STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES

A PATH FORWARD

Committee on Identifying the Needs of the Forensic Science Community

Committee on Science, Technology, and Law
Policy and Global Affairs

Committee on Applied and Theoretical Statistics
Division on Engineering and Physical Sciences

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS 500 Fifth Street, N.W. Washington, DC 20001

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was supported by Contract No. 2006-DN-BX-0001 between the National Academy of Sciences and the National Institute of Justice. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

Library of Congress Cataloging-in-Publication Data

Strengthening forensic science in the United States : a path forward : summary / Committee on Identifying the Needs of the Forensic Science Community, Committee on Science, Technology, and Law Policy and Global Affairs, Committee on Applied and Theoretical Statistics, Division on Engineering and Physical Sciences.
p. cm.
Includes index.
ISBN-13: 978-0-309-13135-3 (hardcover)
ISBN-10: 0-309-13135-9 (hardcover)
ISBN-13: 978-0-309-13131-5 (pbk.)
ISBN-10: 0-309-13131-6 (pbk.)
1. Forensic sciences—United States. 2. Criminal investigation—United States. 3. Evidence, Criminal—United States. I. National Research Council (U.S.). Committee on Identifying the Needs of the Forensic Science Community. II. National Research Council (U.S.). Committee on Science, Technology, and Law Policy and Global Affairs. III. National Research Council (U.S.). Committee on Applied and Theoretical Statistics.
HV8073.S7347 2009
363.250973—dc22
2009011443

Additional copies of this report are available from the National Academies Press, 500 Fifth Street, N.W., Lockbox 285, Washington, DC 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, *http://www.nap.edu*.

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

COMMITTEE ON IDENTIFYING THE NEEDS OF THE FORENSIC SCIENCE COMMUNITY

HARRY T. EDWARDS, (*Co-chair*), Judge, U.S. Court of Appeals for the District of Columbia Circuit
CONSTANTINE GATSONIS, (*Co-chair*), Director, Center for Statistical Sciences, Brown University
MARGARET A. BERGER, Suzanne J. and Norman Miles Professor of Law, Brooklyn Law School
JOE S. CECIL, Project Director, Program on Scientific and Technical Evidence, Federal Judicial Center
M. BONNER DENTON, Professor of Chemistry, University of Arizona
MARCELLA F. FIERRO, Medical Examiner of Virginia (ret.)
KAREN KAFADAR, Rudy Professor of Statistics and Physics, Indiana University
PETE M. MARONE, Director, Virginia Department of Forensic Science
GEOFFREY S. MEARNS, Dean, Cleveland-Marshall College of Law, Cleveland State University
RANDALL S. MURCH, Associate Director, Research Program Development, Virginia Polytechnic Institute and State University
CHANNING ROBERTSON, Ruth G. and William K. Bowes Professor, Dean of Faculty and Academic Affairs, and Professor, Department of Chemical Engineering, Stanford University
MARVIN E. SCHECHTER, Attorney
ROBERT SHALER, Director, Forensic Science Program, Professor, Biochemistry and Molecular Biology Department, Eberly College of Science, The Pennsylvania State University
JAY A. SIEGEL, Professor, Forensic and Investigative Sciences Program, Indiana University-Purdue University
SARGUR N. SRIHARI, SUNY Distinguished Professor, Department of Computer Science and Engineering and Director, Center of Excellence for Document Analysis and Recognition (CEDAR), University at Buffalo, State University of New York
SHELDON M. WIEDERHORN (NAE), Senior NIST Fellow, National Institute of Standards and Technology
ROSS E. ZUMWALT, Chief Medical Examiner, Office of the Medical Examiner of the State of New Mexico

Staff

ANNE-MARIE MAZZA, Study Director
SCOTT T. WEIDMAN, Director, Board on Mathematical Sciences and Their Applications
JOHN SISLIN, Program Officer, Board on Higher Education and Workforce
DAVID PADGHAM, Program Officer, Computer Science and Telecommunications Board (until 5/08)
STEVEN KENDALL, Senior Program Associate
KATIE MAGEE, Senior Program Assistant (until 9/07)
KATHI E. HANNA, Consultant Writer
SARA D. MADDOX, Editor
ROBIN ACKERMAN, Christine Mirzayan Science and Technology Policy Fellow
GEMAYEL JEAN-PAUL, Christine Mirzayan Science and Technology Policy Fellow
JOHNALYN D. LYLES, Christine Mirzayan Science and Technology Policy Fellow
SANDRA OTTENSMANN, Christine Mirzayan Science and Technology Policy Fellow
DEIRDRE PARSONS, Christine Mirzayan Science and Technology Policy Fellow
SARAH RYKER, Christine Mirzayan Science and Technology Policy Fellow
SUNBIN SONG, Christine Mirzayan Science and Technology Policy Fellow

COMMITTEE ON SCIENCE, TECHNOLOGY, AND LAW

DONALD KENNEDY (NAS/IOM), (*Co-chair)*, President Emeritus and Bing Professor of Environmental Science Emeritus, Stanford University; Emeritus Editor-in-Chief, *Science*
RICHARD A. MERRILL (IOM), (*Co-chair*), Daniel Caplin Professor of Law Emeritus, University of Virginia Law School
FREDERICK R. ANDERSON, JR., Partner, McKenna, Long, & Aldridge LLP
MARGARET A. BERGER, Suzanne J. and Norman Miles Professor of Law, Brooklyn Law School
ARTHUR I. BIENENSTOCK, Special Assistant to the President for SLAC and Federal Research Policy, Stanford University
BARBARA E. BIERER, Senior Vice President for Research, Brigham and Women's Hospital
ELIZABETH H. BLACKBURN (NAS/IOM), Morris Herzstein Professor of Biology and Physiology, Department of Biochemistry and Biophysics, University of California, San Francisco
JOE S. CECIL, Project Director, Program on Scientific and Technical Evidence, Federal Judicial Center
RICHARD F. CELESTE, President, Colorado College
JOEL E. COHEN (NAS), Abby Rockefeller Mauzé Professor and Head, Laboratory of Populations, The Rockefeller University and Columbia University
KENNETH W. DAM, Max Pam Professor Emeritus of American and Foreign Law and Senior Lecturer, University of Chicago Law School
ROCHELLE COOPER DREYFUSS, Pauline Newman Professor of Law and Director, Engelberg Center on Innovation Law and Policy, New York University School of Law
ALICE P. GAST (NAE), President, Lehigh University
LAWRENCE O. GOSTIN (IOM), Associate Dean for Research and Academic Programs, Linda D. and Timothy J. O'Neill Professor of Global Health Law, Georgetown University; Professor of Public Health, The Johns Hopkins University
GARY W. HART, Wirth Chair Professor, School of Public Affairs, University of Colorado, Denver
BENJAMIN W. HEINEMAN, JR., Senior Fellow, Harvard Law School and Harvard Kennedy School of Government
DAVID BROCK HORNBY, Judge, U.S. District Court, District of Maine
DAVID KORN (IOM), Vice Provost for Research, Harvard University
RICHARD A. MESERVE (NAE), President, Carnegie Institution of Washington

DUNCAN T. MOORE (NAE), Professor, The Institute of Optics, University of Rochester
ALAN B. MORRISON, Visiting Professor, Washington College of Law, American University
HARRIET RABB, Vice President and General Counsel, Rockefeller University
PAUL D. RHEINGOLD, Senior Partner, Rheingold, Valet, Rheingold, Shkolnik & McCartney LLP
BARBARA ROTHSTEIN, Director, Federal Judicial Center
JONATHAN M. SAMET (IOM), Founding Director, Institute for Global Health and Chairman, Department of Preventive Medicine, University of Southern California
DAVID S. TATEL, Judge, U.S. Court of Appeals for the District of Columbia Circuit

Staff

ANNE-MARIE MAZZA, Director
STEVEN KENDALL, Senior Program Associate

COMMITTEE ON APPLIED AND THEORETICAL STATISTICS

KAREN KAFADAR, (*Chair*), Rudy Professor of Statistics and Physics, Indiana University
AMY BRAVERMAN, MISR Co-Investigator, Statistics and Data Analysis, Earth and Space Sciences Division, Jet Propulsion Laboratory
CONSTANTINE GATSONIS, Director, Center for Statistical Sciences, Brown University
MICHAEL GOODCHILD (NAS), Professor, Department of Geography, University of California, Santa Barbara
KATHRYN B. LASKEY, Professor, Department of Systems Engineering and Operations Research, George Mason University
MICHAEL LESK (NAE), Professor, Library and Information Sciences, Rutgers University
THOMAS A. LOUIS, Professor, Department of Biostatistics, Bloomberg School of Public Health, The Johns Hopkins University
MICHAEL A. NEWTON, Professor, Department of Biostatistics and Medical Informatics, University of Wisconsin, Madison
MICHAEL L. STEIN, Professor, Department of Statistics, The University of Chicago

Staff

SCOTT WEIDMAN, Director
NEAL GLASSMAN, Senior Program Officer
BARBARA WRIGHT, Administrative Assistant

Acknowledgments

ACKNOWLEDGMENT OF PRESENTERS

The committee gratefully acknowledges the contributions of the following individuals who made thoughtful presentations before it:

Chris Asplen, *Gordon Thomas Honeywell Government Affairs*; Peter D. Barnett, *Forensic Science Associates*; Richard E. Bisbing, *McCrone Associates, Inc.*, and *Scientific Working Group on Materials Analysis* (*SWGMAT*); Joseph P. Bono, *U.S. Secret Service*; Michael R. Bromwich, *Fried, Frank, Harris, Shriver & Jacobson LLP*; Bruce Budowle, *Federal Bureau of Investigation*; James Burans, *U.S. Department of Homeland Security*; Thomas Cantwell, *U.S. Department of Defense*; Larry Chelko, *U.S. Army Criminal Investigation Laboratory*; John Collins, *DuPage County Sheriff's Office Crime Laboratory*; Charles Cooke, *Office of the Director of National Intelligence*; Robin Cotton, *Boston University School of Medicine*; Joseph A. DiZinno, *Federal Bureau of Investigation*; James Downs, *National Association of Medical Examiners* and *Consortium of Forensic Science Organizations* and *Georgia Bureau of Investigation*; Itiel Dror, *University of Southampton*; Arthur Eisenberg, *Forensic Quality Services*; Barry A. J. Fisher, *Los Angeles County Sheriff's Department*; Eric Friedberg, *Stroz Friedberg, LLC*; Robert E. Gaensslen, *University of Illinois at Chicago*; Brandon L. Garrett, *University of Virginia*; Michael D. Garris, *National Institute of Standards and Technology*; Ed German, *U.S. Army* (ret.); Paul C. Giannelli, *Case Western Reserve University School of Law*; Bruce A. Goldberger, *American Academy of Forensic Sciences*; Hank

Greely, *Stanford University*; Barbara Guttman, *National Institute of Standards and Technology*; David W. Hagy, *U.S. Department of Justice*; Randy Hanzlick, *Fulton County Medical Examiner's Center* and *Emory University School of Medicine*; Carol Henderson, *National Clearinghouse for Science, Technology and the Law* and *Stetson University*; Matthew J. Hickman, *U.S. Department of Justice*; Peter T. Higgins, *The Higgins-Hermansen Group*; Max M. Houck, *West Virginia University*; Vici Inlow, *U.S. Secret Service*; Jan L. Johnson, *Illinois State Police*; Jay Kadane, *Carnegie Mellon University*; David Kaye, *Arizona State University*; Peter D. Komarinski, *Komarinski & Associates, LLC*; Roger G. Koppl, *Farleigh Dickinson University*; Glenn Langenburg, *Minnesota Bureau of Criminal Apprehension*; Deborah Leben, *U.S. Secret Service*; John Lentini, *Scientific Fire Analysis, LLC*; Alan I. Leshner, *American Association for the Advancement of Science*; William MacCrehan, *National Institute of Standards and Technology*; Bill Marbaker, *American Society of Crime Laboratory Directors*; Kenneth F. Martin, *Massachusetts State Police*; Carole McCartney, *University of Leeds*; Stephen B. Meagher, *Federal Bureau of Investigation* and *Scientific Working Group on Friction Ridge Analysis, Study and Technology* (*SWGFAST*); Jennifer Mnooken, *University of California, Los Angeles Law School*; John E. Moalli, *Exponent*; John Morgan, *U.S. Department of Justice*; Michael Murphy, *Las Vegas Office of the Coroner*; Peter Neufeld, *The Innocence Project*; John Onstwedder III, *Illinois State Police*; Garry F. Peterson, *Hennepin County Medical Examiner's Office* and *National Association of Medical Examiners*; Joseph L. Peterson, *California State University, Los Angeles*; Peter Pizzola, *New York Police Department Crime Laboratory*; Joe Polski, *Consortium of Forensic Science Organizations* and *International Association for Identification*; Larry Quarino, *Cedar Crest College*; Irma Rios, *City of Houston Crime Lab*; Michael Risinger, *Seton Hall Law School*; Michael J. Saks, *Sandra Day O'Connor College of Law, Arizona State University*; Nelson A. Santos, *Scientific Working Group for the Analysis of Seized Drugs* (*SWGDRUG*); David R. Senn, *The University of Texas Health Science Center at San Antonio*; Robert Stacey, *American Society of Crime Laboratory Directors, Laboratory Accreditation Board*; David Stoney, *Stoney Forensic, Inc.*; Peter Striupaitis, *International Association for Identification* and *Scientific Working Group for Firearms and Toolmarks* (*SWGGUN*); Rick Tontarski, *U.S. Army Criminal Investigation Laboratory*; Richard W. Vorder Bruegge, *Federal Bureau of Investigation*; Victor W. Weedn; and Tom Witt, *West Virginia University.*

ACKNOWLEDGMENT OF REVIEWERS

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report: R. Stephen Berry, University of Chicago; Christophe Champod, Universite de Lausanne, Switzerland; William Chisum, Retired, National Crime Investigation and Training; Joel Cohen, Rockefeller University; Peter DeForest, John Jay College of Criminal Justice; Stephen Fienberg, Carnegie Mellon University; Barry Fisher, Los Angeles County Sheriff's Department; Mark Flomenbaum, Boston University; Ross Gardner, Gardner Forensic Consulting; Paul Giannelli, Case Western Reserve University; Randy Hanzlick, Emory University; Keith Inman, Forensic Analytical Sciences, Inc.; Dan Kahan, Yale Law School; Roger Kahn, Harris County Medical Examiner's Office; Elizabeth Loftus, University of California, Irvine; C. Owen Lovejoy, Kent State University; Kenneth Melson, George Washington University; Michael Murphy, Office of the Coroner/Medical Examiner, Las Vegas, Nevada; Hyla Napadensky, Retired, Napadensky Energetics, Inc.; Joseph Peterson, California State University, Los Angeles; William Press, University of Texas, Austin; Jed Rakoff, U.S. District Court Southern District of New York; Carl Selavka, U.S. Army Criminal Investigation Laboratory; David Stoney, Stoney Forensic, Inc.; and Charles Wellford, University of Maryland.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by John Bailar, University of Chicago, and Royce Murray, University of North Carolina, Chapel Hill. Appointed by the National Academies, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Contents

Preface xix

Summary 1
Introduction, 1
Findings and Recommendations, 14

1 Introduction 35
What Is Forensic Science?, 38
Pressures on the Forensic Science System, 39
Organization of This Report, 53

2 The Forensic Science Community and the Need for Integrated Governance 55
Crime Scene Investigation, 56
Forensic Science Laboratories and Service Providers, 57
Case Backlogs, 61
NIJ's Coverdell Forensic Science Improvement Grant Program, 62
Forensic Services Beyond the Traditional Laboratory, 64
Federal Forensic Science Activities, 65
Research Funding, 71
Professional Associations, 75
Conclusions and Recommendation, 77

3 The Admission of Forensic Science Evidence in Litigation Law and Science 85
Law and Science, 86
The *Frye* Standard and Rule 702 of the Federal Rules of Evidence, 88
The *Daubert* Decision and the Supreme Court's Construction of Rule 702, 90
The 2000 Amendment of Rule 702, 92
An Overview of Judicial Dispositions of *Daubert*-Type Questions, 95
Some Examples of Judicial Dispositions of Questions Relating to Forensic Science Evidence, 99
Conclusion, 110

4 The Principles of Science and Interpreting Scientific Data 111
Fundamental Principles of the Scientific Method, 112
Conclusion, 125

5 Descriptions of Some Forensic Science Disciplines 127
Biological Evidence, 128
Analysis of Controlled Substances, 134
Friction Ridge Analysis, 136
Other Pattern/Impression Evidence: Shoeprints and Tire Tracks, 145
Toolmark and Firearms Identification, 150
Analysis of Hair Evidence, 156
Analysis of Fiber Evidence, 162
Questioned Document Examination, 164
Analysis of Paint and Coatings Evidence, 167
Analysis of Explosives Evidence and Fire Debris, 171
Forensic Odontology, 174
Bloodstain Pattern Analysis, 177
An Emerging Forensic Science Discipline: Digital and Multimedia Analysis, 179
Conclusions, 183

6 Improving Methods, Practice, and Performance in Forensic Science 183
Independence of Forensic Science Laboratories, 183
Uncertainties and Bias, 184
Reporting Results, 185
The Need for Research, 187
Conclusions and Recommendations, 188

7 Strengthening Oversight of Forensic Science Practice 193
Accreditation, 195
Standards and Guidelines for Quality Control, 201
Proficiency Testing, 206
Certification, 208
Oversight as a Requirement of Paul Coverdell Forensic Science Improvement Grants, 211
Codes of Ethics, 212
Conclusions and Recommendations, 213

8 Education and Training in Forensic Science 217
Status of Forensic Science Education, 218
Challenges and Opportunities to Improve Forensic Science Education, 224
Research as a Component of Forensic Science Education Programs, 230
Status of Training, 231
Education in the Legal System, 234
Conclusions and Recommendation, 237

9 Medical Examiner and Coroner Systems: Current and Future Needs 241
Medical Examiners and Coroners (ME/C), 243
ME/C Jurisdiction, 244
ME/C Missions, 244
Variations in ME/C Systems, 245
Qualifications of Coroners and Medical Examiners, 247
ME/C Administration and Oversight, 249
ME/C Staffing and Funding, 249
The Movement to Convert Coroner Systems to Medical Examiner Systems, 251
Utilization of Best Practices, 252
Potential Scientific Advances That May Assist ME/Cs, 253
The Shortage of Medical Examiners and Forensic Pathologists, 256
Standards and Accreditation for Death Investigation Systems, 258
Quality Control and Quality Assurance, 259
Continuing Medical Education, 259
Homeland Security, 260
Forensic Pathology Research, 261
Common Methods of Sample and Data Collection, 263
Conclusions and Recommendation, 265

10 Automated Fingerprint Identification Systems **269**
Interoperability Challenges, 273
Conclusions and Recommendation, 276

11 Homeland Security and the Forensic Science Disciplines **279**
Conclusion and Recommendation, 285

Appendixes

A Biographical Information of Committee and Staff **287**

B Committee Meeting Agendas **303**

Index **315**

Preface

Recognizing that significant improvements are needed in forensic science, Congress directed the National Academy of Sciences to undertake the study that led to this report. There are scores of talented and dedicated people in the forensic science community, and the work that they perform is vitally important. They are often strapped in their work, however, for lack of adequate resources, sound policies, and national support. It is clear that change and advancements, both systemic and scientific, are needed in a number of forensic science disciplines—to ensure the reliability of the disciplines, establish enforceable standards, and promote best practices and their consistent application.

In adopting this report, the aim of our committee is to chart an agenda for progress in the forensic science community and its scientific disciplines. Because the work of forensic science practitioners is so obviously wide-reaching and important—affecting criminal investigation and prosecution, civil litigation, legal reform, the investigation of insurance claims, national disaster planning and preparedness, homeland security, and the advancement of technology—the committee worked with a sense of great commitment and spent countless hours deliberating over the recommendations that are included in the report. These recommendations, which are inexorably interconnected, reflect the committee's strong views on policy initiatives that must be adopted in any plan to improve the forensic science disciplines and to allow the forensic science community to serve society more effectively.

The task Congress assigned our committee was daunting and required serious thought and the consideration of an extremely complex and decentralized system, with various players, jurisdictions, demands, and limitations. Throughout our lengthy deliberations, the committee heard testimony from the stakeholder community, ensuring that the voices of forensic practitioners were heard and their concerns addressed. We also heard from professionals who manage forensic laboratories and medical examiner/coroner offices; teachers who are devoted to training the next generation of forensic scientists; scholars who have conducted important research in a number of forensic science fields; and members of the legal profession and law enforcement agencies who understand how forensic science evidence is collected, analyzed, and used in connection with criminal investigations and prosecutions. We are deeply grateful to all of the presenters who spoke to the committee and/or submitted papers for our consideration. These experts and their work served the committee well.

In considering the testimony and evidence that was presented to the committee, what surprised us the most was the consistency of the message that we heard:

> **The forensic science system, encompassing both research and practice, has serious problems that can only be addressed by a national commitment to overhaul the current structure that supports the forensic science community in this country. This can only be done with effective leadership at the highest levels of both federal and state governments, pursuant to national standards, and with a significant infusion of federal funds.**

The recommendations in this report represent the committee's studied opinion on how best to achieve this critical goal.

We had the good fortune to serve as co-chairs of the committee entrusted with addressing Congress' charge. The committee, formed under the auspices of the National Academies' Committee on Science, Technology, and Law and Committee on Applied and Theoretical Statistics, was composed of many talented professionals, some expert in various areas of forensic science, others in law, and still others in different fields of science and engineering. They listened, read, questioned, vigorously discussed the findings and recommendations offered in this report, and then worked hard to complete the research and writing required to produce the report. We are indebted to our colleagues for all the time and energy they gave to this effort. We are also most grateful to the staff, Anne-Marie Mazza, Scott Weidman, Steven Kendall, and the consultant writer, Kathi Hanna, for their superb work and dedication to this project; to staff members David Padgham and John Sislin, and editor, Sara Maddox, for their assistance; and to Paige Herwig, Laurie Richardson, and Judith A. Hunt for their sterling contributions in checking source materials and assisting with the final production of the report.

Harry T. Edwards and Constantine Gatsonis
Committee Co-chairs

Summary

INTRODUCTION

On November 22, 2005, the Science, State, Justice, Commerce, and Related Agencies Appropriations Act of 2006 became law.[1] Under the terms of the statute, Congress authorized "the National Academy of Sciences to conduct a study on forensic science, as described in the Senate report."[2] The Senate Report to which the Conference Report refers states:

> While a great deal of analysis exists of the requirements in the discipline of DNA, there exists little to no analysis of the remaining needs of the community outside of the area of DNA. Therefore . . . the Committee directs the Attorney General to provide [funds] to the National Academy of Sciences to create an independent Forensic Science Committee. This Committee shall include members of the forensics community representing operational crime laboratories, medical examiners, and coroners; legal experts; and other scientists as determined appropriate.[3]

The Senate Report also sets forth the charge to the Forensic Science Committee, instructing it to:

(1) assess the present and future resource needs of the forensic science community, to include State and local crime labs, medical examiners, and coroners;

[1] P.L. No. 109-108, 119 Stat. 2290 (2005).
[2] H.R. Rep. No. 109-272, at 121 (2005) (Conf. Rep.).
[3] S. Rep. No. 109-88, at 46 (2005).

(2) make recommendations for maximizing the use of forensic technologies and techniques to solve crimes, investigate deaths, and protect the public;
(3) identify potential scientific advances that may assist law enforcement in using forensic technologies and techniques to protect the public;
(4) make recommendations for programs that will increase the number of qualified forensic scientists and medical examiners available to work in public crime laboratories;
(5) disseminate best practices and guidelines concerning the collection and analysis of forensic evidence to help ensure quality and consistency in the use of forensic technologies and techniques to solve crimes, investigate deaths, and protect the public;
(6) examine the role of the forensic community in the homeland security mission;
(7) [examine] interoperability of Automated Fingerprint Information Systems [AFIS]; and
(8) examine additional issues pertaining to forensic science as determined by the Committee.[4]

In the fall of 2006, a committee was established by the National Academy of Sciences to implement this congressional charge. As recommended in the Senate Report, the persons selected to serve included members of the forensic science community, members of the legal community, and a diverse group of scientists. Operating under the project title "Identifying the Needs of the Forensic Science Community," the committee met on eight occasions: January 25-26, April 23-24, June 5-6, September 20-21, and December 6-7, 2007, and March 24-25, June 23-24, and November 14-15, 2008. During these meetings, the committee heard expert testimony and deliberated over the information it heard and received. Between meetings, committee members reviewed numerous published materials, studies, and reports related to the forensic science disciplines, engaged in independent research on the subject, and worked on drafts of the final report.

Experts who provided testimony included federal agency officials; academics and research scholars; private consultants; federal, state, and local law enforcement officials; scientists; medical examiners; a coroner; crime laboratory officials from the public and private sectors; independent investigators; defense attorneys; forensic science practitioners; and leadership of professional and standard setting organizations (see the Acknowledgments and Appendix B for a complete listing of presenters).

[4] Ibid.

The issues covered during the committee's hearings and deliberations included:

(a) the fundamentals of the scientific method as applied to forensic practice—hypothesis generation and testing, falsifiability and replication, and peer review of scientific publications;
(b) the assessment of forensic methods and technologies—the collection and analysis of forensic data; accuracy and error rates of forensic analyses; sources of potential bias and human error in interpretation by forensic experts; and proficiency testing of forensic experts;
(c) infrastructure and needs for basic research and technology assessment in forensic science;
(d) current training and education in forensic science;
(e) the structure and operation of forensic science laboratories;
(f) the structure and operation of the coroner and medical examiner systems;
(g) budget, future needs, and priorities of the forensic science community and the coroner and medical examiner systems;
(h) the accreditation, certification, and licensing of forensic science operations, medical death investigation systems, and scientists;
(i) Scientific Working Groups (SWGs) and their practices;
(j) forensic science practices—
pattern/experience evidence
    - fingerprints (including the interoperability of AFIS)
    - firearms examination
    - toolmarks
    - bite marks
    - impressions (tires, footwear)
    - bloodstain pattern analysis
    - handwriting
    - hair

  analytical evidence
    - DNA
    - coatings (e.g., paint)
    - chemicals (including drugs)
    - materials (including fibers)
    - fluids
    - serology
    - fire and explosive analysis

  digital evidence;
(k) the effectiveness of coroner systems as compared with medical examiner systems;

(l) the use of forensic evidence in criminal and civil litigation—
  - the collection and flow of evidence from crime scenes to courtrooms
  - the manner in which forensic practitioners testify in court
  - cases involving the misinterpretation of forensic evidence
  - the adversarial system in criminal and civil litigation
  - lawyers' use and misuse of forensic evidence
  - judges' handling of forensic evidence;

(m) forensic practice and projects at various federal agencies, including NIST, the FBI, DHS, U.S. Secret Service, NIJ, DEA, and DOD;
(n) forensic practice in state and local agencies;
(o) nontraditional forensic service providers; and
(p) the forensic science community in the United Kingdom.

The testimonial and documentary evidence considered by the committee was detailed, complex, and sometimes controversial. Given this reality, the committee could not possibly answer every question that it confronted, nor could it devise specific solutions for every problem that it identified. Rather, it reached a consensus on the most important issues now facing the forensic science community and medical examiner system and agreed on 13 specific recommendations to address these issues.

Challenges Facing the Forensic Science Community

For decades, the forensic science disciplines have produced valuable evidence that has contributed to the successful prosecution and conviction of criminals as well as to the exoneration of innocent people. Over the last two decades, advances in some forensic science disciplines, especially the use of DNA technology, have demonstrated that some areas of forensic science have great additional potential to help law enforcement identify criminals. Many crimes that may have gone unsolved are now being solved because forensic science is helping to identify the perpetrators.

Those advances, however, also have revealed that, in some cases, substantive information and testimony based on faulty forensic science analyses may have contributed to wrongful convictions of innocent people. This fact has demonstrated the potential danger of giving undue weight to evidence and testimony derived from imperfect testing and analysis. Moreover, imprecise or exaggerated expert testimony has sometimes contributed to the admission of erroneous or misleading evidence.

Further advances in the forensic science disciplines will serve three important purposes. First, further improvements will assist law enforcement officials in the course of their investigations to identify perpetrators with higher reliability. Second, further improvements in forensic science practices should reduce the occurrence of wrongful convictions, which reduces the risk that true offenders continue to commit crimes while innocent persons inappropriately serve time. Third, any improvements in the forensic science disciplines will undoubtedly enhance the Nation's ability to address the needs of homeland security.

Numerous professionals in the forensic science community and the medical examiner system have worked for years to achieve excellence in their fields, aiming to follow high ethical norms, develop sound professional standards, ensure accurate results in their practices, and improve the processes by which accuracy is determined. Although the work of these dedicated professionals has resulted in significant progress in the forensic science disciplines in recent decades, major challenges still face the forensic science community. It is therefore unsurprising that Congress instructed this committee to, among other things, "assess the present and future resource needs of the forensic science community," "make recommendations for maximizing the use of forensic technologies and techniques," "make recommendations for programs that will increase the number of qualified forensic scientists and medical examiners," and "disseminate best practices and guidelines concerning the collection and analysis of forensic evidence to help ensure quality and consistency in the use of forensic technologies and techniques." These are among the pressing issues facing the forensic science community. The best professionals in the forensic science disciplines invariably are hindered in their work because these and other problems persist.

The length of the congressional charge and the complexity of the material under review made the committee's assignment challenging. In undertaking it, the committee first had to gain an understanding of the various disciplines within the forensic science community, as well as the community's history, its strengths and weaknesses, and the roles of the people and agencies that constitute the community and make use of its services. In so doing, the committee was able to better comprehend some of the major problems facing the forensic science community and the medical examiner system. A brief review of some of these problems is illuminating.[5]

Disparities in the Forensic Science Community

There are great disparities among existing forensic science operations in federal, state, and local law enforcement jurisdictions and agencies. This is true with respect to funding, access to analytical instrumentation, the availability of skilled and well-trained personnel, certification, accreditation, and

[5] In this report, the "forensic science community," broadly speaking, is meant to include forensic pathology and medicolegal death investigation, which is sometimes referred to as "the medical examiner system" or "the medicolegal death investigation system."

oversight. As a result, it is not easy to generalize about current practices within the forensic science community. It is clear, however, that any approach to overhauling the existing system needs to address and help minimize the community's current fragmentation and inconsistent practices.

Although the vast majority of criminal law enforcement is handled by state and local jurisdictions, these entities often are sorely lacking in the resources (money, staff, training, and equipment) necessary to promote and maintain strong forensic science laboratory systems. By comparison, federal programs are often much better funded and staffed. It is also noteworthy that the resources, the extent of services, and the amount of expertise that medical examiners and forensic pathologists can provide vary widely in different jurisdictions. As a result, the depth, reliability, and overall quality of substantive information arising from the forensic examination of evidence available to the legal system vary substantially across the country.

Lack of Mandatory Standardization, Certification, and Accreditation

The fragmentation problem is compounded because operational principles and procedures for many forensic science disciplines are not standardized or embraced, either between or within jurisdictions. There is no uniformity in the certification of forensic practitioners, or in the accreditation of crime laboratories. Indeed, most jurisdictions do not require forensic practitioners to be certified, and most forensic science disciplines have no mandatory certification programs. Moreover, accreditation of crime laboratories is not required in most jurisdictions. Often there are no standard protocols governing forensic practice in a given discipline. And, even when protocols are in place (e.g., SWG standards), they often are vague and not enforced in any meaningful way. In short, the quality of forensic practice in most disciplines varies greatly because of the absence of adequate training and continuing education, rigorous mandatory certification and accreditation programs, adherence to robust performance standards, and effective oversight.[6] These shortcomings obviously pose a continuing and serious threat to the quality and credibility of forensic science practice.

The Broad Range of Forensic Science Disciplines

The term "forensic science" encompasses a broad range of forensic disciplines, each with its own set of technologies and practices. In other words, there is wide variability across forensic science disciplines with regard to

[6] See, e.g., P.C. Giannelli. 2007. Wrongful convictions and forensic science: The need to regulate crime labs. 86 N.C. L. Rev. 163 (2007); B. Schmitt and J. Swickard. 2008. "Detroit Police Lab Shut Down After Probe Finds Errors." *Detroit Free Press*. September 25.

techniques, methodologies, reliability, types and numbers of potential errors, research, general acceptability, and published material. 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 hair). The "forensic science community," in turn, consists of a host of practitioners, including scientists (some with advanced degrees) in the fields of chemistry, biochemistry, biology, and medicine; laboratory technicians; crime scene investigators; and law enforcement officers. There are very important differences, however, between forensic laboratory work and crime scene investigations. There are also sharp distinctions between forensic practitioners who have been trained in chemistry, biochemistry, biology, and medicine (and who bring these disciplines to bear in their work) and technicians who lend support to forensic science enterprises. Many of these differences are discussed in the body of this report.

The committee decided early in its work that it would not be feasible to develop a detailed evaluation of each discipline in terms of its scientific underpinning, level of development, and ability to provide evidence to address the major types of questions raised in criminal prosecutions and civil litigation. However, the committee solicited testimony on a broad range of forensic science disciplines and sought to identify issues relevant across definable classes of disciplines. As a result of listening to this testimony and reviewing related written materials, the committee found substantial evidence indicating that the level of scientific development and evaluation varies substantially among the forensic science disciplines.

Problems Relating to the Interpretation of Forensic Evidence

Often in criminal prosecutions and civil litigation, forensic evidence is offered to support conclusions about "individualization" (sometimes referred to as "matching" a specimen to a particular individual or other source) or about classification of the source of the specimen into one of several categories. With the exception of nuclear DNA analysis, however, no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source. In terms of scientific basis, the analytically based disciplines generally hold a notable edge over disciplines based on expert interpretation. But there are important variations among the disciplines relying on expert interpretation. For example, there are more established protocols and available research for fingerprint analysis than for the analysis of bite marks. There also are significant variations within each discipline. For example, not all fingerprint evidence is equally good, because the true value of the evidence is determined by the quality of the latent fingerprint image. These disparities between and within the forensic science disciplines highlight a major problem in the forensic science community: The simple reality is that the interpretation of forensic evidence is not always based on scientific studies to determine its validity. This is a serious problem. Although research has been done in some disciplines, there is a notable dearth of peer-reviewed, published studies establishing the scientific bases and validity of many forensic methods.[7]

The Need for Research to Establish Limits and Measures of Performance

In evaluating the accuracy of a forensic analysis, it is crucial to clarify the type of question the analysis is called on to address. Thus, although some techniques may be too imprecise to permit 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 some characteristics of the individual from which the specimen was taken, but it may not be able to reliably match the specimen with a specific individual. However, the definition of the appropriate question is only a first step in the evaluation of the performance of a forensic technique. A body of research is required to establish the limits and measures of performance and to address the impact of sources of variability and potential bias. Such research is sorely needed, but it seems to be lacking in most of the forensic disciplines that rely on subjective assessments of matching characteristics. These disciplines need to develop rigorous protocols to guide these subjective interpretations and pursue equally rigorous research and evaluation programs. The development of such research programs can benefit significantly from other areas, notably from the large body of research 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.[8]

---

[7] Several articles, for example, have noted the lack of scientific validation of fingerprint identification methods. See, e.g., J.J. Koehler. Fingerprint error rates and proficiency tests: What they are and why they matter. 59 HASTINGS L.J. 1077 (2008); L. Haber and R.N. Haber. 2008. Scientific validation of fingerprint evidence under *Daubert*. *Law, Probability and Risk* 7(2):87; J.L. Mnookin. 2008. The validity of latent fingerprint identification: Confessions of a fingerprinting moderate. *Law, Probability and Risk* 7(2):127.

[8] The findings of forensic science experts are vulnerable to cognitive and contextual bias. See, e.g., I.E. Dror, D. Charlton, and A.E. Péron. 2006. Contextual information renders experts vulnerable to making erroneous identifications. *Forensic Science International* 156:74, 77. ("Our study shows that it is possible to alter identification decisions on the same fingerprint, solely by presenting it in a different context."); I.E. Dror and D. Charlton. 2006. Why experts make errors. *Journal of Forensic Identification* 56(4):600; Giannelli, *supra* note 6, pp. 220-222. Unfortunately, at least to date, there is no good evidence to indicate that the forensic

The Admission of Forensic Science Evidence in Litigation

Forensic science experts and evidence are used routinely in the service of the criminal justice system. DNA testing may be used to determine whether sperm found on a rape victim came from an accused party; a latent fingerprint found on a gun may be used to determine whether a defendant handled the weapon; drug analysis may be used to determine whether pills found in a person's possession were illicit; and an autopsy may be used to determine the cause and manner of death of a murder victim. In order for qualified forensic science experts to testify competently about forensic evidence, they must first find the evidence in a usable state and properly preserve it. A latent fingerprint that is badly smudged when found cannot be usefully saved, analyzed, or explained. An inadequate drug sample may be insufficient to allow for proper analysis. And, DNA tests performed on a contaminated or otherwise compromised sample cannot be used reliably to identify or eliminate an individual as the perpetrator of a crime. These are important matters involving the proper processing of forensic evidence. The law's greatest dilemma in its heavy reliance on forensic evidence, however, concerns the question of whether—and to what extent—there is *science* in any given forensic science discipline.

Two very important questions should underlie the law's admission of and reliance upon forensic evidence in criminal trials: (1) the extent to which a particular forensic discipline is founded on a reliable scientific methodology that gives it the capacity to accurately analyze evidence and report findings and (2) the extent to which practitioners in a particular forensic discipline rely on human interpretation that could be tainted by error, the threat of bias, or the absence of sound operational procedures and robust performance standards. These questions are significant. Thus, it matters a great deal whether an expert is qualified to testify about forensic evidence and whether the evidence is sufficiently reliable to merit a fact finder's reliance on the truth that it purports to support. Unfortunately, these important questions do not always produce satisfactory answers in judicial decisions pertaining to the admissibility of forensic science evidence proffered in criminal trials.

In 1993, in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[9] the Supreme Court ruled that, under Rule 702 of the Federal Rules of Evidence (which covers both civil trials and criminal prosecutions in the federal courts), a "trial judge must ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable."[10] The Court indicated

---

science community has made a sufficient effort to address the bias issue; thus, it is impossible for the committee to fully assess the magnitude of the problem.

[9] 509 U.S. 579 (1993).

[10] Ibid., p. 589.

that the subject of an expert's testimony should be scientific knowledge, so that "evidentiary reliability will be based upon scientific validity."[11] The Court also emphasized that, in considering the admissibility of evidence, a trial judge should focus "solely" on the expert's "principles and methodology," and "not on the conclusions that they generate."[12] In sum, *Daubert*'s requirement that an expert's testimony pertain to "scientific knowledge" established a standard of "evidentiary reliability."[13]

In explaining this evidentiary standard, the *Daubert* Court pointed to several factors that might be considered by a trial judge: (1) whether a theory or technique can be (and has been) tested; (2) whether the theory or technique has been subjected to peer review and publication; (3) the known or potential rate of error of a particular scientific technique; (4) the existence and maintenance of standards controlling the technique's operation; and (5) a scientific technique's degree of acceptance within a relevant scientific community.[14] In the end, however, the Court emphasized that the inquiry under Rule 702 is "a flexible one."[15] The Court expressed confidence in the adversarial system, noting that "[v]igorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence."[16] The Supreme Court has made it clear that trial judges have great discretion in deciding on the admissibility of evidence under Rule 702, and that appeals from *Daubert* rulings are subject to a very narrow abuse-of-discretion standard of review.[17] Most importantly, in *Kumho Tire Co., Ltd. v. Carmichael*, the Court stated that "whether *Daubert*'s specific factors are, or are not, reasonable measures of reliability in a particular case is a matter that the law grants the trial judge broad latitude to determine."[18]

---

[11] Ibid., pp. 590 and 591 n.9 (emphasis omitted).

[12] Ibid., p. 595. In *General Electric Co. v. Joiner*, 522 U.S. 136, 146 (1997), the Court added: "[C]onclusions and methodology are not entirely distinct from one another. Trained experts commonly extrapolate from existing data. But nothing in *Daubert* or the Federal Rules of Evidence requires a district court to admit opinion evidence that is connected to existing data only by the *ipse dixit* of the expert."

[13] *Daubert*, 509 U.S. at 589, 590 n.9, 595.

[14] Ibid., pp. 593-94.

[15] Ibid., p. 594. *In Kumho Tire Co., Ltd. v. Carmichael*, 526 U.S. 137 (1999), the Court confirmed that the *Daubert* factors do not constitute a definitive checklist or test. *Kumho Tire* importantly held that Rule 702 applies to both scientific and nonscientific expert testimony; the Court also indicated that the *Daubert* factors might be applicable in a trial judge's assessment of the reliability of nonscientific expert testimony, depending upon "the particular circumstances of the particular case at issue." Ibid., at 150.

[16] *Daubert*, 509 U.S. at 596.

[17] See *Gen. Elec. Co. v. Joiner*, 522 U.S. 136, 142-143 (1997).

[18] *Kumho Tire*, 526 U.S. at 153.

Daubert and its progeny have engendered confusion and controversy. In particular, judicial dispositions of *Daubert*-type questions in criminal cases have been criticized by some lawyers and scholars who thought that the Supreme Court's decision would be applied more rigorously.[19] If one focuses solely on reported federal appellate decisions, the picture is not appealing to those who have preferred a more rigorous application of *Daubert*. Federal appellate courts have not with any consistency or clarity imposed standards ensuring the application of scientifically valid reasoning and reliable methodology in criminal cases involving *Daubert* questions. This is not really surprising, however. The Supreme Court itself described the *Daubert* standard as "flexible." This means that, beyond questions of relevance, *Daubert* offers appellate courts no clear substantive standard by which to review decisions by trial courts. As a result, trial judges exercise great discretion in deciding whether to admit or exclude expert testimony, and their judgments are subject only to a highly deferential "abuse of discretion" standard of review. Although it is difficult to get a clear picture of how trial courts handle *Daubert* challenges, because many evidentiary rulings are issued without a published opinion and without an appeal, the vast majority of the *reported* opinions in criminal cases indicate that trial judges rarely exclude or restrict expert testimony offered by prosecutors; most *reported* opinions also indicate that appellate courts routinely deny appeals contesting trial court decisions admitting forensic evidence against criminal defendants.[20] But the reported opinions do not offer in any way a complete sample of federal trial court dispositions of *Daubert*-type questions in criminal cases.

The situation appears to be very different in civil cases. Plaintiffs and defendants, equally, are more likely to have access to expert witnesses in civil cases, while prosecutors usually have an advantage over most defendants in offering expert testimony in criminal cases. And, ironically, the appellate courts appear to be more willing to second-guess trial court judgments on the admissibility of purported scientific evidence in civil cases than in criminal cases.[21]

---

[19] See, e.g., P.J. Neufeld. 2005. The (near) irrelevance of *Daubert* to criminal justice: And some suggestions for reform. *American Journal of Public Health* 95(Supp.1):S107.

[20] Ibid., p. S109.

[21] See, e.g., *McClain v. Metabolife Int'l, Inc.*, 401 F.3d 1233 (11th Cir. 2005); *Chapman v. Maytag Corp.*, 297 F.3d 682 (7th Cir. 2002); *Goebel v. Denver & Rio Grande W. R.R. Co.*, 215 F.3d 1083 (10th Cir. 2000); *Smith v. Ford Motor Co.*, 215 F.3d 713 (7th Cir. 2000); *Walker v. Soo Line R.R. Co.*, 208 F.3d 581 (7th Cir. 2000); 1 D.L. Faigman, M.J. Saks, J. Sanders, and E.K. Cheng. 2007-2008. *Modern Scientific Evidence: The Law and Science of Expert Testimony.* Eagan, MN: Thomson/West, § 1.35, p. 105 (discussing studies suggesting that courts "employ *Daubert* more lackadaisically in criminal trials—especially in regard to prosecution evidence—than in civil cases—especially in regard to plaintiff evidence").

Prophetically, the *Daubert* decision observed that "there are important differences between the quest for truth in the courtroom and the quest for truth in the laboratory. Scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly."[22] But because accused parties in criminal cases are convicted on the basis of testimony from forensic science experts, much depends upon whether the evidence offered is reliable. Furthermore, in addition to protecting innocent persons from being convicted of crimes that they did not commit, we are also seeking to protect society from persons who have committed criminal acts. Law enforcement officials and the members of society they serve need to be assured that forensic techniques are *reliable*. Therefore, we must limit the risk of having the reliability of certain forensic science methodologies judicially certified before the techniques have been properly studied and their accuracy verified by the forensic science community. "[T]here is no evident reason why ['rigorous, systematic'] research would be infeasible."[23] However, some courts appear to be loath to insist on such research as a condition of admitting forensic science evidence in criminal cases, perhaps because to do so would likely "demand more by way of validation than the disciplines can presently offer."[24]

The adversarial process relating to the admission and exclusion of scientific evidence is not suited to the task of finding "scientific truth." The judicial system is encumbered by, among other things, judges and lawyers who generally lack the scientific expertise necessary to comprehend and evaluate forensic evidence in an informed manner, trial judges (sitting alone) who must decide evidentiary issues without the benefit of judicial colleagues and often with little time for extensive research and reflection, and the highly deferential nature of the appellate review afforded trial courts' *Daubert* rulings. Given these realities, there is a tremendous need for the forensic science community to improve. Judicial review, by itself, will not cure the infirmities of the forensic science community.[25] The development

[22] *Daubert*, 509 U.S. at 596-97.

[23] J. Griffin and D.J. LaMagna. 2002. *Daubert* challenges to forensic evidence: Ballistics next on the firing line. *The Champion*, September-October:20, 21 (quoting P. Giannelli and E. Imwinkelried. 2000. Scientific evidence: The fallout from Supreme Court's decision in *Kumho Tire*. *Criminal Justice Magazine* 14(4):12, 40).

[24] Ibid. See, e.g., *United States v. Crisp*, 324 F.3d 261, 270 (4th Cir. 2003) (noting "that while further research into fingerprint analysis would be welcome, to postpone present in-court utilization of this bedrock forensic identifier pending such research would be to make the best the enemy of the good." (internal quotation marks omitted)).

[25] See J.L. Mnookin. Expert evidence, partisanship, and epistemic competence. 73 Brook. L. Rev. 1009, 1033 (2008) ("[S]o long as we have our adversarial system in much its present form, we are inevitably going to be stuck with approaches to expert evidence that are imperfect, conceptually unsatisfying, and awkward. It may well be that the real lesson is this: those who believe that we might ever fully resolve—rather than imperfectly manage—the

of scientific research, training, technology, and databases associated with DNA analysis have resulted from substantial and steady federal support for both academic research and programs employing techniques for DNA analysis. Similar support must be given to all credible forensic science disciplines if they are to achieve the degrees of reliability needed to serve the goals of justice. With more and better educational programs, accredited laboratories, certified forensic practitioners, sound operational principles and procedures, and serious research to establish the limits and measures of performance in each discipline, forensic science experts will be better able to analyze evidence and coherently report their findings in the courts. The current situation, however, is seriously wanting, both because of the limitations of the judicial system and because of the many problems faced by the forensic science community.

Political Realities

Most forensic science methods, programs, and evidence are within the regulatory province of state and local law enforcement entities or are covered by statutes and rules governing state judicial proceedings. Thus, in assessing the strengths, weaknesses, and future needs of forensic disciplines, and in making recommendations for improving the use of forensic technologies and techniques, the committee remained mindful of the fact that Congress cannot directly fix all of the deficiencies in the forensic science community. Under our federal system of government, Congress does not have free reign to amend state criminal codes, rules of evidence, and statutes governing civil actions; nor may it easily and directly regulate local law enforcement practices, state and local medical examiner units, or state policies covering the accreditation of crime laboratories and the certification of forensic practitioners.

Congress' authority to act is significant, however. Forensic science programs in federal government entities—whether within DOJ, DHS, DOD, or the Department of Commerce (DOC)—are funded by congressional appropriations. If these programs are required to operate pursuant to the highest standards, they will provide an example for the states. More importantly, Congress can promote "best practices" and strong educational, certification, accreditation, ethics, and oversight programs in the states by offering funds that are contingent on meeting appropriate standards of practice. There is every reason to believe that offers of federal funds with "strings attached" can effect significant change in the forensic science com-

---

deep structural tensions surrounding both partisanship and epistemic competence that permeate the use of scientific evidence within our legal system are almost certainly destined for disappointment.").

munity, because so many state and local programs currently are suffering for want of adequate resources. In the end, however, the committee recognized that state and local authorities must be willing to enforce change if it is to happen.

In light of the foregoing issues, the committee exercised caution before drawing conclusions and avoided being too prescriptive in its recommendations. It also recognized that, given the complexity of the issues and the political realities that may pose obstacles to change, some recommendations will have to be implemented creatively and over time in order to be effective.

FINDINGS AND RECOMMENDATIONS

The Fragmented System: Symptoms and Cures

The forensic science disciplines currently are an assortment of methods and practices used in both the public and private arenas. Forensic science facilities exhibit wide variability in capacity, oversight, staffing, certification, and accreditation across federal and state jurisdictions. Too often they have inadequate educational programs, and they typically lack mandatory and enforceable standards, founded on rigorous research and testing, certification requirements, and accreditation programs. Additionally, forensic science and forensic pathology research, education, and training lack strong ties to our research universities and national science assets. In addition to the problems emanating from the fragmentation of the forensic science community, the most recently published *Census of Crime Laboratories* conducted by BJS describes unacceptable case backlogs in state and local crime laboratories and estimates the level of additional resources needed to handle these backlogs and prevent their recurrence. Unfortunately, the backlogs, even in DNA case processing, have grown dramatically in recent years and are now staggering in some jurisdictions. The most recently published BJS *Special Report of Medical Examiners and Coroners' Offices* also depicts a system with disparate and often inadequate educational and training requirements, resources, and capacities—in short, a system in need of significant improvement.

Existing data suggest that forensic laboratories are underresourced and understaffed, which contributes to case backlogs and likely makes it difficult for laboratories to do as much as they could to (1) inform investigations, (2) provide strong evidence for prosecutions, and (3) avoid errors that could lead to imperfect justice. Being underresourced also means that the tools of forensic science—and the knowledge base that underpins the analysis and interpretation of evidence—are not as strong as they could be, thus hindering the ability of the forensic science disciplines to excel at informing investigations, providing strong evidence, and avoiding errors in important ways. NIJ is the only federal agency that provides direct support to crime laboratories to alleviate the backlog, and those funds are minimal. The forensic science system is underresourced also in the sense that it has only thin ties to an academic research base that could support the forensic science disciplines and fill knowledge gaps. There are many hard-working and conscientious people in the forensic science community, but this under-resourcing inherently limits their ability to do their best work. Additional resources surely will be necessary to create high-quality, self-correcting systems.

However, increasing the staff within existing crime laboratories and medical examiners' offices is only part of the solution. What also is needed is an upgrading of systems and organizational structures, better training, the widespread adoption of uniform and enforceable best practices, and mandatory certification and accreditation programs. The forensic science community and the medical examiner/coroner system must be upgraded if forensic practitioners are to be expected to serve the goals of justice.

Of the various facets of underresourcing, the committee is most concerned about the knowledge base. Adding more dollars and people to the enterprise might reduce case backlogs, but it will not address fundamental limitations in the capabilities of forensic science disciplines to discern valid information from crime scene evidence. For the most part, it is impossible to discern the magnitude of those limitations, and reasonable people will differ on their significance.

Forensic science research is not well supported, and there is no unified strategy for developing a forensic science research plan across federal agencies. Relative to other areas of science, the forensic disciplines have extremely limited opportunities for research funding. Although the FBI and NIJ have supported some research in forensic science, the level of support has been well short of what is necessary for the forensic science community to establish strong links with a broad base of research universities. Moreover, funding for academic research is limited and requires law enforcement collaboration, which can inhibit the pursuit of more fundamental scientific questions essential to establishing the foundation of forensic science. The broader research community generally is not engaged in conducting research relevant to advancing the forensic science disciplines.

The forensic science enterprise also is hindered by its extreme disaggregation—marked by multiple types of practitioners with different levels of education and training and different professional cultures and standards for performance and a reliance on apprentice-type training and a guild-like structure of disciplines, which work against the goal of a single forensic science profession. Many forensic scientists are given scant opportunity for professional activities, such as attending conferences or publishing their research, which could help strengthen the professional community and offset some of the disaggregation. The fragmented nature of the enterprise raises the worrisome prospect that the quality of evidence presented in court, and its interpretation, can vary unpredictably according to jurisdiction.

Numerous professional associations are organized around the forensic science disciplines, and many of them are involved in training and education (see Chapter 8) and are developing standards and accreditation and certification programs (see Chapter 7). The efforts of these groups are laudable. However, except for the largest organizations, it is not clear how these associations interact or the extent to which they share requirements, standards, or policies. Thus, there is a need for more consistent and harmonized requirements.

In the course of its deliberations and review of the forensic science enterprise, it became obvious to the committee that, although congressional action will not remedy all of the deficiencies in forensic science methods and practices, truly meaningful advances will not come without significant concomitant leadership from the federal government. The forensic science enterprise lacks the necessary governance structure to pull itself up from its current weaknesses. Of the many professional societies that serve the enterprise, none is dominant, and none has clearly articulated the need for change or presented a vision for accomplishing it. And clearly no municipal or state forensic office has the mandate to lead the entire enterprise. The major federal resources—NIJ and the FBI Laboratory—have provided modest leadership, for which they should be commended: NIJ has contributed a helpful research program and the FBI Laboratory has spearheaded the SWGs. But again, neither entity has recognized, let alone articulated, a need for change or a vision for achieving it. Neither has the full confidence of the larger forensic science community. And because both are part of a prosecutorial department of the government, they could be subject to subtle contextual biases that should not be allowed to undercut the power of forensic science.

The forensic science enterprise needs strong governance to adopt and promote an aggressive, long-term agenda to help strengthen the forensic science disciplines. Governance must be strong enough—and independent enough—to identify the limitations of forensic science methodologies, and must be well connected with the Nation's scientific research base to effect meaningful advances in forensic science practices. The governance structure must be able to create appropriate incentives for jurisdictions to adopt and adhere to best practices and promulgate the necessary sanctions to discourage bad practices. It must have influence with educators in order to effect improvements to forensic science education. It must be able to identify standards and enforce them. A governance entity must be geared toward (and be credible within) the law enforcement community, but it must have strengths that extend beyond that area. Oversight of the forensic science community and medical examiner system will sweep broadly into areas of criminal investigation and prosecution, civil litigation, legal reform, investigation of insurance claims, national disaster planning and preparedness, homeland security, certification of federal, state, and local forensic practitioners, public health, accreditation of public and private laboratories, research to improve forensic methodologies, education programs in colleges and universities, and advancing technology.

The committee considered whether such a governing entity could be established within an existing federal agency. The National Science Foundation (NSF) was considered because of its strengths in leading research and its connections to the research and education communities. NSF is surely capable of building and sustaining a research base, but it has very thin ties to the forensic science community. It would be necessary for NSF to take many untested steps if it were to assume responsibility for the governance of applied fields of science. The committee also considered NIST. In the end analysis, however, NIST did not appear to be a viable option. It has a good program of research targeted at forensic science and law enforcement, but the program is modest. NIST also has strong ties to industry and academia, and it has an eminent history in standard setting and method development. But its ties to the forensic science community are still limited, and it would not be seen as a natural leader by the scholars, scientists, and practitioners in the field. In sum, the committee concluded that neither NSF nor NIST has the breadth of experience or institutional capacity to establish an effective governance structure for the forensic science enterprise.

There was also a strong consensus in the committee that no existing or new division or unit within DOJ would be an appropriate location for a new entity governing the forensic science community. DOJ's principal mission is to enforce the law and defend the interests of the United States according to the law. Agencies within DOJ operate pursuant to this mission. The FBI, for example, is the investigative arm of DOJ and its principal missions are to produce and use intelligence to protect the Nation from threats and to bring to justice those who violate the law. The work of these law enforcement units is critically important to the Nation, but the scope of the work done by DOJ units is much narrower than the promise of a strong forensic science community. Forensic science serves more than just law enforcement; and when it does serve law enforcement, it must be equally available to law enforcement officers, prosecutors, *and* defendants in the criminal justice system. The entity that is established to govern the forensic science community cannot be principally beholden to law enforcement. The potential for conflicts of interest between the needs of law enforcement and the broader needs of forensic science are too great. In addition, the committee determined that the research funding strategies of DOJ have not adequately served the broad needs of the forensic science community. This is understandable, but not acceptable when the issue is whether an agency is best suited to support and oversee the Nation's forensic science community. In sum, the committee concluded that advancing *science* in the forensic science enterprise is not likely to be achieved within the confines of DOJ.

Furthermore, there is little doubt that some existing federal entities are too wedded to the current "fragmented" forensic science community, which is deficient in too many respects. Most notably, these existing agencies have failed to pursue a rigorous research agenda to confirm the evidentiary reliability of methodologies used in a number of forensic science disciplines. These agencies are not good candidates to oversee the overhaul of the forensic science community in the United States.

Finally, some existing federal agencies with other missions occasionally have undertaken projects affecting the forensic science community. These entities are better left to continue the good work that defines their principal missions. More responsibility is not better for these existing entities, nor would it be better for the forensic science community or the Nation.

The committee thus concluded that the problems at issue are too serious and important to be subsumed by an existing federal agency. It also concluded that no existing federal agency has the capacity or appropriate mission to take on the roles and responsibilities needed to govern and improve the forensic science enterprise.

The committee believes that what is needed to support and oversee the forensic science community is a new, strong, and independent entity that could take on the tasks that would be assigned to it in a manner that is as objective and free of bias as possible—one with no ties to the past and with the authority and resources to implement a fresh agenda designed to address the problems found by the committee and discussed in this report. A new organization should not be encumbered by the assumptions, expectations, and deficiencies of the existing fragmented infrastructure, which has failed to address the needs and challenges of the forensic science disciplines.

This new entity must be an independent federal agency established to address the needs of the forensic science community, and it must meet the following minimum criteria:

- It must have a culture that is strongly rooted in science, with strong ties to the national research and teaching communities, including federal laboratories.
- It must have strong ties to state and local forensic entities as well as to the professional organizations within the forensic science community.

- It must not be in any way committed to the existing system, but should be informed by its experiences.
- It must not be part of a law enforcement agency.
- It must have the funding, independence, and sufficient prominence to raise the profile of the forensic science disciplines and push effectively for improvements.
- It must be led by persons who are skilled and experienced in developing and executing national strategies and plans for standard setting; managing accreditation and testing processes; and developing and implementing rulemaking, oversight, and sanctioning processes.

No federal agency currently exists that meets all of these criteria.

Recommendation 1:

> **To promote the development of forensic science into a mature field of multidisciplinary research and practice, founded on the systematic collection and analysis of relevant data, Congress should establish and appropriate funds for an independent federal entity, the National Institute of Forensic Science (NIFS). NIFS should have a full-time administrator and an advisory board with expertise in research and education, the forensic science disciplines, physical and life sciences, forensic pathology, engineering, information technology, measurements and standards, testing and evaluation, law, national security, and public policy. NIFS should focus on:**
>
> **(a) establishing and enforcing best practices for forensic science professionals and laboratories;**
> **(b) establishing standards for the mandatory accreditation of forensic science laboratories and the mandatory certification of forensic scientists and medical examiners/forensic pathologists—and identifying the entity/entities that will develop and implement accreditation and certification;**
> **(c) promoting scholarly, competitive peer-reviewed research and technical development in the forensic science disciplines and forensic medicine;**
> **(d) developing a strategy to improve forensic science research and educational programs, including forensic pathology;**
> **(e) establishing a strategy, based on accurate data on the forensic science community, for the efficient allocation of available funds to give strong support to forensic methodologies and practices in addition to DNA analysis;**

(f) **funding state and local forensic science agencies, independent research projects, and educational programs as recommended in this report, with conditions that aim to advance the credibility and reliability of the forensic science disciplines;**
(g) **overseeing education standards and the accreditation of forensic science programs in colleges and universities;**
(h) **developing programs to improve understanding of the forensic science disciplines and their limitations within legal systems; and**
(i) **assessing the development and introduction of new technologies in forensic investigations, including a comparison of new technologies with former ones.**

The benefits that will flow from a strong, independent, strategic, coherent, and well-funded federal program to support and oversee the forensic science disciplines in this country are clear: The Nation will (1) bolster its ability to more accurately identify true perpetrators and exclude those who are falsely accused; (2) improve its ability to effectively respond to, attribute, and prosecute threats to homeland security; and (3) reduce the likelihood of convictions resting on inaccurate data. Moreover, establishing the scientific foundation of the forensic science disciplines, providing better education and training, and requiring certification and accreditation will position the forensic science community to take advantage of current and future scientific advances.

The creation of a new federal entity undoubtedly will pose challenges, not the least of which will be budgetary constraints. The committee is not in a position to estimate how much it will cost to implement the recommendations in this report; this is a matter best left to the expertise of the Congressional Budget Office. What is clear, however, is that Congress must take aggressive action if the worst ills of the forensic science community are to be cured. Political and budgetary concerns should not deter bold, creative, and forward-looking action, because the country cannot afford to suffer the consequences of inaction. It will also take time and patience to implement the recommendations in this report. But this is true with any large, complex, important, and challenging enterprise.

The committee strongly believes that the greatest hope for success in this enterprise will come with the creation of the National Institute of Forensic Science (NIFS) to oversee and direct the forensic science community. The remaining recommendations in this report are crucially tied to the creation of NIFS. However, each recommendation is a separate, essential piece of the plan to improve the forensic science community in the United States. Therefore, even if the creation of NIFS is forestalled, the committee vigorously supports the adoption of the core ideas and principles embedded in each of the following recommendations.

Standardized Terminology and Reporting

The terminology used in reporting and testifying about the results of forensic science investigations must be standardized. Many terms are used by forensic scientists in scientific reports and in court testimony that describe findings, conclusions, and 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 and does have a profound effect on how the trier of fact in a criminal or civil matter perceives and evaluates scientific evidence. Although some forensic science disciplines have proposed reporting vocabulary and scales, the use of the recommended language is not standard practice among forensic science practitioners.

As a general matter, laboratory reports generated as the result of a scientific analysis should be complete and thorough. They should contain, at minimum, "methods and materials," "procedures," "results," "conclusions," and, as appropriate, sources and magnitudes of uncertainty in the procedures and conclusions (e.g., levels of confidence). Some forensic science laboratory reports meet this standard of reporting, but many 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 greenish, brown plant material in item #1 was identified as marijuana"), and they include no mention of methods or any discussion of measurement uncertainties.

Many clinical and testing disciplines outside the forensic science disciplines have standards, templates, and protocols for data reporting. A good example is the ISO/IEC 17025 standard (commonly called "ISO 17025"). ISO 17025 is an international standard published by the International Organization for Standardization (ISO) that specifies the general requirements for the competence to carry out tests and/or calibrations. These requirements have been used by accrediting agencies to determine what a laboratory must do to secure accreditation. In addition, some SWGs in the forensic disciplines have scoring systems for reporting findings, but these systems are neither uniformly nor consistently used. In other words, although appropriate standards exist, they are not always followed. Forensic reports, and any courtroom testimony stemming from them, must include clear characterizations of the limitations of the analyses, including measures of uncertainty in reported results and associated estimated probabilities where possible.

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 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.**

More and Better Research

As noted above, some forensic science disciplines are supported by little rigorous systematic research to validate the discipline's basic premises and techniques. There is no evident reason why such research cannot be conducted. Much more federal funding is needed to support research in the forensic science disciplines and forensic pathology in universities and private laboratories committed to such work.

The forensic science and medical examiner communities will be improved by opportunities to collaborate with the broader science and engineering communities. In particular, there is an urgent need for collaborative efforts to (1) develop new technical methods or provide in-depth grounding for advances developed in the forensic science disciplines; (2) provide an interface between the forensic science and medical examiner communities and basic sciences; and (3) create fertile ground for discourse among the communities. NIFS should recommend, implement, and guide strategies for supporting such initiatives.

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 realisticcase 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 needs to distinguish between average performance (achieved across individual practitioners and laboratories) and individual performance (achieved by the specific practitioner and laboratory). Whether 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. (Some of the legal issues are addressed in Chapter 3.)

Best Practices and Standards

Although there have been notable efforts to achieve standardization and develop best practices in some forensic science disciplines and the medical examiner system, most disciplines still lack best practices or any coherent structure for the enforcement of operating standards, certification, and accreditation. Standards and codes of ethics exist in some fields, and there are some functioning certification and accreditation programs, but none are mandatory. In short, oversight and enforcement of operating standards, certification, accreditation, and ethics are lacking in most local and state jurisdictions.

Scientific and medical assessment conducted in forensic investigations should be independent of law enforcement efforts either to prosecute criminal suspects or even to determine whether a criminal act has indeed been committed. Administratively, this means that forensic scientists should function independently of law enforcement administrators. The best science is conducted in a scientific setting as opposed to a law enforcement setting. Because forensic scientists often are driven in their work by a need to answer a particular question related to the issues of a particular case, they sometimes face pressure to sacrifice appropriate methodology for the sake of expediency.

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 appropriate 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.**

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 examina-**

tions, 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 findings and recommendations to NIFS for further dissemination and implementation.

Quality Control, Assurance, and Improvement

In a field such as medical diagnostics, a health care provider typically can track a patient's progress to see whether the original diagnosis was accurate and helpful. For example, widely accepted programs of quality control ensure timely feedback involving the diagnoses that result from mammography. Other examples of quality assurance and improvement—including the development of standardized vocabularies, ontologies, and scales for interpreting diagnostic tests and developing standards for accreditation of services—pervade diagnostic medicine. This type of systematic and routine feedback is an essential element of any field striving for continuous improvement. The forensic science disciplines likewise must become a self-correcting enterprise, developing and implementing feedback loops that allow the profession to discover past mistakes. A particular need exists for routine, mandatory proficiency testing that emulates a realistic, representative cross-section of casework, for example, DNA proficiency testing.

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.**

Codes of Ethics

A number of forensic science organizations—such as AAFS, the Midwestern Association of Forensic Scientists, ASCLD, and NAME—have adopted codes of ethics. The codes that exist are sometimes comprehensive, but they vary in content. While there is no reason to doubt that many forensic scientists understand their ethical obligations and practice in an ethical way, there are no consistent mechanisms for enforcing any of the existing codes of ethics. Many jurisdictions do not require certification in the same way that, for example, states require lawyers to be licensed. Therefore, few forensic science practitioners face the threat of official sanctions or loss of certification for serious ethical violations. And it is unclear whether and to what extent forensic science practitioners are required to adhere to ethics standards as a condition of employment.

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.**

Insufficient Education and Training

Forensic science examiners need to understand the principles, practices, and contexts of scientific methodology, as well as the distinctive features of their specialty. Ideally, training should move beyond apprentice-like transmittal of practices to education 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 instruction on how to document and report the analysis. A trainee also should have working knowledge of basic quantitative calculations, including statistics and probability, as needed for the applicable discipline.

To correct some of the existing deficiencies, it is crucially important to improve undergraduate and graduate forensic science programs. Legitimization of practices in forensic disciplines must be based on established scientific knowledge, principles, and practices, which are best learned through formal education. Apprenticeship has a secondary role, and under no circumstances can it supplant the need for the scientific basis of education in and 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 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 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 between experts in the forensic science disciplines and law schools, 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 instructions, law enforcement practices, litigation strategies, and judicial decisionmaking. Law schools should enhance this connection by offering courses in the forensic science disciplines, by offering credit for forensic science courses taken in other colleges, and by developing joint degree programs. And judges need to be better educated in forensic science methodologies and practices.

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.

The Medicolegal Death Investigation System

Although steps have been taken to transform the medicolegal death investigation system, the shortage of resources and lack of consistent educational and training requirements (particularly in the coroner system)[26] prevent the system from taking full advantage of tools—such as CT scans and digital X-rays—that the medical system and other scientific disciplines have to offer. In addition, more rigorous efforts are needed in the areas of accreditation and adherence to standards. Currently, requirements for practitioners vary from nothing more than age and residency requirements to certification by the American Board of Pathology in forensic pathology.

Funds are needed to assess the medicolegal death investigation system to determine its status and needs, using as a benchmark the current requirements of NAME relating to professional credentials, standards, and accreditation. And funds are needed to modernize and improve the medicolegal death investigation system. As it now stands, medical examiners and coroners (ME/Cs) are essentially ineligible for direct federal funding and grants from DOJ, DHS, or the Department of Health and Human Services (through the National Institutes of Health). The Paul Coverdell National Forensic Science Improvement Act is the only federal grant program that names medical examiners and coroners 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 are inadequate. The simple reality is that the program has not been sufficiently funded to provide significant improvements in ME/C systems.

In addition to direct funding, there are other initiatives that should be pursued to improve the medicolegal death investigation system. The Association of American Medical Colleges and other appropriate profes-

[26] Institute of Medicine. 2003. *Workshop on the Medicolegal Death Investigation System*. Washington, DC: The National Academies Press.

sional organizations should 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 eligible to compete for funds. Funding should be available to support pathologists seeking forensic fellowships. In addition, forensic pathology fellows could be allowed to apply for medical school loan forgiveness if they stay full time at a medical examiner's office for a reasonable period of time.

Additionally, NIFS should seek funding from Congress to support the joint development of programs to include medical examiners and medical examiner offices in national disaster planning, preparedness, and consequence management, involving the Centers for Disease Control and Prevention (CDC) and DHS. Uniform statewide and interstate standards of operation would be needed to assist in the management of cross-jurisdictional and interstate events. NIFS should support a federal program underwriting the development of software for use by ME/C systems for the management of multisite, multiple fatality events.

NIFS should 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.

The foregoing ideas must be developed further before any concrete plans can be pursued. There are, however, 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 Congress and NIFS.

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.

(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.

AFIS and Database Interoperability

Great improvement is necessary in AFIS interoperability. Crimes may go unsolved today simply because it is not possible for investigating agencies to search across all the databases that might hold a suspect's fingerprints or that may contain a match for an unidentified latent print from a crime scene. It is also possible that some individuals have been wrongly convicted because of the limitations of fingerprint searches.

At present, serious practical problems pose obstacles to the achievement of nationwide AFIS interoperability. These problems include convincing AFIS equipment vendors to cooperate and collaborate with the law enforcement community and researchers to create and use baseline standards for sharing fingerprint data and create a common interface. Second, law enforcement agencies lack the resources needed to transition to interoperable AFIS implementations. Third, coordinated jurisdictional agreements and public policies are needed to 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 from increased AFIS interoperability, the committee believes that a broad-based 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 federal, state, and local funds to support jurisdictions in upgrading, operating, and ensuring the integrity and security of their systems; retraining current staff; and training 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.

Forensic Science Disciplines and Homeland Security

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 more thorough investigations of crime scenes that have been damaged physically. 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, the forensic science community has a role to play in 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 the establishment of good working relationships between federal, state, and local jurisdictions, the creation of strong security programs to protect data transmittals between jurisdictions, the development of additional training for forensic scientists and crime scene investigators, and the promulgation of contingency plans that will promote efficient team efforts on demand. Policy issues relating to the enforcement of homeland security are not within the scope of the committee's charge and, thus, are beyond the scope of the report. It can hardly be doubted, however, that improvements in the forensic science community and 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 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.**

1

Introduction

The world of crime is a complex place. Crime takes place in the workplace, schools, homes, places of business, motor vehicles, on the streets, and, increasingly, on the Internet. Crimes are committed at all hours of the day and night and in all regions of the country, in rural, suburban, and urban environments. In many cases, a weapon is used, such as a handgun, knife, or blunt object. Sometimes the perpetrator is under the influence of alcohol or illicit drugs. In other cases, no one is physically hurt, but property is damaged or stolen—for example, when burglary, theft, and motor vehicle theft occur. In recent years, information technology has provided the opportunity for identity theft and other types of cybercrime. A crime scene often is rich in information that reveals the nature of the criminal activity and the identities of those persons involved. Perpetrators and victims may leave behind blood, saliva, skin cells, hair, fingerprints, footprints, tire prints, clothing fibers, digital and photographic images, audio data, handwriting, and the residual effects and debris of arson, gunshots, and unlawful entry. Some crimes transcend borders, such as those involving homeland security, for which forensic evidence can be gathered.

Crime scene investigators, with varying levels of training and experience, search for and collect evidence at the scene, preserve and secure it in tamper-evident packaging, label it, and send it to an appropriate agency—normally a crime laboratory, where it may be analyzed by forensic examiners. If a death was sudden, unexpected, or resulted from violence, a medicolegal investigator (e.g., coroner, medical examiner, forensic pathologist, physician's assistant) will be responsible for determining whether a homicide, suicide, or accident occurred and will certify the cause and manner of death.

Crime scene evidence moves through a chain of custody in which, depending on their physical characteristics (e.g., blood, fiber, handwriting), samples are analyzed according to any of a number of analytical protocols, and results are reported to law enforcement and court officials. When evidence is analyzed, typically forensic science "attempts to uncover the actions or happenings of an event . . . by way of (1) identification (categorization), (2) individualization, (3) association, and (4) reconstruction."[1] Evidence also is analyzed for the purpose of excluding individuals or sources.

Not all forensic services are performed in traditional crime laboratories by trained forensic scientists. Some forensic tests might be conducted by a sworn law enforcement officer with no scientific training or credentials, other than experience. In smaller jurisdictions, members of the local police or sheriff's department might conduct the analyses of evidence, such as latent print examinations and footwear comparisons. In the United States, if evidence is sent to a crime laboratory, that facility might be publicly or privately operated, although private laboratories typically do not visit crime scenes to collect evidence or serve as the first recipient of physical evidence. Public crime laboratories are organized at the city, county, state, or federal level. A law enforcement agency that does not operate its own crime laboratory typically has access to a higher-level laboratory (e.g., at the state or county level) or a private laboratory for analysis of evidence.

According to a 2005 census by the Bureau of Justice Statistics (BJS),[2] 389 publicly funded forensic crime laboratories were operating in the United States in 2005: These included 210 state or regional laboratories, 84 county laboratories, 62 municipal laboratories, and 33 federal laboratories, and they received evidence from nearly 2.7 million criminal cases[3] in 2005. These laboratories are staffed by individuals with a wide range of training and expertise, from scientists with Ph.D.s to technicians who have been trained largely on the job. No data are available on the size and depth of the private forensic laboratories, except for private DNA laboratories.

In general, a traditional crime laboratory has been defined as constituting "a single laboratory or system comprised of scientists analyzing evidence

---

[1] K. Inman and N. Rudin. 2002. The origin of evidence. *Forensic Science International* 126:11-16.

[2] 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.

[3] Ibid., p. 9. "A 'case' is defined as evidence submitted from a single criminal investigation. A case may include multiple 'requests' for forensic services. For example, one case may include a request for biology screening and a request for latent prints."

in one or more of the following disciplines: controlled substances, trace, biology (including DNA), toxicology, latent prints, questioned documents, firearms/toolmarks, or crime scene."[4] More recently, increasing numbers of laboratories specialize in the analysis of evidence in one area, for example, DNA or digital evidence. (See Chapter 5 for a more complete description and discussion of the forensic science disciplines.)

The capacity and quality of the current forensic science system have been the focus of increasing attention by Congress, the courts, and the media. New doubts about the accuracy of some forensic science practices have intensified with the growing number of exonerations resulting from DNA analysis (and the concomitant realization that guilty parties sometimes walk free). Greater expectations for precise forensic science evidence raised by DNA testing have forced new scrutiny on other forensic techniques. Emerging scientific advances that could benefit forensic investigation elicit concerns about resources, training, and capacity for implementing new techniques. A crisis in backlogged cases, caused by crime laboratories lacking sufficient resources and qualified personnel, raises concerns about the effectiveness and efficiency of the criminal justice system. When backlogs prolong testing time, issues involving speedy trials may arise. In addition, backlogs discourage law enforcement personnel and organizations from submitting evidence. Laboratories also may restrict submissions of evidence to reduce backlogs. All of these concerns, and more, provide the background against which this report is set.

Finally, if evidence and laboratory tests are mishandled or improperly analyzed; if the scientific evidence carries a false sense of significance; or if there is bias, incompetence, or a lack of adequate internal controls for the evidence introduced by the forensic scientists and their laboratories, the jury or court can be misled, and this could lead to wrongful conviction or exoneration. If juries lose confidence in the reliability of forensic testimony, valid evidence might be discounted, and some innocent persons might be convicted or guilty individuals acquitted.

Recent years have seen a number of concerted efforts by forensic science organizations to strengthen the foundations of many areas of testimony. However, substantial improvement is necessary in the forensic science disciplines to enhance law enforcement's ability to identify those who have or have not committed a crime and to prevent the criminal justice system from erroneously convicting or exonerating the persons who come before it.

[4] Ibid., p. 24.

WHAT IS FORENSIC SCIENCE?

Although there are numerous ways by which to categorize the forensic science disciplines, the committee found the categorization used by the National Institute of Justice to be useful:

1. general toxicology;
2. firearms/toolmarks;
3. questioned documents;
4. trace evidence;
5. controlled substances;
6. biological/serology screening (including DNA analysis);
7. fire debris/arson analysis;
8. impression evidence;
9. blood pattern analysis;
10. crime scene investigation;
11. medicolegal death investigation; and
12. digital evidence.[5]

Some of these disciplines are discussed in Chapter 5. Forensic pathology is considered a subspecialty of medicine and is considered separately in Chapter 9.

The term "forensic science" encompasses a broad range of disciplines, each with its own distinct practices. The forensic science disciplines exhibit wide variability with regard to techniques, methodologies, reliability, level of error, research, general acceptability, and published material (see Chapters 4 through 6). Some of the 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). Some activities require the skills and analytical expertise of individuals trained as scientists (e.g., chemists or biologists); other activities are conducted by scientists as well as by individuals trained in law enforcement (e.g., crime scene investigators, blood spatter analysts, crime reconstruction specialists), medicine (e.g., forensic pathologists), or laboratory methods (e.g., technologists). Many of the processes used in the forensic science disciplines are largely empirical applications of science—that is, they are not based on a body of knowledge that recognizes the underlying limitations of the scientific principles and methodologies used for problem solving and discovery. It is therefore important to focus on ways to improve, systematize, and monitor the activities and practices

[5] National Institute of Justice. 2006. *Status and Needs of Forensic Science Service Providers: A Report to Congress*. Available at www.ojp.usdoj.gov/nij/pubs-sum/213420.htm.

in the forensic science disciplines and related areas of inquiry. Thus, in this report, the term "forensic science" is used with regard to a broad array of activities, with the recognition that some of these activities might not have a well-developed research base, are not informed by scientific knowledge, or are not developed within the culture of science.

PRESSURES ON THE FORENSIC SCIENCE SYSTEM

As mentioned above, a number of factors have combined in the past few decades to place increasing demands on an already overtaxed, inconsistent, and underresourced forensic science infrastructure. These factors have not only stressed the system's capacity, but also have raised serious questions and concerns about the validity and reliability of some forensic methods and techniques and how forensic evidence is reported to juries and courts.

The Case Backlog—Insufficient Resources

According to the 2005 BJS census report, a typical publicly funded crime laboratory ended the year with a backlog of about 401 requests for services, received another 4,328 such requests, and completed 3,980 of them. Roughly half of all requests were in the area of controlled substances. The average backlog has risen since the 2002 census,[6] with nearly 20 percent of all requests backlogged by year end. The Department of Justice (DOJ) defines a case as backlogged if it remains in the laboratory 30 days or more without the development of a report or analysis. Federal, state, and local laboratories reported a combined backlog of 435,879 requests for forensic analysis.[7] According to the census, a typical laboratory performing DNA testing in 2005 started the year with a backlog of 86 requests, received 337 new requests, completed 265 requests, and finished the year with 152 backlogged requests.

The backlog is exacerbated further by increased requests for quick laboratory results by law enforcement and prosecutors. Witnesses before the committee testified that prosecutors increasingly rely on laboratories to provide results prior to approving charges and have increased requests for additional work on the back end of a case, just before trial.[8] Backlogs are compounded by rising police agency requests for testing (e.g., for DNA evidence found on guns and from nonviolent crime scenes). Laboratories

[6] 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.

[7] Durose, op. cit.

[8] J.L. Johnson, Laboratory Director, Illinois State Police, Forensic Science Center at Chicago. Presentation to the committee. January 25, 2007.

are thus challenged to balance requests for analyses of "older" and "cold" cases with new cases and must make choices to allocate resources by prioritizing the evidence to be analyzed. In California, voters passed Proposition 69, requiring that a DNA sample be obtained from all convicted felons. This increased the workload and resulted in 235,000 backlogged cases by the end of 2005.[9]

These backlogs can result in prolonged incarceration for innocent persons wrongly charged and awaiting trial and delayed investigation of those who are not yet charged, and they can contribute to the release of guilty suspects who go on to commit further crimes.

The Ascendancy of DNA Analysis and a New Standard

In the 1980s, the opportunity to use the techniques of DNA technologies to identify individuals for forensic and other purposes became apparent. Early concerns about the use of DNA for forensic casework included the following: (1) whether the detection methods were scientifically valid—that is, whether they correctly identified true matches and true nonmatches and (2) whether DNA analysis of forensic samples is reliable—that is, whether it yields reproducible results under defined conditions of use. A 1990 report by the congressional Office of Technology Assessment concluded that DNA tests were both reliable and valid in the forensic context but required a strict set of standards and quality control measures before they could be widely adopted.[10]

In 1990, the Federal Bureau of Investigation (FBI) established guidelines for DNA analysis and proficiency testing and four years later created the Combined DNA Index System (CODIS), which allows federal, state, and local crime laboratories to exchange and compare DNA profiles electronically, thereby linking crimes to each other and to convicted offenders.

In 1992, the National Research Council (NRC) issued *DNA Technology in Forensic Science*, which concluded that, "No laboratory should let its results with a new DNA typing method be used in court, unless it has undergone . . . proficiency testing via blind trials."[11] In addition, the report cautioned that numerous questions must be answered about using DNA evidence in a forensic context that rarely had to be considered by scientists engaged in DNA research—for example, questions involving contamination, degradation, and a number of statistical issues. While confirming that

---

[9] Durose, op. cit.

[10] U.S. Congress, Office of Technology Assessment. 1990. *Genetic Witness: Forensic Uses of DNA Tests*. OTA-BA-438. Washington, DC: U.S. Government Printing Office, NTIS order #PB90-259110.

[11] National Research Council. 1992. *DNA Technology in Forensic Science*. Washington, DC: National Academy Press, p. 55.

the science behind DNA analysis is valid, a subsequent NRC report in 1996 recommended new ways of interpreting DNA evidence to help answer a key question for jurors—the likelihood that two matching samples can come from different people.[12] This 1996 report recommended a set of statistical calculations that takes population structure into account, which enhanced the validity of the test. The report also called for independent retesting and made recommendations to improve laboratory performance and accountability through, for example, adherence to high-quality standards, accreditation, and proficiency testing.

Since then, the past two decades have seen tremendous growth in the use of DNA evidence in crime scene investigations. Currently more than 175 publicly funded forensic laboratories and approximately 30 private laboratories conduct hundreds of thousands of DNA analyses annually in the United States. In addition, most countries in Europe and Asia have forensic DNA programs. In 2003, President George W. Bush announced a 5-year, $1 billion initiative to improve the use of DNA in the criminal justice system. Called the *President's DNA Initiative*, the program pushed for increased funding, training, and assistance to ensure that DNA technology "reaches its full potential to solve crimes, protect the innocent, and identify missing persons."[13]

Thus, DNA analysis—originally developed in research laboratories in the context of life sciences research—has received heightened scrutiny and funding support. That, combined with its well-defined precision and accuracy, has set the bar higher for other forensic science methodologies, because it has provided a tool with a higher degree of reliability and relevance than any other forensic technique. However, DNA evidence comprises only about 10 percent of case work and is not always relevant to a particular case.[14] Even if DNA evidence is available, it will assist in solving a crime only if it supports an evidential hypothesis that makes guilt or innocence more likely. For example, the fact that DNA evidence of a victim's husband is found in the house in which the couple lived and where the murder took place proves nothing. The fact that the husband's DNA is found under the fingernails of the victim who put up a struggle may have a very different significance. Thus, it is essential to articulate the reasoning process and the context associated with the evidence that is being evaluated.

[12] National Research Council. 1996. *The Evaluation of Forensic DNA Evidence: An Update*. Washington, DC: National Academy Press.

[13] See www.dna.gov/info/e_summary.

[14] The American Society of Crime Laboratory Directors. 2004. *180 Day Study: Status and Needs of U.S. Crime Labs*. p. 7, table 2.

Questionable or Questioned Science

The increased use of DNA analysis as a more reliable approach to matching crime scene evidence with suspects and victims has resulted in the reevaluation of older cases that retained biological evidence that could be analyzed by DNA. The number of exonerations resulting from the analysis of DNA has grown across the country in recent years, uncovering a disturbing number of wrongful convictions—some for capital crimes—and exposing serious limitations in some of the forensic science approaches commonly used in the United States.

According to The Innocence Project, there have been 223 postconviction DNA exonerations in the United States since 1989 (as of November 2008).[15] Some have contested the percentage of exonerated defendants whose convictions allegedly were based on faulty science. Although the Innocence Project figures are disputed by forensic scientists who have reexamined the data, even those who are critical of the conclusions of The Innocence Project acknowledge that faulty forensic science has, on occasion, contributed to the wrongful conviction of innocent persons.[16]

The fact is that many forensic tests—such as those used to infer the source of toolmarks or bite marks—have never been exposed to stringent scientific scrutiny. Most of these techniques were developed in crime laboratories to aid in the investigation of evidence from a particular crime scene, and researching their limitations and foundations was never a top priority. There is some logic behind the application of these techniques; practitioners worked hard to improve their methods, and results from other evidence have combined with these tests to give forensic scientists a degree of confidence in their probative value. Before the first offering of the use of DNA in forensic science in 1986, no concerted effort had been made to determine the reliability of these tests, and some in the forensic science and law enforcement communities believed that scientists' ability to withstand cross-examination in court when giving testimony related to these tests was sufficient to demonstrate the tests' reliability. However, although the precise error rates of these forensic tests are still unknown, comparison of their results with DNA testing in the same cases has revealed that some of these analyses, as currently performed, produce erroneous results. The

[15] The Innocence Project. *Fact Sheet: Facts on Post-Conviction DNA Exonerations*. Available at www.innocenceproject.org/Content/351.php. See also B.L. Garrett. Judging innocence. 108 COLUM. L. REV. 55 (2008) (discussing the results of an empirical study of the types of faulty evidence that was admitted in more than 200 cases for which DNA testing subsequently enabled postconviction exonerations).

[16] See J. Collins and J. Jarvis. 2008. The wrongful conviction of forensic science. *Crime Lab Report*. July 16. Available at www.crimelabreport.com/library/pdf/wrongful_conviction.pdf. See also N. Rudin and K. Inman. 2008. Who speaks for forensic science? *News of the California Association of Criminalists*. Available at www.cacnews.org/news/4thq08.pdf, p. 10.

conclusions of forensic examiners may or may not be right—depending on the case—but each wrongful conviction based on improperly interpreted evidence is serious, both for the innocent person and also for society, because of the threat that may be posed by a guilty person going free. Some non-DNA forensic tests do not meet the fundamental requirements of science, in terms of reproducibility, validity, and falsifiability (see Chapters 4 through 6).

Even fingerprint analysis has been called into question. For nearly a century, fingerprint examiners have been comparing partial latent fingerprints found at crime scenes to inked fingerprints taken directly from suspects. Fingerprint identifications have been viewed as exact means of associating a suspect with a crime scene print and rarely were questioned.[17] Recently, however, the scientific foundation of the fingerprint field has been questioned, and the suggestion has been made that latent fingerprint identifications may not be as reliable as previously assumed.[18] The question is less a matter of whether each person's fingerprints are permanent and unique—uniqueness is commonly assumed—and more a matter of whether one can determine with adequate reliability that the finger that left an imperfect impression at a crime scene is the same finger that left an impression (with different imperfections) in a file of fingerprints. In October 2007, Baltimore County Circuit Judge Susan M. Souder refused to allow a fingerprint analyst to testify that a latent print was made by the defendant in a death penalty trial. In her ruling, Judge Souder found the traditional method of fingerprint analysis to be "a subjective, untested, unverifiable identification procedure that purports to be infallible."[19]

Some forensic science methods have as their goal the "individualization" of specific types of evidence (typically shoe and tire impressions, dermal ridge prints, toolmarks and firearms, and handwriting). Analysts using such methods believe that unique markings are acquired by a source item in random fashion and that such uniqueness is faithfully transmitted from the source item to the evidence item being examined (or in the case of handwriting, that individuals acquire habits that result in unique handwriting). When the evidence and putative source items are compared, a conclusion of individualization implies that the evidence originated from that source,

---

[17] R. Epstein. Fingerprints meet *Daubert:* The myth of fingerprint "science" is revealed. 75 *Southern California Law Review* 605 (2002).

[18] S.A. Cole. 2002. *Suspect Identities: A History of Fingerprinting and Criminal Identification*. Boston: Harvard University Press; Epstein, op. cit.

[19] *State of Maryland v. Bryan Rose*. In the Circuit Court for Baltimore County. Case No. K06-545.

to the exclusion of all other possible sources.[20,21] The determination of uniqueness requires measurements of object attributes, data collected on the population frequency of variation in these attributes, testing of attribute independence, and calculations of the probability that different objects share a common set of observable attributes.[22] Importantly, the results of research must be made public so that they can be reviewed, checked by others, criticized, and then revised, and this has not been done for some of the forensic science disciplines.[23] As recently as September 2008, the Detroit Police crime laboratory was shut down following a Michigan State Police audit that found a 10 percent error rate in ballistic evidence.[24]

The forensic science community has had little opportunity to pursue or become proficient in the research that is needed to support what it does. Few sources of funding exist for independent forensic research (see Chapter 2). Most of the studies are commissioned by DOJ and conducted by crime laboratories with little or no participation by the traditional scientific community. In addition, most disciplines in the profession are hindered by a lack of enforceable standards for interpretation of data (see Chapter 7).

Errors and Fraud

In recent years, the integrity of crime laboratories increasingly has been called into question, with some highly publicized cases highlighting the sometimes lax standards of laboratories that have generated questionable or fraudulent evidence and that have lacked quality control measures that would have detected the questionable evidence. In one notorious case, a state-mandated review of analyses conducted by West Virginia State Police laboratory employee Fred Zain revealed that the convictions of more than 100 people were in doubt because Zain had repeatedly falsified evidence in criminal prosecutions. At least 10 men had their convictions overturned as a result.[25] Subsequent reviews questioned whether Zain was ever qualified to perform scientific examinations.[26]

Other scandals, such as one involving the Houston Crime Laboratory

[20] M.J. Saks and J.J. Koehler. 2005. The coming paradigm shift in forensic identification science. *Science* 309:892-895.

[21] W.J. Bodziak. 1999. *Footwear Impression Evidence–Detection, Recovery, and Examination*. 2nd ed. Boca Raton, FL: CRC Press.

[22] Ibid. See also NRC, 1996, op. cit.

[23] P.C. Giannelli. Wrongful convictions and forensic science: The need to regulate crime labs. 86 N.C. L. REV. 163 (2007).

[24] B. Schmitt and J. Swickard. 2008. Detroit Police lab shut down after probe finds errors. *Detroit Free Press* on-line. September 25.

[25] *In the Matter of an Investigation of the West Virginia State Police Crime Laboratory, Serology Division* (WVa 1993) 438 S.E.2d 501(Zaine I); and 445 S.E.2d 165 (Zain II).

[26] Ibid.

in 2003, highlight the sometimes blatant lack of proper education and training of forensic examiners. In the Houston case, several DNA experts went public with accusations that the DNA/Serology Unit of the Houston Police Department Crime Laboratory was performing grossly incompetent work and was presenting findings in a misleading manner designed to unfairly help prosecutors obtain convictions. An audit by the Texas Department of Public Safety confirmed serious inadequacies in the laboratory's procedures, including "routine failure to run essential scientific controls, failure to take adequate measures to prevent contamination of samples, failure to adequately document work performed and results obtained, and routine failure to follow correct procedures for computing statistical frequencies."[27,28]

The Innocence Project has documented instances of both intentional and unintentional laboratory errors that have lead to wrongful convictions, including:

- In the laboratory—contamination and mislabeling of evidence.
- In information provided in forensics reports—falsified results (including "drylabbing," i.e., providing conclusions from tests that were never conducted), and misinterpretation of evidence.
- In the courtroom—suppression of exculpatory evidence; providing a statistical exaggeration of the results of a test conducted on evidence; and providing false testimony about test results.[29]

Saks and Koehler have written that the testimony of forensic scientists is one of many problems in criminal cases today.[30] They cite the norms of science, which emphasize "methodological rigor, openness, and cautious interpretation of data," as norms that often are absent from the forensic science disciplines.

Although cases of fraud appear to be rare, perhaps of more concern is the lack of good data on the accuracy of the analyses conducted in forensic science disciplines and the significant potential for bias that is present in some cases. For example, the FBI was accused of bias in the case of the Madrid bombing suspect Brandon Mayfield (see Box 1-1). In that case, the Inspector General of DOJ launched an investigation. The FBI conducted its

---

[27] *Quality Assurance Audit for Forensic DNA and Convicted Offender DNA Databasing Laboratories. An Audit of the Houston Police Department Crime Laboratory-DNA/Serology Section, December 12-13, 2002*. Available at www.scientific.org/archive/Audit%20Document--Houston.pdf.

[28] See also M.R. Bromwich. 2007. *Final Report of the Independent Investigator for the Houston Police Department Crime Laboratory and Property Room*. Available at www.hpdlabinvestigation.org.

[29] The Innocence Project. Available at www.innocenceproject.org/Content/312.php.

[30] Saks and Koehler, op. cit.

Box 1-1
FBI Statement on Brandon Mayfield Case

"After the March terrorist attacks on commuter trains in Madrid, digital images of partial latent fingerprints obtained from plastic bags that contained detonator caps were submitted by Spanish authorities to the FBI for analysis. The submitted images were searched through the Integrated Automated Fingerprint Identification System (IAFIS). An IAFIS search compares an unknown print to a database of millions of known prints. The result of an IAFIS search produces a short list of potential matches. A trained fingerprint examiner then takes the short list of possible matches and performs an examination to determine whether the unknown print matches a known print in the database.

Using standard protocols and methodologies, FBI fingerprint examiners determined that the latent fingerprint was of value for identification purposes. This print was subsequently linked to Brandon Mayfield. That association was independently analyzed and the results were confirmed by an outside experienced fingerprint expert.

Soon after the submitted fingerprint was associated with Mr. Mayfield, Spanish authorities alerted the FBI to additional information that cast doubt on the findings. As a result, the FBI sent two fingerprint examiners to Madrid, who compared the image the FBI had been provided to the image the Spanish authorities had.

Upon review it was determined that the FBI identification was based on an image of substandard quality, which was particularly problematic because of the remarkable number of points of similarity between Mr. Mayfield's prints and the print details in the images submitted to the FBI."

The FBI's Latent Fingerprint Unit has reviewed its practices and adopted new guidelines for all examiners receiving latent print images when the original evidence is not included.

SOURCE: FBI. May 24, 2004, Press Release. Available at www.fbi.gov/pressrel/pressrel04/mayfield052404.htm.

own review by a panel of independent experts. The reviews concluded that the problem was not the quality of the digital images reviewed, but rather the bias and "circular reasoning" of the FBI examiners.[31]

Parts of the forensic science community have resisted the implications of the mounting criticism of the reliability of forensic analyses by investigative units such as Inspector General reports, The Innocence Project,

[31] U.S. Department of Justice, Office of the Inspector General. 2006. *A Review of the FBI's Handling of the Brandon Mayfield Case*. Also see R.B. Stacey. 2005. *Report on the Erroneous Fingerprint Individualization in the Madrid Train Bombing Case*. Available at www.fbi.gov/hq/lab/fsc/current/special_report/2005_special_report.htm.

and studies in the published literature. In testimony before the committee, it was clear that some members of the forensic science community will not concede that there could be less than perfect accuracy either in given laboratories or in specific disciplines, and experts testified to the committee that disagreement remains regarding even what constitutes an error. For example, if the limitations of a given technology lead to an examiner declaring a "match" that is found by subsequent technology (e.g., DNA analysis) to be a "mismatch," there is disagreement within the forensic science community about whether the original determination constitutes an error.[32] Failure to acknowledge uncertainty in findings is common: Many examiners claim in testimony that others in their field would come to the exact same conclusions about the evidence they have analyzed. Assertions of a "100 percent match" contradict the findings of proficiency tests that find substantial rates of erroneous results in some disciplines (i.e., voice identification, bite mark analysis).[33,34]

As an example, in a FBI publication on the correlation of microscopic and mitochondrial DNA hair comparisons, the authors found that even competent hair examiners can make significant errors.[35] In this study, the authors found that in 11 percent of the cases in which the hair examiners declared two hairs to be "similar," subsequent DNA testing revealed that the hairs did not match, which refers either to the competency or the relative ability of the two divergent techniques to identify differences in hair samples, as well as to the probative value of each test.

The insistence by some forensic practitioners that their disciplines employ methodologies that have perfect accuracy and produce no errors has hampered efforts to evaluate the usefulness of the forensic science disciplines. And, although DNA analysis is considered the most reliable forensic tool available today, laboratories nonetheless can make errors working with either nuclear DNA or mtDNA—errors such as mislabeling samples, losing samples, or misinterpreting the data.

Standard setting, accreditation of laboratories, and certification of individuals aim to address many of these problems, and although many laboratories have excellent training and quality control programs, even

---

[32] N. Benedict. 2004. Fingerprints and the *Daubert* standard for admission of scientific evidence: Why fingerprints fail and a proposed remedy. *Arizona Law Review* 46:519; M. Houck, Director of Forensic Science Initiative, West Virginia University. Presentation to the committee. January 25, 2007.

[33] D.L. Faigman, D. Kaye, M.J. Saks, and J. Sanders. 2002. *Modern Scientific Evidence: The Law and Science of Expert Testimony*. St. Paul, MN: Thompson/West.

[34] C.M. Bowers. 2002. The scientific status of bitemark comparisons. In: D.L. Faigman (ed.). *Science in the Law: Forensic Science Issues*. St. Paul, MN: West Publishing.

[35] M. Houck and B. Budowle. 2002. Correlation of microscopic and mitochondrial DNA hair comparisons. *Journal of Forensic Sciences* 47(5):964-967; see also Bromwich, op. cit.

accredited laboratories make mistakes. Furthermore, accreditation is a voluntary program, except in a few jurisdictions in which it is required (New York, Oklahoma, and Texas)[36] (see Chapter 7).

The "CSI Effect"

Media attention has focused recently on what is being called the "CSI Effect," named for popular television shows (such as *Crime Scene Investigation*) that are focused on police forensic evidence investigation.[37] The fictional characters in these dramas often present an unrealistic portrayal of the daily operations of crime scene investigators and crime laboratories (including their instrumentation, analytical technologies, and capabilities). Cases are solved in an hour, highly technical analyses are accomplished in minutes, and laboratory and instrumental capabilities are often exaggerated, misrepresented, or entirely fabricated. In courtroom scenes, forensic examiners state their findings or a match (between evidence and suspect) with unfailing certainty, often demonstrating the technique used to make the determination. The dramas suggest that convictions are quick and no mistakes are made.

The CSI Effect specifically refers to the real-life consequences of exposure to Hollywood's version of law and order. Jurists and crime laboratory directors anecdotally report that jurors have come to expect the presentation of forensic evidence in every case, and they expect it to be conclusive. A recent study by Schweitzer and Saks found that compared to those who do not watch CSI, CSI viewers were "more critical of the forensic evidence presented at the trial, finding it less believable. Forensic science viewers expressed more confidence in their verdicts than did nonviewers."[38] Prosecutors and defense attorneys have reported jurors second guessing them in the courtroom, citing "reasonable doubt" and refusing to convict because they believed that other evidence was available and not adequately examined.[39]

Schweitzer and Saks found that the CSI Effect is changing the manner in which forensic evidence is presented in court, with some prosecutors believing they must make their presentation as visually interesting and appealing as such presentations appear to be on television. Some are concerned that the conclusiveness and finality of the manner in which forensic evidence is

[36] National Institute of Justice. 2006. *Status and Needs of Forensic Science Service Providers: A Report to Congress*. Available at www.ojp.usdoj.gov/nij/pubs-sum/213420.htm.

[37] See *U.S. News & World Report*. 2005. The CSI effect: How TV is driving jury verdicts all across America. April 25.

[38] N.J. Schweitzer and M.J. Saks. 2007. The CSI Effect: Popular fiction about forensic science affects public expectations about real forensic science. *Jurimetrics* 47:357.

[39] See *U.S. News & World Report,* op. cit.

presented on television results in jurors giving more or less credence to the forensic experts and their testimony than they should, raising expectations, and possibly resulting in a miscarriage of justice.[40] The true effects of the popularization of forensic science disciplines will not be fully understood for some time, but it is apparent that it has increased pressure and attention on the forensic science community in the use and interpretation of evidence in the courtroom.

Fragmented and Inconsistent Medicolegal Death Investigation

The medicolegal death investigation system is a fragmented organization of state and local entities called upon to investigate deaths and to certify the cause and manner of unnatural and unexplained deaths. About 1 percent of the U.S. population (about 2.6 million people) dies each year. Medical examiner and coroner offices receive nearly 1 million reports of deaths, constituting between 30 to 40 percent of all U.S. deaths in 2004, and accept about one half of those (500,000, or 1 in 5 deaths) for further investigation and certification.[41] In carrying out this role, medical examiners and coroners are required to decide the scope and course of a death investigation, which may include assessing the scene of death, examining the body, determining whether to perform an autopsy, and ordering other medical tests, forensic analyses, and procedures as needed. Yet the training and skill of medical examiners and coroners and the systems that support them vary greatly. Medical examiners may be physicians, pathologists, or forensic pathologists with jurisdiction within a county, district, or state. A coroner is an elected or appointed official who might not be a physician or have had any medical training. Coroners typically serve a single county.

Since 1877, in the United States, there have been efforts to replace the coroner system with a medical examiner system.[42] In fact, more than 80 years ago, the National Academy of Sciences identified concerns regarding the lack of standardization in death investigations and called for the abolishment of the coroner's office, noting that the office "has conclusively demonstrated its incapacity to perform the functions customarily required of it."[43] In its place, the report called for well-staffed offices of a medical

---

[40] Schweitzer and Saks, op. cit.; S.A. Cole and R. Dioso-Villa. 2007. CSI and its effects: Media, juries, and the burden of proof. *New England Law Review* 41(3):435.

[41] M.J. Hickman, K.A. Hughes, K.J. Strom, and J.D. Ropero-Miller. 2007. *Medical Examiner and Coroners' Offices, 2004*. U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics. Available at www.ojp.usdoj.gov/bjs/pub/pdf/meco04.pdf.

[42] W.U. Spitz and R.S. Fisher. 1982. *Medicolegal Investigation of Death*, 2nd ed. Springfield, IL: Charles C. Thomas.

[43] National Research Council. 1928. *The Coroner and the Medical Examiner*. Washington, DC: National Academy Press.

examiner, led by a pathologist. In strong terms, the 1928 committee called for the professionalization of death investigation, with medical science at its center.

Despite these calls, efforts to move away from a coroner system in the United States have stalled. Currently, 11 states have coroner-only systems, 22 states have medical examiner systems, and 18 states have mixed systems—in which some counties have coroners and others have medical examiners. Some of these states have a referral system, in which the coroner refers cases to medical examiners for autopsy.[44] According to a 2003 Institute of Medicine report, in addition to the variety of systems in the United States, the location and authority of the medical examiner or coroner office also varies, with 43 percent of the U.S. population served by a medical examiner or coroner housed in a separate city, county, or state government office. Other arrangements involve an office under public safety or law enforcement. The least common placement is under a forensic laboratory or health department.[45]

Variability also is evident in terms of accreditation of death investigation systems. As of August 2008, 54 of the medical examiner offices in the United States (serving 23 percent of the population) have been accredited by the National Association of Medical Examiners, the professional organization of physician medical examiners. Most of the country is served by offices lacking accreditation.[46] Similarly, requirements for training are not mandatory. About 36 percent of the population lives where minimal or no special training is required to conduct death investigations.[47] Recently, an 18-year-old high school student was elected a deputy coroner in Indiana after completing a short training course.[48]

Additionally, funding for programs supporting death investigations vary across the country, with the cost of county systems ranging from $0.62 to $5.54 per capita, and statewide systems from $0.32 to $3.20.[49] Most funding comes from tax revenues, and with such limited funds available, the salaries of medical examiners and skilled personnel are much lower than those of other physicians and medical personnel. Consequently, recruiting and retaining skilled personnel is a constant struggle.

At a time when natural disasters or man-made disasters could create

---

[44] R. Hanzlick and D. Combs. 1998. Medical examiner and coroner systems: History and trends. *Journal of the American Medical Association* 279(11):870-874.

[45] Institute of Medicine. 2003. *Medicolegal Death Investigation System: Workshop Report*. Washington, DC: The National Academies Press.

[46] Ibid.

[47] R. Hanzlick. 1996. Coroner training needs. A numeric and geographic analysis. *Journal of the American Medical Association* 276(21):1775-1778.

[48] See www.wthr.com/Global/story.asp?S=6534514&nav=menu188_2.

[49] IOM, op. cit.

great havoc in our country, the death investigation system is one that is of increasing importance. Deaths resulting from terrorism, with the exception of any suicide perpetrators, are homicides that require robust medicolegal death investigation systems to recover and identify remains, collect forensic evidence, and determine cause of death.

Incompatible 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 time needed to identify (or exclude) a given individual from a fingerprint. Before the use of AFIS, the fingerprint identification process involved numerous clerks and fingerprint examiners tediously sifting through thousands of classified and cataloged paper fingerprint cards.

AFIS was an enormous improvement in the way local, state, and federal law enforcement agencies managed fingerprints and identified people. AFIS searches are much faster than manual searches and often allow examiners to search across a larger pool of candidates and produce a shorter list of possible associations of crime scene prints and unidentified persons, living or dead.

Working with a system's software, fingerprint examiners can map the details of a given fingerprint—by features that consist of "minutiae" (e.g., friction ridge endings and ridge bifurcations)—and ask the system to search its database for other records that closely resemble this pattern. Depending on the size of the database being searched and the system's workload, an examiner often can get results back within minutes.

However, even though AFIS has been a significant improvement for the law enforcement community over the last few decades, AFIS deployments and performance (operational capacities) today are still far from optimal. Many law enforcement AFIS installations are stand-alone systems or are part of relatively limited regional networks with shared databases or information-sharing agreements. Today, systems from different vendors often are incompatible and hence cannot communicate. Indeed, different versions of similar systems from the same vendor often cannot effectively share fingerprint data with one another. In addition, many law enforcement agencies also access the FBI's Integrated Automated Fingerprint Identification System database (the "largest biometric database in the world"[50]) through an entirely separate stand-alone system—a fact that often forces fingerprint examiners to enter fingerprint data for one search multiple times in multiple states (at least once for each system being searched). Additionally, searches

[50] See www.fbi.gov/hq/cjisd/iafis.htm.

between latent print to AFIS 10-print[51] files suffer by not being more fully automated: Examiners must manually encode a latent print before searching the AFIS 10-print database. Furthermore, the hit rate for latent prints searched against the AFIS database is approximately 40 percent (see Chapter 10). Much good work in recent years has improved the interoperability of AFIS installations and databases, but the pace of these efforts to date has been slow, and greater progress must be made toward achieving meaningful, nationwide AFIS interoperability.

The Growing Importance of the Forensic Science Disciplines to Homeland Security

Threats to food and transportation, concerns about nuclear and cyber security, and the need to develop rapid responses to chemical, nuclear, radiological, and biological threats underlie the need to ensure that there is a sufficient supply of adequately trained forensic specialists. At present, public crime laboratories are insufficiently prepared to handle mass disasters. In addition, demands will be increasing on the forensic science community to develop real-time plans and protocols for mass disaster responses by the network of crime laboratories and death investigation systems across the country—and internationally. 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 both public health and what is now termed "homeland security" for at least two decades. With the development and deployment of enhanced capabilities came the integration of forensic science disciplines much earlier in the investigative process. As a result, the forensic science disciplines could be more fruitfully leveraged to generate investigative leads to test, direct, or redirect lines of investigation, not just in building a case for prosecution. Forensic science disciplines are essential components of the response to mass fatality events, whether natural or man made.

The Admission of Forensic Science Evidence in Litigation

As explained in Chapter 3, most forensic science disciplines are inextricably tethered to the legal system; many forensic fields (e.g., firearms analysis, latent fingerprint identification) are but handmaidens of the legal system, and they have no significant uses beyond law enforcement. There-

[51] AFIS 10-print records the fingers, thumbs, and a palm print on a large index card. These prints are carefully taken, clear, and easy to read, and they make up the bulk of the AFIS data available today.

fore, any study of forensic science necessarily must include an assessment of the legal system that it serves. As already noted, and as further amplified in Chapters 4 and 5, the forensic science system exhibits serious shortcomings in capacity and quality; yet the courts continue to rely on forensic evidence without fully understanding and addressing the limitations of different forensic science disciplines.

The conjunction between the law and forensic science is explored in detail in Chapter 3. The bottom line is simple: In a number of forensic science disciplines, forensic science professionals have yet to establish either the validity of their approach or the accuracy of their conclusions, and the courts have been utterly ineffective in addressing this problem. For a variety of reasons—including the rules governing the admissibility of forensic evidence, the applicable standards governing appellate review of trial court decisions, the limitations of the adversary process, and the common lack of scientific expertise among judges and lawyers who must try to comprehend and evaluate forensic evidence—the legal system is ill-equipped to correct the problems of the forensic science community. In short, judicial review, by itself, is not the answer. Rather, tremendous resources must be devoted to improving the forensic science community. With more and better educational programs, accredited laboratories, certification of forensic practitioners, sound operational principles and procedures, and serious research to establish the limits and measures of performance in each discipline, forensic science experts will be better able to analyze evidence and coherently report their findings in the courts. This is particularly important in criminal cases in which we seek to protect society from persons who have committed criminal acts and to protect innocent persons from being convicted of crimes that they did not commit.

ORGANIZATION OF THIS REPORT

This report begins with a series of chapters describing the current forensic science system, the use of forensic science evidence in litigation, and science and the forensic science disciplines. It then addresses systemic areas for improvement with the goal of attaining a more rigorous and robust forensic science infrastructure, including standards and best practices, education, and training. Pursuant to its charge, in three chapters the committee addresses special issues in the areas of medicolegal death investigation (Chapter 9), AFIS (Chapter 10), and the interrelationships between homeland security and the forensic science disciplines (Chapter 11).