability, several computers, a home alarm system, a GPS in the car, and more; even children often possess some subset of these items. Workplaces use magnetic card readers to permit access to buildings. Most communication involves some kind of computer, and by the end of each day, hundreds of megabytes of data may have been generated about where individuals have been, how fast they got there, to whom they spoke, and even what was said. Suicide notes are written on

computers. Sexual predators stalk their victims online via e-mail, chat, and instant messaging. Even get-away cars are equipped with GPS devices. Finally, computer systems have become (with ever-increasing frequency) the victims of unauthorized control or intrusions. These intrusions often result in the manipulation of files and the exfiltration of sensitive information. In addition, computers in automobiles that track speed, breaking, and turning are valuable in accident reconstruction. As a result, almost every crime could have digital evidence associated with it.

Sample Data and Collection

The best practices for the collection of digital evidence most often call for the person at the scene to disconnect the power cord for the computer and related peripheral equipments (e.g., monitor, printer) and seize these items, as well as any loose storage media such as thumb drives and CDs. This method works well in most cases. However, some data (like recently typed passwords, malicious programs, and active communication programs) are volatile and are stored in the electronic chips of the system. In these circumstances, this information is lost when the device is turned off. In intrusion investigations or in cases in which encryption software is being used, this volatile information could be the key to a successful analysis and prosecution.¹³⁹

Recognizing potential sources of digital evidence is also an ongoing challenge. Investigators are likely to seize a desktop computer but walk past a PlayStation. Thumb drives can be fashioned to look like a pocket knife, writing pen, or even a piece of sushi. Cell phones and wireless Internet capability present another challenge: If these devices are turned on while in law enforcement custody, they could be remotely accessed and altered by a suspect.

Analyses

The typical approach to examining a computer involves two main phases. The first is the imaging phase. During this process, the storage device (most often a hard drive) is fitted with an appliance that prevents any new information from being written. Then, all of the data are copied to a new blank hard drive. The copy is compared with the original, most often by using a mathematical algorithm called Message Digest-5, otherwise known as MD5 Hash. The MD5 Hash value gives a unique series of numbers and letters for every file. In the examination phase, this forensi-

¹³⁹ See W.G. Kruse and J.G. Heiser. 2001. *Computer Forensics: Incident Response Essentials*. Boston: Addison-Wesley.

cally sound copy is examined for saved computer files with probative value. These so-called logical files often are pictures, documents, spreadsheets, and e-mail files that have been saved by the user in various folders or directories. Logical files are patent evidence. Next, the forensic copy is examined for files that have previously been deleted. The computer files are sometimes called physical, because the data are physically present on the hard drive but they are not logically available to the computer operating system. Such files constitute latent evidence.

Finally, system files that are created and saved by the operating system are examined. These files are analogous to a surveillance tape that shows programs that were running on the computer and files that were changed. The goal of most of these examinations is to find files with probative information and to discover information about when and how these files came to be on the computer.¹⁴⁰

Digital evidence has undergone a rapid maturation process. This discipline did not start in forensic laboratories. Instead, computers taken as evidence were studied by police officers and detectives who had some interest or expertise in computers. Over the past 10 years, this process has become more routine and subject to the rigors and expectations of other fields of forensic science. Three holdover challenges remain: (1) the digital evidence community does not have an agreed certification program or list of qualifications for digital forensic examiners; (2) some agencies still treat the examination of digital evidence as an investigative rather than a forensic activity; and (3) there is wide variability in and uncertainty about the education, experience, and training of those practicing this discipline.

A publication of the Department of Justice Computer Crime and Intellectual Property Section, *Searching and Seizing Computers and Obtaining Electronic Evidence in Criminal Investigations*,¹⁴¹ describes the challenging legal issues surrounding the examination of digital evidence. For example, sometimes the courts have viewed computers as a piece of evidence that is sent to a laboratory for forensic examination, and as having no special legal constraints, while other times, the courts have viewed computers as a virtual room or filing cabinet.¹⁴² For the latter cases, a warrant must be

¹⁴⁰ See E. Casey. 2004. *Digital Evidence and Computer Crime*. San Diego, CA: Academic Press; E. Casey. 2001. *Handbook of Computer Crime Investigation: Forensic Tools & Technology*. San Diego, CA: Academic Press; B. Carrier. 2005. *File System Forensic Analysis*. Boston: Addison-Wesley; S. Anson and S. Bunting. 2007. *Mastering Windows Network Forensics and Investigation*. Indianapolis: Sybex; and H. Carvey and D. Kleiman. 2007. *Windows Forensic Analysis*. Burlington: Syngress.

¹⁴¹ Available at www.usdoj.gov/criminal/cybercrime/s&csmanual2002.htm.

¹⁴² See, e.g., G.R. McLain, Jr., 2007. *United States v. Hill*: A new rule, but no clarity for the rules governing computer searches and seizures. *George Mason Law Review* 14(4):1071-1104; D. Regensburger, B. Bytes, and B. Bonds. 2007. An exploration of the law concerning

obtained that specifies how the examination will be conducted and which files can be recovered before the electronic device can be examined.

Finally, the analysis of digital evidence differs from other forensic science disciplines because the examination generates not only a forensic report, but also brings to light documents, spreadsheets, and pictures that may have probative value. Different agencies have handled these generated files in different ways: Some treat them as exhibits, while others treat them as derivative evidence that requires a chain of custody and special protection.

A growing number of colleges and universities offer courses in computer security and computer forensics. Still, most law enforcement agencies are understaffed in trained computer security experts.

CONCLUSIONS

The term "forensic science" encompasses a broad range of disciplines, each with its own set of technologies and practices. Wide variability exists across forensic science disciplines with regard to techniques, methodologies, reliability, error rates, reporting, underlying research, general acceptability, and the educational background of its practitioners. Some of the forensic science disciplines are laboratory based (e.g., nuclear and mitochondrial DNA analysis, toxicology, and drug analysis); others are based on expert interpretation of observed patterns (e.g., fingerprints, writing samples, toolmarks, bite marks, and specimens such as fibers, hair, and fire debris). Some methods result in class evidence and some in the identification of a specific individual—with the associated uncertainties. The level of scientific development and evaluation varies substantially among the forensic science disciplines.

the search and seizure of computer files and an analysis of the Ninth Circuit's decision in *United States v. Comprehensive Drug Testing, Inc.* *Journal of Criminal Law and Criminology* 97(4)1151-1208.

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Improving Methods, Practice, and Performance in Forensic Science

In a presentation to the committee, Jennifer Mnookin, of the University of California, Los Angeles School of Law, cautioned against yielding to two extremes in developing expectations for the forensic science disciplines. The first is the risk of letting the “perfect” be the enemy of the “good.” That is, many forms of forensic investigation and analysis may work relatively well once appropriate tasks have been set for them. “The opposite danger is the risk of overconfidence about what we think we know—the risk of making unjustified inferences on the basis of limited information, or sometimes a resistance to gaining new information that would help us do it better.”¹

Nonetheless, a number of the forensic science disciplines, as they are currently practiced, do not contribute as much to criminal justice as they could. This chapter discusses the improvements that are needed and makes four major recommendations. It does not evaluate the quality of evidence collection and management—steps that provide the inputs to forensic methods—although, obviously, the quality of those steps is critical in maximizing the investigative and probative value of that evidence.

INDEPENDENCE OF FORENSIC SCIENCE LABORATORIES

The majority of forensic science laboratories are administered by law enforcement agencies, such as police departments, where the laboratory administrator reports to the head of the agency. This system leads to

¹ J. Mnookin, Professor of Law, University of California, Los Angeles Law School. Presentation to the committee. April 23, 2007.

significant concerns related to the independence of the laboratory and its budget. Ideally, public forensic science laboratories should be independent of or autonomous within law enforcement agencies. In these contexts, the director would have an equal voice with others in the justice system on matters involving the laboratory and other agencies. The laboratory also would be able to set its own priorities with respect to cases, expenditures, and other important issues. Cultural pressures caused by the different missions of scientific laboratories vis-à-vis law enforcement agencies would be largely resolved. Finally, the forensic science laboratories would be able to set their own budget priorities and not have to compete with the parent law enforcement agencies.

UNCERTAINTIES AND BIAS

Few forensic science methods have developed adequate measures of the accuracy of inferences made by forensic scientists. All results for every forensic science method should indicate the uncertainty in the measurements that are made, and studies must be conducted that enable the estimation of those values. For the identification sciences (e.g., friction ridge analysis, toolmark analysis, handwriting analysis), such studies would accumulate data about the intraindividual variability (e.g., how much one finger's impressions vary from impression to impression, or how much one toolmark or signature varies from instance to instance) and the interindividual variability (e.g., how much the impressions of many fingerprints vary across a population and in what ways). With that information, one could begin to attach confidence limits to individualization determinations and also begin to develop an understanding of how much similarity is needed in order to attain a given level of confidence that a match exists. Note that this necessary step would change the way the word "individualization" is commonly used. The concept of individualization is that an object found at a crime scene can be uniquely associated with one particular source. By acknowledging that there can be uncertainties in this process, the concept of "uniquely associated with" must be replaced with a probabilistic association, and other sources of the crime scene evidence cannot be completely discounted. The courts already have proven their ability to deal with some degree of uncertainty in individualizations, as demonstrated by the successful use of DNA analysis (with its small, but nonzero, error rate).

Finally, as discussed in Chapter 4, the accuracy of forensic methods resulting in classification or individualization conclusions needs to be evaluated in well-designed and rigorously conducted studies. The level of accuracy of an analysis is likely to be a key determinant of its ultimate probative value.

Some initial and striking research has uncovered the effects of some

biases in forensic science procedures,² but much more must be done to understand the sources of bias and to develop countermeasures.³ Some principles employed in other fields should be useful, although some (e.g., blinding) may not be feasible for some types of forensics work. The forensic science disciplines are just beginning to become aware of contextual bias and the dangers it poses. The traps created by such biases can be very subtle, and typically one is not aware that his or her judgment is being affected. An overview of the effect of bias in the forensic science disciplines can be found in Risinger et al., 2002.⁴ Decisions regarding what analyses need to be performed and in what order also can be influenced by bias and ultimately have the potential to skew results.

Forensic scientists who sit administratively in law enforcement agencies or prosecutors' offices, or who are hired by those units, are subject to a general risk of bias. Bias also is introduced through decisions made about evidence collection, which controls who is listed as a suspect. Evidence collection and crime scene investigation can require scientific knowledge and judgment, and these functions are normally outside the control of forensic scientists.

REPORTING RESULTS

There is a critical need in most fields of forensic science to raise the standards for reporting and testifying about the results of investigations. For example, many terms are used by forensic examiners in reports and in court testimony to describe findings, conclusions, and the degrees of association between evidentiary material (e.g., hairs, fingerprints, fibers) and particular people or objects. Such terms include but are not limited to "match," "consistent with," "identical," "similar in all respects tested," and "cannot be excluded as the source of." The use of such terms can have a profound effect on how the trier of fact in a criminal or civil matter perceives and evaluates evidence. Yet the forensic science disciplines have not reached agreement or consensus on the precise meaning of any of these

² E.g., I.E. Dror and D. Charlton. 2006. Why experts make errors. *Journal of Forensic Identification* 56 (4):600-616; I.E. Dror, D. Charlton, and A. Peron. 2006. Contextual information renders experts vulnerable to making erroneous identifications. *Forensic Science International* 156(1):74-78; D.E. Krane, S. Ford, J.R. Gilder, K. Inman, A. Jamieson, R. Koppl, I.L. Kornfield, D.M. Risinger, N. Rudin, M.S. Taylor, and W.C. Thompson. 2008. Sequential unmasking: A means of minimizing observer effects in forensic DNA interpretation. *Journal of Forensic Sciences* 53(4):1006-1007; L.S. Miller. 1987. Procedural bias in forensic science examinations of human hairs. *Law and Human Behavior* 11(2):157-163.

³ See the discussion of biases provided in Chapter 4.

⁴ D.M. Risinger, M.J. Saks, W.C. Thompson, and R. Rosenthal. 2002. The *Daubert/Kumho* implications of observer effects in forensic science: Hidden problems of expectation and suggestion. *California Law Review* 90:1-56; Krane, et al., op. cit.

terms. Although some disciplines have developed vocabulary and scales to be used in reporting results, they have not become standard practice. This imprecision in vocabulary stems in part from the paucity of research in forensic science and the corresponding limitations in interpreting the results of forensic analyses. Publications such as Evett et al.,⁵ Aitken and Taroni,⁶ and Evett⁷ provide the essential building blocks for the proper assessment and communication of forensic findings.

As a general matter, laboratory reports generated as the result of a scientific analysis should be complete and thorough. They should describe, at a minimum, methods and materials, procedures, results, and conclusions, and they should identify, as appropriate, the sources of uncertainty in the procedures and conclusions along with estimates of their scale (to indicate the level of confidence in the results). Although it is not appropriate and practicable to provide as much detail as might be expected in a research paper, sufficient content should be provided to allow the nonscientist reader to understand what has been done and permit informed, unbiased scrutiny of the conclusion.

Some forensic laboratory reports meet this standard of reporting, but most do not. Some reports contain only identifying and agency information, a brief description of the evidence being submitted, a brief description of the types of analysis requested, and a short statement of the results (e.g., "The green, brown plant material in item #1 was identified as marijuana"). The norm is to have no description of the methods or procedures used, and most reports do not discuss measurement uncertainties or confidence limits. Many disciplines outside the forensic science disciplines have standards, templates, and protocols for data reporting. Although some of the Scientific Working Groups have a scoring system for reporting findings, they are not uniformly or consistently used.

Forensic science reports, and any courtroom testimony stemming from them, must include clear characterizations of the limitations of the analyses, including associated probabilities where possible. Courtroom testimony should be given in lay terms so that all trial participants can understand how to weight and interpret the testimony. In order to enable this, research must be undertaken to evaluate the reliability of the steps of the various identification methods and the confidence intervals associated with the overall conclusions.

⁵ I.W. Evett, G. Jackson, J.A. Lambert, and S. McCrossan. 2000. The impact of the principles of evidence interpretation on the structure and content of statements. *Science and Justice* 40(4):233-239.

⁶ C.G.G. Aitken and F. Taroni. 2004. *Statistics and the Evaluation of Evidence for Forensic Scientists*. 2nd ed. V. Barnett, ed. Chichester, UK: John Wiley & Sons Ltd.

⁷ I.W. Evett. 1990. The theory of interpreting scientific transfer evidence. *Forensic Science Progress* 4:141-179.

THE NEED FOR RESEARCH

Barry Fisher, Director of the Crime Laboratory of the Los Angeles County Sheriff's Department, has said, "We run the risk of our science being questioned in the courts because there is so little research."⁸ In 2001 Giannelli wrote, "In many areas [of forensic science] little systematic research has been conducted to validate the field's basic premises and techniques, and often there is no justification why such research would not be feasible."⁹ As Smith et al. note, the United States has a renowned higher education system, and many basic research discoveries relating to the forensic science disciplines have been made in academia.¹⁰ However, the forensic science disciplines suffer from an inadequate research base: Few forensic scientists have the opportunity to conduct research, few academics are positioned to undertake such research, and, importantly, the funding for forensic research is insufficient. Others believe that the field suffers because the research initiatives being funded and pursued lack an overarching strategic plan.¹¹

There are several explanations for the relative lack of funding for basic and applied research in the forensic science disciplines. First, forensic practice was started in, and has grown out of, the criminal justice and law enforcement systems. Many forensic science techniques were developed to aid in the investigatory phase of law enforcement and then were adapted to the role of aiding in prosecution by providing courtroom testimony. Thus, forensic practitioners who work in public crime laboratories often are seen as part of the prosecution team, not as part of the scientific enterprise. Second, some of the forensic science disciplines rely on an apprenticeship model for training, rather than on codifying their methods in a scientific framework. Third, federal agencies that fund scientific work, such as the National Science Foundation, the National Institutes of Health, and the Department of Defense, generally have not considered forensic science as part of the science base they need to support. It has been only in recent years that the National Institute of Justice has taken interest in funding forensic science research, but the majority of these funds have been awarded to reduce case backlogs, especially for cases that involve the analysis of DNA (see Chapter 2).

⁸ K. Pyrek. 2007. *Forensic Science Under Siege: The Challenges of Forensic Laboratories and the Medico-Legal Investigation System*. Burlington, MA: Academic Press, p. 231.

⁹ P.C. Giannelli. 2001. Scientific evidence in civil and criminal cases. *Arizona State Law Journal* 103:112.

¹⁰ F.P. Smith, R.H. Liu, and C.A. Lindquist. 1988. Research experience and future criminalists. *Journal of Forensic Sciences* 33(4):1074-1080.

¹¹ IAI Positions and Recommendations to the NAS Committee to Review the Forensic Sciences. September 19, 2007. See presentation by K.F. Martin, IAI President, to the committee. December 6, 2007.

The forensic science disciplines need to develop rigorous protocols for performing subjective interpretations, and they must pursue equally rigorous research and evaluation programs. The development of such research programs can benefit significantly from work in other areas, notably from the large body of research that is available on the evaluation of observer performance in diagnostic medicine and from the findings of cognitive psychology on the potential for bias and error in human observers.

In evaluating the accuracy of a forensic analysis, it is crucial to clarify the type of question the analysis is called upon to address. Thus, although some techniques may be too imprecise to permit the accurate identification of a specific individual, they may still provide useful and accurate information about questions of classification. For example, microscopic hair analysis may provide reliable evidence on the subpopulation of the individual from which the specimen was derived, even if it cannot associate reliably the hair with a specific individual. However, the definition of the appropriate question is only a first step in evaluating the performance of a forensic technique. The research design should address the questions that arise in the specific context of forensics.

A complete research agenda should include studies to establish the strengths and limitations of each procedure, sources of bias and variation, quantification of uncertainties created by these sources, measures of performance, procedural steps in the process of analyzing the forensic evidence, and methods for continual monitoring and improving the steps in that process.

CONCLUSIONS AND RECOMMENDATIONS

Wide variability is found across forensic science disciplines not only with regard to techniques and methodologies (see Chapter 5), but also with regard to reliability, error rates, reporting, research foundations, general acceptability, and published material. Some of the disciplines are laboratory based (e.g., nuclear and mitochondrial DNA analysis, toxicology and drug analysis, and analyses of fibers and fire debris); others are based on expert interpretation of observed patterns (e.g., of fingerprints, writing samples, toolmarks, bite marks, and hairs). The briefings and materials that informed this report illustrate that the level of scientific development and evaluation varies substantially among the forensic science disciplines.

In most areas of forensic science, no well-defined system exists for determining error rates, and proficiency testing shows that some examiners perform poorly. In some disciplines, such as forensic odontology, the methods of evidence collection are relatively noncontroversial, but disputes arise over the value and reliability of the resulting interpretations.

In most forensic science disciplines, no studies have been conducted

of large populations to establish the uniqueness of marks or features. Yet, despite the lack of a statistical foundation, examiners make probabilistic claims based on their experience. A statistical framework that allows quantification of these claims is greatly needed. These disciplines also critically need to standardize and clarify the terminology used in reporting and testifying about the results and in providing more information.

Little rigorous systematic research has been done to validate the basic premises and techniques in a number of forensic science disciplines. The committee sees no evident reason why conducting such research is not feasible; in fact, some researchers have proposed research agendas to strengthen the foundations of specific forensic disciplines.¹² Much more federal funding is needed to support research in forensic science and forensic pathology in universities and in private laboratories committed to such work. The forensic science and medical examiner communities (see Chapter 9) will be improved by opportunities to collaborate with the broader science and engineering communities. In particular, collaborative efforts are urgently needed to: (1) develop new technical methods or provide in-depth grounding for advances developed in forensic science; (2) provide an interface between the forensic science and medical examiner communities and basic sciences; and (3) create fertile grounds for discourse among the communities. The proposed National Institute of Forensic Science (NIFS) should recommend, implement, and guide strategies for supporting such initiatives.

Although a long-term research agenda will require a thorough assessment of each of the assumptions that underlie forensic science techniques, many concerns regarding the forensic science disciplines can be addressed immediately through studies in which forensic science practitioners are presented with a standardized set of realistic training materials that vary in complexity. Such studies will not explore the components of the decision process, but they will permit an assessment of the extent to which skilled forensic science practitioners will reach the same or similar conclusions when presented with the types of materials that lead to disagreements.

Recommendation 2:

The National Institute of Forensic Science (NIFS), after reviewing established standards such as ISO 17025, and in consultation with its advisory board, should establish standard terminology to be used in reporting on and testifying about the results of forensic science investigations. Similarly, it should establish model laboratory reports for different forensic science disciplines and specify

¹² See, e.g., L. Haber and R.N. Haber. 2008. Scientific validation of fingerprint evidence under *Daubert*. *Law, Probability and Risk* 7(2):87-109.

the minimum information that should be included. As part of the accreditation and certification processes, laboratories and forensic scientists should be required to utilize model laboratory reports when summarizing the results of their analyses.

Recommendation 3:

Research is needed to address issues of accuracy, reliability, and validity in the forensic science disciplines. The National Institute of Forensic Science (NIFS) should competitively fund peer-reviewed research in the following areas:

- (a) Studies establishing the scientific bases demonstrating the validity of forensic methods.
- (b) The development and establishment of quantifiable measures of the reliability and accuracy of forensic analyses. Studies of the reliability and accuracy of forensic techniques should reflect actual practice on realistic case scenarios, averaged across a representative sample of forensic scientists and laboratories. Studies also should establish the limits of reliability and accuracy that analytic methods can be expected to achieve as the conditions of forensic evidence vary. The research by which measures of reliability and accuracy are determined should be peer reviewed and published in respected scientific journals.
- (c) The development of quantifiable measures of uncertainty in the conclusions of forensic analyses.
- (d) Automated techniques capable of enhancing forensic technologies.

To answer questions regarding the reliability and accuracy of a forensic analysis, the research must distinguish between average performance (achieved across individual practitioners and laboratories) and individual performance (achieved by the specific practitioner and laboratory). Whether or not a forensic procedure is sufficient under the rules of evidence governing criminal and civil litigation raises difficult legal issues that are outside the realm of scientific inquiry.

Recommendation 4:

To improve the scientific bases of forensic science examinations and to maximize independence from or autonomy within the law enforcement community, Congress should authorize and appropri-

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ate incentive funds to the National Institute of Forensic Science (NIFS) for allocation to state and local jurisdictions for the purpose of removing all public forensic laboratories and facilities from the administrative control of law enforcement agencies or prosecutors' offices.

Recommendation 5:

The National Institute of Forensic Science (NIFS) should encourage research programs on human observer bias and sources of human error in forensic examinations. Such programs might include studies to determine the effects of contextual bias in forensic practice (e.g., studies to determine whether and to what extent the results of forensic analyses are influenced by knowledge regarding the background of the suspect and the investigator's theory of the case). In addition, research on sources of human error should be closely linked with research conducted to quantify and characterize the amount of error. Based on the results of these studies, and in consultation with its advisory board, NIFS should develop standard operating procedures (that will lay the foundation for model protocols) to minimize, to the greatest extent reasonably possible, potential bias and sources of human error in forensic practice. These standard operating procedures should apply to all forensic analyses that may be used in litigation.

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Strengthening Oversight of Forensic Science Practice

Several commentators appearing before the committee noted that nearly anyone with a garage and some capital theoretically could open a forensics laboratory and start offering services. Although this might be a bit hyperbolic, the fact is that there are no requirements, except in a few states (New York, Oklahoma, and Texas), for forensics laboratories to meet specific standards for quality assurance or for practitioners to be certified according to an agreed set of standards.¹ Well-publicized problems in large crime laboratories have uncovered systematic deficiencies in quality control. For example, in 2002, the Houston Police Department Crime Laboratory and Property Room came under scrutiny because of a range of quality concerns that created “profound doubts about the integrity of important aspects of the criminal justice system in Harris County.”² Problems included poor documentation, serious analytical and interpretive errors, the absence of quality assurance programs, inadequately trained personnel, erroneous reporting, the use of inaccurate and misleading statistics, and even “drylabbing” (the falsification of scientific results).³ In most cases, existing efforts

¹ See N.Y. EXEC. § 995-b (McKinney 1996); (accreditation by Forensic Science Commission); OKLA. STAT. ANN. tit. 74 § 150.37 (requiring accreditation by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board or the American Board of Forensic Toxicology); TEX. CRIM. PROC. CODE art. 38.35 (accreditation by the Department of Public Safety).

² M.R. Bromwich. 2007. *Final Report of the Independent Investigator for the Houston Police Department Crime Laboratory and Property Room*. June 13. Available at www.hpdlabinvestigation.org, p. 1.

³ *Ibid.*

to impose standards and best practices in forensic science practice rely on the voluntary participation of some members of the forensic science community working diligently to improve overall quality in the field.

Despite important movement in recent years toward developing and implementing quality control measures in the forensic science disciplines, a lack of uniform and mandatory quality assurance procedures, combined with some highly publicized problems involving large crime laboratories, has led to heightened attention to efforts to remedy uneven quality among laboratories through the imposition of standards and best practices. The American Bar Association has recommended that, "Crime laboratories and medical examiner officers should be accredited, examiners should be certified, and procedures should be standardized and published to ensure the validity, reliability, and timely analysis of forensic evidence."⁴

In *Daubert v. Merrell Dow Pharmaceuticals*,⁵ the Supreme Court cited as a relevant factor in assessing expert testimony the "existence and maintenance of standards controlling the technique's operation." Standards and best practices create a professional environment that allows organizations and professions to create quality systems, policies, and procedures and maintain autonomy from vested interest groups. Standards ensure desirable characteristics of services and techniques such as quality, reliability, efficiency, and consistency among practitioners. Typically standards are enforced through systems of accreditation and certification, wherein independent examiners and auditors test and audit the performance, policies, and procedures of both laboratories and service providers. In addition, requirements for quality control can be imposed on entities receiving federal funds, and professional groups can develop codes of ethics and conduct to serve as measures against which performance can be assessed.

This chapter addresses some of the traditional approaches used by technical professions to enhance the quality of performance—accreditation, certification (including proficiency testing), and oversight—tied to federal funding. In each approach, standards are used to measure the quality of institutions or organizations, either in terms of their policies and procedures or in terms of the proficiency and skills of an individual practicing the discipline. However, as mentioned above, with the exception of three states mandating accreditation (New York, Oklahoma, and Texas), the accreditation of laboratories and certification of forensic examiners remains voluntary.

⁴ American Bar Association. 2006. *Report of the ABA Criminal Justice Section's Ad Hoc Innocence Committee to Ensure the Integrity of the Criminal Process. Achieving Justice: Freeing the Innocent, Convicting the Guilty*. P.C. Giannelli and M. Raeder (eds.). Chicago: American Bar Association.

⁵ 509 U.S. 579 (1993).

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ACCREDITATION

Accreditation is just one aspect of an organization's quality assurance program, which also should include proficiency testing where relevant, continuing education, and other programs to help the organization provide better overall services. In the case of laboratories, accreditation does not mean that accredited laboratories do not make mistakes, nor does it mean that a laboratory utilizes best practices in every case, but rather, it means that the laboratory adheres to an established set of standards of quality and relies on acceptable practices within these requirements. An accredited laboratory has in place a management system that defines the various processes by which it operates on a daily basis, monitors that activity, and responds to deviations from the acceptable practices using a routine and thoughtful method. This cannot be a self-assessing program. Oversight must come from outside the participating laboratory to ensure that standards are not self-serving and superficial and to remove the option of taking shortcuts when other demands compete with quality assurance. In addition, accreditation serves as a mechanism to strengthen professional community ties, transmit best practices, and expose laboratory employees directly to the perspectives and expectations of other leaders in the profession.

An example of a strong accreditation system is that required through the Clinical Laboratory Improvement Amendments of 1988 (CLIA).⁶ Through this legislation, the Centers for Medicare & Medicaid Services (CMS) regulates all clinical laboratory testing (except research) performed on humans in the United States. In total, CLIA covers approximately 189,000 laboratory entities (see Box 7-1).

Some key elements of CLIA and of other accreditation programs that might be incorporated into a mandatory accreditation system for forensic science include:

- a national organization that can mediate the accreditation process;
- an application process with criteria by which organizations are eligible to apply;
- a process of self-evaluation;
- an external evaluation process, including site visits by external evaluators;
- an appeals process;
- a repeat cycle of evaluation and external evaluation, and;
- a set of standards by which entities can be evaluated.⁷

⁶ 42 U.S.C. § 263a.

⁷ Institute of Medicine. 2001. *Preserving Public Trust: Accreditation and Human Research Participation Protection Programs*. Washington, DC: National Academy Press.

Box 7-1**Clinical Laboratory Improvement Amendments of 1988 (CLIA)**

The objective of the CLIA program is to ensure quality laboratory testing. All clinical laboratories must be properly certified to receive Medicare or Medicaid payments. CLIA requires all entities that perform even one test using "materials derived from the human body for the purpose of providing information for the diagnosis, prevention or treatment of any disease or impairment of, or the assessment of the health of, human beings" to meet certain federal requirements. If an entity performs tests for these purposes, it is considered to be covered by CLIA and must register with the CLIA program.

CMS and CDC develop standards for laboratory certification (it is actually a certificate of accreditation). In addition, CDC conducts studies and convenes conferences to help determine when changes in regulatory requirements are needed. Oversight is conducted through onsite inspections of laboratories conducted every two years using federal surveyors or surveyors of deemed organizations or state-operated CLIA programs approved for this purpose. Oversight includes a comprehensive evaluation of the laboratory's operating environment and personnel, as well as its proficiency testing, quality control, and quality assurance procedures. The laboratory director plays a critical role in assuring the safe and appropriate use of laboratory tests—he or she must meet required qualifications and must ensure that the test methodologies selected are capable of providing the quality of results required for patient care. Laboratory directors are required to take specific actions to establish a comprehensive quality assurance program.

Six organizations are deemed to offer accreditation of laboratories for CLIA. An accreditation organization that applies or reapplies to CMS for deeming authority, or a state licensure program that applies or reapplies to CMS for exemption from CLIA program requirements of licensed or approved laboratories within the state, must provide extensive documentation of its process. This includes a detailed description of the inspection process, a description of the steps taken to monitor the correction of deficiencies, a description of the process for monitoring performance, procedures for responding to and for the investigation of complaints against its laboratories, and a list of all its current laboratories and the expiration dates of their certification.

CLIA also provides for sanctions that may be imposed on laboratories found to be out of compliance with one or more of the conditions of accreditation (e.g., unsuccessful participation in proficiency testing). These include suspension, limitation, or revocation of the certificate; civil suit to enjoin any laboratory activity that constitutes a significant hazard to the public health; and imprisonment or fine for any person convicted of the intentional violation of CLIA requirements. The regulations also require that the Department of Health and Human Services Secretary annually publish a list of all laboratories that have been sanctioned during the preceding year. Sanctions can be appealed.

SOURCE: www.cms.hhs.gov/clia/.

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In addition, accrediting organizations typically offer education and training programs to help the participating entities comply with the standards. Accreditation cannot guarantee high quality—that is, it cannot guard against those who intentionally disobey or ignore requirements. However, over time it can reduce the likelihood that violations will occur, and reports of infractions should trigger increased scrutiny by an accrediting body. And, by requiring that education be a standard that must be met as a condition of accreditation, incremental change and quality improvement can be achieved individual by individual.

Development of Current Forensic Laboratory Accrediting Organizations

In the 1970s, FBI Director Clarence Kelley and FBI Laboratory Director Briggs White organized a group of crime laboratory directors that eventually became known as the American Society of Crime Laboratory Directors, or ASCLD. ASCLD's Committee on Laboratory Evaluation and Standards was focused on developing quality assurance standards, and in 1981 the ASCLD/Laboratory Accreditation Board (ASCLD/LAB) was formed. In 1988, it was officially incorporated as a not-for-profit organization.

In 1994, the passage of the DNA Identification Act established a DNA Advisory Board (DAB) to develop and enforce quality assurance standards for crime laboratories seeking access to the FBI's national database of DNA profiles (see below). The DAB recommended that crime laboratories seek accreditation as quickly as possible. According to the *Crime Lab Report*, "Because ASCLD/LAB policies and procedures would not allow accreditation to be awarded to a single work unit, laboratories that were not prepared to undergo a full ASCLD/LAB accreditation assessment seemed to have no other alternative but to forfeit access to the DNA database until they were ready for a full accreditation audit."⁸

In 1995, the private not-for-profit corporation National Forensic Science Technology Center (NFSTC) was formed by the ASCLD executive board for training, education, and support of accreditation.⁹ NFSTC could support and assist crime laboratories preparing for a full ASCLD/LAB accreditation as well as audit and temporarily certify DNA units that complied with DNA-specific quality assurance standards.^{10,11} NFSTC subsequently formed a new independent accreditation corporation, Forensic Quality Services (FQS), with the idea that its program would be based on

⁸ *Crime Lab Report*. December 20, 2007. Available at www.crimelabreport.com/monthly_report/12-2007.htm.

⁹ See <http://nfstc.org/aboutus/history/history.htm>.

¹⁰ *Ibid.*

¹¹ DNA procedures are regulated under the DNA Identification Act of 1994. DNA Identification Act of 1994, 42 U.S.C. § 14132 (1994).

the new ISO/IEC 17025 international standard for testing and calibration laboratories.¹²

In 2003, the ASCLD/LAB Delegate Assembly approved the implementation of an ISO/IEC 17025 program, and ASCLD/LAB began offering these accreditations in April 2004. Accreditations for forensic science laboratories are now conducted using *General requirements for the competence of testing and calibration laboratories 17025 ISO/IEC* (2005),¹³ the same requirements under which private and public laboratories are accredited. The international standards are developed through technical committees to deal with particular fields of technical activity. In order for sector specific requirements for forensic laboratories to be addressed, ISO allows for the amplification of requirements or supplemental requirements, such as *ASCLD/LAB-International Supplemental requirements for the accreditation of forensic science testing laboratories* (2006).

ASCLD/LAB's areas of focus are laboratory management and operations, personnel qualifications, and the physical plant. The following must be in place for accreditation:

- procedures to protect evidence from loss, cross-transfer, contamination, and/or deleterious change;
- validated and documented technical procedures;
- the use of appropriate controls and standards;
- calibration procedures;
- complete documentation of all evidence examination;
- documented training programs that include competency testing;
- technical review of a portion of each examiner's work product;
- testimony monitoring of all who testify; and
- a comprehensive proficiency testing program.¹⁴

The ASCLD/LAB accreditation cycle is five years, with annual reports required from each accredited laboratory that consist of any changes in management, staff, facilities, methodologies, proficiency testing, and testimony monitoring. All accredited laboratories must maintain written copies of appropriate technical procedures, including descriptions of sample preparation methods, controls, standards, and calibration procedures, as well as a discussion of precautions, sources of possible error, and literature references. In addition, ASCLD/LAB has a policy regarding the reporting of noncompliance with requirements, a portion of which is excerpted below:

¹² See www.forquality.org.

¹³ See www.iso.org/iso/catalogue_detail?csnumber=39883.

¹⁴ R. Stacey, President, ASCLD/LAB. Presentation to the committee. January 25, 2007.

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In keeping with the stated objective of 'identifying those laboratories which meet established standards,' the ASCLD/LAB Board has determined that, as an accrediting body, we must be timelier in reviewing instances of significant non-compliance. To further this objective, all accredited laboratories must disclose to ASCLD/LAB all substantive occurrences of non-compliance within 30 calendar days of determining that the non-compliance has occurred.¹⁵

In addition to this particular requirement, the ISO program has a requirement for an annual surveillance visit. During this site visit, any issues that may have come to the attention of ASCLD/LAB and/or requirements selected by ASCLD/LAB are reviewed. The accreditation programs are managed by a paid staff member working under the direction of a board of directors, which is elected by the Delegate Assembly. The Delegate Assembly is composed of the directors of all accredited laboratories and laboratory systems. Inspectors must complete a training program and must be employed in an accredited laboratory. At any time, if an issue is brought to the attention of ASCLD/LAB, the board of directors can, after determining that the claim is substantive, implement an interim inspection of that particular issue and the entire laboratory. The program also includes a system of sanctions and an appeal process.

Status of Accreditation

ASCLD/LAB's international program has accredited 60 laboratories as of April 2008, in addition to 337 laboratories accredited under the original Legacy program.¹⁶ FQS-International (FQS-I) has accredited just over 50 laboratories in one or more disciplines; however, FQS-I allows forensic laboratories to customize their accreditation by phasing in one discipline at a time.¹⁷ A survey of International Association for Identification (IAI) members, who tend to work in settings other than traditional crime laboratories, revealed that only 15 percent of respondents are accredited.¹⁸

Only a few jurisdictions require that their forensics laboratories be accredited. According to the 2005 census of 351 publicly funded crime laboratories, more than three-quarters of laboratories (78 percent) were

¹⁵ 2008 version of the ASCLD/LAB Legacy Accreditation Manual.

¹⁶ See www.ascl-d-lab.org/legacy/asclablegacylaboratories.html.

¹⁷ See www.forquality.org/fqs_1_Labs.htm.

¹⁸ T.S. Witt, Director, Bureau of Business and Economic Research, West Virginia University. Presentation to the committee. December 6, 2007.

accredited by ASCLD/ LAB.¹⁹ Another 3 percent were accredited by some other professional organization, such as the ISO. State-operated laboratories (91 percent) were more likely to be accredited than laboratories serving county (67 percent) or municipal (62 percent) jurisdictions. Among the 230 laboratories providing accreditation information in both the 2002²⁰ and 2005 censuses, the accreditation rate increased during the three years from 75 to 87 percent.

However, identification units—that is, those forensic entities outside crime laboratories—do not participate in accreditation systems and are not required to do so. Given that some disciplines are practiced largely outside the laboratory environment (e.g., 66 percent of fingerprint analyses are not conducted in crime laboratories), there is a substantial gap in the number of programs participating in accreditation.^{21,22}

As mentioned previously, DNA analysis is regulated under the DNA Identification Act of 1994, which created an advisory board on quality assurance, tasked with promulgating standards for proficiency testing of laboratories and analysts. The terms of the original advisory board expired, and now the FBI Quality Assurance Standards apply to DNA laboratories receiving federal funds. The standards require periodic (every other year) audits using the FBI Quality Assurance Standards to ensure compliance. The FBI guidelines require that two proficiency tests be completed annually by DNA examiners as well as by technical support personnel performing relevant analytical techniques. The tests must be administered by a source external to the laboratory. The FBI is responsible for developing and maintaining a DNA audit document for assessing compliance with DNA standards and also provides DNA auditor instruction to all ASCLD/LAB inspectors, in addition to the forensic DNA community, on how to interpret the DNA standards. The FBI also reviews audit findings and remedial action, if any. Once all standards are met, it notifies the laboratory of full compliance.

¹⁹ M.R. Durose. 2008. *Census of Publicly Funded Forensic Crime Laboratories, 2005*. U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics. Available at www.ojp.usdoj.gov/bjs/pub/pdf/cpffcl05.pdf.

²⁰ J.L. Peterson and M. J. Hickman. 2005. *Census of Publicly Funded Forensic Crime Laboratories, 2002*. U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics. Available at www.ojp.usdoj.gov/bjs/pub/pdf/cpffcl02.pdf.

²¹ Witt, op. cit.

²² Accreditation is also available for other more specific forensic science disciplines. For example, the National Association of Medical Examiners (NAME) operates an accreditation program for coroners and medical examiners offices (see Chapter 9). The American Board of Forensic Toxicology accredits toxicology laboratories.

STANDARDS AND GUIDELINES FOR QUALITY CONTROL

Standards provide the foundation against which performance, reliability, and validity can be assessed. Adherence to standards reduces bias, improves consistency, and enhances the validity and reliability of results. Standards reduce variability resulting from the idiosyncratic tendencies of the individual examiner—for example, setting conditions under which one can declare a “match” in forensic identifications. They make it possible to replicate and empirically test procedures and help disentangle method errors from practitioner errors. Importantly, standards not only guide practice but also can serve as guideposts in accreditation and certification programs. Many forensic science disciplines have developed standards, but others have not, which contributes to questions about the validity of conclusions.

Several groups produce standards for use in the forensic science disciplines. For example, ASTM International (ASTM), originally known as the American Society for Testing and Materials, is an international standards organization that develops and publishes voluntary technical standards for a wide range of materials, products, systems, and services. In the area of forensic science it offers, for example:

- Standard Guide for Minimum Training Requirements for Forensic Document Examiners
- Standard Guide for Forensic Paint Analysis and Comparison
- Standard Guide for Nondestructive Examination of Paper
- Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy
- Standard Terminology for Expressing Conclusions of Forensic Document Examiners

At the federal level, the National Institute of Standards and Technology (NIST) conducts research to establish standards in a limited number of forensic areas, for example, organic gunshot residue analysis, trace explosives detectors, and improvised explosive devices.²³ Its laboratories develop tests, test methods, produce reference data, conduct proof-of-concept implementations, and perform technical analyses. They also develop guides to help forensic organizations formulate appropriate policies and procedures, such as those concerning mobile phone forensic examinations. These guides are not all-inclusive and they do not prescribe how law enforcement and

²³ B. MacCrehan. National Institute of Standards and Technology. Analytical Chemistry Division. Presentation to the committee. September 21, 2007.

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²³ B. MacCrehan. National Institute of Standards and Technology. Analytical Chemistry Division. Presentation to the committee. September 21, 2007.

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- Scientific Working Group on the Forensic Analysis of Radiological Materials (SWGARM)
- Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST)
- Scientific Working Group on Microbial Genetics and Forensics (SWGMEG)
- Scientific Working Group on Shoeprint and Tire Tread Evidence (SWGTT)

Additional SWGs may be sponsored by other FBI divisions or other agencies. For example, the U.S. Drug Enforcement Administration supports the Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) (see Box 7-2).

Despite the proliferation of standards in many of the forensic science disciplines, their voluntary nature and inconsistent application make it difficult to assess their impact. Ideally, standards should be consistently applicable and measurable. In addition, mechanisms should be in place

Box 7-2
A Sampling of SWGs

SWGDRUG^a

In 1997, the Drug Enforcement Agency and the Office of National Drug Control Policy created and sponsored a Technical Working Group for the Analysis of Seized Drugs (TWGDRUG), which was renamed a Scientific Working Group (SWGDRUG) in 1999. The stated objectives of SWGDRUG include the specification of requirements for forensic drug practitioners, the promotion of professional development, the exchange of information within the forensic science community, the promotion of ethical standards of practitioners, the provision of minimum standards for drug examinations and reporting, the establishment of quality assurance requirements, the consideration of relevant international standards, and the promotion of international acceptance of SWGDRUG recommendations. Individual subcommittees currently are devoted to evaluating analytical methods, setting standards for quality assurance, estimating uncertainty, formatting draft and final recommendations, and maintaining a glossary. The subcommittee develops recommendations, which the core committee votes to accept or reject. If accepted, draft documents are released for public comment for at least 60 days. Following public comment and possible revision, the core committee holds a final vote. Three-quarters of the core committee must be present, and two-thirds of those present must vote affirmatively in order to confer official status to a proposed recommendation.

Box 7-2 Continued

SWGDRUG has produced guidelines for quality assurance protocols, methods of analysis and identification of seized drugs, and education and training materials for forensic practitioners. Quality assurance guidelines emphasize the integrity and storage of evidence, the validation and documentation of procedures, and the verification of standards. Among SWGDRUG's recommendations for education is a requirement that entry level forensic drug analysts possess at least a bachelor's degree in a natural science, with coursework in general, organic, and analytical chemistry. Guidelines on methods and analyses categorize analytical techniques into three groups, according to discriminating ability: "A" techniques are deemed the most discriminating, and "C" techniques are considered the least discriminating. For the purposes of identifying substances, SWGDRUG recommends the use of at least one "A" technique and one other additional test for validation. When an "A" technique cannot be used, at least two uncorrelated "B" tests and one additional method are suggested. SWGDRUG also has released supplementary documents to assist in implementing these guidelines.

SWGgun^a

The FBI established SWGGUN in 1998 and has continued to fund the initiative in subsequent years. Subcommittees of a 20-member board draft guidelines in conjunction with external experts. Guidelines are posted on the SWGGUN Web site for public comment before the board finalizes the recommendations with an affirmative vote by two-thirds of the members present at a meeting.^c Currently, SWGGUN offers guidelines on trigger pull analysis, education and experience requirements for firearm and toolmark examiners and trainees, laboratory training manuals, laboratory quality assurance programs, the range of possible conclusions when comparing toolmarks, projectile path reconstruction, and the examination of silencers. The SWGGUN website also offers an "admissibility resource kit," which offers arguments intended to satisfy the prongs of the *Daubert* standard.

SWGmat^d

Since 1996, SWGMAT has been issuing voluntary guidelines addressing trace evidence, including hair comparison. Quality assurance guidelines, published in 2000, advise that two examiners separately analyze samples and suggest minimum levels for training and qualifications for examiners and laboratories. Hair comparison guidelines, published in 2005, address techniques for collecting hair samples, examining and interpreting protocols for microscopic examination, and using DNA testing in hair analysis. Notably, the use of DNA testing of hair is advised only after an initial microscopic analysis is conducted. In contrast to the larger forensic science community's recent interest in blind testing and statistical verification, SWGMAT proposes the following approach: The examiner should consider what meaning can be attached to an exclusion or association based upon

the known case circumstances. Probabilities and population statistics should not be used in the interpretation of microscopic hair comparisons. Databases, from which population statistics can be generated (as is done in DNA analysis), are not practical or realistic for hair analysis.

SWGFAST⁸

In 1995, the FBI created a Technical Working Group on Friction Ridge Analysis, Study, and Technology (TWGFAST). The group was renamed as a Scientific Working Group (SWGFAST) in 1998 and has continued to provide guidelines on fingerprint evidence, with funding from the FBI. Additionally, a National Institute of Justice grant has supported the development of a forthcoming SWGFAST reference manual.

The SWGFAST bylaws allow for up to 40 members and require biannual meetings. Members have included agency employees from federal, state, local, and foreign bodies and from the academic and private sectors. Proposed guidelines are released to the community for comment after receiving an affirmative vote by two-thirds of the SWGFAST members present at a meeting. A draft document is adopted following community review and feedback, if two-thirds of the members present at a meeting again vote in favor of such action. Accepted guidelines are reconsidered five years after adoption. Existing SWGFAST guidelines address automation training, digital imaging, friction ridge analysis for latent print examination, latent print proficiency testing, professional conduct, minimum qualifications and competency for latent print trainees, quality assurance, interpretation and conclusions, and validation research.⁹

Like all other SWG documents, SWGFAST's guidelines have no inherent authority or force of law. However, in collaboration with academic institutions, law enforcement agencies, and industry, SWGFAST has participated in the development of a standard data format for the Interchange of Fingerprint, Facial, & Scar Mark and Tattoo Information, through the American National Standard for Information Systems-NIST (ANSI-NIST-ITL 1-2007). Additionally, crime laboratories have purportedly relied on SWGFAST guidelines in order to meet the ASCLD/LAB accreditation Standards.⁹

⁸ N. Santos. 2007. "Drug Identification." Presentation to the committee. April 23, 2007.

⁹ P. Strupatis, Chair, IAI Firearm/Toolmark Committee, and member, SWGGUN. Presentation to the committee. April 23, 2007.

^c Ibid.

^d R.E. Bisbing, Executive Vice President, McCrone Associates, Inc., and member SWGMAT. Presentation to the committee. April 24, 2007.

^e S. Meagher, Fingerprint Specialist, Federal Bureau of Investigation, and Vice-Chair SWGFAST. Presentation to the committee. April 24, 2007.

^f See www.theiai.org/guidelines/swgfast/index.php.

^g Meagher, op. cit.

for their enforcement, with sanctions imposed against those who fail to comply. As such, standards should be developed with a consideration of the relevant measures that will be used to provide a meaningful evaluation of an organization's or individual's level of compliance. Appropriate standards must be coupled with effective systems of accreditation and/or certification that include strong enforcement mechanisms and sanctions.

Individual laboratories undergoing accreditation develop their own laboratory protocols. Whether these protocols adhere to the SWG standards depends on the individual examiners in the discipline in the laboratory in question. Accrediting bodies require that the methods meet a level of acceptable practice. Currently, most of these practices are slight variations of the SWG guidelines, with adjustments to accommodate differences in equipment.

PROFICIENCY TESTING

Although many forensic science disciplines have engaged in proficiency testing for the past several decades, several courts have noted that proficiency testing in some disciplines is not sufficiently rigorous.²⁷ ASCLD/LAB's Web site states that "Proficiency testing is an integral part of an effective quality assurance program. It is one of many measures used by laboratories to monitor performance and to identify areas where improvement may be needed. A proficiency testing program is a reliable method of verifying that the laboratory's technical procedures are valid and that the quality of work is being maintained."²⁸ Similarly, ISO/IEC 17025 policies state:

Proficiency testing is one of the important tools used by laboratories and Accreditation Bodies for monitoring test and calibration results and for verifying the effectiveness of the accreditation process. As such, it is an important element in establishing confidence in the competence of Signatories and their accredited laboratories covered by this Arrangement.²⁹

²⁷ See *United States v. Crisp*, 324 F.3d 261, 274 (4th Cir. 2003); *United States v. Llera Plaza*, 188 F. Supp. 2d 549, 565, 558 (E.D. Pa. 2002); *United States v. Lewis*, 220 F. Supp. 2d 548, 554 (S.D. W.Va. 2002).

²⁸ See www.ascl-d-lab.org/legacy/pdf/aslabinternproficiencyreviewprogram.pdf. It is worth noting that several studies have assessed or published crime laboratory proficiency testing results, which generally reveal the need for improvement; J.L. Peterson, E.L. Fabricant, K.S. Field, and J.I. Thornton. 1978. *Crime Laboratory Proficiency Testing Research Program*. Washington, DC: U.S. Government Printing Office; J.L. Peterson and P. Markham. 1995. Crime laboratory proficiency testing results, 1978-1991, I: Identification and classification of physical evidence. *Journal of Forensic Sciences* 40(6):994-1008; J.L. Peterson and P. Markham, 1995. Crime laboratory proficiency testing results, 1978-1991, II: Resolving questions of common origin. *Journal of Forensic Sciences* 40(6):1009-1029.

²⁹ See www.iso.org/iso/catalogue_detail?csnumber=39883.

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There are several types of proficiency tests, with the primary distinction among them being whether the examiner is aware that he or she is being tested (an open or declared test) or does not realize that the sample presented for analysis is a test sample and not a real case (a blind test). Tests can be generated externally, by another laboratory (sometimes called an interlaboratory test), or internally. Another type of testing involves random case reanalysis, in which an examiner's completed prior casework is randomly selected for reanalysis by a supervisor or another examiner.³⁰

Interlaboratory testing can be conducted for a number of purposes:

- (1) to determine the performance of individual laboratories for specific tests or measurements and to monitor laboratories' continuing performance;
- (2) to identify problems in laboratories and initiate remedial actions, which may be related to, for example, individual staff performance or the calibration of instrumentation;
- (3) to determine the performance characteristics of a method and to establish the effectiveness and comparability of new tests or measurement methods; or
- (4) to assign values to reference materials and assess their suitability for use in specific tests or measurement procedures.³¹

Blind proficiency testing is recommended, but not required, by ASCLD/LAB—not as a way to determine error rates, but as a more precise test of a worker's accuracy. Initially, mandatory blind testing was proposed as part of the federal DNA Identification Act. A Department of Justice (DOJ) panel designed blind tests, evaluated them, and estimated it would cost \$500,000 to \$1 million annually for one test per laboratory.³² In appropriate circumstances, proficiency testing should include blind testing.

ASCLD/LAB has a detailed proficiency testing program that requires all active examiners to take at least one proficiency test per year (two tests per year in DNA), that each discipline within the laboratory participate in an external proficiency test that is reviewed by a proficiency test review

³⁰ Refer to ISO/IEC Guide 43-1:1997(E) Section 4 for a list of proficiency testing schemes. Refer to ASTM E 1301 Section 6 for an overview of organization and design of proficiency tests. SWGs also provide guidelines for proficiency testing in the relevant discipline.

³¹ European Network of Forensic Science Institutes. 2005. *Guidance on the Conduct of Proficiency Tests and Collaborative Exercises Within ENFSI*. Available at www.enfsi.eu/uploads/files/QCC-PT-001-003.pdf.

³² J.L. Peterson, G. Lin, M. Ho, Y. Chen, and R.E. Gaensslen. 2003. The feasibility of external blind DNA proficiency testing. Available at www.astm.org/JOURNALS/FORENSIC/PAGES/4241.htm.

panel, and that any proficiency test that is not successfully completed be immediately reported to ASCLD/LAB along with a corrective action plan. To retain accredited status for a full five-year term, a laboratory must continue to meet the standards under which it was accredited. One of the means by which ASCLD/LAB monitors compliance is by reviewing proficiency testing reports submitted by approved test providers.

According to the 2002 BJS census,³³ 274 of the 351 publicly funded laboratories were engaged in proficiency testing. Proficiency testing was slightly less common among smaller laboratories and those serving municipal jurisdictions (8 laboratories did not engage in such testing, and 69 did not answer the survey question). Among the laboratories engaged in proficiency testing, almost all use declared tests. Slightly more than half engaged in proficiency testing use random case reanalysis. Twenty-six percent of the laboratories engaged in proficiency testing use blind tests. In addition, the BJS survey reported that almost all laboratories engaged in proficiency testing used tests that were generated externally (thus allowing comparative analysis). In addition to external tests, 74 percent of laboratories engaged in proficiency testing also used internally generated tests. Data on proficiency testing were not collected for the 2005 census.

CERTIFICATION

The certification of individuals complements the accreditation of laboratories for a total quality assurance program. In other realms of science and technology, professionals, including nurses, physicians, professional engineers, and some laboratorians, typically must be certified before they can practice.³⁴ The same should be true for forensic scientists who practice and testify. Although the accreditation process primarily addresses the management system, technical methods, and quality of the work of a laboratory (which includes the education and training of staff), certification is a process specifically designed to ensure the competency of the individual examiner.

The American Bar Association has recommended that certification standards be required of examiners, including "demanding written examinations, proficiency testing, continuing education, recertification procedures,

³³ Peterson and Hickman, *op. cit.*

³⁴ T. Orrelli. 2008. Characteristics of candidates who have taken the Certified Nurse Educator: CNE examination: A two-year review. *Nursing Education Perspectives* 29(2):120; P. Nowak. 2008. Get IT-certified: Having employees with the right certifications can help dealers and integrators qualify for business and gain access to IT networks. *Network Technology* 38(3):123; S. Space. 2007. Investigator certification. *Issues in Clinical Trials Management* 8(2):73.

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an ethical code, and effective disciplinary procedures.”³⁵ In addition to improving quality, certification programs can enhance the credibility of certificate holders. An excellent description of the certification process is contained in the following excerpt from the National Association of Medical Examiners (NAME) Web site:

In general, certification boards consist of respected professionals in a particular area of professional practice who develop standards for education, training, and experience that are required before one can become ‘certified’ in a particular professional discipline. Successful completion of a written and/or practical examination is also usually required. In essence, ‘certification’ usually means that a particular individual has completed a defined course of education, training, and experience, and has passed an examination prepared by peers which demonstrates that the individual has obtained at least the minimum level of competence required to practice the specific discipline. A number of ‘Certification Boards’ exist for people in various scientific disciplines. . . .³⁶

The professional forensic science community supports the concept of certification. ASCLD recommends that laboratory managers support peer certification programs that promote professionalism and provide objective standards. In 2002, the Technical Working Group on Forensic Science Education recommended certification of an individual’s competency by an independent peer-based organization, if available, from a certifying body with appropriate credentials. In addition, IAI supports certification of forensic science practitioners.³⁷

Some organizations, such as the American Board of Criminalists (ABC), offer examiner certification programs, but some certification organizations appear to lack stringent requirements.³⁸ In response, the American Academy of Forensic Sciences has formed a Forensic Specialties Accreditation Board to accredit certifying organizations. Organizations are invited to participate if they meet established requirements, such as periodic recertification, a sufficient knowledge base for certification, a process for providing credentials, and a code of ethics.³⁹ Currently accredited boards include:

- American Board of Criminalistics

³⁵ American Bar Association, op. cit., p. 7.

³⁶ See http://thename.org/index.php?option=com_content&task=view&id=80&Itemid=41.

³⁷ K.F. Martin, President, IAI. Presentation to the committee. September 19, 2007.

³⁸ See M. Hansen. 2000. Expertise to go. *ABA J.* 86:44-45; E. MacDonald. 1999. “The Making of an Expert Witness: It’s in the Credentials.” *Wall Street Journal*. February 8, p. B1.

³⁹ See FABS Standards for Accrediting Forensic Specialty Certification Boards at www.thefsab.org/standards_20070218.pdf.

- American Board of Forensic Document Examiners
- American Board of Forensic Toxicology
- American Board of Medicolegal Death Investigators
- Board of Forensic Document Examiners
- International Institute of Forensic Engineering Sciences

IAI also has established certification programs in:

- Bloodstain Pattern Analysis
- Crime Scene Investigation
- Footwear
- Forensic Art
- Forensic Photography/Imaging
- Latent Print
- Tenprint Fingerprint⁴⁰

Other certification programs exist for (but are not limited to) the following forensic science disciplines:

- Document Examination (The American Board of Forensic Document Examiners [ABFDE])
- Drug Analysis, Fire Debris Analysis, Molecular Biology, Trace Analysis, and General Criminalistics (ABC)
- Firearms and ToolMark Identification (Association of Firearm and ToolMark Examiners [AFTE])
- Forensic Odontology (The American Board of Forensic Odontology [ABFO])
- Forensic Pathology (The American Board of Pathology [ABP])
- Toxicology (American Board of Forensic Toxicology [ABFT])

Each of these entities has specific educational, training, and experience requirements, including a series of competency tests—both written and practical—and participation in proficiency testing, and provide continuing education/active participation by means of publication, presentation, and membership in professional organizations.

OVERSIGHT AS A REQUIREMENT OF PAUL COVERDELL FORENSIC SCIENCE IMPROVEMENT GRANTS

One way of enforcing quality control is through the conditional funding of programs. The *Justice for All Act of 2004* (P.L. 108-405) that created

⁴⁰ K.F. Martin, President, IAI. Presentation to the committee. September 19, 2007.

the Coverdell Forensic Science Improvement Grants required that grant recipients certify that they have a process in place for independent, external investigations if allegations arise of "serious negligence or misconduct substantially affecting the integrity of the forensic results."⁴¹

In December 2005, the Office of the Inspector General (OIG) of DOJ issued a report of an audit that found that the Office of Justice Programs (OJP), which administers the program, "had not enforced or exercised effective oversight over the external investigation requirement for the Fiscal Year (FY) 2005 Coverdell Program."⁴² OJP did not require grant applicants to identify the government entities that they certified could perform independent external investigations:

Our review found that NIJ did not enforce the Act's certification requirement. NIJ's FY 2005 Coverdell Grant Program Announcement did not give applicants necessary guidance on what constitutes an independent external investigation or how to make the required certification. In addition, the announcement did not provide examples of external investigation certifications and did not require an applicant to name the government entity responsible for conducting independent, external investigations. NIJ was aware of the shortcomings in the announcement because of questions it received from potential applicants and concerns expressed by the OIG, but failed to correct them.⁴³

The OIG made three recommendations to improve the program announcement and application process (see Box 7-3).

A second audit of the program was released in January 2008.⁴⁴ Again, it reported that not all forensic laboratories that had received FY 2006 grant funds were covered by a government entity with the authority and capability to independently investigate allegations of serious negligence or misconduct. "Further, OJP's guidance does not require grantees and subgrantees (forensic laboratories) to refer allegations of serious negligence and misconduct to entities for investigation."⁴⁵ The OIG found that 78 of the 231 entities contacted did not meet the external investigation certification requirement. It also found that "OJP did not adequately review the information it did obtain to ascertain that the certifications submitted by

⁴¹ 42 U.S.C. § 3797k(4).

⁴² U.S. Department of Justice, Office of the Inspector General. 2005. *Review of the Office of Justice Programs' Forensic Science Improvement Grant Program*, Evaluation and Inspections Report I-2006-002. Available at www.usdoj.gov/oig/semiannual/0605/ojp.htm.

⁴³ Ibid.

⁴⁴ U.S. Department of Justice, Office of the Inspector General. 2008. *Review of the Office of Justice Programs' Forensic Science Improvement Grant Program*, Evaluation and Inspections Report I-2008-001.

⁴⁵ Ibid., p. ii.

the grantees were properly completed."⁴⁶ The OIG made three recommendations to OJP to correct its certification process (see Box 7-3).

CODES OF ETHICS

A code of ethics is another mechanism for encouraging the development and use of professional standards of conduct. However, there is disagreement about how effective such codes are in achieving that goal.⁴⁷ In 1991, Ladd argued that codes of ethics serve no good purpose and that reliance on such codes confuses ethics with law.⁴⁸ Some authors have noted that although practicing professionals rarely turn to their codes of ethics for guidance, the adoption of a code of ethics is critical to the professionalization of a group, because it indicates that the group recognizes an obligation to society that transcends its own self-interest.⁴⁹ However, codes of ethics can serve to provide rational bases for punishments, such as exiling violators from the community.

In the field of engineering, Davis asserts that codes of ethics should be understood as conventions among professionals:

The code is to protect each professional from certain pressures (for example, the pressure to cut corners to save money) by making it reasonably likely . . . that most other members of the profession will not take advantage of her good conduct. A code protects members of a profession from certain consequences of competition. A code is a solution to a coordination problem.⁵⁰

Also in the field of engineering, Harris et al. argue that codes can serve as a collective recognition by members of a profession of its responsibilities, creating an environment in which ethical behavior is the norm.⁵¹ Moreover, a code of ethics can serve as an educational tool, providing a starting point for discussion in coursework and professional meetings.

⁴⁶Ibid., p. iii.

⁴⁷ A series of articles published in the *Journal of Forensic Sciences* 34(3) (May 1989) addressed a range of ethical dilemmas facing individuals practicing science in the criminal justice system.

⁴⁸ J. Ladd. 1991. The quest for a code of professional ethics: An intellectual and moral confusion. In: D.G. Johnson (ed.). *Ethical Issues in Engineering*. Englewood Cliffs, NJ: Prentice-Hall, pp. 130-136.

⁴⁹ H.C. Luegenbiehl. 1983. Codes of ethics and the moral education of engineers. *Business and Professional Ethics Journal* 2:41-61; D.G. Johnson (ed.). 1991. *Ethical Issues in Engineering*. 1991. Englewood Cliffs, NJ: Prentice-Hall, pp. 137-154.

⁵⁰ M. Davis. 1991. Thinking like an engineer: The place of a code of ethics in the practice of a profession. *Philosophy and Public Affairs* 20(2):150-167, p. 154.

⁵¹ C.E. Harris, M.S. Pritchard, and M.J. Rabins. 1995. *Engineering Ethics: Concepts and Cases*. Belmont, CA: Wadsworth Publishing.

Box 7-3
Recommendations from Two Reviews of
the Coverdell Grant Program

2005 - We believe that Coverdell Grant Program Announcements must provide necessary guidance to applicants and request the information required for NIJ to evaluate the external investigation certifications and conduct effective oversight of the grants. To meet the requirements of the Justice for All Act of 2004, we recommend that OJP, as part of its oversight of NIJ:

1. Require that all Coverdell Grant Program Announcements contain guidance on what constitutes an independent external investigation and examples of government entities and processes that could satisfy the certification requirement.
2. Require that each Coverdell Grant applicant, prior to receiving funds, provide the name of the government entity with a process in place to conduct independent external investigations into allegations of serious negligence or misconduct.
3. Consider requiring each Coverdell Grant applicant, prior to receiving funds, to submit a letter from the government entity that will conduct independent external investigations acknowledging that the entity has the authority and process to investigate allegations of serious negligence or misconduct.

2006 - To improve OJP's administration of the Coverdell Program and better ensure that allegations of negligence or misconduct are subject to independent external investigation, the OIG recommends that OJP take the following actions:

1. Revise the certification template to require that applicants name the government entities and confirm that the government entities have:
 - a. the authority,
 - b. the independence,
 - c. a process in place that excludes laboratory management, and
 - d. the resources to conduct independent external investigations into allegations of serious negligence or misconduct by labs that will received Coverdell funds.
2. Provide applicants with guidance that allegations of serious negligence or misconduct substantially affecting the integrity of forensic results are to be referred to the certified government entities.
3. Revise and document the Coverdell Program application review process so that only applicants that submit complete external investigation certifications are awarded grants.

SOURCE: U.S. DOJ Office of the Inspector General. 2005. *Review of the Office of Justice Programs' Forensic Science Improvement Grant Program*, Evaluation and Inspections Report I-2006-002. Available at www.usdoj.gov/oig/semiannual/0605/ojp.htm; U.S. DOJ OFFICE of Inspector General. 2008. *Review of the Office of Justice Programs' Forensic Science Improvement Grant Program*, Evaluation and Inspections Report I-2008-001.

Many forensic science organizations—such as the American Academy of Forensic Sciences, the California Association of Criminalists, and ASCLD—have codes of ethics or codes of professional practice imploring members to act with honesty, integrity, and objectivity; to work within the bounds of their professional competence; to present testimony and reports in a clear and objective manner; and to avoid conflicts of interest and potential bias, among other things. The codes that do exist are generally comprehensive, but they vary in content. As a consequence, there is no single code of ethics to which all members of the forensic science profession subscribe. As the committee concluded its work, it learned of an effort by ASCLD/LAB to develop a uniform code of ethics.

CONCLUSIONS AND RECOMMENDATIONS

Although some areas of the forensic science disciplines have made notable efforts to achieve standardization and best practices, most disciplines still lack any consistent structure for the enforcement of “better practices,” operating standards, and certification and accreditation programs. Accreditation is required in only three states—New York, Oklahoma, and Texas. In other states, accreditation is voluntary, as is individual certification. Certification, while broadly accepted by the forensic science community, is not uniformly offered or required.

Although many forensic science organizations have codes of ethics, these codes can be enforced to regulate only the practices of persons who belong to a given organization. A uniform code of ethics should be in place across all forensic organizations to which all forensic practitioners and laboratories should adhere.

Recommendation 6:

To facilitate the work of the National Institute of Forensic Science (NIFS), Congress should authorize and appropriate funds to NIFS to work with the National Institute of Standards and Technology (NIST), in conjunction with government laboratories, universities, and private laboratories, and in consultation with Scientific Working Groups, to develop tools for advancing measurement, validation, reliability, information sharing, and proficiency testing in forensic science and to establish protocols for forensic examinations, methods, and practices. Standards should reflect best practices and serve as accreditation tools for laboratories and as guides for the education, training, and certification of professionals. Upon completion of its work, NIST and its partners should report find-

ings and recommendations to NIFS for further dissemination and implementation.

Recommendation 7:

Laboratory accreditation and individual certification of forensic science professionals should be mandatory, and all forensic science professionals should have access to a certification process. In determining appropriate standards for accreditation and certification, the National Institute of Forensic Science (NIFS) should take into account established and recognized international standards, such as those published by the International Organization for Standardization (ISO). No person (public or private) should be allowed to practice in a forensic science discipline or testify as a forensic science professional without certification. Certification requirements should include, at a minimum, written examinations, supervised practice, proficiency testing, continuing education, recertification procedures, adherence to a code of ethics, and effective disciplinary procedures. All laboratories and facilities (public or private) should be accredited, and all forensic science professionals should be certified, when eligible, within a time period established by NIFS.

Recommendation 8:

Forensic laboratories should establish routine quality assurance and quality control procedures to ensure the accuracy of forensic analyses and the work of forensic practitioners. Quality control procedures should be designed to identify mistakes, fraud, and bias; confirm the continued validity and reliability of standard operating procedures and protocols; ensure that best practices are being followed; and correct procedures and protocols that are found to need improvement.

Recommendation 9:

The National Institute of Forensic Science (NIFS), in consultation with its advisory board, should establish a national code of ethics for all forensic science disciplines and encourage individual societies to incorporate this national code as part of their professional code of ethics. Additionally, NIFS should explore mechanisms of enforcement for those forensic scientists who commit serious ethical violations. Such a code could be enforced through a certification process for forensic scientists.

8

Education and Training in Forensic Science

Forensic examiners must understand the principles, practices, and contexts of science, including the scientific method. Training should move away from reliance on the apprentice-like transmittal of practices to education at the college level and beyond that is based on scientifically valid principles, as discussed in Chapter 4. For example, in addition to learning a particular methodology through a lengthy apprenticeship or workshop during which a trainee discerns and learns to copy the skills of an experienced examiner, the junior person should learn what to measure, the associated population statistics (if appropriate), biases and errors to avoid, other threats to the validity of the evidence, how to calculate the probability that a conclusion is valid, and how to document and report the analysis. Among many skills, forensic science education and training must provide the tools needed to understand the probabilities and the limits of decisionmaking under conditions of uncertainty.

To correct some of the existing deficiencies, the starting place must be better undergraduate and graduate programs, as well as increased opportunities for continuing education. Legitimizing practices in the forensic science disciplines must be based on established scientific knowledge, principles, and practices, which are best learned through formal education and training and the proper conduct of research.

Education and training in the forensic science disciplines serve at least three purposes. First, educational programs prepare the next generation of forensic practitioners. The number of secondary and postsecondary students interested in the forensic science disciplines has grown substantially in recent years. In response, colleges and universities have created new

certificate and degree programs to prepare students for forensic science careers. There are several types of forensic practitioners, including criminalists (those who work in crime laboratories), who make up a large part of the forensic science workforce and who often enter the profession with a bachelor's degree, and other forensic science practitioners (e.g., pathologists, odontologists, entomologists, toxicologists, anthropologists), who typically have advanced degrees, often Ph.D.s, and who might work part time in forensic science activities. Another group of forensic examiners include crime scene investigators, who usually do not have advanced degrees; many do not have college degrees above the associate level.

Second, forensic science practitioners require continuing professional development and training. Scientific advances in forensic science techniques and research in the forensic science disciplines are of interest to practitioners who must be aware of these new developments. Forensic science practitioners also may need to complete additional training for certification purposes or may desire to learn new skills as part of their career development. Training refers to the "formal, structured process through which a forensic scientist reaches a level of scientific knowledge and expertise required to conduct specific forensic analyses."¹ Continuing professional development is the "mechanism through which a forensic scientist remains current or advances to a higher level of expertise, specialization, or responsibility."²

Third, there is a need to educate the users of forensic science analyses, especially those in the legal community. Judges, lawyers, and law students can benefit from a greater understanding of the scientific bases underlying the forensic science disciplines and how the underlying scientific validity of techniques affects the interpretation of findings. These three objectives are explored in more detail in this chapter.

STATUS OF FORENSIC SCIENCE EDUCATION

Demand for Forensic Science Practitioners

Demand for more and better-skilled forensic science practitioners is rising at both the macro and micro levels. At the macro level, the appropriate question to ask is, what is the need for forensic science expertise in the United States? At the micro level, the question to ask is, what are the needs of a crime laboratory in hiring new forensic science personnel?

¹ National Institute of Justice. 2004. *Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students*. Washington, DC: National Institute of Justice, p. 25.

² Ibid.

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As the National Institute of Justice (NIJ) notes:

In recent years, the demand for forensic scientists has increased for many reasons, including population demographics, increased awareness of forensic science by law enforcement, increased numbers of law enforcement officers, database automation in several categories of physical evidence, jury expectations, legal requirements, accreditation and certification requirements of laboratories and personnel, impending retirement of a large number of currently practicing forensic scientists, and increased public awareness of forensic science through the popular media.³

One manifestation of the need for more examiners is the backlog of requests for forensic services at crime laboratories. As noted in previous chapters of this report (based on the 2005 Census of Publicly Funded Forensic Crime Laboratories), many forensic laboratories experience large backlogs in requests for forensic services. To achieve a 30-day turnaround on all 2005 requests, the different forensic science disciplines would have needed varying increases in the number of full-time examiners performing that work—ranging from an estimated 73 percent increase in DNA examiners to an estimated 6 percent increase in examiners conducting toxicology analysis.⁴

The most recent *Occupational Outlook Handbook*, prepared by the Bureau of Labor Statistics at the U.S. Department of Labor, found that job growth for forensic science technicians will grow much faster than average, with 13,000 jobs available in 2006 and a projected 31 percent rise, or 17,000 jobs, projected by 2016.⁵ Yet one analyst argued that “existing science programs overproduce graduates relative to the actual labor market” in criminalistics.⁶ Having an accurate picture of demand—as well as the capacity of employers to absorb new forensic science professionals—is important for colleges and universities that are educating and training the future workforce. Additional information on such factors as retirement and attrition rates and on trends in funding for laboratory personnel could assist educational providers in obtaining a more accurate picture of future employment prospects for their students.

The micro level focuses on the skills that individuals need to gain

³ Ibid., p. 3.

⁴ M.R. Durose. 2008. *Census of Publicly Funded Forensic Crime Laboratories, 2005*. U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics. Available at www.ojp.usdoj.gov/bjs/pub/pdf/cpffcl05.pdf.

⁵ Bureau of Labor Statistics, Department of Labor. “Science Technicians.” In: *Occupational Outlook Handbook, 2008-09 edition*. Available at www.bls.gov/oco/ocos115.htm#projections_data.

⁶ R.E. Gaensslen. 2003. How do I become a forensic scientist? Educational pathways to forensic science careers. *Analytical and Bioanalytical Chemistry* 376:1151-1155.

TABLE 8-1 Educational Pathways to Some Forensic Science Careers

Forensic Discipline	Educational Requirements
Crime scene investigation	Jobs are typically held by law enforcement personnel. Meet requirements for joining the law enforcement agency. For federal jobs, a college degree is required.
Computer crime investigation/forensic computer science	B.S. in computer science or computer engineering; M.S. may be common.
Criminalistics	B.S. in the physical sciences, with background in chemistry
Forensic engineering	B.S. in engineering; practitioners may also be licensed as professional engineers (PEs).
Forensic pathology	Appropriate college degree; M.D.; internship and pathology residency; and specialized training in forensic pathology; additionally requires state license and board certification.
Forensic odontology	Appropriate college degree; D.D.S. or D.D.M.; may include additional specialty training; additionally requires state license and board certification.
Forensic entomology	Ph.D. in entomology.
Forensic anthropology	M.S. or M.A. at minimum; many have Ph.D.s.
Forensic psychiatry	Similar to forensic pathology, with residency in psychiatry.
Forensic psychology	M.S.W. or Ph.D. in psychology; often must meet state requirements for clinical practice and may be certified.

SOURCE: Gaensslen, 2003.

entry into forensic science careers (see Table 8-1). As a starting point, one needs an appropriate degree. The required minimum degree for entry-level forensic science positions ranges from a bachelor's degree to a doctoral or medical degree.⁷ Almirall and Furton⁸ suggest that it is possible to begin a career as a crime scene investigator or in firearms, documents, or fingerprints with an associate degree.

It should be noted that the preferred degree is often higher than an

⁷ Gaensslen, op. cit.

⁸ R. Almirall and K.G. Furton. 2003. Trends in forensic science education: Expansion and increased accountability. *Analytical and Bioanalytical Chemistry* 376:1156-1159.

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associate degree. Almirall and Furton posit that future trends favor a minimum of a graduate degree in almost all areas of forensic science.⁹

An issue that has received much attention is the degree requirements for positions in crime laboratories. A requirement for an entry-level position in most crime laboratories is at least a bachelor's degree in a natural science or forensic science, and many laboratories require a year or two of experience, with a master's degree. Over the years, most crime laboratory hires have been and continue to be graduates with degrees in chemistry or biology.

Several studies have focused on the needs of crime laboratories. In 1988 Siegel conducted a survey of undergraduate students at Michigan State University, forensic science practitioners employed by the Michigan State Police, and 240 members of the American Society of Crime Laboratory Directors (ASCLD).¹⁰ Survey respondents expressed a strong preference for a master's degree in forensic science and a lack of preference for the B.S. in criminalistics/forensic science. One explanation noted by the respondents was "that too many programs passing themselves off as forensic science programs were actually little more than criminal justice programs with a forensic science internship and a smattering of 'hard' science."¹¹ Another finding was the importance of chemistry in the backgrounds of prospective forensic science examiners.

Also in 1988, Higgins and Selavka surveyed laboratory managers.¹² Similar to the findings of Siegel, "chemical knowledge was the most important ability they considered when evaluating potential employees. . . ." In 1996, Furton et al. surveyed members of the ASCLD, primarily drug chemists and trace evidence analysts.¹⁴ This survey found that "the majority of crime lab directors responding require applicants to have B.S. degrees with a preference for chemistry/biochemistry, followed by biology and forensic science with a requirement for a substantial number of chemistry and other natural science courses."¹⁵

⁹ Ibid.

¹⁰ J.A. Siegel. 1988. The appropriate educational background for entry level forensic scientists: A survey of practitioners. *Journal of Forensic Sciences* 33(4):1065-1068.

¹¹ Ibid., pp. 1067-1068.

¹² K.M. Higgins and C.M. Selavka. 1988. Do forensic science graduate programs fulfill the needs of the forensic science community? *Journal of Forensic Sciences* 33(4):1015-1021.

¹³ Ibid., p. 1017.

¹⁴ K.G. Furton, Y.L. Hsu, and M.D. Cole. 1999. What educational background is required by crime laboratory directors? *Journal of Forensic Sciences* 44:128-132.

¹⁵ Ibid., p. 130.

Proliferation of Forensic Science Programs

In recent years, increasing attention has been paid to the forensic science disciplines by the media in the form of many new books, movies, high-profile court cases, and, especially, television shows such as *Crime Scene Investigation* (or CSI).¹⁶ This media attention has resulted in explosive demand by college (as well as primary and secondary school) students for academic courses and degree programs that will prepare them for careers in forensic science that are like those portrayed in the media. Evidence of this is the dramatic rise in enrollments in forensic science courses on college campuses.¹⁷

One issue facing academic forensic science programs is combating Hollywood's version of the career of a forensic practitioner. "Students who enter forensic science programs often expect to work in conditions similar to the television crime shows they watch. Many find they are unprepared for the reality of a career in the field. 'A lot of new students come to our programs looking for an exciting career. Unfortunately, they come with unrealistic expectations,' says Charles Tindall, director of forensic science at the Metropolitan State College of Denver."¹⁸

Until recently, there were few academic programs in the forensic science disciplines. The earliest forensic science degree programs and the oldest continually functioning educational degree programs in forensic science in the United States were established at Michigan State University in 1946 and the University of California at Berkeley in 1950.¹⁹ A survey conducted in the mid-1970s located 22 colleges and universities in the United States offering degrees (in one case a certificate) in criminalistics/forensic science, although some of these institutions offered multiple degrees.²⁰

¹⁶ See, e.g., S. Smallwood. 2002. As seen on TV. *Chronicle of Higher Education* 48(45): A8-A10.

¹⁷ There have been similar increases in demand at the K-12 level. Forensic science has become a popular component of science teaching. An informal survey conducted in 2004 by the National Science Teachers Association found that, "Of the 450 middle and high school science educators who responded to an informal survey, 77 percent indicated that their school or school district is using forensic investigations to teach science. When asked if the popularity of forensic-based TV shows had ignited students' interest in science, the response was a resounding 'yes' (78 percent)." *NSTA Survey Reveals Forensic Science Is Hottest New Trend in Science Teaching*. Available at http://science.nsta.org/nstaexpress/nstaexpress_2004_10_25_forensic.htm.

¹⁸ National Institute of Justice. 2007. *Addressing Shortfalls in Forensic Science Education*. InShorr, NCJ 216886. Washington, DC: U.S. Department of Justice, National Institute of Justice.

¹⁹ A. Vollmer, Chief of Police, Berkeley, California, established the School of Criminology at the University of California at Berkeley.

²⁰ J.L. Peterson, D. Crim, and P.R. De Forest. 1977. The status of forensic science degree programs in the United States. *Journal of Forensic Sciences* 22(1):17-33.

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In the 1980s, a contraction of programs occurred—particularly at the graduate level. Stoney argues that this was because of a lack of financial and administrative support.²¹ Higgins and Selavka suggest that the end of funding provided by the Law Enforcement Assistance Administration in 1978 took important federal support away from many institutions.²² Additionally, they suggest that the then-declining enrollment in graduate programs might have reflected the generally low-paying opportunities available to newly minted graduates.

In recent years, this trend has reversed itself. Many colleges and universities, seeing the potential revenue from increasing numbers of new students, have responded by creating all manner of new academic programs. The American Academy of Forensic Sciences (AAFS) now lists 138 undergraduate, 59 graduate, and 6 doctoral forensic science degree programs in the United States.²³ Not all are science based—many are criminal justice programs. The curricula of these degrees range from rigorous scientific coursework amounting to a degree in chemistry or biology with forensic science content, to little more than criminal justice degrees with an internship.

Doctoral Programs in Forensic Science

There is no doctoral program specifically in forensic science; the programs noted by AAFS offer Ph.D.s (mostly in chemistry) with a concentration in that area. Some scholars consider this to be a shortcoming in forensic science education. More than 20 years ago, Kobilinsky and Sheehan conducted a survey of crime laboratories throughout the United States and found that almost 73 percent of those responding believed there was a need for a Ph.D. program.²⁴ The advantages of a Ph.D. program lie in its positive effect on basic research in the field. Doctoral programs offer more research depth and capacity, have ties to other fields, have high expectations for quality, supply graduate student personnel to question and check past work and challenge conventional wisdom, and inspire more mentoring, which has two-way benefits.

²¹ D.A. Stoney. 1988. A medical model for criminalistics education. *Journal of Forensic Sciences* 33(4):1086-1094.

²² Higgins and Selavka, op. cit.

²³ See www.aafs.org.

²⁴ L. Kobilinsky and F.X. Sheehan. 1984. The desirability of a Ph.D. program in forensic science. *Journal of Forensic Sciences* 29(3):706-710.

CHALLENGES AND OPPORTUNITIES TO IMPROVE FORENSIC SCIENCE EDUCATION

The overarching challenges facing forensic science education, since its inception, have been inconsistent quality and insufficient funding. Commentators have noted repeatedly the deficiencies of forensic science education programs.²⁵ Because, until recently, no nationally recognized, mandated standards existed for forensic science degree programs at any level, consistent quality cannot be achieved. Peterson et al. note that while “the primary objective of all degree programs is similar, the capabilities of graduates from the respective institutions are not uniform. Laboratories are forced to evaluate each graduate student individually to determine his suitability for a given position.”²⁶

Unevenness in the quality of these programs has caused problems for students and future employers. The Council of Forensic Science Educators stated that, “Students completing these lesser programs expect to find employment in crime labs but are surprised to learn that lab management is not impressed by the curriculum.”²⁷

Additionally, the lack of applicants with a science or forensic background means that crime laboratories have to spend precious time and resources in the training of new scientists.²⁸ If forensic science education programs had sufficient rigor in science, law, and forensics, crime laboratories would have to spend less time and money for training,²⁹ thereby shortening as well the apprenticeship time needed. Forensic science methods should be taught in the framework of common scientific practice (see Chapters 4 through 6). Even if a student graduates with a science degree, he or she often lacks education in issues that are critical to the functioning of crime laboratories, including quality assurance and control, ethics, and expert testimony. Peterson et al. found that, “The faculty surveyed believes their students to be well prepared for entry into the field. This is not totally consistent with the feedback from some laboratories which have been less than satisfied with newly graduated recruits.”³⁰ They continue to recommend that, “Measures should be taken to improve feedback from the laboratories to the schools to insure that the curriculum is not only comprehensive

²⁵ See, e.g., Peterson et al., op. cit.; L.W. Bradford. 1980. Barriers to quality achievement in crime laboratory operations. *Journal of Forensic Sciences* 25(4):902-907; Stoney, op. cit.; NIJ, op. cit.

²⁶ Peterson et al., op. cit., p. 31.

²⁷ See www.criminology.fsu.edu/COFSE/default.htm.

²⁸ Stoney, op. cit.

²⁹ NIJ, 2007, op. cit.

³⁰ Peterson et al., op. cit., p. 32.

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from an academic standpoint but also meets the practical requirements of operating laboratories.”³¹

Over the past few years, major strides have been taken in bringing a measure of standardization to forensic science education programs and boosting their quality. The NIJ report, *Forensic Science: Review of Status and Needs*, called in part for an accreditation system for such programs. Following this report, in 2001, NIJ established a Technical Working Group for Education and Training in Forensic Science (TWGED)—consisting of 47 experts, including educators, judges, attorneys, crime laboratory directors, and subject matter scientists—that developed recommended curricular guidelines for undergraduate and graduate forensic science programs. These were provided in a 2004 report.³² In 2002, the American Academy of Forensic Sciences created an ad hoc committee, the Forensic Education Program Accreditation Committee, to look into issues regarding an accreditation system. The committee was made a standing committee in 2004, at which time the name was changed to the Forensic Science Education Program Accreditation Commission (FEPAC). FEPAC is made up of five forensic science educators, five crime laboratory directors, and one public member. FEPAC created a process for accrediting undergraduate and graduate forensic science programs using the TWGED standards.³³

FEPAC standards are divided into three parts (see Table 8-2). There are general standards that all programs must meet and then additional standards for undergraduate and graduate programs.

An important note regarding the accreditation process is that the program must award at least a bachelor's degree in either forensic science or a natural science with a concentration in forensic science at both the bachelor's and master's levels. Programs that award certificates or associate degrees are ineligible for accreditation in this system. Additionally, at this time only U.S. programs are eligible for accreditation.

To summarize the general standards, such programs shall:

- have an explicit process for evaluating and monitoring its overall efforts to fulfill its mission, goals, and objectives; for assessing its effectiveness in serving its various constituencies; for modifying

³¹ Programs accredited by FEPAC are required to complete periodic self-assessments, which include job placement statistics and employer satisfaction surveys.

³² Technical Working Group for Education and Training in Forensic Science. 2004. *Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions and Students*, Special Report. Washington, DC: U.S. Department of Justice, National Institute of Justice. NCJ 203099.

³³ See FEPAC Accreditation Standards. Available at www.aafs.org/pdf/FEPAC%20Accreditation%20Standards%20_082307_.pdf.

TABLE 8-2 Major Areas of FEPAC Standards

General Standards for All Programs

- Eligibility
- Planning and Evaluation
- Institutional Support
- Student Support Services
- Recruiting and Admissions Practices, Academic Calendars, Catalogs, Publications, Grading, and Advertising
- Record of Student Complaints
- Distance Learning and Other Alternative Delivery Mechanisms

Undergraduate Program Standards

- Mission, Goals, and Objectives
- Undergraduate Admissions Requirements
- Curriculum
- Program Director
- Faculty
- Success with Respect to Student Achievement
- Professional Involvement

Graduate Program Standards

- Mission, Goals, and Objectives
- Graduate Admissions Requirements
- Curriculum
- Program Director
- Faculty
- Success with Respect to Student Achievement
- Professional Involvement

SOURCE: www.aafs.org.

- the curriculum as necessary, based on the results of its evaluation activities; and for planning to achieve its mission in the future;
- have adequate institutional support in the form of financial resources, facilities, instructional, and support services;
 - provide adequate student support services, such as mentoring, advising, and career placement;
 - have policies and procedures for student recruitment and admissions, with advisers to students regarding requirements for employment;
 - have procedures for handling student complaints; and
 - consider the use of distance learning as an instructional technique, demonstrating that all required laboratory experiences are hands-on for all students.

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Concerning the undergraduate curriculum, it should, at a minimum, ensure that each student (1) obtain a thorough grounding in the natural sciences; (2) build upon this background by taking a series of more advanced science classes; and (3) develop an appreciation of issues specific to forensic science through course work and laboratory-based instruction.

Forensic science undergraduates in the chemistry track should take, at a minimum, chemistry courses required for chemistry majors—general chemistry, organic chemistry, physical chemistry, analytical chemistry, instrumental analysis, and biochemistry. Forensic science students in the biology track should take those chemistry courses required for biology majors and biology courses for biology majors, including general biology, biochemistry, instrumental analysis, genetics, molecular biology, and population genetics. All forensic science students should, at the earliest point possible, take a hands-on crime scene investigation course that teaches the principles of evidence, including its collection, preservation, and value. Additionally, the forensic science courses in drug analysis, criminalistics, and forensic biology (including DNA analysis) should be at the highest level. All forensic science majors should take a capstone course.

For graduate programs, the curriculum should, at a minimum, ensure that each student (1) understand essential issues in the forensic science disciplines, including the reduction of error rates; (2) develop an understanding of the areas of knowledge that are essential to forensic science; (3) acquire skills and experience in the application of basic forensic science concepts and of specialty knowledge to problem solving; (4) be oriented in professional values, concepts and ethics; and (5) demonstrate integration of knowledge and skills through a capstone experience, such as a formal, objective tool (e.g., the American Board of Criminalistics Forensic Science Aptitude Test) or another comprehensive examination or a thesis and/or research project.

Depending on the specialty track of interest, graduate students should take advanced courses in specialty areas of interest—drug analysis, toxicology, criminalistics, forensic biology, and forensic DNA analysis (including mtDNA sequencing, low copy number techniques, and SNPs). The criminalistics and forensic biology courses should be advanced beyond those seen at the undergraduate level. If the student has not had those lower-level courses, they should be taken first. Graduate students also should take a hands-on crime scene investigation class that covers investigation techniques and evidence association, including its examination, collection, and preservation. In addition, in-service work with a collaborating institution can provide significant practical training.

Finally, the standards lay out a suggested curriculum for forensic science education programs. At the undergraduate level, coursework includes several classes in the natural sciences (with a focus on chemistry); special-

ized science courses (e.g., microbiology, genetics, biochemistry); forensic science courses—which cover courtroom testimony; introduction to law; quality assurance; ethics; professional practice; evidence identification, collection and processing; a survey of the forensic science disciplines; and additional courses in the student's area of specialization. Laboratory work must be complemented with hands-on training that closely mimics the experiences of the crime laboratory. At the graduate level, students should take core forensic science topics, such as physical evidence concepts and ethics and professional responsibilities; courses in specialized areas; and a graduate seminar—all aimed at developing skills for conducting independent research.

FEPAC began a pilot accreditation program in the fall of 2003, accrediting five programs,³⁴ and the number of accredited programs has continued to grow (see Table 8-3). As of January 2008, 16 programs have met FEPAC's rigorous standards and accordingly have been accredited by FEPAC.

Accredited forensic science programs are listed on the AAFS Web site. Accreditation is seen as providing a "seal of quality to an institution;" helping faculty to improve their curricula; creating a standard for measuring the quality of forensic science programs; and benefiting laboratories by reducing the need for in-house training.³⁵ Accreditation should become the norm. The committee believes that, to encourage accreditation, a mechanism could be developed whereby only accredited programs would be eligible to receive certain federal grants and/or scholarships for its students. If the forensic science disciplines are to grow in stature and be recognized for their scientific rigor and high standards of quality, their research base must be broadened and strengthened. This will occur only if significant federal research funds are made available to universities by scientific granting agencies such as the National Institutes of Health and the National Science Foundation. Crime laboratories would be the beneficiaries of a wave of well-educated workers who would elevate the scientific standards of the field. The forensic science degree programs that are not sufficiently rigorous eventually would disappear, because their graduates would not be competitive in the employment arena. Consequently, employers would be more confident in the capabilities of graduates of forensic science programs and hence would be more inclined to hire them.

³⁴ Cedar Crest College (Allentown, Pennsylvania), Eastern Kentucky University (Richmond, Kentucky), Florida International University (Miami, Florida), Metropolitan State College of Denver (Denver, Colorado), and Michigan State University (East Lansing, Michigan).

³⁵ NIJ, 2000, *op. cit.*

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TABLE 8-3 FEPAC Accredited Programs, 2008

Programs	Degree Program
Albany State University	Bachelor of Science Degree in Forensic Science
Arcadia University	Master of Science Degree Program in Forensic Science
Cedar Crest College	Bachelor of Science Degree Program in Chemistry, Biochemistry, Biology, and Genetic Engineering, with a concentration in Forensic Science
Eastern Kentucky University	Bachelor of Science Degree Program in Forensic Science
Florida International University	Certificate Programs in Conjunction with the Bachelor of Science in a Natural Science such as Chemistry or Biology
Florida International University	Master of Science Degree Program in Forensic Science
Marshall University	Master of Science Degree Program in Forensic Science
Metropolitan State College of Denver	Bachelor of Science Degree Program in Chemistry with a concentration in Criminalistics
Michigan State University	Master of Science Degree Program (biology and chemistry tracks)
University of Mississippi	Bachelor of Science Degree in Forensic Chemistry
Ohio University	Bachelor of Science Degree in Forensic Chemistry
SUNY at Albany	Master of Science Degree in Forensic Molecular Biology
Virginia Commonwealth University	Bachelor of Science Degree in Forensic Science
Virginia Commonwealth University	Master of Science Degree in Forensic Science
West Chester University	Bachelor of Science Degree Program In Forensic and Toxicological Chemistry
West Virginia University	Bachelor of Science Degree—Forensic and Investigative Science Program

SOURCE: www.aafs.org.

RESEARCH AS A COMPONENT OF FORENSIC SCIENCE EDUCATION PROGRAMS

Student research and exposure to research is a critical component of an appropriate forensic science education.³⁶ Research funding supports both faculty and graduate student research. Funding also supports the acquisition and maintenance of equipment and major research instrumentation and laboratory renovation.³⁷ As noted in Chapter 2, the level of funding for forensic science research programs is seen by many observers as inadequate. Fisher notes that “labs are looking for more forensic scientists at the master’s and doctorate level. For universities to run graduate-level programs in the science, research dollars must be made available. However, the amounts of such R&D funds available to support forensic science at the National Institute of Justice are small and are all but non-existence [sic] from the National Science Foundation, and other funding sources.”³⁸ Likewise, NIJ reported in 2004 that, “Currently, no sustainable source of State or Federal funding exists to support graduate education or research in forensic science. Nor should state and local governments fund research, as their funds have to support the service mission of the laboratories. The National Institute of Justice has traditionally provided virtually all federal research funding for forensic science, but additional funding from alternative sources is essential.”³⁹

Many forensic degree programs are found at small colleges or universities with few graduate programs in science and where research resources are limited. The lack of research funding has discouraged universities in the United States from developing research-based forensic degree programs, which leads to limited opportunities to attract graduate students into such programs. Only a few universities offer Ph.D.-level education and research opportunities in forensic science, and these are chemistry or biology programs with a forensic science focus. Most graduate programs in forensic science are master’s programs, where financial support for graduate study is limited.

In addition, the lack of research funds means that universities are unlikely to develop research programs in forensic science. This lack of funding discourages top scientists from exploring the many scientific issues in the forensic science disciplines. This has become a vicious cycle during

³⁶ To receive accreditation by FEPAC, a graduate program must include a component in which each student completes an independent research project leading to a thesis or written report, presented orally in a public forum for evaluation.

³⁷ NIJ, 2004, op. cit., p. 23.

³⁸ B.A.J. Fisher. 2003. Field needs adequate funding, national forensic science commission. *Forensic Focus*. See <http://forensicfocusmag.com/articles/3b1persp1.html>.

³⁹ NIJ, 2004, op. cit., p. 22.

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which the lack of funding keeps top scientists away and their unavailability discourages funding agencies from investing in forensic science research. Traditional funding agencies have never had a mission to support forensic science research.

STATUS OF TRAINING

Continuing education and in-service training in forensic science have been significant issues for many years. Funding programs initially were offered in the early 1970s through the Law Enforcement Assistance Administration. As forensic science grew, the needs for ongoing training and continuing education also grew. Several studies funded by NIJ have been undertaken since 1999—*Forensic Sciences: Review of Status and Needs* (1999);⁴⁰ *Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students* (2004),⁴¹ developed by TWGED; and a report prepared by ASCLD for NIJ, published in May 2004, which has become known as the *180-day Study Report: Status and Needs of United States Crime Laboratories*.⁴²

The issues addressed in all of these reports are the same ones confronting this committee today, namely the need for continuing education and the ongoing training of working examiners in the various disciplines:

Prior to conducting analysis on evidence, forensic scientists require both basic scientific education and discipline-specific training. To be in compliance with widely-accepted accreditation standards, scientists in each of the disciplines must have, at a minimum, a baccalaureate degree in a natural science, forensic science, or a closely-related field. Each examiner must also have successfully completed a competency test (usually after a training period) prior to assuming independent casework.⁴³

After the initial training period, continuing training is necessary to maintain and update knowledge and skills in new technology, equipment, and methods.

Accreditation and certification programs require some type of continuing education, and the various Scientific Working Groups (SWGs) recom-

⁴⁰ National Institute of Justice. 1999. *Forensic Sciences: Review of Status and Needs*. Washington, DC: National Institute of Justice.

⁴¹ National Institute of Justice. 2004. *Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students*. Washington, DC: National Institute of Justice.

⁴² American Society of Crime Laboratory Directors. 2004. *180-day Study Report: Status and Needs of United States Crime Laboratories*. Largo, FL: ASCLD.

⁴³ *Ibid.*, p. 12.

mend such programs (see Chapter 7). Continuing professional development also is a means of expanding expertise and career advancement.

Training Needs

As described by ASCLD:

When a new analyst or examiner is hired, usually a recent university graduate, that individual requires initial training to build competency. The length of the initial training provided to an analyst depends upon the laboratory specialty area the trainee will enter.

For example, controlled substance analysts may require only six to twelve months of training. Those training in experience-based disciplines such as latent prints examinations, firearms and toolmarks analyses, and questioned documents examinations may require up to three years of training before being permitted to perform independent casework. During their training period, individuals in experience-based disciplines serve much like an apprentice to a senior examiner.⁴⁴

NIJ describes a variety of training needs for forensic scientists in crime laboratories by position.⁴⁵ For operational scientists, training is needed to stay up to date in theoretical and practical issues (such as applying methods and performing analyses). Everyone in a laboratory needs orientation in such topics as the criminal justice system, the legal system, ethics, professional organizations, the basic philosophy of forensic science, overview of disciplines of forensic science, quality control (e.g., good laboratory practice), effective expert testimony, and safety. First-line supervisors need training in quality assurance, case file review, and basic supervision skills; and managers need training in fiscal management, quality systems management, leadership, project management, human resource management, and customer service. Training can be done in-service or through short courses. The 1999 NIJ report identifies a number of examples of such courses.

On-the-job training involves specific challenges; it is labor intensive and can be expensive.⁴⁶ The costs of training include the salary of the trainee as well as the opportunity cost of the lost productivity of the trainer. Moreover, there are no uniform recommendations on the content of training in the forensic science disciplines. ASCLD has suggested some examples of efforts to make training more efficient, including conducting some training in conjunction with universities (essentially conducting training while forensic

⁴⁴ ASCLD, *op. cit.*, p. 15.

⁴⁵ NIJ, 1999, *op. cit.*

⁴⁶ *Ibid.*

scientists are students and before they are full-time employees), and some laboratories have tried collaborating to train employees.

Continuing Education

Continuing education is critical for all personnel working in crime laboratories as well as for those in other forensic science disciplines, such as forensic pathologists or anthropologists. Some commonly used approaches to continuing education are instructor led, professional conferences/seminars, distributed learning, apprenticeship, residency, internship, teaching and presentations by trainee/employee, and independent learning.⁴⁷

The greatest issue for continuing education is quality. TWGED has provided guidelines for training courses. First, there should be specific eligibility requirements. Specified minimum and experiential requirements should be consistent with recognized, peer-defined standards (e.g., SWGs, ASCLD/Laboratory Accreditation Board). Factors such as drug use, credit and criminal history, and personal references may affect career opportunities. Second, the structure of the training programs should include: learning objectives; instructor qualifications; student requirements; a detailed syllabus; performance goals; periodic assessments; and competency testing. Third, program content can include a mix of discipline-specific and core elements. Core elements are essential topics that lay the foundation for entry into professional practice, regardless of the specialty area. They include the following:

- Standards of conduct—includes professional ethics training.
- Safety—includes biological, chemical, and physical hazards.
- Policy—includes such administrative and laboratory policies as standard operating procedures, quality assurance, accreditation, and security.
- Legal—includes expert testimony, depositions, rules of evidence, criminal and civil law and procedures, and evidence authentication.
- Evidence handling—includes interdisciplinary issues; recognition, collection, and preservation of evidence; and chain of custody.
- Communication—includes written, verbal, and nonverbal communication skills; report writing; exhibit and pretrial preparation; and trial presentation.

Discipline-specific elements include such topics as the history of the discipline, relevant literature, methodologies and validation studies, instru-

⁴⁷ NIJ, 2004, *op. cit.*

mentation, statistics, knowledge of related fields, and testimony. Finally, individuals should be assessed through mechanisms such as oral examinations, written examinations, laboratory practicals and laboratory exercises, mock trials, and the assessment of technical performance by appropriate senior staff.

EDUCATION IN THE LEGAL SYSTEM

The forensic science community needs to educate those who use their services and therefore needs to understand the services and their terminology. Users of forensic science analyses include law enforcement officers, forensic pathologists, the bar, the judiciary, the general public, and policymakers. This section focuses on education for the legal community of judges, lawyers, and juries.

In recent years, some judges have struggled to understand increasingly complex scientific evidence. Sophisticated epidemiology and toxicology studies often are introduced in mass tort litigation. Complex econometric models are common in antitrust cases. Disputes over sophisticated engineering principles often are at the core of patent litigation. Failure to consider such evidence in a thoughtful and thorough manner threatens the integrity and independence of the judiciary. Following the *Daubert* decision, the Federal Judicial Center published the *Reference Manual on Scientific Evidence*, and a second edition was issued in 2000 to "facilitate the process of identifying and narrowing issues concerning scientific evidence by outlining for judges the pivotal issues in the areas of science that are often subject to dispute."⁴⁸ In addition, the courts have responded to the growing complexity of evidence by developing science-based judicial education programs that explain scientific issues as they may arise in the context of litigation. However, these courses are not mandatory, there is no fixed routine of continuing education in legal practice with regard to science, and there are no good ways to measure the proficiency of judges who attend these programs.

Pfefferli suggests that it is important to tailor education programs to the needs of judges:

Forensic educational programs directed towards proficiency in evidence matter must meet the needs of judicial magistrates, which goes beyond a better understanding of the scientific principles and technical methods applied to criminal investigations to demonstrate the existence of a crime. These programs have to look at a variety of different kinds of forensic evidence and their interacting processes, giving special attention to individualization/identification process; evidential value and evaluation of

⁴⁸ Federal Judicial Center. 2000. *Reference Manual on Scientific Evidence*. 2nd ed., p. vi.

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evidence; critical issues and quality assurance, and deterministic versus probabilistic opinions of experts.”⁴⁹

Pfefferli further notes that different members of the judicial community should benefit from customized training. For example, prosecutors and defense attorneys might benefit from a focus on the interpretation of and requirements for evidence; and judges may benefit from information on evaluating the scientific rigor of expert testimony and the reliability of forensic evidence.

At the end of the 1990s, NIJ noted that training for the judiciary was sporadic at the federal, state, and local levels and rare in general.⁵⁰ Virginia is one state that provides annual seminars for the judiciary, and ASCLD formerly provided training to judges.

Reliance on DNA technology for identification purposes in forensic science spurred the development of judicial education programs. As part of the President’s DNA Initiative, the Department of Justice developed a series of publications and online training programs designed for officers of the courts, including judges. The course, “Principles of Forensic DNA for Officers of the Court,” released in 2006, is designed “to educate criminal justice professionals and other practitioners about the science of DNA analysis and the legal issues regarding the use of DNA in the courtroom.”⁵¹ The 15 training modules in the course include:

- information on the biology of DNA;
- the history of forensic DNA analysis;
- how to understand a forensic DNA laboratory report;
- factors in postconviction DNA testing requests;
- information about forensic DNA databases;
- issues involved in presenting DNA evidence in the courtroom;
- information on the admissibility issues regarding the use of DNA evidence; and
- an extensive glossary with basic definitions relating to forensic DNA analysis.

But other than this initiative, judicial education programs have not focused on the forensic science disciplines.

⁴⁹ P.W. Pfefferli. 2003. *Forensic Education & Training of Judges and Law Enforcement Magistrates*. Presentation at the International Society for the Reform of Criminal Law, 17th International Conference, The Hague. Available at www.isrcl.org/Papers/Pfefferli.pdf, p. 2.

⁵⁰ NIJ, 1999, op. cit.

⁵¹ Office of Justice Programs, U.S. Department of Justice. 2006. *Department of Justice Releases Interactive Training Tool on Principles of Forensic DNA*. Available at www.ojp.usdoj.gov/newsroom/pressreleases/2006/NIJ06036.htm.

Another avenue for education would be courses taught by forensic science education programs, but geared to continuing education participants rather than full-time students. The University of Florida, for example, offers a distance learning, continuing education course for Florida lawyers that is certified by the Florida Bar Association and that covers a variety of forensic science topics. Professional organizations also have offered courses. For example, the National District Attorneys Association founded the American Prosecutors Research Institute (APRI) as a nonprofit research, technical assistance, and program development resource for prosecutors at all levels of government. In the past, APRI has offered training opportunities in forensic science, although its programs have decreased in recent years. The National College of District Attorneys and the National Association of Criminal Defense Attorneys also periodically offer courses in forensic science. A third option is for law schools to offer more courses in the forensic disciplines, statistics, or basic science methodology, or to provide credit for students wishing to take courses in those fields.

Unfortunately, it might be too late to effectively train most lawyers and judges once they enter their professional fields. Training programs are beneficial in the short term, because they offer responsible jurists a way to learn what they need to know. For the long term, however, the best way to get lawyers and judges up to speed is for law schools to offer better courses in forensic science in their curricula.

Juries and Scientific Evidence

Despite common stereotypes about jury incompetence and runaway juries, research has demonstrated a consistency between jury and bench trial verdicts, regardless of the level of scientific complexity involved.⁵² Even in cases in which jurors express incomplete and flawed understandings of scientific and technical evidence, researchers have described jury results as generally justified.⁵³ Moreover, it has been suggested that jurors' errors in interpreting evidentiary information are often traceable in part to misleading presentations and instructions by attorneys and judges.⁵⁴

However, juries have been described as least comfortable and compe-

⁵² V.P. Hans, D.H. Kaye, M.B. Dann, E.J. Farley, and S. Albertson. 2007. *Science in the Jury Box: Jurors' Views and Understanding of Mitochondrial DNA Evidence*. Cornell Law School Legal Studies Research Paper No. 07-02. Available at <http://ssrn.com/abstract=1025582>; T. Eisenberg, P.L. Hannaford-Agor, V.P. Hans, N.L. Mott, G.T. Munsterman, S.J. Schwab, and M.T. Wells. 2005. Judge-jury agreement in criminal cases: A partial replication of Kalven & Zeisel's *The American Jury*. *Journal of Empirical Legal Studies* 2:171-206.

⁵³ Hans, *op. cit.*

⁵⁴ *Ibid.*

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tent with regard to statistical evidence.⁵⁵ Interestingly, juries are often hesitant to give as much credence as experts suggest to the statistics associated with DNA evidence.⁵⁶ Juries frequently raise concerns about laboratory error and sample contamination, even when opposing counsel does not introduce such issues.⁵⁷

Jurors' use and comprehension of forensic evidence is not well studied. Better understanding is needed in this area, and recommendations are needed for programs or methods that will better prepare juries in appropriate, unbiased ways for trials in which scientific evidence is expected to play a large or pivotal role. However, several studies indicate that trial judges agree with jury verdicts in an overwhelming proportion of criminal cases.⁵⁸

CONCLUSIONS AND RECOMMENDATION

Despite major strides made in recent years in bringing a measure of standardization to forensic science education programs and boosting their quality, more information is required on the number of programs that are available and the depth and breadth of the course offerings. It appears that there are no formal and systematically applied standards or standardization requirements for forensic science education programs, making the quality and relevance of existing programs uncertain. Moreover, there are no requirements or incentives in place to ensure that forensic science education programs must be accredited in order to receive federal funds.

Current funding is insufficient for developing graduate training programs that cut across organizational, programmatic, and disciplinary boundaries and that can attract students in the life and physical sciences to pursue graduate studies in multidisciplinary fields critical to forensic science. Similarly, too few funding sources exist for research conducted in association with forensic science graduate programs.

In addition, forensic researchers, legal scholars, and forensic practitioners and members of the bench and bar do not have sufficient opportuni-

⁵⁵ Ibid. See also W.C. Thompson and E.L. Schumann. 1987. Interpretation of statistical evidence in criminal trials: The prosecutor's fallacy and the defense attorney's fallacy. *Law and Human Behavior* 11:167-187; W.C. Thompson. 1989. Are juries competent to evaluate statistical evidence? *Law and Contemporary Problems* 52:9-41.

⁵⁶ J.J. Koehler. 2001. When are people persuaded by DNA match statistics? *Law and Human Behavior* 25:493-513; D.A. Nance and S.B. Morris. 2002. An empirical assessment of presentation formats for trace evidence with a relatively large and quantifiable random match probability. *Jurimetrics Journal* 42:403-448; J. Schklar and S.S. Diamond. 1999. Juror Understanding of DNA evidence: An empirical assessment of presentation formats for trace evidence with a relatively small random-match probability. *Journal of Legal Studies* 34:395-444.

⁵⁷ Schklar and Diamond, op. cit.

⁵⁸ Hannaford-Agor, Hans, and Munsterman, op. cit.

ties and venues for interaction and sharing information. This impedes the translation of advances in forensic science to legal scholars and litigators (including civil litigators, prosecutors, and criminal defense counsel), federal, state, and local legislators, members of the judiciary, and law enforcement officials. The result is needless delay in improvements in criminal and civil laws and procedures, law enforcement practices, litigation strategies, and judicial decisionmaking.

Lawyers and judges often have insufficient training and background in scientific methods, and they often fail to fully comprehend the approaches employed by different forensic science disciplines and the strengths and vulnerabilities of forensic science evidence offered during trials.

Forensic science examiners need additional training in the principles, practices, and contexts of scientific methodology, as well as in the distinctive features of their specialty. Training should move well beyond intern-like transmittal of practices to teaching that is based on scientifically valid principles. In addition to the practical experience and learning acquired during an internship, a trainee should acquire rigorous interdisciplinary education and training in the scientific areas that constitute the basis for the particular forensic discipline and should also receive instruction on how to document and report the analysis. A trainee in addition should have working knowledge of basic probability and statistics as they relate to the tasks he or she may need to address in the applicable discipline.

To correct some of the existing deficiencies, it is crucially important to improve undergraduate and graduate forensic science programs. The legitimization of practices in the forensic science disciplines must be based on established scientific knowledge, principles, and practices, which are best learned through formal education. Apprenticeship has a secondary role; under no circumstances can it supplant the need for the scientific basis of education and of the practice of forensic science. In addition, lawyers and judges often have insufficient training and background in scientific methodology, and they often fail to fully comprehend the approaches employed by different forensic science disciplines and the degree of reliability of forensic science evidence that is offered in trial. Such training is essential, because any checklist for the admissibility of scientific or technical testimony (such as the *Daubert* standards) is imperfect. Conformance with items on a checklist can suggest that testimony is reliable, but it does not guarantee it. Better connections must be established and promoted among experts in forensic science and legal scholars and practitioners. The fruits of any advances in the forensic science disciplines should be transferred directly to legal scholars and practitioners (including civil litigators, prosecutors, and criminal defense counsel), federal, state, and local legislators, members of the judiciary, and law enforcement officials, so that appropriate adjustments can be made in criminal and civil laws and procedures, model jury

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instructions, law enforcement practices, litigation strategies, and judicial decisionmaking. Law schools should enhance this connection by offering courses in forensic science, by offering credit for forensic science courses students take in other colleges, and by developing joint degree programs.

Recommendation 10:

To attract students in the physical and life sciences to pursue graduate studies in multidisciplinary fields critical to forensic science practice, Congress should authorize and appropriate funds to the National Institute of Forensic Science (NIFS) to work with appropriate organizations and educational institutions to improve and develop graduate education programs designed to cut across organizational, programmatic, and disciplinary boundaries. To make these programs appealing to potential students, they must include attractive scholarship and fellowship offerings. Emphasis should be placed on developing and improving research methods and methodologies applicable to forensic science practice and on funding research programs to attract research universities and students in fields relevant to forensic science. NIFS should also support law school administrators and judicial education organizations in establishing continuing legal education programs for law students, practitioners, and judges.

9

Medical Examiner and Coroner Systems: Current and Future Needs

The role of coroner emerged in England in the ninth or tenth century. In the twelfth century, under King Richard I, the role of coroner was formalized in the Articles of Eyre.¹ Coroners or “crowners” were “guardians of the crown’s pleas.” The office originally was created to provide a local official whose primary duty was to protect the financial interest of the crown in criminal proceedings. On behalf of the crown, the crowner was responsible for inquests to confirm the identity of the deceased, determine the cause and manner of death, confiscate property, collect death duties, and investigate treasure troves. Through the implementation of British Common Law, settlers in North America brought coroner laws to the early colonies.² Moreover, early state constitutions explicitly mentioned the position of coroner, often without defining the role.³ Georgia’s state constitution was the first. Article XL stated that, “[i]n the absence of the chief justice, the senior justice on the bench shall act as chief justice with the clerk of the county, attorney for the State, sheriff, coroner, constable, and the jurors.”⁴

The first formal acknowledgment of the need for medical training for coroners occurred in 1860, when Maryland passed legislation allowing coroners to require that a physician be present at an inquest. In 1877, Massachusetts became the first state to replace its coroners with medical

¹ Institute of Medicine (IOM). 2003. *Medicolegal Death Investigation System: Workshop Summary*. Washington, DC: The National Academies Press, p. 8.

² Ibid.

³ Ibid.

⁴ GA. CONST. of 1777, art. XL.

examiners, who were required to be physicians. Physician medical examiners began performing autopsies for coroners in Baltimore in 1890. In 1918, New York City instituted a medical examiner system.⁵

The National Academy of Sciences first addressed the state of death investigation in 1928. The National Research Council's (NRC's) Committee on Medical Legal Problems, whose members included Roscoe Pound, Dean of Harvard Law School, and John Henry Wigmore, Dean of Northwestern Law School, released a harshly critical report entitled *The Coroner and the Medical Examiner*.⁶ In its first four recommendations, the 1928 committee suggested the following: (1) that the office of coroner be abolished. It is an anachronistic institution which has conclusively demonstrated its incapacity to perform the functions customarily required of it; (2) that the medical duties of the coroner's office be vested in the office of medical examiner; (3) that the office of medical examiner be headed by a scientifically trained and competent pathologist, selected and retained under civil service, and compensated by a salary which will attract men of genuine scientific training and ability; and (4) that the office of medical examiner be provided with the services of a staff competent in toxicology, bacteriology and other sciences necessary in the scientific investigation of causes of death, and with adequate scientific equipment. . . .⁷

Additionally, the 1928 committee recommended the development of medicolegal institutes, which would affiliate medical examiners with hospitals and universities.⁸ In 1932, another NRC committee produced a review of existing medicolegal collaborations, which were mostly located in Europe.⁹ This committee again advised a larger role for medical doctors within forensic science and criminal proceedings.¹⁰

In 1954, the National Conference of Commissioners on Uniform State Laws issued the Model Post-Mortem Examinations Act (the Model Act).¹¹ In its prefatory note, the Model Act stated the following:

The purpose of the Post-Mortem Examinations Act is to provide a means whereby greater competence can be assured in determining causes of death where criminal liability may be involved. Experience has shown that many

⁵ IOM, 2003, op. cit.

⁶ Bulletin of the National Research Council, No. 64. 1928. *The Coroner and the Medical Examiner*. Washington, DC: National Research Council.

⁷ Ibid., p. 89.

⁸ Ibid., p. 90.

⁹ Bulletin of the National Research Council, No. 87. 1932. *Possibilities and Need for Development of Legal Medicine in the United States*. Washington, DC: National Research Council.

¹⁰ Ibid., pp. 111-112.

¹¹ The model act has been posted by the National Association of Medical Examiners (NAME) at http://thename.org/index.php?option=com_content&task=view&id=97&Itemid=41.

elected coroners are not well trained in the field of pathology, and the Act should set up in each state an Office headed by a trained pathologist, this Office to have jurisdiction over post-mortem examinations for criminal purposes. The Office would supersede the authority of Coroner's Offices in this field.¹²

Following the release of the Model Act, a number of states implemented the proposed guidelines. Between 1960 and 1979, 12 states converted from coroners to medical examiners.¹³ However, in the subsequent decades, updates to death investigation organizations slowed considerably. Between 1980 and 1999, only three states converted from coroner to medical examiner systems.¹⁴ Since then, 11 states with coroners have remained unchanged, and only a handful of individual counties have independently implemented recommendations from the Model Act.¹⁵ Several of the remaining coroner states have provisions in their state constitutions requiring that coroners be elected.¹⁶ Although these provisions may be amended or removed, to do so will require political momentum. However, these provisions do not prohibit the addition of appointed medical examiners. For example, Kentucky has maintained county coroners, as dictated by its constitution, while also implementing medical examiners to serve at the state and district levels.¹⁷

MEDICAL EXAMINERS AND CORONERS (ME/C)

About 2,342 medical examiner and coroner offices provided death investigation services across the United States in 2004.¹⁸ Individual state statutes determine whether a medical examiner or coroner delivers death investigation services, which include death scene investigations, medical investigations, reviews of medical records, medicolegal autopsies, determination of the cause and manner of death, and completion of the certificate of death.

¹² Ibid.

¹³ Hanzlick, 2003, op. cit.

¹⁴ Ibid.

¹⁵ Ibid.

¹⁶ ARK. CONST. art. VII, § 46; COLO. CONST. art. XIV, § 8; IDAHO CONST. art. XVIII, § 6; IND. CONST. art. VI, § 2; MISS. CONST. ANN. art. V, § 135.

¹⁷ KY. CONST. § 99; KY. REV. STAT. ANN § 72.210 (2007).

¹⁸ Hanzlick, 2007, op. cit. The Bureau of Justice Statistics omits Louisiana and classifies Texas as a medical examiner state, and accordingly reports the total as 1,998. According to Hanzlick, many of Texas's 254 counties maintain justice of the peace/coroner's offices.

ME/C JURISDICTION

ME/C jurisdiction is determined by each state code and generally extends to deaths that are sudden and unexpected, deaths that have no attending physician, and all suspicious and violent deaths. The actual classes of death over which the ME/C assumes jurisdiction vary from state to state. Classes may include deaths resulting from injury, such as by violence or poisoning; by circumstance, such as related to fire or under anesthesia; by decedent status, such as prisoners or mental health patients; or by time-frame, such as deaths that occur within 24 hours of admission to a hospital. About 1 percent of the U.S. population (about 2.6 million people) dies each year. In 2004, ME/C offices received nearly 1 million reports of deaths, constituting between 30 to 40 percent of all U.S. deaths, and accepted about one half of those (500,000, or 1 in 6 deaths) for further investigation and certification.¹⁹ Depending on the jurisdiction, about 40 to 50 percent of deaths referred to the ME/C will, after investigation and examination, be attributed to natural causes, 27 to 40 percent to accident, 12 to 15 percent to suicide, 7 to 10 percent to homicide, and 1 percent as undetermined.²⁰

ME/C MISSIONS

ME/Cs serve dual purposes. First, they serve the criminal justice system as medical detectives by identifying and documenting pathologic findings in suspicious or violent deaths and testifying in courts as expert medical witnesses. Second, as public health officers, they surveil for index cases of infection or toxicity that may herald biological or chemical terrorism, identify diseases with epidemic potential, and document injury trends.

Additional ME/C responsibilities include the response to and investigation of all deaths resulting from all hazards, including terrorism and mass fatality events, and the identification of the unidentified dead. In addition, some 13,000 unidentified individuals are currently entered into databases for the unidentified dead, and many thousands more are entered as missing persons, as thousands of families search for them. Accessing these databases and matching them to the many thousands of individuals entered as missing persons is a major challenge for all organizations. Eighty percent of surveyed ME/C systems "rarely or never" utilize the National Crime Information Center Unidentified and Missing Persons (NCIC UP/MP) files to match their dead bodies to those reported as missing by law enforcement

¹⁹ J.M. Hickman, K.A. Hughes, K.J. Strom, and J.D. Roper-Miller. 2004. *Medical Examiners and Coroners' Offices, 2004*. U.S. Department of Justice, Bureau of Justice Statistics Special Report NCJ216756.

²⁰ *Office of the Chief Medical Examiner's Annual Report: 2006*. Available at www.vdh.state.va.us/medExam/Reports.htm.

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agencies, even though NCIC recently granted access to the files by ME/Cs. Access, however, is not uniform, and the information that may be available could be limited.²¹

The newly established National Institute of Justice (NIJ) Office of Justice Programs, National Missing and Unidentified Persons System, NamUs, remains underutilized. Identification efforts for either of the national government databases require multiple investigative as well as data entry skills, and they are labor intensive. ME/Cs need a functional death investigation system; staff to develop identification features; and the necessary education, training, and equipment to utilize the multiple databases that are necessary to identify the unidentified dead and to meet the increasing societal expectations that ME/C systems should be able to identify the unidentified.²² Critically needed is a federal requirement that ME/C systems enter information on the unidentified into federal databases. A later section in this report discusses the medical examiner/coroner role in homeland security.

VARIATIONS IN ME/C SYSTEMS

As of 2004, administratively, 16 states had a centralized statewide medical examiner system, 14 had a county coroner system, 7 had a county medical examiner system, and 13 had a mixed county ME/C system.²³ Eight states had hybrid arrangements, with coroners and a state medical examiner office that performed medicolegal duties. The District of Columbia relies on a medical examiner system (see Figure 9-1). In large cities and counties, forensic pathologists serve both as medical examiners and pathologists. A few large systems, such as those of Los Angeles, California, and Cuyahoga County, Ohio, bear the historical name of a coroner system, but function essentially under a medical examiner structure. Eighty percent of ME/C offices are run by county coroners.

In total, there are approximately 2,342 separate death investigation jurisdictions.²⁴ Of 1,590 coroner offices in the United States, 82 serve jurisdictions with more than 250,000 people; 660 medium-sized offices serve between 25,000 and 249,999 people; and 848 offices serve small jurisdictions

²¹ J.C.U. Downs, Board Member and Chair, Governmental Affairs Committee, National Association of Medical Examiners; Vice Chair, Consortium of Forensic Science Organizations; Coastal Regional Medical Examiner, Georgia Bureau of Investigation. Presentation to the committee. June 5, 2007.

²² National Missing and Unidentified Persons System, NamUS. See www.namus.gov.

²³ Downs, *op. cit.*

²⁴ R. Hanzlick. "An Overview of Medical Examiner/Coroner Systems in the United States—Development, Current Status, Issues, and Needs." Presentation to the committee. June 5, 2007.

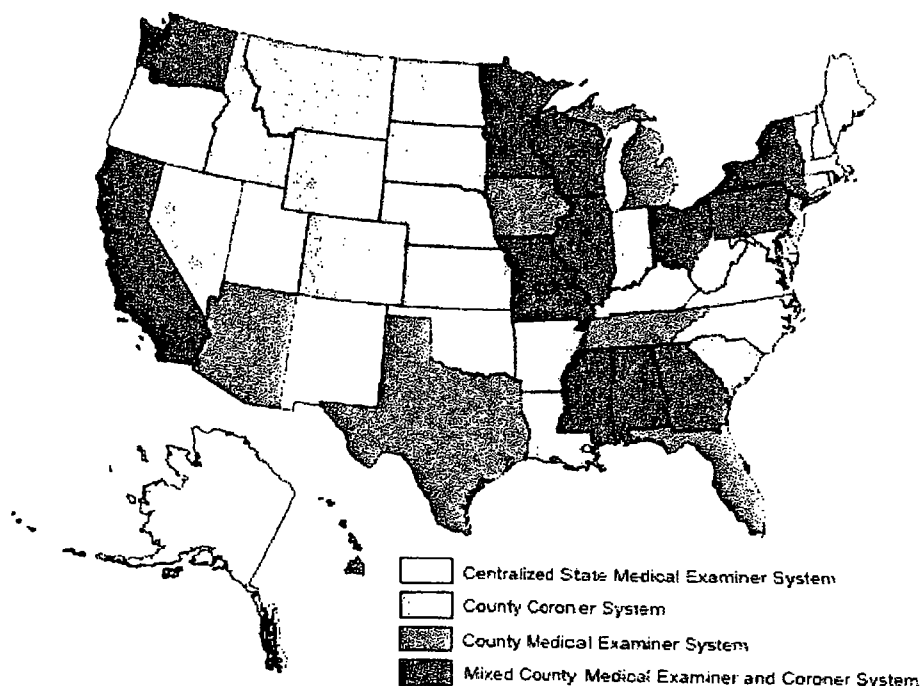


FIGURE 9-1 Death investigation systems in the United States, 2004.

SOURCE: J.M. Hickman, K.A. Hughes, K.J. Strom, and J.D. Roper-Miller. 2004. Medical Examiners and Coroners' Offices, 2004. U.S. Department of Justice, Bureau of Justice Statistics Special Report NCJ216756. (In 2007, Kentucky became legally a mixed county ME/C system.^a)

^a Constitution of the State of Kentucky, § 99.

of fewer than 25,000 people.²⁵ The hodgepodge and multiplicity of systems and controlling statutes makes standardization of performance difficult, if not impossible. Some observers believe that a revisiting of the model code is required, as has been proposed by numerous study groups over the years, in order to work toward the development of a modern model code for death investigation systems that utilizes new and available technologies that are responsive to the needs of the citizens.²⁶

²⁵ Ibid.

²⁶ Ibid.

QUALIFICATIONS OF CORONERS AND MEDICAL EXAMINERS

Jurisdictions vary in terms of the required qualifications, skills, and activities for death investigators. Coroners are constitutional officers, with 82 percent being elected and 18 percent appointed.²⁷ Coroners as elected officials fulfill requirements for residency, minimum age, and any other qualifications required by statute. They may or may not be physicians, may or may not have medical training, and may or may not perform autopsies (see Box 9-1). Some serve as administrators of death investigation systems, while others are responsible solely for decisions regarding the cause and manner of death. Typical qualifications for election as a coroner include being a registered voter, attaining a minimum age requirement ranging from 18 to 25 years, being free of felony convictions, and completing a training program, which can be of varying length. The selection pool is local and small (because work is inconvenient and pay is relatively low), and medical training is not always a requirement. Coroners are independent of law enforcement and other agencies, but as elected officials they must be responsive to the public, and this may lead to difficulty in making unpopular determinations of the cause and manner of death.

Recently a 17-year-old high school senior successfully completed the coroner's examination and was appointed a deputy coroner in an Indiana jurisdiction.²⁸ In one state, justices of the peace are charged with determining cause and manner of death, but they are not medical death investigators. Whether coroners refer cases to pathologists for autopsy is largely budget driven (an autopsy costs about \$2,000), although access to pathologists may be an issue if regional interjurisdictional arrangements do not exist. Even so, 84 percent of coroner offices see a need for professional standards,²⁹ and they identify resources for infrastructure, staff, and training as continuing needs.

Options for improving death investigation by coroners include (1) replacing coroner systems with medical examiner systems; (2) increasing the statutory requirements for performance of coroners; or (3) infusing funding to improve the capabilities of coroners.³⁰

Some coroners have suggested establishing a "Coroner College."³¹ Coroners want grants for equipment, accreditation incentives, and access to forensic laboratories, NCIC, and automated fingerprint identification

²⁷ P.M. Murphy, Coroner, Clark County Coroner's Office, Las Vegas, Nevada. "The Coroner System." Presentation to the committee. June 5, 2007.

²⁸ "Teen Becomes Indiana's Youngest Coroner." See <http://happynews.com/news/5122007/teen-becomes-indiana-youngest-coroner.htm>.

²⁹ Murphy, op. cit.

³⁰ Ibid.

³¹ Ibid.

Box 9-1
What Is an Autopsy?

An autopsy is the systematic external and internal examination of a body to establish the presence or absence of disease by gross and microscopic examination of body tissues. The pathologist makes a surgical incision from shoulder to shoulder and from the midpoint of the shoulder to shoulder incision to the pubic bone. The skin is reflected, and each organ in the chest, including the neck structures, abdomen, and pelvis is removed and carefully examined. An incision is also made from the mastoid bone on the right to the mastoid bone on the left, and the scalp is pulled forward and the bony cap removed to reveal the brain. The brain is removed and examined. The pathologist takes a small sample or biopsy of all tissues and archives them in formalin to maintain them for future reference. In medicolegal autopsies, all tissues other than the biopsies are replaced in the body, except for perhaps the brain or heart, which may be retained and examined by consultants for diagnoses causing or contributing to death. For hospital autopsies, depending on the list of permissions given by the person qualified to give permission, tissues and organs may be retained for study, research, or other investigations. The pathologist submits small 2 x 2 cm sections of tissue to the histology laboratory, where thin slices a few microns thick are subjected to chemical treatment to preserve them. The tissue blocks are shaved, so that a thin layer can be mounted on a glass slide and stained with dyes to differentiate cells. The pathologist can recognize diseases in the stained tissue. Medicolegal autopsies are conducted to determine the cause of death; assist with the determination of the manner of death as natural, suicide, homicide, or accident; collect medical evidence that may be useful for public health or the courts; and develop information that may be useful for reconstructing how the person received a fatal injury.

systems.³² Lack of direct access to laboratories and insufficient funding for testing impair the expertise of coroners. Some coroners are amenable to protocols that would ensure the use of forensic pathologists for autopsy. However, even with these improvements, the assessment of the dead for disease, injury, medical history, and laboratory studies is a medical decision, as opposed to a decision that would be made by a lay person with investigative and some medical training. The disconnect between the determination a medical professional may make regarding the cause and manner of death and what the coroner may independently decide and certify as the cause and manner of death remains the weakest link in the process.

In contrast, medical examiners are almost always physicians, are appointed, and are often pathologists or forensic pathologists. They bring

³² Murphy, *op. cit.*

the body of knowledge of medicine to bear when assessing the history and physical findings and when deciding on the appropriate laboratory studies needed to determine the cause and manner of death. In statewide systems, cities and counties have local medical examiners that are physicians trained to receive the reports of death, decide jurisdiction, examine the body, and make a determination of the cause and manner of death. They certify locally many obvious natural and accidental deaths. In statewide and regionalized statewide systems, local medical examiners do not need to be forensic pathologists and do not perform autopsies, but they do refer, according to protocols, deaths from violence—particularly suicides, homicides, and deaths occurring under suspicious circumstances—to a central or regional autopsy facility for autopsy and further follow-up by a forensic pathologist. In hybrid or mixed state systems, coroners may refer cases for autopsy to forensic pathologists, but there is no supervision or quality assurance to ensure that the coroner's certification of the cause of death and manner of death is concordant with the pathologist's conclusions.

ME/C ADMINISTRATION AND OVERSIGHT

ME/Cs have varying forms of organizational oversight. Forty-three percent of the U.S. population is served by systems that are independent, 33 percent by offices residing administratively in public safety or law enforcement organizations, 14 percent by offices in health departments, and 10 percent by offices within a forensic laboratory. Government reports over the years have recommended that a medical examiner system should be an independent agency or should report to a commission so that it avoids any conflicts of interest and so that it reports directly to the jurisdictional governing body. When this is not possible, incorporation into a health department, instead of into law enforcement agencies, seems to provide the next most compatible location.³³

ME/C STAFFING AND FUNDING

ME/C offices serving populations of less than 25,000 people employ 1 to 2 full-time equivalent (FTE) staff members, while offices serving populations of 1 million or more employ an average of 50 FTEs.³⁴ Competent death investigations require that trained medical death investigators attend scenes; medically credentialed persons perform external physical examinations; and forensic pathologists perform medicolegal autopsies, employ and

³³ V. Weedn. "Legal Impediment to Adequate Medicolegal Death Investigation." Presentation to the committee. June 5, 2007.

³⁴ Downs, *op. cit.*

interpret radiographs, prepare records, maintain databases, and provide competent and credible testimony in courts. Staff requires training and expensive equipment to utilize and integrate new technologies. Efforts are restricted by budgets, and budgets vary widely, ranging from \$18,000 to \$2.5 million annually for county systems, depending on the size of the population. A 2007 survey conducted for the National Association of Medical Examiners (NAME) by Hanzlick revealed that county systems' per capita cost ranged from \$1.31 to \$9.19, with a mean of \$2.89. State systems benefit from economies of scale and function more economically at \$.64 to \$2.81, with a mean of \$1.76.³⁵ The large variation in qualifications, staffing, budgets, and the multiple skills required for competent death investigations, especially in small jurisdictions, has resulted in marked variation in the quantity and quality of death investigations in the United States.

Physical facilities also vary in adequacy. Only one-third of offices have in-house facilities to perform the histology needed to make microscopic diagnoses on tissues sampled at autopsy. Only one-third have in-house toxicology capabilities to identify drugs present in the deceased that either contributed to or were the primary cause of death. One-third do not have radiology services in-house that would allow the identification of missiles, disease, bony injury or identification features in decedents.³⁶ Some coroner systems do not have any physical facility at all.

It is clear that death investigations in the United States rely on a patchwork of coroners and medical examiners and that these vary greatly in the budgets, staff, equipment, and training available to them, and in the quality of services they provide. No matter what the level of quality of other forensic science disciplines that are supported by a particular jurisdiction may be, if the death investigation does not include competent death investigation and forensic pathology services, both civil and criminal cases may be compromised.

All ME/Cs share the following deficiencies to some degree:

- imperfect legal structure/code controlling death investigations;
- inadequate expertise to investigate and medically assess decedents;
- inadequate resources to perform competent death investigations;
- inadequate facilities and equipment for carrying out body views and conducting autopsies;
- inadequate technical infrastructure (laboratory support);
- inadequate training of personnel in the forensic science disciplines;

³⁵ R. Hanzlick. "An Overview of Medical Examiner/Coroner Systems in the United States—Development, Current Status, Issues, and Needs." Presentation to the committee. June 5, 2007.

³⁶ Murphy, *op. cit.*

- lack of best practices and information standards;
- lack of quality measures and controls;
- lack of information systems; and
- lack of translational research and associations with university research.³⁷

THE MOVEMENT TO CONVERT CORONER SYSTEMS TO MEDICAL EXAMINER SYSTEMS

As mentioned above, the movement to improve death investigations by bringing in medical expertise in the form of medical examiner systems is not new. Early NRC reports were followed in 2003 by an Institute of Medicine Workshop on the Medicolegal Death Investigation System, which also concluded that the medical examiner system is the best organizational structure for utilizing medical expertise to assess the presence or absence of disease and injury and for correlating the medical findings and investigative information to arrive at a determination of cause of death and manner of death. Progress has been very slow.

Additional impediments to progress include the need for some states to change state constitutions or codes, the political constituent base underpinning local coroners, insufficient population and budget to support a competent independent system in small localities, an unwillingness to develop cooperative regionalization for provision of autopsy services, the shortage of physicians—especially pathologists and forensic pathologists—and lack of interest, advocacy, or the perception of need.³⁸ To implement such conversions, the United States will require a national vision, a model code, increased numbers of forensic pathologists, and funding for infrastructure, staff, education, training, and equipment.

One possible model for providing incentives for these conversions could be an initiative similar to the Law Enforcement Assistance Administration (LEAA). LEAA was a federal agency operating from 1968 to 1982 with the purpose of funneling federal funding to state and local law enforcement agencies. The agency created state planning agencies and funded educational programs, research, and matching grants for physical plants and a variety of local crime control initiatives. For example, an \$8 million grant to Virginia established the Virginia Department of Forensic Science, a premier state forensic laboratory that provides forensic science services to all state agencies and the Medical Examiner System in Virginia.³⁹ If

³⁷ Downs, *op. cit.*

³⁸ Downs, *op. cit.*; Weedn, *op. cit.*; Hanzlick, *op. cit.*

³⁹ Law Enforcement Assistance Administration at www.archives.gov/research/guide-fed-records/groups/423.html.

the capitalization of a medical examiner system is the major impediment to progress, an LEAA model can remove that barrier. However, a Medical Examiner Assistance Administration, or MEAA, would need to be structured so that the medical examiner would not be considered a servant of law enforcement and thus would not be placed in a position in which there is even an appearance of conflict of interest. Sensitive cases, such as police shootings and police-encounter deaths, jail and prison deaths, deaths in public institutions, and others, require an unbiased death investigation that is clearly independent of law enforcement. All previous studies have recommended that the medical examiner be independent of other agencies, or if they are to be under the umbrella of a central agency that the reporting chain should be through a health department. The medical examiner is first and foremost a physician, whose education, training, and experience is in the application of the body of medicine to situations that have a legal dimension that must be answered by a practitioner of medicine.

UTILIZATION OF BEST PRACTICES

The tremendous variation in death investigation systems also impedes interagency and interjurisdictional communication and the development of standardized best practices both in death investigation and in the performance of medicolegal autopsies.

NIJ and NAME have attempted to provide guidance for best practices. The NIJ document *Death Investigation: A Guide for the Scene Investigator*; *Medicolegal Death Investigator: A Systematic Training Program for the Professional Death Investigator*; the NAME Autopsy Standards and Inspection Checklist; and NAME's Forensic Pathology Autopsy Standards are available, but there is no incentive for death investigation systems to adopt them for use.⁴⁰

Compliance is further limited because of heavy case loads, deficiencies in trained staff, absence of equipment, nonavailability of required day-to-day and consultative services, and the presence of contradictory policies and practices.

⁴⁰ U.S. Department of Justice, Office of Justice Programs, National Institute of Justice. *Death Investigation: A Guide for the Scene Investigator*. Available at www.ojp.usdoj.gov; S.C. Clark, M.F. Ernst, W.D. Haglund, and J.M. Jentzen. 1996. *Medicolegal Death Investigator: A Systematic Training Program for the Professional Death Investigator*. Occupational Research and Assessment. Grand Rapids; NAME Autopsy Standards and Inspection Checklist at www.thename.org; and G. Peterson and S. Clark. 2006. *Forensic Autopsy Performance Standards* at www.thename.org.

POTENTIAL SCIENTIFIC ADVANCES THAT MAY ASSIST ME/CS

In addition to current technologies, which are often unavailable and underutilized, new technologies are on the horizon to assist death investigators, medical examiners, and forensic pathologists.

Computerization of case records and the development of case information databases should be standard in any death investigation office, so that death data may be tracked for trends, response to public health and public safety interventions can be streamlined and accelerated, and continuing quality assurance measures can be implemented. There is no standard method of sample and data collection for ME/C systems. Multiple systems are commercially available that can be structured to meet the particular needs of any death investigation system. The initial cost of such systems is significant, and they require continuing maintenance, which rules out their utilization by small and/or underfunded offices. Even if such computer systems were present in each office, there is no standardization that would allow them to talk to one another, a necessity in a multijurisdictional event such as the Hurricane Katrina disaster, for which databases across states were critical to the identification of the dead and the tracking of survivors.

Laboratory information systems are available for the management of medical evidence, laboratory specimens, laboratory data, forensic samples, and personal effects. Effective database management allows information to be gathered and utilized by staff and analyzed for trends and quality issues. Effective databases are essential for managing any multiple fatality event. Rapid electronic transmission of reports is feasible if encryption software is available. At this time, ME/C information systems are less interoperable than current Automated Fingerprint Identification Systems (see Chapter 10). Although the standard autopsy report generally covers the internal examination by organ systems, reporting formats are not standardized among jurisdictions. And, although the NAME Forensic Autopsy Performance Standards provide a model for reporting autopsy findings,⁴¹ it is not widely used.

Imaging equipment is critical to documenting findings sufficient for courts, for review by outside experts, and for reevaluation as medical knowledge advances. Fluoroscopy is helpful for locating missiles. Computed tomography scanning and nuclear magnetic resonance imaging may often present a better visual picture of some injuries and would likely reduce the number of autopsies carried out to rule out occult injury and to document in greater detail the extent of injury in accidents. The "Virtual

⁴¹ G. Peterson and S. Clark. 2006. Forensic Autopsy Performance Standards. Available at www.thename.org.

Autopsy," or "virtopsy," utilizes multislice computed tomography and magnetic resonance imaging combined with 3-D imaging technology to create vivid images of the interior of the human body.⁴²

The advantages of the virtopsy are that it is not invasive or destructive of tissue and can provide dramatic pictures of skeletal and soft tissue injury. It also provides some information when there is a religious objection to autopsy. Virtopsy has the potential to detect internal bleeding, missile paths, bone and missile fragmentation, fracture patterns, brain contusion, and gas embolism, in addition to occult fractures that are technically difficult to demonstrate during the traditional autopsy. Although a standard forensic autopsy is needed to recover evidence such as bullets or bomb fragments within the body and to collect specimens for testing, virtopsy offers a valuable tool for examination when dissection of the body is not feasible, when evidence is hard to visualize, or when a more complete assessment of injury is desired in noncriminal cases. For example, instead of a simple external examination for an obviously lethal injury in a vehicular violence death, virtopsy would permit more extensive cataloging of the injury to help automotive engineers design safer vehicles. The same technology can enhance bite mark impressions and some patterned injuries. Only a few ME/Cs have access to virtopsy at this time, and very few have the budget to purchase the expensive equipment or to build a suitable facility and staff and maintain it.

Scanning electron microscopy is not new but few ME/Cs have access to it to assist in identifying the metal conductor(s) in electrocution injuries, gunpowder residues in gunshot injuries, and other trace metals on skin or in tissues.

The anthrax bioterrorism attack that occurred in Connecticut, Maryland, New York, Virginia, and Washington, DC, highlighted the need to have biosafety capability for autopsy facilities. Currently, most autopsy facilities are 20 years old, on average, and are outdated in physical plant, technology, and biosafety capability. One-third of them lack design/airflow control of pathogens, and most function at biosafety level 2 rather than level 3.⁴³ Upgrading facilities to handle the potential biohazards associated with bioterrorism will require a massive infusion of funds that localities currently are unable or unwilling to provide. Laboratory safety in an era in which bioterrorism is a real threat remains an ongoing issue.

In-house toxicology services utilizing state-of-the-art equipment are essential for identifying drugs, intoxicants, and poisons and for detecting unsuspected homicides, suicides, and child and elder abuse. Yet only 37

⁴² See www.nlm.nih.gov/visibleproofs/galleries/technologies/virtopsy.html.

⁴³ Downs, *op. cit.*

percent of systems have in-house toxicology capabilities.⁴⁴ The cost for complete toxicology utilizing private sector laboratories for cases is high, resulting in insufficient toxicology screening and minimal testing on cases even when they are clearly indicated.

Molecular diagnosis conducted on blood and tissue samples is routine in hospital laboratories to diagnose disease. Investigations of unexplained sudden deaths, especially in young people and infants, would benefit from greater access to molecular diagnostics. Molecular diagnostic procedures are available, but most ME/C offices cannot afford to conduct these procedures and do not have the medical expertise to request them or the skills to interpret them. For example, testing for inborn errors of metabolism should be a part of any examination of the unexpected death of an infant or toddler, and testing for long QT syndrome is important in determining the cause of cardiac death in young people or in those whose family pedigree discloses other sudden unexpected deaths. Molecular testing is available for the etiology of multiple causes of sudden cardiac death, including abnormalities in ion channels in cell membranes or channelopathies, hypertrophic cardiomyopathy, long QT syndrome, Marfan syndrome, right ventricular cardiomyopathy, dilated cardiomyopathy, and Ehlers-Danlos syndrome.⁴⁵

Some testing can be carried out on a dried blood sample long after death has occurred.⁴⁶ Some molecular diseases are heritable, and it could be argued that the ME/C has a duty to identify these diseases and alert families about their presence. Many medical examiner offices archive a card with a dried blood sample on decedents, primarily to document personal identification, should the need arise, but also for future study. In the future, kin may request the archived blood cards, as the molecular diagnosis of disease improves and families seek to identify their risk. Thus, ME/Cs need education and training in and access to the specialized laboratory testing available to establish the molecular basis of disease and of sudden unexpected natural death.

⁴⁴ Ibid.

⁴⁵ S.E. Lehnart, M.J. Ackerman, D.W. Benson, R. Brugada, C.E. Clancy, J.K. Donahue, A.L. George, A.O. Grant, S.C. Groft, C.T. January, D.A. Lathrop, W.J. Lederer, J.C. Makielski, P.J. Mohler, A. Moss, J.M. Nerbonne, Y.M. Olson, D.A. Przywara, J.A. Towbin, L.H. Wang, A.R. Marks. Inherited arrhythmias: a National Heart, Lung, and Blood Institute and Office of Rare Diseases workshop consensus report about the diagnosis, phenotyping, molecular mechanisms, and therapeutic approaches for primary cardiomyopathies of gene mutations affecting ion channel function. *Circulation* 13;116(20):2325-2345.

⁴⁶ Personal communication between M.J. Ackerman and Marcella Fierro. June 16, 2008.

THE SHORTAGE OF MEDICAL EXAMINERS AND FORENSIC PATHOLOGISTS

Medical examiners are physicians who are appointed and charged with determining the cause and manner of death. In some states, medical examiners are forensic pathologists, while in other statewide systems, local, city, and county medical examiners are physicians but do not need to be forensic pathologists. They receive death investigation training and are responsible for examining bodies that do not require medicolegal autopsy and, according to system guidelines, for referring cases that need autopsy to regional offices where forensic pathologists perform the examinations and initiate further investigation as needed. Well-trained local medical examiners keep costs in line by reducing transportation costs to regional or central offices and are more accessible than pathologists in distant offices. Changes in the delivery of health care, increased patient caseloads, the inconvenience of attending scenes, the need for before and after hours examination of decedents, and the level of remuneration have made it difficult for statewide systems to recruit busy physicians to serve as community or local medical examiners. If this trend continues, systems will rely more heavily on lay medical death investigators and will need to develop training programs that assure competency.

Forensic pathology is the subspecialty of medicine devoted to the investigation and physical examination of persons who die a sudden, unexpected, suspicious, or violent death. Forensic pathology derives its name from "forensis" (public), or pertaining to the forum, and "pathos" (suffering), referring to pathos or suffering. The term ultimately evolved to encompass the study of deaths due to injury and disease and of deaths that are of interest to the legal "forum." Forensic pathologists are physicians who have completed, at a minimum, four years of medical school and three to four years of medical specialty training in anatomical pathology or anatomical and clinical pathology, followed by an accredited fellowship year in forensic pathology. They are certified by examination and assessment of their credentials by the American Board of Pathology in, at a minimum, anatomical pathology, and by subspecialty examination, as having special competence in forensic pathology.

As of 2008, approximately 38 forensic pathology residency programs accredited by the Accreditation Council for Graduate Medical Education sponsored approximately 70 training fellowships. Some positions are unfunded, and others did not find suitable candidates. Forty-two candidates were certified in forensic pathology by the American Board of Pathology in January 2008. Pathologists must recertify by examination every 10 years to maintain their certifications, in addition to maintaining a professional license in the state in which they are practicing, by submitting a descrip-

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tion of practice for pathologists that do not practice as hospital staff and by earning continuing medical education credits.⁴⁷

Forensic pathologists examine the dead to identify specific classes of injury, collect medical evidence, determine the presence or absence of natural disease, and determine the physiological cause of death. They document their findings in reports for the civil and criminal courts and provide information to family members and others who have a legitimate need to know. They may sign the death certificate describing the manner or circumstances under which death occurred (natural, accident, suicide, homicide, or undetermined). The examinations forensic pathologists carry out may be inspections or "views" of the external surfaces of a body or a medicolegal autopsy, which comprises an external and internal examination of the head, thorax, abdomen, and any other body region pertinent to the case. The nature of the death and its circumstances dictate which type of examination the forensic pathologist performs on an individual case. Pathologists who are not certified in forensic pathology perform many of the medicolegal autopsies in the United States.

Forensic pathologists practice in multiple settings. Most operate within death investigation systems and are appointed as civil servants and serve as medical examiner forensic pathologists. Some function as private practitioners, while others serve as consultants. They may operate under a fee-for-service agreement or be under contract to a city or county jurisdiction to provide medical examiner services. Others may serve as coroner's pathologists, and perform autopsies and prepare reports for coroners, who by statute assign the cause and manner of death and sign the death certificate.

An estimated 1,300 pathologists have been certified in forensic pathology since the American Board of Pathology first offered the certification in 1959 (about 5,000 medical residents enter internal medicine programs each year). Currently, approximately 400 to 500 physicians practice forensic pathology full time. Although there are only about 70 positions available each year, recent data indicate that only 70 percent of the slots are filled. NAME recommends an autopsy caseload of no more than 250 cases per year. The estimated need is for about 1,000 forensic pathologists; about 10 percent of available positions are vacant because of manpower shortages and/or insufficient funding of pathologist positions.⁴⁸ Although many forensic pathologists earn between \$150,000 and \$180,000 annually, this range is much lower than the average income of most hospital-based pathologists starting at the entry level.

An Association of American Medical Colleges (AAMC) survey indi-

⁴⁷ American Board of Pathology at www.abpath.org/200801newsltr.htm; *ABP Examiner* 39, January 1, 2008 at www.abpath.org/200802newsltr.htm.

⁴⁸ Hanzlick, 2007, op. cit.

cates that the average medical school graduate in 2006 finished with debt in excess of \$130,571 (including premedical school borrowing), with 72 percent having a debt of at least \$100,000.⁴⁹ Interested pathology residents are less likely to elect to practice forensic pathology as a career if they are already burdened by debt load, and a program of loan forgiveness for years of service in a medical examiner system would be a major enticement to students who are considering a career in pathology. The shortage of qualified forensic pathologists required to staff aspiring medical examiner systems constitutes a major challenge not only for offices that are currently seeking staff, but for the future as well.

STANDARDS AND ACCREDITATION FOR DEATH INVESTIGATION SYSTEMS

Currently, the standard for quality in death investigation for medical examiner offices is accreditation by NAME. Accreditation attests that an office has a functional governing code, adequate staff, equipment, training, and a suitable physical facility and produces a forensically documented accurate, credible death investigation product. Of all ME/C systems nationally, only 54 are accredited by NAME. The NAME accreditation checklist is available online and describes the requirements for accreditation.⁵⁰ Accreditation is for a period of five years. NAME also offers an individualized assessment program to enable jurisdictions to identify what they need to meet accreditation standards. Impediments to developing systems that meet accreditation requirements include the following:

- Most coroner systems cannot qualify for accreditation because of problems related to size, insufficient staff and equipment, and insufficiently trained personnel, which inhibit their ability to perform a competent physical examination, make and/or exclude medical diagnoses on dead bodies, and make determinations of the cause and manner of death. The historic role of the coroner is insufficient to accurately perform the medicolegal and public health functions related to sudden, unexpected, or violent death.
- Many medical examiner systems are constrained by budget, lack of staff, lack of equipment, and insufficient facilities and cannot meet NAME standards.
- The accreditation process requires considerable staff work, including written policies and procedures.

⁴⁹ Association of American Medical Colleges at www.ama-assn.org/ama/pub/category/5349.html.

⁵⁰ NAME Autopsy Standards and Inspection Checklist at www.thename.org.

- The process requires renewal.
- There is administrative cost of the process.
- Many offices do not see any benefit to accreditation.

Federal incentives are lacking for states to perform an assessment of death investigation systems to determine status and needs, using as a benchmark and goal compliance with NAME current professional standards, guidelines, and accreditation requirements.

QUALITY CONTROL AND QUALITY ASSURANCE

Quality control and quality assurance begin with the implementation of standardized policies and procedures by qualified staff. For lay medical investigators, registration and certification by the American Board of Medicolegal Death Investigators requires standard performance procedures as outlined in the NIJ document *Death Investigation: A Guide for the Scene Investigator* and other published education and training documents.⁵¹ For forensic pathologists, basic competence is initially documented by examination and certification and subsequently by recertification by the American Board of Pathology. Written office and morgue policies and procedures with scheduled reviews and updates help ensure consistent performance over time. Professional performance parameters, such as the NIJ investigation guidelines for investigators and the NAME forensic autopsy standards, are offered as national documents that all systems should be able to follow. Professional continuing education must be available and supported, and it should be mandatory.

CONTINUING MEDICAL EDUCATION

For pathologists to maintain professional standing they must earn Continuing Medical Education (CME) credits in accordance with the number required by their state medical licensing board. Attendance at forensic educational meetings, such as the annual meetings of NAME and the American Academy of Forensic Sciences (AAFS), help keep medical staff current. Other opportunities that offer valuable CME credits are meetings that focus on pediatric forensic issues and general pathology updates. AAFS meetings are multidisciplinary and afford an opportunity for updating in forensic anthropology, forensic odontology, and other forensic disciplines. The American Society of Clinical Pathologists offers CheckSample exercises and

⁵¹ U.S. Department of Justice, Office of Justice Programs, National Institute of Justice. *Death Investigation: A Guide for the Scene Investigator*. Available at www.ojp.usdoj.gov.

quizzes on forensic subjects prepared by experts.⁵² Regular in-house training on emerging technologies in pathology and forensic science, and journal clubs covering a broad spectrum of journals, can help educate and reeducate forensic pathologists and investigators. Medical death investigators may attend the same meetings. The College of American Pathologists offers self-assessment programs in anatomical and forensic pathology, as well as a continuing education program of forensic pathology case challenges.⁵³

HOMELAND SECURITY

As part of homeland security, the National Response Plan (National Response Framework as of March 2008) identifies ME/Cs under Emergency Support Function 8 as responsible for management of the dead resulting from any hazardous event.⁵⁴ All deaths resulting from any form of terrorism are under the jurisdiction of the ME/C. MED-X, the bioterrorism surveillance program provided by the Centers for Disease Control and Prevention (CDC) for ME/Cs, utilizes syndromic surveillance of primarily out-of-hospital deaths (deaths occurring before the opportunity occurs for hospitalization and medical assessment and testing) to quickly identify deaths resulting from bioterrorism.⁵⁵

With the exception of some large city, county, and state systems, the level of preparedness of ME/C jurisdictions is generally very low. Larger medical examiner systems may be able to manage events causing several hundred simultaneous single-site recoverable bodies with minimal outside assistance. Any event with thousands of fatalities would require federal assistance. Some statewide systems have developed consortia with neighboring states to supplement staff and equipment, but smaller cities and counties will need to rely entirely on federal assets such as Disaster Mortuary Operational Response Teams and the DOD Joint Task Force Civil Support.⁵⁶ Homeland security and disaster response would be well served by universal improvement in ME/C offices to manage mass fatality events such as the multistate Hurricane Katrina tragedy and the World Trade Center attacks, while also surveilling for the links between bioterrorism

⁵² American Society of Clinical Pathologists CheckSample. Available at www.ascp.org/Education/selfStudyPublications/checkSample/default.aspx.

⁵³ See <http://cap.org/apps/cap.portal>.

⁵⁴ Homeland Security National Response Plan (known as the National Response Framework after March 2008) at www.dhs.gov.

⁵⁵ Ibid; K.B. Nolte, S.L. Lathrop, M.B. Nashelsky, J.S. Nine, M.M. Gallaher, E.T. Umland, J.L. McLemore, R.R. Reichard, R.A. Irvine, P.J. McFeeley, R.E. Zumwalt. 2007. "Med-X": A medical examiner surveillance model for bioterrorism and infectious disease mortality. *Human Pathology* 38:718-725.

⁵⁶ Disaster Mortuary Operational Response Team at www.dmort.org; Joint Task Force Civil Support at <http://jtfcs.northcom.mil>.

deaths. Multiple fatality management across jurisdictional lines, such as was needed in response to Hurricane Katrina, is nearly impossible under current conditions, given the absence of medical expertise in some systems, the absence of standards of performance, and the noninteroperability of systems and procedures. The recent infusion of funds to the states through the Department of Health and Human Services (DHHS) and the Department of Homeland Security (DHS) is of little assistance when there are no competent systems able or willing to employ those funds. Uniform state-wide and interstate standards of operation, consolidation of small systems, regionalization of services, and standardization of staff training are needed to assist in the management of interstate and cross-jurisdictional events. A software program is needed that is universally usable and available, and its use should be promulgated by ME/C systems for multiple fatality management. (See also Chapter 11.)

FORENSIC PATHOLOGY RESEARCH

Currently, little research is being conducted in the areas of death investigation and forensic pathology in the United States. Individual ME/C offices mainly utilize their databases for epidemiological retrospective reviews. Individual forensic pathologists operating in any system carry heavy caseloads and often have no dedicated time, expertise, facilities, or funding for research. Research is further limited because many offices operate training programs independent of university medical schools. Occasionally, a specific case may inspire "litigation research" directed to the elucidation of a specific problem related to a case that is being litigated actively, but this does not replace broad and systematic research of a forensic issue. Few university pathology departments promote basic pathology research in forensic problems such as time of death, injury response and timing, or tissue response to poisoning. In general, research interest often is inspired by a national goal that is funded through grants. A review of the forensic literature for basic research in forensic pathology reveals that efforts are originating largely from Europe, Scandinavia, and Japan. In other countries, universities house a department of legal medicine and/or departments of forensic medicine and pathology where forensic pathologists have the time, expertise, and funding needed to perform basic forensic research.

The Accreditation Council for Graduate Medical Education (ACGME) requires forensic pathology training programs to provide fellows an opportunity for scholarly research or other scholarly activities.⁵⁷ These research projects are usually small and limited in scope because of the constraints of a one-year fellowship, legislation that does not permit most basic research

⁵⁷ Accreditation Council for Graduate Medical Education. Available at www.acgme.org/acWebsite/downloads/RRC_progReq/310forensicpath07012004.pdf.

on tissues that are available upon autopsy without the permission of next of kin, lack of funding, and lack of space. Historically, the consent issue derives from the fact that forensic autopsies are carried out for medicolegal purposes and thus do not require permission from the next of kin. But without this permission, research that utilizes tissue from medical examiner offices does not take place. The time constraints for the performance of medicolegal autopsies make finding families and obtaining consent difficult. Many projects consist of epidemiological reviews that while of interest are not basic science.

Some U.S. universities may administer some forensic pathology fellowship programs, while others may include forensic pathologists within their departments of pathology. In these instances, the forensic pathologist usually supervises a departmental autopsy service that performs hospital and forensic autopsies. A university connection usually provides the university with the opportunity to rotate pathology residents and medical students through an ME/C office for a brief period, usually several months, and provides exposure to forensic pathology as part of an overall education program for medical students or as required by ACGME for training residents in general pathology. Even in universities that have a department of forensic science, research is limited to the forensic science disciplines, and little or no research is devoted to forensic pathology or forensic medicine. In some cases, there may be collaborative, ongoing epidemiological activities, such as when forensic pathologists work with members of departments of trauma surgery to develop statistical studies or when a forensic pathologist presents data at surgical or pediatric death review conferences. Of the many impediments to academic research in forensic pathology in the United States, the most significant are the lack of understanding of forensic research challenges, the lack of a perceived need and national goals, the lack of grant funding of any kind to support research, the lack of forensic pathology researchers, and the lack of recognition for efforts directed to forensic pathology research within the university community. Grant funding drives research, but virtually no funding is available to encourage departments of pathology to make forensic pathology research a focus, and there is little tradition of collaboration between academic and forensic pathologists.

Translational research bridges the gap between basic science discoveries and their practical applications. In the case of forensic pathology/medicine, this means taking basic science research knowledge to the autopsy table.⁵⁸ Given the large numbers of autopsies performed in the

⁵⁸NIH Roadmap for Medical Research: Re-engineering the Clinical Research Enterprise—Translational Research. Available at <http://nihroadmap.nih.gov/clinicalresearch/overview-translational.asp>.

United States in medical examiner offices, there is a great need for new knowledge that will filter down to the autopsy pathologist and for opportunities for practicing forensic pathologists to identify problems that need basic research.

COMMON METHODS OF SAMPLE AND DATA COLLECTION

State statute determines the sample or collection of cases that ME/Cs investigate and examine. The minimal data collected on each case is demographic and is entered on the certificate of death by the state division of vital records and death statistics, which also maintains the data. The data are reported nationally each year to the National Center for Health Statistics. ME/C offices with databases may keep records pertaining to their particular jurisdiction and collect additional data on specific diagnoses, or classes, of death. They collect useful death data through child fatality review teams, adult fatality review teams, surveillance programs for family and intimate partner violence, and the National Violent Death Review System.⁵⁹ None of these data collection projects is federally mandated, and for small systems there is no perceived benefit. ME/C reports are available to next of kin and others as provided by statute. ME/C investigations recognize product and equipment failures leading to death and report them to appropriate agencies. Before 2005, when funding was withdrawn, CDC maintained the Medical Examiner and Coroner Information Sharing Program (MECISP) to receive reports of product-associated deaths, which allowed early recognition of problem products.⁶⁰ Originally, MECISP was established to obtain data from all deaths investigated by ME/Cs and to share such information with relevant agencies. The major goals of MECISP were to improve medicolegal death investigation and to facilitate the sharing of death investigation information.⁶¹ Many agencies depend on ME/C investigations and autopsies to complete their work, such as the Occupational Health and

⁵⁹National Violent Death Reporting System. Available at www.cdc.gov/ncipc/profiles/nvdrs/default.htm.

⁶⁰ Centers for Disease Control and Injury Prevention Medical Examiner Coroner Information Sharing Project. Available at www.cdc.gov/ncphi/diseases/nndss/contact.htm#mecisp.

⁶¹ MECISP was established in 1986 by CDC with goals that included improving the quality of death investigation in the United States mainly by achieving uniformity and improving the quality of information obtained during the investigation of deaths by ME/Cs. The program was active and productive and very well received by medical examiners. It constituted the major interface between the public health and the ME/C systems. Approximately 10 years ago, CDC went through a period of internal reorganization and administratively began decreasing the budget for MECISP. MECISP was moved from the CDC National Center for Environmental Health to the CDC Epidemiology Program Office. The budget was eliminated in 2004, despite the efforts of NAME. R. Hanzlick. 2006. Medical examiners, coroners, and public health. *Archives of Pathology and Laboratory Medicine* 130:1247-1282.

Safety Administration, social services agencies, victim witness compensation programs, and workers compensation agencies.

Systems with in-house forensic pathologists may collect autopsy data, but often the data are collected in a format that is different from the one used for the underlying (proximate) cause of death data as listed on death certificates. The reporter may use a pathology classification system such as SNOMED (Systematized Nomenclature of Medicine) or an individually devised system that tracks diseases or injuries of personal or system-specific interest.⁶² There is no universally accepted or required system for collection or maintenance of autopsy data by medical examiners and coroners. Analysis of data may be local or regional, and it may be conducted by review teams or by national organizations or agencies with interests in specific classes of data.

Scientific interpretation and summaries of the results are included in the reports generated by each ME/C office. Reports by medical death investigators that describe the circumstances of death are descriptive and vary in quality depending on the standards of the office. Pathologists produce the autopsy reports and may or may not provide an interpretive summary of findings. Reports vary from the academic pathology report that lists each organ system and any deviations from normal to the problem-oriented autopsy report that prioritizes diagnoses from the most important leading to death followed by any contributory and then noncontributory pathology of interest. Not all pathologists follow the NAME autopsy standards. The general expectation, at least for the legal forum, is that each autopsy will have documented the findings in sufficient detail through narrative and photographs and that review by another pathologist will confirm the adequacy of the examination.

Requiring the adoption of standards for death investigations and autopsies as well as accreditation of all ME/C offices would benefit all parties, including the recipients of ME/C services. Because the credibility of unaccredited offices is rarely challenged, implementing and enforcing standards will require major incentives as well as negative consequences for nonadherence.

CONCLUSIONS AND RECOMMENDATION

ME/C systems function at varying levels of expertise, often with deficiencies in facilities, equipment, staff, education, and training. And, unfortunately, most systems are under budgeted and understaffed. As with other forensic science fields, there are no mandated national qualifications or certifications required for death investigators. Nor is medical expertise

⁶² SNOMED. Available at www.snomed.org.

always required. In addition, there is no one recognized set of performance standards or best practices for ME/C systems nor are there incentives to implement one recognized set. Also lacking are universally accepted or promulgated methods of quality control or quality assurance. It is clear that the conversion of coroner systems to medical examiner systems as recommended by many studies has essentially halted and requires federal incentives to move forward.

The Model Post-Mortem Examination Act of 1954 needs to be revisited and updated to include the elements of a progressive and responsive death investigation law. The revised code should include standards for administration, staffing, and training. Any changes to the system will require federal incentives to implement the changes in each state.

The shortage of forensic pathologists speaks to the need to provide incentives for young physicians to train in forensic pathology. Systems with authorized positions cannot fill them, because of this shortage and budget deficits. The National Forensic Sciences Improvement Act (NFSIA) must be fully funded to support the core needs of ME/C grantees for equipment and facilities, training and education, and infrastructure.

Many ME/C systems do not utilize up-to-date technologies that would help in making accurate medical diagnoses. Moreover, many are unable to make use of advances in forensic technology because of staff educational deficiencies, untrained staff, and budget stringencies. Basic and translational forensic pathology research are nearly nonexistent.

Homeland security is compromised because operating units related to forensic pathology are not standardized, and the multiplicity of systems precludes meaningful communication among units. Surveillance for bioterrorism and chemical terrorism is not universal, and database systems cannot operate across jurisdictional lines to share data or manage multiple fatality incidents.

Although steps have been taken to transform the medicolegal death investigation system, the shortage of resources and the lack of consistent educational and training requirements prevent investigators from taking full advantage of tools, such as CT scans and digital X-rays, that the health care system and other scientific disciplines offer. In addition, more rigorous efforts are needed in the areas of accreditation and adherence to standards. Currently, requirements for practitioners vary from an age and residency requirement to certification by the American Board of Pathology in forensic pathology.

Funds are needed to assess and modernize the medicolegal death investigation system, using as a benchmark the current requirements of NAME related to professional credentials, standards, and accreditation. As it now stands, ME/Cs are essentially ineligible for direct federal funding and cannot receive grants from DHHS (including the National Insti-

tutes of Health [NIH]) and the Department of Justice or DHS. The Paul Coverdell NFSIA is the only federal grant program that names ME/Cs as eligible for grants. However, ME/Cs must compete with public safety agencies for Coverdell grants; as a result, the funds available to ME/Cs have been significantly reduced. NFSIA is not funded sufficiently to provide significant improvements in ME/C systems. In addition to more direct funding, other initiatives could be pursued to improve medicolegal death investigation practices.

AAMC and other appropriate professional organizations might organize collaborative activities in education, training, and research to strengthen the relationship between the medical examiner community and its counterparts in the larger academic medical community. Medical examiner offices with training programs affiliated with medical schools should be encouraged to compete for funds. Funding should be available to support pathologists who are seeking forensic fellowships. In addition, forensic pathology fellows could apply for medical school loan forgiveness if they stay full time at a medical examiner's office for a reasonable period of time.

Additionally, the proposed National Institute of Forensic Science (NIFS) should seek funding from Congress to allow it, CDC, and DHS, jointly, to design programs of interest to medical examiners and medical examiner offices in national disaster planning, preparedness, and consequence management. Uniform statewide and interstate standards of operation would be needed to assist in the management of cross-jurisdictional and interstate events. NIFS also might consider whether to support a federal program underwriting the development of software for use by ME/C systems for the management of multisite, multistate, or multiple fatality events.

NIFS also could work with groups such as the National Conference of Commissioners on Uniform State Laws, the American Law Institute, and NAME, in collaboration with other appropriate professional groups, to update the 1954 Model Post-Mortem Examinations Act and draft legislation for a modern model death investigation code. An improved code might, for example, include the elements of a competent medical death investigation system and clarify the jurisdiction of the medical examiner with respect to organ donation. Although these ideas must be developed in greater detail before any concrete plans can be pursued, the committee makes a number of specific recommendations, which, if adopted, will help to modernize and improve the medicolegal death investigation system. These recommendations deserve the immediate attention of NIFS and Congress.

Recommendation 11:

To improve medicolegal death investigation:

- (a) Congress should authorize and appropriate incentive funds to the National Institute of Forensic Science (NIFS) for allocation to states and jurisdictions to establish medical examiner systems, with the goal of replacing and eventually eliminating existing coroner systems. Funds are needed to build regional medical examiner offices, secure necessary equipment, improve administration, and ensure the education, training, and staffing of medical examiner offices. Funding could also be used to help current medical examiner systems modernize their facilities to meet current Centers for Disease Control and Prevention-recommended autopsy safety requirements.
- (b) Congress should appropriate resources to the National Institutes of Health (NIH) and NIFS, jointly, to support research, education, and training in forensic pathology. NIH, with NIFS participation, or NIFS in collaboration with content experts, should establish a study section to establish goals, to review and evaluate proposals in these areas, and to allocate funding for collaborative research to be conducted by medical examiner offices and medical universities. In addition, funding, in the form of medical student loan forgiveness and/or fellowship support, should be made available to pathology residents who choose forensic pathology as their specialty.
- (c) NIFS, in collaboration with NIH, the National Association of Medical Examiners, the American Board of Medicolegal Death Investigators, and other appropriate professional organizations, should establish a Scientific Working Group (SWG) for forensic pathology and medicolegal death investigation. The SWG should develop and promote standards for best practices, administration, staffing, education, training, and continuing education for competent death scene investigation and postmortem examinations. Best practices should include the utilization of new technologies such as laboratory testing for the molecular basis of diseases and the implementation of specialized imaging techniques.

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- (d) All medical examiner offices should be accredited pursuant to NIFS-endorsed standards within a timeframe to be established by NIFS.
- (e) All federal funding should be restricted to accredited offices that meet NIFS-endorsed standards or that demonstrate significant and measurable progress in achieving accreditation within prescribed deadlines.
- (f) All medicolegal autopsies should be performed or supervised by a board certified forensic pathologist. This requirement should take effect within a timeframe to be established by NIFS, following consultation with governing state institutions.

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Automated Fingerprint Identification Systems

In the late 1970s and early 1980s law enforcement agencies across the Nation began adopting Automated Fingerprint Identification Systems (AFIS) to improve their efficiency and reduce the amount of time it took to identify (or not exclude) a given individual from a fingerprint or to conduct a background investigation. AFIS introduced an enormous improvement in the way local, state, and federal law enforcement agencies managed fingerprints and identified people. Before the use of AFIS, the fingerprint identification process involved numerous clerks and fingerprint examiners sifting through thousands of tediously classified and cataloged paper fingerprint cards, while dealing with delays and challenges caused by the realities of exchanging information with other agencies by mail, fax, or other means. With AFIS, fingerprint examiners use computer workstations to mark the features of a scanned fingerprint image (e.g., ridge endings, bifurcations), encode the resulting data in a machine-readable format, and then search for similar fingerprints in an associated database of known fingerprints and records. AFIS searches are fast, and they often allow examiners to search across a larger pool of candidates. Although challenging cases can be time consuming, depending on the size of the database being searched and the system's workload, AFIS often can return results to the examiner within minutes.

AFIS searches today fall into two distinct categories:

10-print searches, which typically involve comparing relatively high-quality, professionally obtained fingerprint images—for example, prints taken during an arrest or booking or as part of a background check—

with fingerprint records in an agency database, such as the FBI's Integrated Automated Fingerprint Identification System (IAFIS) or a state's criminal fingerprint database; and

Latent print searches, which are considerably more complicated than 10-print searches. In a latent print search, a fingerprint examiner attempts to identify an individual by comparing a full or partial latent fingerprint from a crime scene with the records contained in an AFIS database. Latent prints are regularly of poor quality and may be only a partial print, and often fingerprint examiners may not even know from which finger a given latent print came.

A third category (albeit one that includes elements of both categories listed above) might also be called "unidentified burned, decomposed, or fragmented prints," which may be either a complete 10-print card to be compared with known prints on file to confirm identity or partial prints recovered from the skin or dermis of damaged fingers of an unknown decedent to determine identity. This third category can include prints from single individuals recovered from a small single event or victims of a mass casualty event resulting from naturally occurring catastrophes or terrorism. In either case, AFIS systems have reduced the time required to accomplish many identifications from weeks to hours.

Today, the process of populating AFIS systems with records is managed primarily by uploading 10-print records from police bookings and background checks. Because images from these sources are generally of good quality (indeed, poor-quality 10-print records are normally redone at the time they are taken), an automated algorithm is adequate for extracting the features used to index an image for retrieval. Computer algorithms work well for performing comparisons of 10-print records (e.g., to see if the prints taken when one applies for a security clearance match the prints taken during a previous background check). However, submitting a latent print for comparison is a more customized process, requiring fingerprint examiners to mark or adjust the features manually to retrieve stored prints with the same features in analogous places. Because latent print images normally are not as clear or as complete as images from a 10-print card, the image processing algorithms used for 10-prints are not as good as the human eye in spotting features in poor images.

AFIS has been a significant improvement for the law enforcement community over the past decades, but AFIS deployments today are still far from optimal. Many law enforcement AFIS implementations are stand-alone systems or are part of relatively limited regional networks with shared databases or information-sharing agreements—the Western Identification

Box 10-1
The Western Identification Network

WIN was formed in May 1988 to facilitate the creation of a multistate AFIS implementation. A year later, the state legislatures of Alaska, California, Idaho, Oregon, Nevada, Utah, Washington, and Wyoming appropriated the necessary funding to begin work on the system.

The initial WIN AFIS was installed in Sacramento, California, with remote subsystems in Cheyenne, Wyoming; Salt Lake City, Utah; Boise, Idaho; Carson City, Nevada; and Salem and Portland, Oregon. Booking terminals also were installed in numerous locations throughout these states, and existing similar stand-alone systems in Alaska, California, and Washington were connected to WIN in 1990 to complete the initial network. At first, WIN's centralized automated database included 900,000 fingerprint records, but after connecting to Alaska, California, and Washington, the number of searchable fingerprint records increased to more than 14 million. Today, WIN members have access to more than 22 million fingerprint records from the western United States.

NOTE: For information about WIN, see www.winid.org/winid/who/documents/WINServiceStrategyJanuary2008.pdf.

Network (WIN) is one example of such a regional network (for more information on WIN, see Box 10-1).

Today, AFIS systems from different vendors most often cannot interoperate with one another. Indeed, different versions of similar systems from the same vendor sometimes cannot share fingerprint data with one another. In addition, many law enforcement agencies also access the FBI's IAFIS database¹ through an entirely separate stand-alone system—a fact that often forces fingerprint examiners into entering fingerprint data for one search multiple times (at least once for each system being searched).

There is no doubt that much good work has been done in recent years aimed at improving the interoperability of AFIS implementations and databases (see Box 10-2), but the committee believes that, given the potential benefits of more interoperable systems, the pace of these efforts to date has been too slow, and greater progress needs to be made toward achieving meaningful, nationwide AFIS interoperability.

¹ See www.fbi.gov/hq/cjisd/iafis.htm.

Box 10-2
Working Toward AFIS Interoperability

As early as 1986, the American National Standards Institute (ANSI) and the National Bureau of Standards (now known as the National Institute of Standards and Technology, or NIST) were working on ways to facilitate the exchange of fingerprint data. Their collaboration produced a standard defining minutiae data and both low- and high-resolution fingerprint images. The standard was not successful, however, because of conflicts with proprietary systems.

In 1993, ANSI and NIST teamed up again to create another fingerprint data standard, a standard later updated in 1997. It defined standards for minutiae data and low- and high-resolution fingerprint images in both binary and grayscale format, as well as methods for compressing and decompressing image data.

In the late 1990s, the International Association for Identification's AFIS Committee successfully demonstrated a method of conducting remote fingerprint searches across jurisdictions and across equipment from different vendors.^a

In 2003, the ANSI/NIST standard was updated again. It grew to include 16 record types in total, with the addition of standards for such things as palm print data and latent print data.^b The standard was recently updated once more and has subsequently been approved by ANSI's Board of Standards Review as an ANSI standard.^c

The NIST-sponsored Minutiae Interoperability Exchange Test (MINEX) program is an ongoing series of coordinated development efforts aimed at improving the performance and interoperability of fingerprint minutiae standards. In 2004, the original project undertook to determine the feasibility of using minutiae data (rather than image data) as the interchange medium for fingerprint information between different fingerprint matching systems.^d

^a The committee's final report is available at www.onin.com/iaiafis/IAI_AFIS_071998_Report.pdf.

^b For more information on the ANSI/NIST standards, see P. Komarinski. 2005. *Automated Fingerprint Identification Systems*. Boston: Elsevier Academic Press, pp. 162-166.

^c This approved revision of the ANSI/NIST-ITL 1-2000 standard is now available as NIST Special Publication 500-271: *Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information-Part 1* (ANSI/NIST-ITL 1-2007) at <http://fingerprint.nist.gov/standard/Approved-Std-20070427.pdf>.

^d More information about the work of the MINEX series is available at <http://fingerprint.nist.gov/minexII/>.

INTEROPERABILITY CHALLENGES

Despite the work done to date to achieve broader AFIS interoperability and its potential benefits (i.e., more crimes solved, quicker and more effi-

cient searches, and better use of limited law enforcement resources), several persistent challenges to reaching this goal remain.

Technical Challenges

The technical challenges to AFIS interoperability involve both those that are encountered and addressed by the information technology community in other disciplines (such as data sharing and algorithmic performance) and those that are specific to AFIS and the sharing of fingerprint information (e.g., feature identification, reliability of latent print comparisons). In addition, systems will need to be designed with the flexibility to handle other kinds of biometric data in the future (e.g., iris and palm scans and possibly genomic data). As these latter challenges are addressed, retrieval algorithms within proprietary AFIS systems also may tend to converge, which could simplify the broader interoperability challenges.

Creating useful technical standards is never a simple undertaking, especially given a diverse array of stakeholders, proprietary systems, and ever-advancing technological capabilities (e.g., improved pattern recognition, better hardware, increased data compression). However, the successful interoperability of other distributed information networks—such as modern banking systems (e.g., ATM machines²), information sharing networks in the real estate world,³ the Centers for Disease Control and Prevention's Public Health Information Network,⁴ and even the Internet itself, each of which functions only by reliance on a number of finely crafted and agreed standards and protocols—is proof that efforts to develop and implement standards pay off in the end by allowing greater collaboration and sharing of information.

One other major area of technical challenge to achieving AFIS interoperability involves the algorithms that systems use to identify features in fingerprint images (e.g., how a system determines that a given pattern of pixels corresponds to a true ridge ending or bifurcation and how it infers what type of feature those pixels actually represent). To date, these algorithms

² Indeed, financial card transactions are facilitated by their own ISO standard (ISO 8583-1:2003). For more information, see www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31628.

³ See, e.g., the Metropolitan Regional Information System (MRIS) at www.mris.com/about/WhoWeAre.cfm.

⁴ CDC's Public Health Information Network is a national initiative to improve the capacity of the public health community to use and exchange information electronically by promoting the use of standards and defining functional and technical requirements. The network employs a messaging system (PHINMS) to rapidly and securely share sensitive health information among CDC and other local, state, and federal organizations over the Internet—information such as HIV records, pandemic information, and information on bioterrorism. Complete information about PHIN and PHINMS is available at www.cdc.gov/phinf/.

have been largely proprietary and vendor specific (i.e., different for each type of system). In fact, experienced latent print examiners have found that different systems will retrieve different stored prints in response to a given input map of features, and they have learned system-specific ways of annotating features on a latent print in order to maximize the success of each system's (inferred) search algorithms. However, achieving broad-based AFIS interoperability will require baseline standards for these algorithms, so that fingerprint examiners can be assured of consistent feature mapping across systems. As mentioned previously, fingerprint examiners have learned by experience to provide different inputs to different vendors' systems, often purposely leaving out information—knowing that the added input will degrade the search quality:

The examiner does not necessarily encode every point he can find in the latent print. LPU [latent print unit] examiners have learned through experience with the IAFIS program which types of points are most likely to yield a correct match. LPU Unit Chief Meagher told the OIG [Office of Inspector General] that examiners are taught to avoid encoding points in areas of high curvature ridge flow, such as the extreme core of a print. Unit Chief Wieners and Supervisor Green told the OIG that IAFIS does not do well when asked to search prints in which points have been encoded in two or more clusters separated by a gap. One reason is that IAFIS gives significant weight to the ridge count between points. If the ridge count between two clusters of points in a latent is unclear, IAFIS may fail to retrieve the true source of the print. Thus, an examiner will not necessarily encode every point that can be seen in a latent fingerprint, but rather may limit his encoding to points in a defined area in which the ridge count between points is clear.⁵

The fact that today's systems often do not effectively utilize most of the available feature information and require substantial input from fingerprint examiners suggests that there is significant room for improvement. An ideal, comprehensive AFIS, for example, would be capable of automated:

- reading of latent prints;
- encoding of most features of usable quality, including those features identified as Level 1 (fingerprint classes such as whorl, arch), Level 2 (minutiae), Level 3 (pores, cuts), and ridge paths, together with a provision for including other features that could be defined by the vendor/user;

⁵ Office of the Inspector General, Oversight and Review Division, U.S. Department of Justice. 2006. *A Review of the FBI's Handling of the Brandon Mayfield Case*, p. 119.

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- recognizing absent, blurred, double/multioverlap, poor-quality sections of an observed print and encoding the system to downweight, or omit entirely, during the search process;
- recognizing any orientation information;
- conducting database searches;
- providing “best matches”; and
- collecting statistical data based on the quality of the print and numbers/types of features.

Other technical challenges might include the development and use of a secure Web interface (or an analogous system) that would permit authorized latent print examiners in any jurisdiction to submit queries to IAFIS and other federated AFIS databases, as well as the development of standard procedures for maintaining AFIS databases securely, removing redundancies, ensuring that fingerprint data are entered properly, and conducting quality control and validation of searches (i.e., ensuring that queries are actually searching an entire database). Although some of the capabilities mentioned here are present in today’s commercially available systems, significant improvement still can be realized.

Support from Policymakers

Given the complexity of the AFIS interoperability challenge and the large number of players whose contributions and cooperation will be necessary to meet that challenge, it is clear that no effort aimed at nationwide interoperability will succeed without strong, high-level support from policymakers in federal and state government. Resources available to law enforcement agencies for the deployment, use, and maintenance of AFIS systems vary greatly from jurisdiction to jurisdiction, and the considerable expenses associated with purchasing, maintaining, training for, operating, and upgrading an AFIS implementation—which can easily cost millions of dollars⁶—must be well thought out and weighed against other competing costs and interests facing law enforcement.

The committee hopes that this report will help convince policymakers of the benefits to nationwide interoperability and move them to provide much-needed support to law enforcement agencies, vendors, and researchers to help them achieve this goal. Indeed, the committee believes that true AFIS interoperability can be achieved in a timely manner only if policymakers provide a strong, clear mandate and additional funding from federal and state governments—both to support the research and development

⁶ See P. Komarinski. 2005. *Automated Fingerprint Identification Systems*. Boston: Elsevier Academic Press, p. 145.

work necessary to achieve truly interoperable systems and to assist law enforcement agencies in purchasing, implementing, and managing systems and training personnel.

Vendors

As suggested above, AFIS equipment and service vendors must cooperate to ensure nationwide AFIS interoperability. However, to date—and as one could reasonably expect in a technology sector in which product differentiation and the maintenance of competitive advantages are prime concerns—vendors have had little incentive to design their systems to enable them to share information with competitors' systems. The committee believes that increased cooperation among AFIS vendors is a key to achieving meaningful interoperability. For example, one can imagine how it might prove useful if AFIS vendors could collaborate (perhaps through work facilitated by the proposed National Institute of Forensic Science [NIFS]) on developing standard (or baseline) retrieval algorithms. Such a step conceivably could make it less time consuming for fingerprint examiners to run searches on many different systems because they would not have to manually *tune* their searches to work on the systems of different vendors.

Administrative, Legal, and Policy Issues

As noted earlier, most AFIS implementations are either stand-alone systems or are part of relatively limited regional databases. To achieve truly interoperable systems, jurisdictions must work more closely together to craft acceptable agreements and policies to govern the routine sharing of fingerprint information. NIFS can facilitate the development of standard agreements along these lines, which could include issues such as the extent of system access to other jurisdictions, the management of search priorities, and the recovery of costs associated with processing the requests from outside agencies. In addition, many jurisdictions also might want assurances that they will not be held responsible for any possible misuse of fingerprint information that is provided to other law enforcement agencies.

CONCLUSIONS AND RECOMMENDATION

Great improvement is possible with respect to AFIS interoperability. Many crimes no doubt go unsolved today simply because investigating agencies cannot search across all the individual databases that might hold a suspect's fingerprints or contain a match for an unidentified latent print from a crime scene. It is possible that some perpetrators have gone free because of the limitations on fingerprint searches.

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The committee believes that, in addition to the technical challenges noted above, a number of other critical obstacles to achieving nationwide AFIS interoperability exist involving issues of practical implementation. These include (1) convincing federal and state policymakers to mandate nationwide AFIS interoperability; (2) persuading AFIS equipment vendors to cooperate and collaborate with the law enforcement community and researchers to create and use baseline standards for sharing fingerprint image and minutiae data and interfaces that support all searches; (3) providing law enforcement agencies with the resources necessary to develop interoperable AFIS implementations; and (4) coordinating jurisdictional agreements and public policies that would allow law enforcement agencies to share fingerprint data more broadly.

Given the disparity in resources and information technology expertise available to local, state, and federal law enforcement agencies, the relatively slow pace of interoperability efforts to date, and the potential gains that would accrue from increased AFIS interoperability, the committee believes that a new emphasis on achieving nationwide fingerprint data interoperability is needed.

Recommendation 12:

Congress should authorize and appropriate funds for the National Institute of Forensic Science (NIFS) to launch a new broad-based effort to achieve nationwide fingerprint data interoperability. To that end, NIFS should convene a task force comprising relevant experts from the National Institute of Standards and Technology and the major law enforcement agencies (including representatives from the local, state, federal, and, perhaps, international levels) and industry, as appropriate, to develop:

- (a) standards for representing and communicating image and minutiae data among Automated Fingerprint Identification Systems. Common data standards would facilitate the sharing of fingerprint data among law enforcement agencies at the local, state, federal, and even international levels, which could result in more solved crimes, fewer wrongful identifications, and greater efficiency with respect to fingerprint searches; and
- (b) baseline standards—to be used with computer algorithms—to map, record, and recognize features in fingerprint images, and a research agenda for the continued improvement, refinement, and characterization of the accuracy of these algorithms (including quantification of error rates).

These steps toward AFIS interoperability must be accompanied by the provision of federal, state, and local funds to support jurisdictions in upgrading, operating, and ensuring the integrity and security of their systems; the retraining of current staff; and the training of new fingerprint examiners to gain the desired benefits of true interoperability. Additionally, greater scientific benefits can be realized through the availability of fingerprint data or databases for research purposes (using, of course, all the modern security and privacy protections available to scientists when working with such data). Once created, NIFS might also be tasked with the maintenance and periodic review of the new standards and procedures.

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Homeland Security and the Forensic Science Disciplines

In its charge to the committee, Congress raised the question of the role of forensic science in homeland security. The committee recognized that, to address this issue thoroughly, it would need additional expertise and more time to fully undertake an analysis of the role that forensic science currently plays and could possibly play in the future. Such an analysis would require serious study of the current configuration of the Department of Homeland Security (DHS) and its relationships with the forensic science community, law enforcement, and national security. Indeed, as the committee began to explore this issue it became clear that the question of the role of forensic science in homeland security is a study unto itself. Not wanting to ignore this issue, the committee limited its analysis to the presentations made to the committee and the expertise of its membership. Consequently, this chapter should be viewed as a first step in addressing the role of forensic science in homeland security.

The development and application of the forensic science disciplines to support intelligence, investigations, and operations aimed at the prevention, interdiction, disruption, attribution, and prosecution of terrorism has been an important component of what is now termed "homeland security" for at least two decades. Major terrorist bombings in the United States and abroad in the 1980s and 1990s influenced the U.S. government to enhance federal investigative and forensic science entities to be able to respond more effectively. For example, forensic science played an important role in investigating the bombing of Pan Am Flight 103 (1988), the first bombing of the World Trade Center in New York City (1993), the Oklahoma City bombing (1995), the suspected attack or sabotage of Trans World Airline

Flight 800 (1996), the bombing of the USS Cole (2000), and the bombings of the U.S. Embassies in Kenya and Tanzania (1998). And even though the identification of the Unabomber (1996) occurred as a result of the cooperation of his brother with the authorities, the forensic evidence against Theodore Kaczynski was substantial and crucial to the case.

The nature of homeland security requires the integration of forensic science into the investigative process much earlier than is the case for criminal justice. That is, for homeland security, forensic science plays not only its traditional role of inferring what happened at a crime scene and who was involved, but also contributes more intensively to generating investigative leads and testing, directing, or redirecting lines of investigation. In this role, forensic science contributes to the gathering of effective and timely intelligence and investigative information on terrorists and terrorist groups. This requires both traditional forensic science tools and enhanced and specialized forensic analysis and information sharing—new tools that are being developed primarily by the intelligence and defense communities in the United States, with each community tailoring the new tools to its specialized needs and missions.

The intelligence and investigative capabilities thus build on a foundation of traditional forensic science expertise that exists in the military and the FBI. The Department of Defense (DOD), for example, includes the U.S. Army Criminal Investigation Laboratory, which, with its 137-member staff, carries out criminal investigations. It also conducts research activities to develop specialized techniques needed by the military. Some of the nontraditional forensic science capabilities available within that laboratory include methods suited to intelligence gathering and counter-intelligence and the ability to make inferences about foreign language documents. Plans for the future include developing capabilities such as increased integration of biometrics (used for security) and forensic science and improved accident investigation and reconstruction.¹

Other DOD forensic science capabilities are found in the Armed Forces Institute of Pathology (with a staff of 25), the Cyber Crime Center (with a staff of approximately 190), the Joint POW/MIA Accounting Command Central Identification Laboratory (more than 46 staff members), and the Armed Forces DNA Identification Laboratory (with staff of approximately 138).² The Joint POW/MIA Accounting Command Central Identification Laboratory bills itself as the largest forensic anthropology laboratory in the world.³ Also contributing to DOD's forensic science capabilities is its

¹ L.C. Chelko, Director, U.S. Army Criminal Investigation Laboratory. "Department of Defense Forensic Capabilities." Presentation to the committee. September 21, 2007.

² *Ibid.*

³ *Ibid.*

Biometrics Task Force, which leads in the development and implementation of biometric technologies for combatant commands, military services, and other DOD agencies.⁴ The DOD forensic science capabilities are not centrally managed.⁵

DOD has a particular interest in DNA identification, both of its own people and of enemies. The department has a repository of five million DNA samples, primarily from military service members, intended mostly for casualty identification. DOD also pools data with intelligence and law enforcement programs to build and maintain the Joint Federal Agencies Intelligence DNA Database, a searchable database of DNA profiles from detainees and known or suspected terrorists.⁶

The DOD forensic science laboratories are relatively well resourced, according to the Director of the U.S. Army Criminal Investigation Laboratory, and DOD personnel are active in professional forensic science organizations, national certification/accreditation bodies, and national scientific working groups. Of particular note is that all of DOD's institutional laboratories are nationally accredited,⁷ unlike many civilian law enforcement laboratories.

An example of federal efforts to develop forensic science methods of importance to homeland security is the relatively new National Biodefense Forensic Analysis Center, established by DHS in 2004. The center's mission is to provide a national capability to conduct and coordinate forensic analyses of evidence from biocrime and bioterror investigations. It is supported by DHS research to fill short- and long-term capabilities gaps, but the center itself is devoted to actual casework. Before its establishment, the Nation had no dedicated biocontainment laboratories, staff, or equipment to conduct bioforensic analysis. It had no methods to enable the handling of biothreat agent powders, no methods to support traditional forensic analyses of evidence contaminated with a biothreat agent, and no place in which to receive large quantities or large pieces of evidence contaminated with a biothreat agent. There were no established methods for handling evidence and conducting analysis, no quality guidelines or peer review of methodologies, and no central coordination for bioforensic analyses. These gaps became very apparent during the Nation's response to the anthrax attacks of 2001.⁸

⁴ T. Cantwell, Senior Forensic Analyst, Biometric Task Force and Leader, Forensic Integrated Product Team, Department of Defense, "Latent Print Analysis." Presentation to the committee. December 6, 2007.

⁵ Chelko, *op. cit.*

⁶ *Ibid.*

⁷ *Ibid.*

⁸ J. Burans, Director, National Bioforensics Analysis Center. "The National Biodefense Analysis and Countermeasures Center." Presentation to the Committee. September 21, 2007.

Bioforensics, which is sometimes referred to as microbial forensics, or as forensic microbiology, is a developing interdisciplinary field of microbiology devoted to the development, assessment, and validation of methods for fully characterizing microbial samples for the ultimate purpose of high-confidence comparative analyses. It supports attribution investigations involving pathogens or toxins of biological origin used in a biological attack. The bioforensics toolkit includes diagnostic assay systems that can identify infectious agents rapidly, as well as organic and inorganic analytical chemistry, electron microscopy, and genetic engineering. Much of the work must be conducted according to stringent safety and containment protocols, and dedicated laboratories are now under construction. The center's capabilities enable the identification and/or characterization of biological threats, physical and chemical analyses, and the generation of data that can help in investigations and ultimate attribution. In addition to conducting casework, the center aims to develop and evaluate assays for high-consequence biological agents that threaten humans, animals, and plants, achieve accreditation for bioforensic casework and then continue to expand the scope of accreditation for newly established capabilities, and establish and maintain reference collections of biological agents for comparative forensic identifications.⁹

Another component of forensic science for homeland security is found in the Office of the Director of National Intelligence, which coordinates the various elements of the intelligence community. Within that office is a National Counterproliferation Center that also carries out work in bioforensics.¹⁰ The considerable threat of the acquisition, development, and use of weapons of mass destruction (WMD; chemical, biological, radiological, and nuclear weapons) has led U.S. government agencies to develop new forensic science capabilities. In 1996, this development was begun with the establishment of a specialized forensic hazardous materials unit in the FBI Laboratory, which came at a time of greater awareness of and concern over WMD in the hands of terrorists and in preparing for the 1996 Olympic Games in Atlanta. Interest and investment in this type of capability has diversified and expanded since that time in the FBI as well as in DOD, the Department of Energy, the Intelligence Community, and DHS. The programs described above are visible evidence of the government's commitment to forensic science and infrastructure as integral components of homeland security. At the time of this writing, the importance of forensic science and its potential for improving the attribution of WMD are also active topics in discussions internationally.

⁹ Ibid.

¹⁰ C.L. Cooke Jr., Office of the Deputy Director for Strategy & Evaluation, National Counterproliferation Center. "Microbial Forensics: Gaps, Opportunities and Issues." Presentation to the committee. September 21, 2007.

The traditional U.S. forensic science community generally has not been included directly in planning, preparedness, resourcing, response, training, and the exercising of large-scale or specialized forensic science capabilities for terrorism and homeland security, although the FBI Laboratory provides a link between homeland security applications of forensic science and traditional uses in criminal justice. One reason for this segmentation is that the traditional community has heavy commitments to day-to-day law enforcement requirements, timelines, and backlogs. Also, many of the homeland security applications of forensic science require specialized expertise and infrastructure that are not widespread, and they might require access to information that is protected by security classification. Although major metropolitan law enforcement agencies and forensic laboratories, such as those in New York City and Los Angeles, have developed some specialized tactical capacities of these types, most of the U.S. forensic science enterprise does not and will not legitimately invest in such capacities and will rely instead on agencies such as the FBI and those who are part of the FBI-led Joint Terrorism Task Forces¹¹ in some 100 U.S. cities.

For the most part, the specialized capacities and capabilities needed for homeland security are not warranted for most civilian forensic science laboratories and medical examiner offices, although there are exceptions, and some of the skills embodied in these new forensic efforts may have direct applicability to traditional forensic science disciplines. However, the skills embodied within the traditional forensic science and medical examiners communities are potentially an important asset for assisting in homeland security. The geographic dispersion of those communities is an additional asset, because a security event or natural disaster can occur anywhere, beyond the quick reach of specialized federal capabilities. In addition, to the extent that members of the forensic science and medical examiners communities might respond to WMD attacks before specialized experts can, it is important to train those local responders sufficiently so that they can properly preserve critical evidence while protecting themselves from harmful exposure. More generally, there would be value in strengthening the links between civil forensic scientists and those affiliated with DOD and DHS, so that all sectors can pool their knowledge.

The medical examiner community, in particular, could be viewed as a geographically distributed and rapidly deployable "corps" that can augment federal experts in efforts to monitor emerging public health threats or respond to catastrophes. When a catastrophic event takes place, whether it is the result of nature or terrorism, a large contingent of medical examin-

¹¹ *Protecting America Against Terrorist Attack: A Closer Look at the FBI's Joint Terrorism Task Forces*. Federal Bureau of Investigation, December 2004. Available at www.fbi.gov/page2/dec04/jttf120114.htm.

ers is sometimes needed on short notice. Yet medical examiners have not been appropriately funded or trained in the management of mass fatality incidents. (See Chapter 9 for a more complete discussion of the medical examiner's role in homeland security.) Plans and policies must be developed that enable this contingent use of medical examiners.

In written input to the committee, Barry A.J. Fisher, Director of the Scientific Services Bureau of the Los Angeles County Sheriff's Department, stated the needs and opportunities as follows:

. . . [C]onsider a situation where there are multiple events in the US and aboard occurring simultaneously. Resources could be stretched to the breaking point, not to mention the concept of *surge capacity*. There is not an unlimited supply of forensic scientists available to the FBI. But there are probably 5,000+ public forensic scientists at State and local crime labs who could be enlisted to help. Some jurisdictions have plans in place to use local talent. Others do not. It varies from region to region.

Forensic scientists are often called to crime scenes to assist in the collection of evidence. Yet few would recognize that they were looking at a potential improvised explosive lab. There is little training available at the national level. Much of the information is classified. State and local forensic scientists have no need for security clearances but often go through law enforcement background checks. This creates a classic 'Catch 22' situation. State and local forensic personnel can't be given classified information to recognize terrorist devices which they might be able to disable before they and others are injured.

The identification of victims in mass casualties is another area where State and local forensic labs could play a part. (They could, for example, provide fingerprint identification services.) While few labs have the capacity to mount a major DNA testing effort, personnel are knowledgeable in evidence collection and can assist in such efforts. Again there are no consistent plans for using local or regional resources.

Medical examiners and coroners use a system of volunteers called D-MORT (Disaster Mortuary Operational Response Team) to assist in mass casualty events whether natural or caused by terrorist incidents. A similar program could be considered to enlist State and local forensic scientist to assist in major incident situations.¹²

This chapter illustrates the overlap between the capabilities of forensic science and the needs of homeland security, but ideally, the forensic science community and homeland security communities should be more integrated with better communication. However, the committee limited its recom-

¹² B.A.J. Fisher. June 12, 2007. "Contemporary Issues in Forensic Science," unpublished paper submitted to the committee.

mendations on this matter because it recognized two critical factors: (1) the forensic science system is in need of a major overhaul (see Chapters 2 through 8), and until these issues are addressed it makes little sense to expand the efforts of state and local forensic scientists into homeland security operations and (2) many issues that would arise from such integration (e.g., federal jurisdiction, national security issues, restrictions on sharing of information) go beyond the charge and principal focus of the committee.¹³

CONCLUSIONS AND RECOMMENDATION

Good forensic science and medical examiner practices are of clear value from a homeland security perspective because of their roles in bringing criminals to justice and in dealing with the effects of natural and human-made mass disasters. Forensic science techniques (e.g., the evaluation of DNA fragments) enable the thorough investigations of crime scenes. Routine and trustworthy collection of digital evidence, and improved techniques and timeliness for its analysis, can be of great potential value in identifying terrorist activity. Therefore, a strong and reliable forensic science community is needed to maintain homeland security. However, to capitalize on this potential, the forensic science and medical examiner communities must be well interfaced with homeland security efforts, so that they can contribute when needed. To be successful, this interface will require: (1) the establishment of good working relationships among federal, state, and local jurisdictions; (2) the creation of strong security programs to protect data transmittals across jurisdictions; (3) the development of additional training for forensic scientists and crime scene investigators; and (4) the promulgation of contingency plans that will promote efficient team efforts on demand. Although policy issues relating to the enforcement of homeland security are beyond the scope of this report, it is clear that improvements in the forensic science community and the medical examiner system could greatly enhance the capabilities of homeland security.

Recommendation 13:

Congress should provide funding to the National Institute of Forensic Science (NIFS) to prepare, in conjunction with the Centers for Disease Control and Prevention and the Federal Bureau of Investigation, forensic scientists and crime scene investigators for their potential roles in managing and analyzing evidence from

¹³ See Institute of Medicine. 2008. *Research Priorities in Emergency Preparedness and Response for Public Health Systems* and workshop summaries of the Disasters Roundtable, dels.nas.edu/drt/

events that affect homeland security, so that maximum evidentiary value is preserved from these unusual circumstances and the safety of these personnel is guarded. This preparation also should include planning and preparedness (to include exercises) for the interoperability of local forensic personnel with federal counterterrorism organizations.

Appendix A

Biographical Information of Committee and Staff

Harry T. Edwards (Co-chair) was appointed to the United States Court of Appeals for the District of Columbia Circuit by President Carter in 1980. He served as Chief Judge from September 15, 1994, until July 16, 2001. Judge Edwards graduated from Cornell University, B.S., 1962, and the University of Michigan Law School, J.D., 1965, with distinction and honors. He was a member of the Michigan Law Review and was elected to the Order of the Coif. Before joining the bench, Judge Edwards practiced law in Chicago from 1965 to 1970. Between 1970 and 1980, he was a tenured Professor of Law at the University of Michigan and at Harvard Law School. He also served as Visiting Professor at the University of Brussels and as a member of the faculty at the Institute for Educational Management at Harvard University. Since joining the bench, he has taught at numerous law schools, including Duke, Georgetown, Harvard, Pennsylvania, Michigan, and New York University, where he has been a member of the faculty since 1990. Judge Edwards is currently a Visiting Professor of Law at the New York University School of Law. During his years as Chief Judge of the D.C. Circuit, Judge Edwards directed numerous automation initiatives at the Court of Appeals; oversaw a complete reorganization of the Clerk's Office; implemented case management programs that helped to cut the court's case backlog and reduce case disposition times; successfully pursued congressional support for the construction of the William B. Bryant Annex to the E. Barrett Prettyman U.S. Courthouse; presided over the court's hearings in *United States v. Microsoft*; established programs to enhance communications with the lawyers who practice before the court; and received high praise from members of the bench, bar, and press for fostering collegial

relations among the members of the court. Judge Edwards' many positions have included Chairman of the Board of Directors of AMTRAK; member of the Board of Directors of the National Institute for Dispute Resolution; member of the Executive Committee of the Order of the Coif; member of the Executive Committee of the Association of American Law Schools, and Chairman of the Minority Groups Section; Vice President of the National Academy of Arbitrators; and member of the President's National Commission on International Women's Year. He also has received many awards for outstanding service to the legal profession and numerous Honorary Doctor of Laws degrees. Judge Edwards is a member of the American Law Institute; the American Academy of Arts and Sciences; the American Judicature Society; the American Bar Foundation; the American Bar Association; and the Supreme Court Historical Society. He is director/mentor at the Unique Learning Center in Washington, D.C., a volunteer program to assist disadvantaged inner city youth. Judge Edwards is the coauthor of five books. His most recent book, coauthored by Linda A. Elliot, *Federal Courts—Standards of Review: Appellate Court Review of District Court Decisions and Agency Actions*, was published in 2007. He has also published scores of law review articles dealing with labor law, equal employment opportunity, labor arbitration, higher education law, alternative dispute resolution, federalism, judicial process, comparative law, legal ethics, judicial administration, legal education, and professionalism. One of his most significant publications, "The Growing Disjunction Between Legal Education and the Legal Profession," published in the *Michigan Law Review* in 1992, has been the source of extensive comment, discussion, and debate among legal scholars and practitioners in the United States and abroad.

Constantine Gatsonis (Co-chair) is Professor of Biostatistics at Brown University and the founding Director of the Center for Statistical Sciences. He is a leading authority on statistical methods for the evaluation of diagnostic tests and biomarkers and has extensive involvement in research in Bayesian biostatistics, meta-analysis, and statistical methods for health services and outcome research. He is Network Statistician of the American College of Radiology Imaging Network, a National Cancer Institute-funded national collaborative group conducting multicenter studies of imaging in cancer diagnosis and therapy. Dr. Gatsonis has served on numerous review and advisory panels, including the Immunization Safety Review Committee of IOM, the Committee on Applied and Theoretical Statistics of NAS, panels of the Center for Devices and Radiological Health of U.S. Food and Drug Administration, the HSDG Study Section of the Agency for Health Care Policy Research, the Commission of Technology Assessment of the American College of Radiology, the Data Safety and Monitoring Boards for the National Institute of Neurological Disorders and Stroke and the

U.S. Department of Veterans Affairs, and several National Institutes of Health grant review panels. He is co-convenor of the Screening and Diagnostic Tests Methods Working Group of the Cochrane Collaboration and a member of the steering group of the Cochrane Diagnostic Reviews initiative to develop systematic reviews of diagnostic accuracy for the Cochrane Library. Dr. Gatsonis is the founding editor-in-chief of *Health Services and Outcomes Research Methodology* and serves as Associate Editor of the *Annals of Applied Statistics*, *Clinical Trials* and *Bayesian Analysis*. Previous editorial positions include membership of the editorial board of *Statistics in Medicine*, *Medical Decision Making*, and *Academic Radiology*. He was elected fellow of the American Statistical Association and the Association for Health Services Research.

Margaret A. Berger received her A.B. from Radcliffe College and her J.D. from Columbia University School of Law. She is widely recognized as one of the nation's leading authorities on scientific evidentiary issues and is a frequent lecturer across the country on these topics. Professor Berger is the recipient of the Francis Rawle Award for outstanding contribution to the field of postadmission legal education by the American Law Institute/American Bar Association for her role in developing new approaches to judicial treatment of scientific evidence and in educating legal and science communities about ways in which to implement these approaches. Professor Berger served as the Reporter for the Working Group on Post-Conviction Issues for the National Commission on the Future of DNA Evidence. She has been called on as a consultant to the Carnegie Commission on Science, Technology, and Government and has served as the Reporter to the Advisory Committee on the Federal Rules of Evidence. She is the author of numerous amicus briefs, including the brief for the Carnegie Commission on the admissibility of scientific evidence in the landmark case of *Daubert v. Merrell Pharmaceutical, Inc.* She also has contributed chapters to both editions of the Federal Judicial Center's Reference Manual on Scientific Evidence (1994, 2000). Professor Berger has been a member of the Brooklyn Law School faculty since 1973. She has served on the following National Academies committees: the Committee on Tagging Smokeless and Black Powder; the Committee on DNA Technology in Forensic Science: An Update; and the IOM Committee on Evaluation of the Presumptive Disability Decision-Making Process for Veterans. She currently serves as a member of the National Academies Committee on Science, Technology, and Law, on the Committee on Science, Engineering, and Public Policy, and on the Committee on Ensuring the Utility and the Integrity of Research Data.

Joe S. Cecil is a Senior Research Associate and Project Director in the Division of Research at the Federal Judicial Center. Currently, he is directing

the center's Program on Scientific and Technical Evidence. As part of this program, he serves as principal editor of the Center's *Reference Manual on Scientific Evidence*. He has published several articles on the use of court-appointed experts and is currently examining changes in summary judgment practice in federal district courts over the past 30 years. Dr. Cecil received his J.D. and a Ph.D. in psychology from Northwestern University. He serves on the editorial boards of social science and legal journals. He has served as a member of several panels of NAS, and currently is serving as a member of the National Academies Committee on Science, Technology, and Law. Other areas of research interest include federal civil and appellate procedure, jury competence in complex civil litigation, claim construction in patent litigation, and judicial governance.

M. Bonner Denton is a Professor of Chemistry and a Professor of Geosciences at the University of Arizona. He received his B.S. and B.A. in 1967 from Lamar State College of Technology. In 1972, he received his Ph.D. from the University of Illinois. He is the recipient of the American Chemical Society Division of Analytical Chemistry Award in Spectrochemical Analysis, 2001; the Pittsburgh Spectroscopy Award, 1998; the University of Arizona Excellence in Teaching Award, 1993; and the SAS Lester Strock Award, 1991. Dr. Denton has served as the editor of four texts on scientific optical imaging and has authored more than 190 peer-reviewed manuscripts. He has served as President of the Society of Applied Spectroscopy; Chair of the Analytical Division of the American Chemical Society; a Galileo Fellow, College of Science, University of Arizona, 2004; Fellow, Royal Society of Chemistry, 2004; Fellow, Society for Applied Spectroscopy, 2006; and Fellow, National Association of the Advancement of Science, 2006. His research interests include analytical instrumentation and spectroscopy and mass spectrometry.

Marcella F. Fierro served as Chief Medical Examiner for the Commonwealth of Virginia, and Professor of Pathology and Professor and Chair of the Department of Legal Medicine at Virginia Commonwealth University from 1994 to 2008. Dr. Fierro oversaw the medical examiner investigations of all violent, suspicious, and unnatural deaths in Virginia. She teaches forensic pathology to medical schools, law students, law enforcement agencies, the Commonwealth's attorneys, and other interested groups. She received a B.A. in biology cum laude from D'Youville College, Buffalo, New York, and earned her M.D. from the State University of New York at Buffalo School of Medicine. She completed residency training in pathology at the Cleveland Clinic and the Medical College of Virginia, Virginia Commonwealth University. She was a fellow in forensic pathology and legal medicine at Virginia Commonwealth University and the Office of the

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Chief Medical Examiner in Richmond, Virginia. Dr. Fierro is certified by the American Board of Pathology in anatomical, clinical, and forensic pathology. After serving as Deputy Chief Medical Examiner for Central Virginia for 17 years, Dr. Fierro accepted a position as Professor of Pathology at East Carolina University School of Medicine, where she served as a Professor of Pathology in the division of forensic pathology and taught general and forensic pathology until she returned to Virginia in 1994 as Chief. Dr. Fierro has been active in professional organizations as a member of the Forensic Pathology Council of the American Society of Clinical Pathologists and Chair of the Forensic Pathology Committee of the College of American Pathologists. She is past president of the National Association of Medical Examiners and served on the board of directors and the executive committee of that organization and currently serves on several committees. Dr. Fierro is a Fellow of the American Academy of Forensic Sciences, was a member of the Forensic Science Board for the Commonwealth, and has served as a consultant to the Federal Bureau of Investigation for the National Crime Information Center Unidentified and Missing Persons Files and on federal panels and committees that are developing best practices in mass fatality management. Dr. Fierro has been active in the legislative process, serving as a resource and advocate in Virginia for matters related to forensic and medical examiner issues. Recent activities include establishing child and maternal mortality review teams and the National Violent Death Reporting System and Family and Interpersonal Violence surveillance programs for Virginia. Dr. Fierro has published in professional journals, edited a textbook, contributed chapters to several books, and presented at international meetings. Dr. Fierro served as a reviewer for the American Journal of Forensic Medicine and Pathology. She received Virginia's Public Health Hero Award and the National Association of Medical Examiners Service award, and she was elected to Alpha Omega Alpha as a distinguished alumna of the School of Medicine, State University of New York at Buffalo.

Karen Kafadar is Rudy Professor of Statistics and Physics at Indiana University. She received her B.S. and M.S. degrees from Stanford and her Ph.D. in statistics from Princeton under John Tukey. Her research focuses on exploratory data analysis, robust methods, characterization of uncertainty in quantitative studies, and analysis of experimental data in the physical, chemical, biological, and engineering sciences. Previously, she was Professor and Chancellor's Scholar in the Departments of Mathematical Sciences and Preventive Medicine & Biometrics at the University of Colorado-Denver; Fellow at the National Cancer Institute (Cancer Screening section); and Mathematical Statistician at Hewlett Packard Company (R&D laboratory for RF/Microwave test equipment) and at the National Institute of Standards and Technology (where she continues as Guest Fac-

ulty Visitor on problems of measurement accuracy, experimental design, and data analysis). Previous engagements include consultancies in industry and government, as well as visiting appointments at the University of Bath, Virginia Tech, and Iowa State University. She has served on previous NRC committees and also on the editorial review boards for several professional journals as editor or associate editor and on the governing boards for the American Statistical Association, the Institute of Mathematical Statistics, and the International Statistical Institute. She is an Elected Fellow of the American Statistical Association and the International Statistical Institute, and she has authored more than 80 journal articles and book chapters and has advised numerous M.S. and Ph.D. students.

Peter M. Marone is the Executive Director of the Virginia Department of Forensic Sciences. He joined the department in 1978 and served as Central Laboratory Director from 1998 until 2005, when he was named Director of Technical Services. Mr. Marone began his forensic career at the Allegheny County Crime Laboratory in 1971 and remained in Pittsburgh until 1978. Mr. Marone is a member of the American Society of Crime Laboratory Directors (ASCLD), the American Academy of Forensic Sciences, the Mid-Atlantic Association of Forensic Scientists, and the International Association for Chemical Testing and the Forensic Science Society. He has served on the ASCLD's DNA Credential Review Committee (for DNA) and was Co-chair of the Undergraduate Curriculum Committee of the Technical Working Group for Forensic Science Training and Education. He is a past chair of the American Society of Crime Laboratory Directors Laboratory Accreditation Board, a member of the Forensic Education Program Accreditation Commission for the American Academy of Forensic Sciences, and the chair of the Board of Directors of the Consortium of Forensic Science Organizations. Mr. Marone received his B.S. and M.S. in chemistry from the University of Pittsburgh.

Geoffrey S. Mearns is the Dean of the Cleveland-Marshall College of Law at Cleveland State University. Before his appointment in July 2005, Dean Mearns was a practicing lawyer. His practice focused on federal criminal investigations and prosecutions and complex commercial litigation. While in private practice, he was also actively involved in pro bono work. Before commencing private practice in 1998, Dean Mearns had a distinguished nine-year career as a prosecutor with the U.S. Department of Justice. During his tenure with the Justice Department, he was an Assistant United States Attorney for the Eastern District of New York, where he was Chief of the Organized Crime and Racketeering Section. In that position, he was responsible for investigating, prosecuting, and supervising cases against members and associates of organized crime families charged with

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racketeering, murder, extortion, bribery, and obstruction of justice. Dean Mearns also was the First Assistant United States Attorney for the Eastern District of North Carolina. From 1997 to 1998, as Special Assistant to the United States Attorney General, he participated in the prosecution of Terry Nichols, one of two men convicted for bombing the Oklahoma City Federal Building. Dean Mearns received his undergraduate degree from Yale University in 1981, and he received his law degree from the University of Virginia in 1987. After graduating from law school, he clerked for the Honorable Boyce F. Martin, Jr., of the United States Court of Appeals for the Sixth Circuit. Dean Mearns has been active in professional and community service. Among other activities, he was twice Chair of the Merit Selection Committee on Bankruptcy Judgeships for the Northern District of Ohio; he was Chair of the Merit Selection Committee on United States Magistrate Judgeship for the Northern District of Ohio; and he was Chair of the Board of Trustees of Applewood Centers, Inc. He is a trustee of Wingspan Care Group, Inc., of the Cleveland Metropolitan Bar Association, and of the Sisters of Charity Foundation of Cleveland. Dean Mearns has been an adjunct professor at Case Western Reserve University School of Law and New York Law School. He has published articles on criminal litigation, and he is a frequent speaker and commentator on various criminal law issues, including counterterrorism.

Randall S. Murch is the Associate Director, Research Program Development, Research Division, National Capital Region, Virginia Tech. He holds Adjunct Professorships in the School of Public and International Affairs, College of Architecture and Urban Studies, and the Department of Plant Pathology, College of Agriculture and Life Sciences. He is also a Visiting Professor, Department of War Studies, King's College London, United Kingdom. Dr. Murch received his B.S. in biology from the University of Puget Sound, Tacoma, Washington, his M.S. in botanical sciences from the University of Hawaii in 1976, and his Ph.D. in plant pathology from the University of Illinois, Urbana-Champaign in 1979. He has extensive strategy, analysis, and leadership experience in the design, development, and implementation of advanced forensic capabilities for intelligence, counterterrorism, and other national security applications and purposes. Following brief service in the U.S. Army Reserve, Dr. Murch's first career was with the Federal Bureau of Investigation (FBI), where he was a Special Agent. He was assigned to the Indianapolis and Los Angeles Field Offices, where he performed counterterrorism, counterintelligence, and other investigations. During his career, Dr. Murch was assigned to the FBI Laboratory as a forensic biologist, research scientist, department head, and deputy director, at various times. Interdispersed with his Laboratory assignments were four assignments in the bureau's technical investigative program: as a program

manager for complex operations planning, Intelligence Division; unit chief for a technology development and deployment group, Technical Services Division; squad supervisor, New York Field Office; and Deputy Director, Investigative Technology Division (formally Technical Services Division). Between his last Laboratory assignment and his last technical investigative program assignment, he was detailed to the Defense Threat Reduction Agency, Department of Defense, where he was the director of the Advanced Systems and Concepts Office and led advanced studies on complex current and future challenges dealing with weapons of mass destruction. He created the FBI's WMD forensic investigative program, served as the Bureau's science advisor to the 1996 Olympic Games, led forensic investigative aspects of a number of major terrorism cases, and initiated a number of new programs for both the FBI Laboratory and technical investigative program. In 1996, Dr. Murch created the FBI's Hazardous Materials Response Unit, the Nation's focal point for the forensic investigation of WMD threats, events and hoaxes. Throughout his FBI career, he also was involved with extensive liaison at the national and international levels in furthering science and technology for law enforcement, counterterrorism, and national security purposes. Dr. Murch retired from the FBI in November 2002, after nearly 23 years of service. From December 2002 through December 2004, Dr. Murch was employed as a Research Staff Member, Institute for Defense Analyses, a leading Federally Funded Research and Development Center, where he led and participated in studies for the defense, intelligence, and homeland security communities. He is still an adjunct staff member at the institute. He joined Virginia Tech in December 2004, where he now works in the areas of life science research program development, systems biology, microbial systems biology, microbial forensics, and biosecurity and university strategic planning. He has served or still serves on several advisory boards, including the Board of Life Sciences, NRC; the Defense Threat Reduction Agency's Threat Reduction Advisory Committee; the Defense Intelligence Agency's BioChem 2020; the FBI's Scientific Working Group on Microbial Genomics and Forensics, and a new standing committee of NAS for the Department of Homeland Security's National Biodefense Analysis and Countermeasures Center. He has also been a member of or advised study committees of NRC, NAS, IOM, the Defense Science Board, and the Threat Reduction Advisory Committee. Dr. Murch has been a member of the American Academy of Forensic Sciences and the American Society of Crime Laboratory Directors; has served on the Board of Directors, American Society of Crime Laboratory Directors; and has been a member of the National Institute of Justice DNA Proficiency Testing Panel. He also served as the Designated Federal Employee on the DNA Advisory Board.

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Channing Robertson received his B.S. in chemical engineering from the University of California, Berkeley; his M.S. in chemical engineering from Stanford University; and his Ph.D. in chemical engineering, with an emphasis on fluid mechanics and transport phenomena, from Stanford University. Professor Robertson began his career at the Denver Research Center of the Marathon Oil Company and worked in the areas of enhanced oil recovery, geophysical chemistry, and polyurethane chemistry. Since 1970, he has been on the faculty of Stanford's Department of Chemical Engineering and has educated and trained more than 40 doctoral students, holds 7 patents, and has published more than 140 articles. He is Director of the Stanford-National Institutes of Health Graduate Training Program in Biotechnology. He was Co-director of the Stanford initiative in biotechnology known as BioX, which in part includes the Clark Center for Biomedical Engineering and Sciences. He directed the summer Stanford Engineering Executive Program. Dr. Robertson received the 1991 Stanford Associates Award for service to the university, the 1991 Richard W. Lyman Award, and the Society of Women Engineers Award for Teacher of the Year 2000 at Stanford. He is a Founding Fellow of the American Institute of Medical and Biological Engineering. Dr. Robertson serves on the Scientific Advisory Committee on Tobacco Product Regulation of the World Health Organization and on the Panel on Court-Appointed Scientific Experts of the American Association for the Advancement of Science. Because of his interests in biotechnology, he has consulted widely in the design of biomedical diagnostic devices. Dr. Robertson has also served as an expert witness in several trials, including the Copper-7 intrauterine contraceptive cases (United States and Australia), the Stringfellow Superfund case, and, most recently, the Minnesota tobacco trial.

Marvin E. Schechter has been a solo practitioner, specializing in criminal defense matters before state, federal, and appeals courts, since 1994. Mr. Schechter has held several positions with the Legal Aid Society of New York, including Deputy Attorney-in-Charge, Criminal Defense Division, Kings County. He is currently a member of the Board of Directors of the National Association of Criminal Defense Attorneys, a member of the Executive Committee of the Criminal Justice Section of the New York State Bar Association, and a past president of the New York State Association of Criminal Defense Attorneys. Mr. Schechter co-founded Getting Out/Staying Out, a program that provides 18- to 22-year-old Rikers Island Correctional Facility inmates with the opportunity to earn a GED and receive job counseling, employment, and housing. He has taught at the National Institute for Trial Advocacy programs at Hofstra University and Cardozo Law School and has been an adjunct professor for trial advocacy at Fordham University Law School. He received his J.D. from Brooklyn Law School.

Robert Shaler received his Ph.D. from Pennsylvania State University in 1968 and has had academic appointments at the University of Pittsburgh School of Medicine, the University of Pittsburgh School of Pharmacy, the City University of New York, New York University School of Medicine, and, most recently, at Pennsylvania State University. He joined the scientific staff of the Pittsburgh and Allegheny County Crime Laboratory in 1970, where, as a criminalist, he practiced forensic science, testified in court, and investigated crime scenes. He joined the Aerospace Corporation staff in 1977 and managed four Law Enforcement Assistance Administration contracts, one of which resulted in setting the bloodstain analysis standard for the Nation's crime laboratories until the mid 1980s. In 1978, he joined the staff of the New York City Medical Examiner's Office as the head of its serology laboratory, a position he held until 1987, when he moved to the Lifecodes Corporation, the Nation's first forensic DNA typing laboratory. As the Director of Forensic Science and Business Development, he introduced "DNA Fingerprinting" to the Nation's legal and law enforcement communities, through a series of nationwide, informational lectures. Dr. Shaler returned to the Medical Examiner's Office in 1990, where he created a modern Department of Forensic Biology, designed its current 300,000 square foot modern building, and established the city's first crime reconstruction team, which still operates from within the Medical Examiner's Office. In the wake of the 9/11 attacks on the World Trade Center, he assumed responsibility for the DNA identification effort, designing the testing strategy and coordinating the work of six different laboratories. In 2005, he published a book, *Who They Were—Inside the World Trade Center DNA Story: The Unprecedented Effort to Identify the Missing*, that told the story of the people working behind the scenes of the DNA work done at the Medical Examiner's Office in New York City. In July 2005, he retired from the Medical Examiner's Office and accepted a professorship at Pennsylvania State University, where he is the director of the university's forensic science program. His crime scene investigation course has attracted national attention, and his research interests are broad, focusing on applying science and technology to crime scene investigation and quantifying the biological response to trauma and stress. He has taught several workshops to working law enforcement professionals in crime scene investigation, crime reconstruction, and bloodstain pattern analysis.

Jay A. Siegel is Professor and Director of the Forensic and Investigative Sciences Program at Indiana University Purdue University, Indianapolis. He was Director of the Forensic Science Program at Michigan State University. He was Professor of Chemistry at Metropolitan State College in Denver, Colorado, and he spent three years as a forensic chemist with the Virginia Bureau of Forensic Sciences, where he analyzed illicit drugs and

trace evidence. Dr. Siegel has testified as an expert witness more than 200 times in 7 states, as well as in federal and military courts. Dr. Siegel is a Fellow with the American Academy of Forensic Sciences, where he was awarded the Paul Kirk Award for outstanding service to the Criminalistics section in 2005. He is also a member of the American Chemical Society, the Midwest Association of Forensic Scientists, and the Forensic Science Society (United Kingdom). He is a member of the International Association for Identification and an Academic Affiliate member of the American Society of Crime Lab Directors. Dr. Siegel is an active researcher in forensic science, with many scientific publications. He currently serves as the principal investigator on a research grant from the National Institute of Justice on ink analysis, his second grant for this work. He also is the author of two textbooks in forensic science and is the editor in chief of the *Encyclopedia of Forensic Sciences*.

Sargur Srihari received a B.Sc. in physics and mathematics from the Bangalore University in 1967, a B.E. in electrical communication engineering from the Indian Institute of Science, Bangalore, in 1970, and a Ph.D. in computer and information science from the Ohio State University, Columbus, in 1976. Dr. Srihari is a State University of New York Distinguished Professor at the University of Buffalo in the Department of Computer Science and Engineering. He is the founding director of the Center of Excellence for Document Analysis and Recognition. He has supervised 30 completed doctoral dissertations. Dr. Srihari is a member of the Board of Scientific Counselors of the National Library of Medicine. He is chairman of CedarTech, a corporation for university technology transfer. Dr. Srihari has been general chairman of several international conferences and workshops: the Third International Workshop on Handwriting Recognition held in Buffalo, New York, in 1993, the Second International Conference on Document Analysis and Recognition, in Montreal, Canada, 1995, the Fifth International Conference on Document Analysis and Recognition, 1999, held in Bangalore, India, and the Eighth International Workshop on Handwriting Recognition, 2002, held in Niagara-on-the-Lake, Ontario, Canada. Dr. Srihari has served as chairman of TC-11 (technical committee on Text Processing) of the International Association for Pattern Recognition. He is currently Chair of the International Association for Pattern Recognition's Publicity and Publications Committee. Dr. Srihari received a New York State/United University Professions Excellence Award for 1991. He became a Fellow of the Institute of Electronics and Telecommunications Engineers (India) in 1992, a Fellow of the Institute of Electrical and Electronics Engineers in 1995, and a Fellow of the International Association for Pattern Recognition in 1996. He was named a distinguished alumnus of the Ohio State University College of Engineering in 1999.

Sheldon M. Wiederhorn (NAE) received his B.S. in chemical engineering from Columbia University in 1956 and his M.S. and Ph.D. from the University of Illinois, also in chemical engineering, with a minor in solid state physics. His Ph.D. topic was high pressure physics, with an emphasis on phase transformations in alkali halides. After finishing graduate school, he worked at DuPont at the Research Station in Wilmington, Delaware, during which time his research and scientific interests gradually changed toward materials science with a specialization in the mechanical behavior of ceramic materials. After three years, he began work at the National Bureau of Standards, where he carried out an independent research program on the mechanical behavior of glasses and ceramic materials. At the National Bureau of Standards, now the National Institute of Standards and Technology, Dr. Wiederhorn carried out a program on the mechanical reliability of brittle materials. He was one of the first to apply fracture mechanics techniques to study the fracture of ceramic materials. A result of his research was the development of techniques to assure the structural reliability of brittle ceramic materials. Techniques pioneered by Dr. Wiederhorn are now used to assure the reliability of glass windows in airplanes and in space vehicles. Dr. Wiederhorn is best known for the experiments he developed to study and to characterize subcritical crack growth in glasses. The results of these studies illustrated the complexity of subcritical crack growth, and a natural conclusion of his study was that the failure of glass was caused by the slow growth of cracks to a critical size, which determined the time-to-failure. In addition to his work on the fracture of glass, Dr. Wiederhorn directed a program to measure the deformation of structural ceramics at very high temperatures. The objective of this work was to develop ceramic materials that could be used as turbine blades in power turbines used for more efficient production of electricity. The program has resulted in the development of new measurement techniques for characterizing creep at elevated temperatures. A new mechanism of creep has also been discovered by Dr. Wiederhorn and his group, and ways have been suggested to improve the creep behavior of nonoxide materials at high temperatures. Dr. Wiederhorn has received many awards for his research and leadership at the National Institute of Standards and Technology. These include both a Silver and Gold Medal awarded by the Department of Commerce and the Samuel Wesley Stratton Award by the National Bureau of Standards. He is also a Fellow of the American Ceramic Society and has received a number of important awards for his research from this society, including the Jeppson Award for outstanding research on ceramic materials. He is now a Distinguished Lifetime Member of the American Ceramic Society. In 1991, Dr. Wiederhorn was elected a member of the National Academy of Engineering. At the National Institute of Standards and Technology, Dr. Wiederhorn is now a Senior Fellow and continues to carry out a research

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program on the mechanical properties of ceramic materials. His current interests are to use the Atomic Force Microscope to investigate the atomistics of crack growth in glasses and ceramic materials, with the hope of learning more about the crack growth process and the relation between crack growth and the microstructure of glass.

Ross E. Zumwalt is Chief Medical Investigator of the State of New Mexico. He received his undergraduate education from Wabash College in Crawfordsville, Indiana. Dr. Zumwalt graduated from the University of Illinois College of Medicine. He completed a rotating internship and one year of pathology residency at the Mary Imogene Bassett Hospital in Cooperstown, New York. Dr. Zumwalt then completed his pathology residency at the Southwestern Medical School and Parkland Hospital in Dallas. He received his forensic fellowship training at the Dallas County Medical Examiner's Office. Dr. Zumwalt served in the United States Navy as director of laboratories at the Navy Regional Medical Center in Camp Lejeune, North Carolina. He spent two years as deputy coroner in Cleveland, Ohio, and six years as deputy coroner in Cincinnati, Ohio, before coming to the Office of the Medical Investigator in 1987. Dr. Zumwalt is certified in anatomic and forensic pathology by the American Board of Pathology. He was a trustee of the American Board of Pathology from 1993 to 2004. He is currently a member of the Residency Review Committee for Pathology. Dr. Zumwalt has served as president of the National Association of Medical Examiners and is a member of the following professional organizations: The National Association of Medical Examiners; the American Academy of Forensic Sciences; the College of American Pathologists; the American Society of Clinical Pathologists; the United States and Canadian Academy of Pathology; the American Medical Association; and the American Association for the Advancement of Science.

Staff

Anne-Marie Mazza is Director of the Committee on Science, Technology and Law. She joined the National Academies in 1995. She has served as Senior Program Officer with both the Committee on Science, Engineering, and Public Policy and the Government-University-Industry Research Roundtable. In 1999 she was named the first director of the Committee on Science, Technology, and Law, a newly created program designed to foster communication and analysis among scientists, engineers, and members of the legal community. In 2007, she became the director of the Christine Mirzayan Science and Technology Graduate Policy Fellowship Program. Dr. Mazza has been the study director on numerous Academy reports, including *Science and Security in a Post 9-11 World, 2007*; *Reaping the Benefits*

of *Genomic and Proteomic Research*, 2005; *Intentional Human Dosing Studies for EPA Regulatory Purposes: Scientific and Ethical Issues*, 2004; *The Age of Expert Testimony: Science in the Courtroom*, 2002; *Issues for Science and Engineering Researchers in the Digital Age*, 2001; and *Observations on the President's Fiscal Year 2000 Federal Science and Technology Budget*, 1999. Between October 1999 and October 2000, she divided her time between the Committee on Science, Technology, and Law and the White House Office of Science and Technology Policy, where she served as a Senior Policy Analyst responsible for issues associated with the government-university research partnership. Before joining the Academy, Dr. Mazza was a Senior Consultant with Resource Planning Corporation. She received a B.A., M.A., and Ph.D. from The George Washington University.

Scott T. Weidman is the Director of NRC's Board on Mathematical Sciences and Their Applications. He joined NRC in 1989 with the Board on Mathematical Sciences and moved to the Board on Chemical Sciences and Technology in 1992. In 1996, he established a new board to conduct annual peer reviews of the Army Research Laboratory, which conducts a broad array of science, engineering, and human factors research and analysis, and he later directed a similar board that reviews the work of the National Institute of Standards and Technology. He has worked full time with the Board on Mathematical Sciences and Their Applications since June 2004. During his NRC career, he has staffed studies on a wide variety of topics related to mathematical, chemical, and materials sciences; laboratory assessment; and science and technology policy. His current focus is on building NRC's capabilities and portfolio related to all areas of analysis and computational science. He holds bachelor degrees in mathematics and materials science from Northwestern University and an M.S. and Ph.D. in applied mathematics at the University of Virginia. Before joining NRC, he held positions with General Electric, General Accident Insurance Company, Exxon Research and Engineering, and MRJ, Inc.

David Padgham is Policy Director at the High Performance Computing Initiative Council on Competitiveness. Before joining the council, he was an associate program officer at the Computer Science and Telecommunications Board of NRC. His work there comprised a robust mix of writing, research, and project management, and he was involved in the production of numerous reports, including, most recently, *Software for Dependable Systems: Sufficient Evidence?*; *Engaging Privacy and Information Technology in a Digital Age*; and *Renewing U.S. Telecommunications Research*. Before joining the Computer Science and Telecommunications Board in 2006, Mr. Padgham was a policy analyst for the Association for Computing Machinery, where he worked closely with its public policy committee, USACM, to

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support the organization's policy principles and promote its policy interests. Mr. Padgham holds a master's degree in library and information science, from the Catholic University of America in Washington, D.C., and a B.A. in English, from Warren Wilson College in Asheville, North Carolina.

John Sislin is a Program Officer with the Board on Higher Education and Workforce. His work focuses on topics in international affairs, higher education, globalization, and the impact of science and technology on society and security. His work on international affairs includes developing a system to monitor compliance with international labor standards for the U.S. Department of Labor and development of a biographical database on world leaders with foreign education or employment experience sponsored by the MacArthur Foundation. Dr. Sislin's work in higher education has focused on gender (three projects on recruiting, retaining, and advancing women in science and engineering in higher education and academic careers) and the role of community colleges in educating future engineers. He has worked on program evaluations for the NIST, the United States Institute of Peace, and NSF. Other projects include a survey of life scientists' attitudes toward personal responsibility regarding dual-use research and biosecurity and a study of priorities in civil aeronautics research sponsored by NASA. Before coming to the Academies, Dr. Sislin's previous research focused on international and civil conflict, human rights, international security, and U.S. foreign policy. Dr. Sislin received a B.A. from the University of Michigan in Russian and East European Studies and a Ph.D. in Political Science from Indiana University.

Steven Kendall is Senior Program Associate for the Committee on Science, Technology, and Law. He is a Ph.D. candidate in the Department of the History of Art and Architecture at the University of California, Santa Barbara, where he is completing a dissertation on nineteenth-century British painting. Mr. Kendall received his M.A. in Victorian art and architecture at the University of London. Before joining The National Academies in 2007, he worked at the Smithsonian American Art Museum and The Huntington in San Marino, California.

Kathi E. Hanna is a science and health policy consultant, writer, and editor specializing in biomedical research policy and bioethics. She served as Research Director and Senior Consultant to President Clinton's National Bioethics Advisory Commission and as Senior Advisor to President Clinton's Advisory Committee on Gulf War Veterans Illnesses. More recently, she served as the lead author and editor of President Bush's Task Force to Improve Health Care Delivery for Our Nation's Veterans. In the 1980s and 1990s, Dr. Hanna was a Senior Analyst at the congressional Office

of Technology Assessment, contributing to numerous science policy studies requested by congressional committees on science education, research funding, biotechnology, women's health, human genetics, bioethics, and reproductive technologies. In the past decade, she has served as an analyst and editorial consultant to the Howard Hughes Medical Institute, the National Institutes of Health, IOM, NAS, and several charitable foundations, voluntary health organizations, and biotechnology companies. Before coming to Washington, D.C., she was the Genetics Coordinator at Children's Memorial Hospital in Chicago, where she directed clinical counseling and coordinated an international research program in prenatal diagnosis. Dr. Hanna received an A.B. in biology from Lafayette College, an M.S. in human genetics from Sarah Lawrence College, and a Ph.D. from the School of Business and Public Management, The George Washington University.

Sara D. Maddox is a science and health policy editor who served as senior editor for reports to the President of the National Bioethics Advisory Commission, including *Ethical Issues in Human Stem Cell Research* and *Research Involving Human Biological Materials: Ethical Issues and Policy Guidance*. Earlier in her career she was a writer and editor at the Howard Hughes Medical Institute, and she has served as a science editor and writer for reports of the Secretary's Advisory Committee on Genetics, Health, and Society. Ms. Maddox participated in editing *Firepower in the Lab: Automation in the Fight Against Infectious Diseases and Bioterrorism*, a publication based on a colloquium on bioterrorism and laboratory-based data held at NAS. She has edited reports of the National Resource Council, including *Intentional Human Dosing Studies for EPA Regulatory Purposes: Scientific and Ethical Issues and Participants* and *Science and Security in a Post 9/11 World*. She also was editor for IOM's *Genes, Behavior, and the Social Environment: Moving Beyond the Nature/Nurture Debate*.

Appendix B

Committee Meeting Agendas

MEETING 1 WASHINGTON, D.C. JANUARY 25, 2007

- 8:30 Welcome and Introductions
- Committee Co-chairs
Harry T. Edwards, Judge, U.S. Court of Appeals for the District of Columbia Circuit
Constantine Gatsonis, Director, Center for Statistical Studies, Brown University
- 8:45 Charge to Committee
- David W. Hagy, Deputy Assistant Attorney General for Policy Coordination, Office of Justice Programs, U.S. Department of Justice and Principal Deputy Director, National Institute of Justice, U.S. Department of Justice
- 9:10 Discussion
- 9:30 Importance of Study to the Forensics Community
- Joe Polski, Chair, Consortium of Forensic Science Organizations
- 9:45 Discussion
- 10:15 Current State of Forensics: Census of Publicly Funded Forensic Crime Labs
- Joseph L. Peterson, Director and Professor, School of Criminal Justice and Criminalistics, California State University, Los Angeles

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APPENDIX B

Matthew J. Hickman, U.S. Department of Justice, Bureau of
Justice Statistics

10:45 Discussion

11:15 Overview of Forensics Training and Education

Max M. Houck, Director, Forensic Science Initiative and
Director, Forensic Business Development, College of Business and
Economics, West Virginia University

Larry Quarino, Assistant Professor, Cedar Crest College

12:00 Discussion

12:15 Lunch

1:00 Daily Operations of Forensic Labs

Joseph A. DiZinno, Assistant Director, Laboratory Division,
Federal Bureau of Investigation

Jan L. Johnson, Laboratory Director, Forensic Science Center at
Chicago, Illinois State Police

Irma Rios, Assistant Director, City of Houston Crime Lab

2:15 Discussion

3:00 National Institute of Justice Research Program and Budget—
Future Needs and Priorities

John Morgan, Deputy Director for Science and Technology,
National Institute of Justice, DOJ

3:20 Discussion

3:45 Views from the Major Forensic Science Organizations: Issues and
Challenges

Bruce A. Goldberger, President-Elect, American Academy of
Forensic Sciences

APPENDIX B

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Bill Marbaker, President, American Society of Crime Laboratory Directors

Robert Stacey, President, American Society of Crime Laboratory Directors, Laboratory Accreditation Board

Arthur Eisenberg, Board Member, Forensic Quality Services

Joe Polski, Chief Operations Officer, International Association for Identification

James Downs, Board Member and Chair, Government Affairs Committee, National Association of Medical Examiners

5:00 Discussion

5:30 Adjourn

JANUARY 26, 2007

8:30 Opportunities for Improvement: Critical Areas

Michael Risinger, Professor of Law, Seton Hall Law School

Peter Neufeld, Co-founder and Co-director, The Innocence Project

David Stoney, Chief Scientist, Stoney Forensic, Inc.

9:30 Discussion

10:00 Adjourn

MEETING 2
WASHINGTON, D.C.
APRIL 23, 2007

8:00 Welcome and Introductions

Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs

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APPENDIX B

- 8:10 Essential Elements of Science: Hypotheses, Falsifiability, Replication, Peer Review

Alan I. Leshner, Chief Executive Officer, American Association for the Advancement of Science

The Science of Statistics: Error Testing, Probabilities, Observer Bias

Jay Kadane, Senior Statistician, Department of Statistics, Carnegie Mellon University

- 9:00 Discussion

- 9:20 Forensic DNA

Science

Robin Cotton, Director, Biomedical Forensic Sciences Program, Boston University School of Medicine

Policy and Politics

Chris Asplen, Vice President, Gordon Thomas Honeywell Government Affairs and former Executive Director, U.S. Attorney General's National Commission on the Future of DNA Evidence

- 10:10 Discussion

- 10:45 The Science of Forensic Disciplines

What is the state of the art? Where is research conducted? Where is it published? What is the scientific basis that informs the interpretation of the evidence? Where are new developments coming from? What are the major problems in the scientific foundation or methods and in the practice? What research questions would you like to have answered?

Moderator: Constantine Gatsonis, Committee Co-Chair

APPENDIX B

307

10:50 Drug Identification

Joseph P. Bono, Laboratory Director, Forensic Services Division,
U.S. Secret Service

11:15 Discussion

11:45 Lunch

12:30 Pattern Evidence with Fingerprints and Toolmarks as Illustrations

Fingerprints

Ed German, Latent Print Examiner, U.S. Army, Retired

Toolmarks

Peter Striupaitis, Chair, International Association for Identification,
Firearm/Toolmark Committee and Member, Scientific Working
Group for Firearms and Toolmarks (SWGGUN)

1:30 Discussion

2:00 Trace Evidence with Arson and Hair as Illustrations

Arson

John Lentini, Scientific Fire Analysis, LLC

Hair

Max M. Houck, Director, Forensic Science Initiative and
Director, Forensic Business Development, College of Business and
Economics, West Virginia University

3:00 Discussion

3:45 Forensic Odontology: Bite Marks

David R. Senn, Director, Center for Education and Research in
Forensics and Clinical Assistant Professor, Department of Dental
Diagnostic Science, The University of Texas Health Science
Center at San Antonio

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APPENDIX B

4:10 Discussion

4:30 Commentators

Robert E. Gaensslen, Head of Program in Forensic Science,
College of Pharmacy, University of Illinois at Chicago

Jennifer Mnookin, Professor of Law, University of California, Los
Angeles Law School

David Kaye, Regents' Professor of Law and Professor of Life
Sciences, Arizona State University

5:15 Comments from the Floor

5:45 Adjourn

APRIL 24, 2007

8:00 Welcome and Introductions

Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs

8:10 From Crime Scene to Courtroom: The Collection and Flow of Evidence

Barry A. J. Fisher, Director, Scientific Services Bureau, Los
Angeles County Sheriff's Department and former President,
American Academy of Forensic Sciences

8:45 Discussion

9:15 Practice and Standards: Scientific Working Groups

What is the process for establishing the guidelines and standards?
What are the guidelines/standards for each of these disciplines?
How is quality control/quality assurance monitored and
enforced? What recommendations have these organizations made
and have they been implemented? What is needed?

Moderator: Harry T. Edwards, Committee Co-chair

APPENDIX B

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9:20 Drug Identification

Nelson A. Santos, Drug Enforcement Administration and Chair,
Scientific Working Group for the Analysis of Seized Drugs
(SWGDRUG)

9:40 Discussion

10:00 Pattern Evidence: Latent Prints

Stephen B. Meagher, Fingerprint Specialist, Federal Bureau
of Investigation and Vice-Chair, Scientific Working Group on
Friction Ridge Analysis, Study and Technology (SWGFAST)

10:30 Discussion

11:00 Trace Evidence: Hair Analysis

Richard E. Bisbing, Executive Vice President, McCrone
Associates, Inc. and member, Scientific Working Group on
Materials Analysis (SWGMA)

11:20 Discussion

11:45 Commentators

Paul C. Giannelli, Weatherhead Professor, Case Western Reserve
University School of Law

Carol Henderson, Director, National Clearinghouse for Science,
Technology and the Law and Professor of Law, Stetson University

Michael J. Saks, Professor of Law & Psychology and Faculty
Fellow, Center for the Study of Law, Science, & Technology,
Sandra Day O'Connor College of Law, Arizona State University

12:30 Comments from the Floor

1:00 Adjourn

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APPENDIX B

MEETING 3
WASHINGTON, D.C.
JUNE 5, 2007

- 8:15 Welcome and Introductions
- Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs
- 8:30 Forensic Sciences: Issues and Direction
- Bruce Budowle, Senior Scientist, Laboratory Division, Federal
Bureau of Investigation
- 9:30 Challenges for Crime Laboratories: City, County, and Private
- Peter Pizzola, Director, New York Police Department Crime
Laboratory
- John Collins, Director, DuPage County Sheriff's Office Crime
Laboratory
- John E. Moalli, Group Vice President and Principal Engineer,
Exponent
- 11:00 Emerging Issues: Cybercrime, fMRI (functional Magnetic
Resonance Imaging) and Lie Detection, and Photographic
Comparison Analysis
- Eric Friedberg, Co-president, Stroz Friedberg, LLC
- Hank Greely, Deane F. and Kate Edelman Johnson Professor of
Law, Stanford University
- Richard W. Vorder Bruegge, Supervisory Photographic
Technologist-Examiner of Questioned Photographic Evidence,
Federal Bureau of Investigation
- 12:30 Working Lunch: Continuation of Morning Session

APPENDIX B

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1:15 Automated Fingerprint Identification Systems (AFIS)
Interoperability

John Onstwedder III, Statewide AFIS Coordinator for the
Forensic Sciences Command, Forensic Science Center at Chicago,
Illinois State Police

Peter T. Higgins, Principal Consultant, The Higgins-Hermansen
Group

Peter D. Komarinski, Komarinski & Associates, LLC

2:15 Medical Examiner System

Randy Hanzlick, Chief Medical Examiner, Fulton County
Medical Examiner's Center, Fulton County, Georgia and
Professor of Forensic Pathology, Emory University School of
Medicine

James Downs, Board Member and Chair, Governmental Affairs
Committee, National Association of Medical Examiners; Vice
Chair, Consortium of Forensic Science Organizations; Coastal
Regional Medical Examiner, Georgia Bureau of Investigation

Garry F. Peterson, Chief Medical Examiner Emeritus, Hennepin
County Medical Examiner's Office, Minnesota; Chair, Standards,
Inspection and Accreditation Committee and Standards
Subcommittee and Past President, National Association of
Medical Examiners

Victor W. Weedn, Medical Examiner

4:15 Comments from the Floor

5:00 Adjourn

MEETING 4
WOODS HOLE, MASSACHUSETTS
SEPTEMBER 20, 2007

1:30 Welcome

Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs

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APPENDIX B

1:35 Lessons Learned From the Houston Police Department Investigation

Michael R. Bromwich, Independent Investigator, Fried, Frank, Harris, Shriver & Jacobson LLP

2:45 200 Exonerations: A Look at the Cases Involving Faulty Forensic Evidence

Brandon L. Garrett, Associate Professor of Law, University of Virginia

Peter Neufeld, Co-Founder and Co-Director, The Innocence Project

4:15 Ethics in Forensic Science

Peter D. Barnett, Partner, Forensic Science Associates

5:00 Reducing Error Rates: A New Institutional Arrangement for Forensic Science

Roger G. Koppl, Director, Institute for Forensic Science Administration, Fairleigh Dickinson University

6:00 Adjourn

SEPTEMBER 21, 2007

8:15 Welcome

Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs

8:20 The U.K. Forensics System

Carole McCartney, Centre for Criminal Justice Studies, School of Law, University of Leeds

APPENDIX B

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9:20 The Role of Forensics in Homeland Security

Charles Cooke, Bio-Specialist, Office of the Deputy Director for Strategy and Evaluation, National Counterproliferation Center, Office of the Director of National Intelligence

James Burans, Bioforensics Program Manager, National Bioforensics Analysis Center, U.S. Department of Homeland Security

Larry Chelko, Director, U.S. Army Criminal Investigation Laboratory

Rick Tontarski, Chief, Forensic Analysis Division, U.S. Army Criminal Investigation Laboratory

11:00 Forensics at the National Institute of Standards and Technology

Michael D. Garris, Image Group Manager, National Institute of Standards and Technology

Barbara Guttman, Line Manager, National Software Reference Library, National Institute of Standards and Technology

William MacCrehan, Research Chemist, Analytical Chemistry Division, National Institute of Standards and Technology

12:20 Adjourn

MEETING 5
WASHINGTON, D.C.
DECEMBER 6, 2007

8:15 Welcome and Introductions

Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs

8:30 Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST)

Glenn Langenburg, Minnesota Bureau of Criminal Apprehension

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APPENDIX B

9:15 Fingerprint Source Book

John Morgan, Deputy Director for Science and Technology,
National Institute of Justice, U.S. Department of Justice

9:45 International Association of Identification: Key Issues

Kenneth F. Martin, Crime Scene Services, Massachusetts State
Police

10:30 Forensic Science Issues at the U.S. Secret Service

Vici Inlow, Forensic Services Division, U.S. Secret Service

Deborah Leben, Forensic Services Division, U.S. Secret Service

11:10 Contextual Bias

Itiel Dror, School of Psychology, University of Southampton

12:00 Lunch

1:00 The Coroner System

Michael Murphy, Las Vegas Office of the Coroner

1:50 Survey of Non-Traditional Forensic Service Providers

Tom Witt, Bureau of Business and Economic Research, College of
Business and Economics, West Virginia University

2:30 Department of Defense Latent Print Analysis

Thomas Cantwell, Senior Forensic Analyst, Biometric Task Force
and Leader, Forensic Integrated Product Team, U.S. Department
of Defense

3:15 Comments from the Floor

3:45 Adjourn

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