FORENSIC SCIENCE HANDBOOK

VOLUME I

THIRD EDITION

edited by
Richard Saferstein
Adam B. Hall

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Forensic Science Handbook

Volume I

Third Edition

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Dedication

Dr. Richard Saferstein: His Life, Legacy and Contributions to the Field of Forensic Science

Dr. Richard Saferstein, a leading author, national expert in the field of forensic science and co-Editor of this 3rd Edition of the *Forensic Science Handbook* passed away on July 28, 2017, before the completion of these texts. He is survived by his wife, Gail; son, Neal; daughter, Sharon and her husband, James Brophy; his two grandchildren, Xavier and Gabrielle Brophy; and his sister, Rochelle Saferstein.

Richard was born on July 17, 1941 at Brooklyn Women's Hospital, Brooklyn, NY. He was the first born to Milton and Sadie Saferstein and was raised in Brooklyn, NY.

> *"He was a very precocious and intelligent child, very mischievous, with a strong mind of his own. During his early years in school, he did very well. His attention span was exceptional as was his memory. He became very interested in science around the age of nine or ten and spent a great deal of time reading science related books from the local library. The only gift he requested for the holidays was a microscope. He would play with slides for hours and experimented dissecting insects. He went to Boys High School in Brooklyn, NY, which at that time offered programs for advanced students. He excelled and graduated with high honors and went on to attend City College in New York, NY, where he received his Bachelor of Science and his Master of Science degrees." (Rochelle Saferstein, Richard's Sister)*

As a pre-teen Richard often spoke of his desire to become a dentist and was encouraged to do so by his own dentist whom he adored, Dr. Knoll. At the age of 15, Richard and Rochelle lost their father, Milton Saferstein; financial reality set in, and Richard's hopes of pursuing dental school never materialized.

> *"Rich's interest in science was always there. He was an extraordinary student and would not let anything stand in his way of doing well in school. When he was in high school, he had mono – he was adamant about keeping up with all his classes and arrangements were made with the school to have his lessons and homework assignments brought to his home. We lived in the same apartment building and I would visit him every day after school. I'd stand outside his bedroom door and many times he would tell me he couldn't talk because he was busy with his work." (Sandy Schargel, Richard's Cousin)*

As an undergraduate student at CCNY in New York, NY, Richard worked while pursuing his studies full time. The long trip from Brooklyn to Manhattan and back each day often occurred early in the morning and again late in the evening. At one point he requested and was granted a key to one of the Chemistry laboratories in order to conduct work into the evening hours.

In 1970, Richard Saferstein earned a PhD in Chemistry from the City University of New York (CUNY), which launched his professional career as a scientist. Following his PhD, he became the Laboratory Director for the New Jersey State Police. Very few individuals can claim such a distinguished position within months of earning their doctorate. For 21 years from 1970 until his retirement in 1991, Richard headed one of the largest forensic laboratories in the United States.

During the late morning hours of May 30th, 1973, Richard experienced a chilling tragedy that would forever change him in ways that most never experience. Richard's first wife, Mrs. Francine Saferstein, and their 3 1/2-year-old son, Michael, were fatally injured by an explosion that occurred outside their home in Willingboro, NJ. Their 3-week old son Neal was inside the home and was unharmed. Richard was at work at the time, directing the NJ State Police Crime Laboratory. Their case has never been solved.

During a personal conversation one day over breakfast in Boston, MA, Richard told me that for months following this horrific tragedy, he secluded himself and wrote much of the content, which was later published in his renowned texts that we still know today. He credited his family for their strength in helping him through this unthinkable time. Years later, in 1998, Richard established the Francine and Michael Saferstein Memorial Lectures in Forensic Science at Northeastern University in Boston, MA. The first lecture was held in 2000 and delivered by Dr. Walter P. Rowe, Professor of Forensic Sciences, Department of Forensic Sciences at The George Washington University. The Francine and Michael Saferstein Memorial Lectures in Forensic Science are held annually in late March or early April. The distinguished lecturers are selected by committee vote each October.

> *"The Saferstein Lecture series will emphasize the role of forensic science in the criminal justice system; however, its format and subject matter must be encouraged to be flexible in style and content to allow for appropriate invited lecturers outside of the forensic science community." (Dr. Richard Saferstein)* [Original letter from Dr. Richard Saferstein to Dr. Barry Karger, dated February 28, 1998]

2000–2020 Francine and Michael Saferstein Memorial Lecturers in Forensic Science

NOTE: The affiliations of the individuals cited in this section were those at the time of their lectures, and they may not necessarily be current.

- **2000 Dr. Walter P. Rowe**, Department of Forensic Sciences, The George Washington University
- **2001 Dr. Bruce Budowle**, Senior Scientist in Biology, FBI Labs, Washington D.C. and Research Professor, George Mason University
- **2002 Mr. Rick Tontarski, Jr.**, Chief of Fire Research Laboratory, Bureau of Alcohol, Tobacco and Firearms
- **2003 Dr. Robert Shaler**, Director of Forensic Biology, New York City Medical Examiner's Office
- **2004 Hon. George Clarke**, Superior Court Judge, San Diego, California
- **2005 Dr. Jimmie Carol Oxley**, Professor of Chemistry, University of Rhode Island
- **2006 Dr. Catherine Fenselau**, Professor of Chemistry and Biochemistry, University of Maryland
- **2007 Mr. Edward Appel**, Principal and Proprietor, iNameCheck and retired FBI expert
- **2008 Dr. Graham Cooks**, Henry B. Hass University Distinguished Professor of Analytical Chemistry, Purdue University

2009 Dr. Paul Giannelli, Albert J. Weatherhead III & Rich and W. Weatherhead Professor of Law, Case Western Reserve University
2010 Dr. Joseph Almog, Professor of Forensic Chemistry, Casali Institute of Applied Chemistry, The Hebrew University of Jerusalem
2011 Dr. James Landers, Departments of Chemistry, Mechanical Engineering, & Pathology, and the Emily Couric Clinical Cancer Center, University of Virginia
2012 Dr. Judith Edersheim, Co-Director, Center for Law, Brain and Behavior, Massachusetts General Hospital
2013 Dr. John Butler, Fellow and Applied Genetics Group Leader, National Institute of Standards and Technology
2014 Dr. Barry Logan, National Director of Forensic and Toxicological Services, NMS Labs; Past President, American Academy of Forensic Sciences
2015 Dr. Jeff Salyards, Executive Director, Defense Forensic Science Center
2016 Professor Dr. Dr. (h.c.) Marilyn A. Huestis, Adjunct Professor, University of Maryland School of Medicine and Retired Senior Investigator and Chief, Chemistry and Drug Metabolism, National Institute on Drug Abuse
2017 Mr. John Lentini, Scientific Fire Analysis, LLC
2018* Dr. Bruce Goldberger, Chief of Forensic Medicine, and Professor and Director of Toxicology, College of Medicine, University of Florida
2019* Mr. Barry Scheck and Mr. Peter Neufel, Co-Founders and Special Counsel at the Innocence Project at the Benjamin N. Cardozo School of Law
2020* Dr. Peter DeForest, Professor Emeritus of Criminalistics, John Jay College of Criminal Justice, NY, NY

NOTE: Following Dr. Saferstein's passing in 2017, the annual lecture was renamed the Dr. Richard Saferstein Award Lecture in Forensic Science.

In 1974, Richard met Gail Tarnoff, and his life was once again changed, this time in a very positive way. On June 12, 1975 Richard and Gail were married, and in 1977 their daughter Sharon was born. Richard often referred to Gail as the "pillar of his life," a sentiment that was obvious to many who knew them well. I have fond memories of a trip to Miami, FL during initial discussions surrounding the 3rd Edition of the *Forensic Science Handbooks* and dinners with Richard and Gail in 2015.

Dr. Saferstein was an active member of the American Academy of Forensic Sciences Criminalistics Section throughout his career. In 1975 he was elected a Provisional Member, promoted to Member in 1976 and Fellow in 1977, and named a Retired Fellow in 2017. In 1995 he received an award of merit and in 2006 was the recipient of the Paul L. Kirk Award for distinguished service and contributions to the field of Criminalistics.

He often went above and beyond the call of duty as a member of numerous professional organizations, including the American Chemical Society, the International Association for Identification, the Canadian Society of Forensic Scientists, the New Jersey Association of Forensic Scientists, the Northeastern Association of Forensic Scientists, the Mid-Atlantic Association of Forensic Scientists, the Society of Forensic Toxicologists, the New York Microscopical Society, and the Eastern Analytical Symposium (he served as EAS President in 1989). He served on the editorial boards of the Journal of Analytical and Applied Pyrolysis (1980–1984), the Journal of Forensic Sciences (1984–1994), the Microchemical Journal (1988–1995), and the Journal of Forensic Identification (2001–2017).

Richard often presented forensic science seminars at high schools, colleges and major research universities. He was always happy to be involved in educating the next generation

of forensic science practitioners and honored when doing so. He was an adjunct professor at The College of New Jersey where he taught an Introduction to Forensic Science course for over 10 years and also taught at Widener University School of Law. In 1994, he was selected as the Rosenblatt Memorial Lecturer in Forensic Science at Northeastern University and served as an advisory board member for the Barnett Institute of Chemical and Biological Analysis at Northeastern University.

"Dr. Saferstein was a prolific writer who authored many papers and 14 books and laboratory manuals including five books published by Prentice-Hall. His most notable is the standard forensic science text available in the field, Criminalistics: An Introduction to Forensic Science, which continues to be the leading textbook in most forensic science academic programs in the United States. Dr. Saferstein was also the editor of the leading professional reference books in forensic science - Forensic Science Handbook Vol. I, Forensic Science Handbook Vol. II, and Forensic Science Handbook Vol. III (as well as) Forensic Science: From the Crime Scene to the Crime Lab." (Dr. Thomas Brettell)

"Saferstein was a highly sought-after consultant who participated in a multitude of high profile cases throughout the country, serving as an expert witness over 2000 times in nearly 150 federal and state courts involving a variety of forensic issues. His areas of expertise encompassed breath and blood testing for alcohol, pharmacological effects of alcohol and drugs, detection and identification of drugs in biological fluids, arson-related analysis, and the forensic examination of blood, semen, hair, paint, fiber and glass evidence. His expertise also included review and evaluation of forensic DNA evidence." (Dr. Thomas Brettell)

Dr. Saferstein had an immeasurable impact on the field of forensic science. The Francine and Michael Saferstein Memorial Lectures have been and will continue to be treasured for their ability to bring together scientists, law enforcement professionals, attorneys, politicians, students, friends and family each spring. For three years before his passing, Richard and I communicated on a weekly and sometimes daily basis on matters pertaining to fully updating and modernizing each of the chapters constituting Volume I and II of this 3rd Edition. Sometimes he was happy with my progress, other times he was not; either way, he was never shy in letting me know! He would be pleased to know that the 3rd Edition was finally completed.

Dr. Saferstein, your memory will live on through your beautiful family, your generosity, your formative texts, and all those you inspired, including myself. It is with the deepest sadness that I dedicate this 3rd Edition of the *Forensic Science Handbook* to you: there is no one more deserving, for it is through your tireless efforts that these texts have become what they are and that legacy will never perish. I'm grateful for the opportunity to have learned from you, to have worked closely with you during this time and to call you a friend. I can assure you as well as all of the authors and the readers that I am fully committed to continuing the *Forensic Science Handbook* for many years to come.

I would like to recognize the contributions of Gail Saferstein (Richard's wife), Rochelle Saferstein (Richard's sister), Sandy Schargel (Richard's cousin), Dr. Melvin Dubnick (Richard's cousin) and Dr. Thomas Brettell (Richard's close colleague and friend) for content, encouragement and assistance in fact checking when producing this dedication.

"Throughout my career, if I have done anything, I have paid attention to every note and every word I sing – if I respect the song. If I cannot project this to a listener, I fail." (Frank Sinatra)

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Preface

Forensic Science is a highly interdisciplinary field. It is a field that reaches nearly every facet of society through the application of scientific principles and approaches to the examination of a wide array of physical evidence. The role of forensic scientists is to tell a story of the scientific truth in a professionally responsible and ethical manner. Their job is not to tell a story that the prosecution or the defense wants to hear and must adhere to the integrity of the science available to them at that time. Forensic Science is also a field that is forever under the public spotlight and is often critiqued and criticized. The growth and vitality of the field are inextricably linked to the ongoing accumulation of scientific knowledge through discovery and experience. As new legal cases set precedence in criminal and civil law, new developments in science and technology redirect protocols and procedures in forensic laboratories. This reality should be embraced by the field and by the criminal justice system at large. Forensic Science as a field is not without flaws but it is a field dominated by highly trained and dedicated individuals who are most often underpaid, overworked and under appreciated. However, those who engage in the rigor of Forensic Science truly love it and for good reasons. While most individuals' knowledge of the field is derived from popularized television shows that have both helped to increase awareness among the general public and at the same time have created unrealistic expectations among juries, forensic scientists are most often trained as classical biologists or chemists, at least within the field of Criminalistics. Following their formal education, most forensic scientists become subject matter experts in selected disciplines and must remain current in the field through literature reviews, trainings and conference attendance. They are most often ethical individuals, with the occasional mountebanks as we have seen.

While the 2009 National Academy of Sciences (NAS) Report pointed out areas of improvement and questionable practices of the field, what is desperately needed is for governmental agencies to provide additional financial support to Forensic Science for research and casework purposes. Over the past 10 years, the field has begun to appreciate that many of the recommendations made by the 2009 NAS Report are valid and are being acted upon, although many within the field fought the recommendations initially. More recently, the 2016 President's Council of Advisors on Science and Technology (PCAST) report has received much discussion including both criticism and praise. Reports such as these are in fact needed, whether or not they're received favorably, as are well-founded scientific studies and rebuttals with support from practitioners, those truly doing the work within society in support of criminal investigations.

The first edition of the *Forensic Science Handbook* was published 37 years ago (1982) and grew into a three-volume series. The three Handbooks have proven over time to be widely circulated professional desk references, as well as standard textbooks for graduate courses in forensic science. The third edition of the *Forensic Science Handbook* is presented as a two-part series: Volume I and Volume II and has been fully updated to

include new chapters, revised text, updated bibliographies and the inclusion of color figures. The authors and editors spent over four years producing this edition.

Forensic Science Handbook – Volume I places into one reference source authoritative reviews embracing important areas of Criminalistics. The content presented is designed to provide the reader with the material necessary to comprehend, evaluate, and appreciate the application and interpretation of scientific methodologies to an array of physical evidence.

Chapter 1 (Legal Aspects of Forensic Science) serves as the introductory chapter and highlights important updates including the admissibility of laboratory reports and expert witness testimony in the *Crawford v. Washington, Melendez-Diaz v. Massachusetts, Bullcoming v. New Mexico* and *Williams v. Illinois* decisions, the impact of the 2009 NAS report, the development of the Organization of Scientific Area Committees (OSAC) by NIST in 2015 and the PCAST report in 2016. It is through such efforts that provide criticisms and attract the attention and support for our field that will ultimately lead to advancement. I encourage everyone in the field including practitioners, researchers, attorneys, judges and policy makers alike to become involved in efforts such as those put forth by the NAS, OSAC and PCAST. Chapter 2 (Forensic Paint Examination), Chapter 3 (The Forensic Identification and Association of Human Hair), Chapter 4 (A Guide to The Analysis of Forensic Household Dust Specimens and Their Statistical Significance) and Chapter 7 (Forensic Characterization and Comparisons of Inks) provide in-depth discussions on trace-related disciplines. Updated content and new authors have added significantly to the quality of the material presented within these chapters. Other chapters are devoted to specific analytical techniques including Visible Microspectrophotometry (Chapter 5) Infrared Spectroscopy (Chapter 6), Gas Chromatography (Chapter 8), High Performance Liquid Chromatography and Capillary Electrophoresis (Chapter 9) and Mass Spectrometry (Chapter 10). Each of these chapters has been updated from previous editions of the Handbooks to provide important developments since the second edition was published. This volume ends with two forensic biology-related chapters including an updated Biological Fluid Identification Chapter (Chapter 11) and a new contribution on Capillary Electrophoresis-based DNA Analysis (Chapter 12).

I wish to express my sincerest appreciation to all of the authors for their time, dedication, patience and expertise in the production of this 3rd edition. Without your knowledge, contributions and support the *Forensic Science Handbooks* would not exist. I also wish to thank Richard Saferstein's family for their support and confidence in my abilities to continue his legacy with the *Forensic Science Handbooks*; Ken Radwill for his time, assistance and support with reviews; Rebecca Millard, a forensic DNA analyst with the Boston Police Department Crime Laboratory for her dedication, enthusiasm and attention to detail during final reviews of both Volumes I and II, Mark Listewnik, Misha Kydd, Iris Fahrer, Jay Margolis, Cynthia Klivecka, Ragesh Nair, and Teena Lawrence for their tireless efforts, communication, typesetting, copy editing and reviews involved in the production of the Handbooks.

Last, but certainly not least, I would like to extend my deepest appreciation to my wife, Kathryne Hall from the Boston Police Department Crime Laboratory for her patience, unwavering support and for the important work that she does within this field as well as my three sons, Connor Hall, Jameson Hall, and Emmett Hall for keeping me young, making me laugh and for allowing me the time to complete this 3rd Edition.

The views and opinions expressed in this book are those of the contributors and do not necessarily represent those of any governmental agency, forensic science laboratory or university.

Adam B. Hall, PhD, D-ABC
Boston, Massachusetts

About the Editors

Dr. Richard Saferstein headed the crime laboratory of the New Jersey State Police from 1970 to 1991. Dr. Saferstein served as an expert witness over 2000 times in nearly 150 federal and state courts involving a variety of forensic issues. His areas of expertise encompassed breath and blood testing for alcohol, pharmacological effects of alcohol and drugs, detection and identification of drugs in biological fluids, fire debris analysis, the forensic examination of blood, semen, hair, paint, fiber, and glass as well as the review and evaluation of forensic DNA evidence. Dr. Saferstein was a prolific writer who authored numerous papers and had five books published by Prentice-Hall. His name can be found in the membership rolls of numerous professional organizations, which reflect his broad range of professional interests. Dr. Saferstein was a Fellow of the American Academy of Forensic Sciences. In 1970 Richard earned a PhD in Chemistry from the City University of New York (CUNY).

Dr. Adam B. Hall is an Assistant Professor within the Biomedical Forensic Sciences Program, Department of Anatomy and Neurobiology at Boston University School of Medicine where he instructs and mentors graduate students in various areas of forensic chemistry and instrumental analysis. Dr. Hall is also the Associate Director of the Center for Advanced Research in Forensic Science (CARFS), a jointly supported NSF and NIJ Industry/University Cooperative Research Center (I/UCRC) in Forensic Science. His career has taken him from the crime scene to the crime lab as a forensic chemist with the Massachusetts State Police Crime Laboratory and now the academic lab. Previously, he was the Director of the Mass Spectrometry Facility at the Barnett Institute of Chemical and Biological Analysis, and a Lecturer within the Department of Chemistry and Chemical Biology at Northeastern University in Boston, Massachusetts. He earned a Bachelor's degree in Chemistry from Stonehill College, a Master's degree in Chemistry and a PhD in Analytical Chemistry from Northeastern University.

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Contributors

Jose R. Almirall, PhD
Department of Chemistry and Biochemistry
Florida International University
Miami, Florida

Richard E. Bisbing, BS
Michigan State Police and McCrone Associates, Inc.
Chicago, Illinois

Thomas A. Brettell, PhD, F-ABC
Department of Chemical & Physical Sciences
Cedar Crest College
Allentown, Pennsylvania

Michael B. Eyring, BS
President, Micro Forensics Institute
Phoenix, Arizona

Adam B. Hall, PhD, D-ABC
Biomedical Forensic Sciences Program
Boston University School of Medicine
Boston, Massachusetts

Edwin L. Jones, Jr., MS
Ventura County Sheriff's Office
Forensic Sciences Laboratory
Ventura, California

Daniel P. Kirby, PhD
Conservation Scientist in Private Practice
Milton, Massachusetts

and

Visiting Scientist
Barnett Institute of Chemical and Biological Analysis
Northeastern University
Boston, Massachusetts

Bruce R. McCord, PhD
Department of Chemistry and Biochemistry
Florida International University
Miami, Florida

David M. Northrop, PhD
Supervising Forensic Scientist
Washington State Patrol Crime Laboratory
Marysville, Washington

Nicholas Petraco, MS, D-ABC
Forensic Consultant
Amityville, New York

Nicholas D. K. Petraco, PhD
Department of Sciences
City University of New York
John Jay College of Criminal Justice
New York, New York

Richard Saferstein, PhD
Forensic Scientist
Mt. Laurel, New Jersey

Gil I. Sapir, JD, MSc
Forensic Science Consultant and Attorney
Chicago, Illinois

David T. Stafford, PhD
Forensic Scientist
Oak Ridge, Tennessee

Edward M. Suzuki, PhD, F-ABC
Washington State Crime Laboratory
Washington State Patrol
Seattle, Washington

John I. Thornton, DCrim
Emeritus Professor of Forensic Science
University of California
Berkeley, California

Tatiana Trejos, PhD
Department of Forensic and Investigative Science
West Virginia University
Morgantown, West Virginia

Diana M. Wright, PhD, F-ABC
Forensic Examiner, Chemistry Unit
FBI Laboratory
Quantico, Virginia

CHAPTER 1

Legal Aspects of Forensic Science

Gil I. Sapir, JD, MSc
Forensic Science Consultant and Attorney, Chicago, Illinois

Freedom is only a word until it is lost

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The author acknowledges the contributions of Mark G. Giangrande (1951–2019), JD, MLIS, legal research specialist (retired) at DePaul University College of Law, Rinn Law Library, Chicago, IL.

INTRODUCTION

Today almost all scientific or professional disciplines provide scientific or technological evidence in court. This evidence is known as expert evidence. It encompasses both testimonial and non-testimonial evidence, such as demonstrative evidence presented by experts. The testimony offered by specialists is frequently couched in terms of opinions, conclusions, and evaluations, which themselves are not scientifically measurable.[1]

This chapter discusses essential, practical, utilitarian, and fundamental concepts of scientific evidence and expert evidence. It is intended to provide the constructs necessary for understanding the legal aspects of forensic science and being a successful consulting and testimonial witness. The overview presentation is applicable to both the novice and experienced occupational expert witness.

"The value of liberty is impossible to quantify, but liberty is clearly cherished by our society."[2] Our adversarial criminal justice system is designed to ensure the application of the principles set forth in the U.S. Constitution. The right to confront the prosecution's critical evidence through independent testing and its purported analytical effect is a fundamental right that cannot be restricted.[3]

Forensic science is a resource of the adversarial justice system, not a product of scientific inquiry. It is an essential, integral aspect of the law enforcement and judicial systems. Forensic science is the application of science to law.[4] Forensic science, at its best, is used to convict the guilty and to protect and exonerate the innocent.[5] Typically, it is the most persuasive evidence. Attorneys seldom feel comfortable or confident in their ability to obtain, interpret, and understand scientific information. Hence, they rely on experts to provide them with scientific material relevant to the case.[6] The law needs science to help it know about facts of the world in which legal policy and understanding must operate.[7]

The reverse is also true of the scientist's understanding of the law. Without the legal system and attorneys, the vocation of consulting and testimonial experts would not exist.[8]

The practice of law is a business in a very competitive market. Attorneys attempt to distinguish themselves through marketing their accomplishments or specialization. The self-proclaimed moniker of "Lawyer-Scientist" creates and perpetuates improprieties. Issues of competency, validation, and ethical problems are inherent in the use of the term. The appellation incorrectly insinuates scientific competence that is most probably misleading. Attorneys advertising themselves as a "Lawyer-Scientist" invite professional sanctions.[9]

The use of experts is an important aspect of the adjudicatory process because science and technology can reduce uncertainty about particular facts, thereby facilitating the decision making process and resolution of a case. Louis Pasteur's assertion that "there are no such things as applied sciences, only application of science" is particularly true in litigation.

Courts do not control how forensic science is practiced or regulated. Courts determine issues of admissibility of evidence. Experts control knowledge of their field within the legal system, while judges and attorneys control the case and what is made part of the case.

The primary function of forensic scientists or opinion witnesses at trial is to assist the trier of fact - the judge or the jury - in understanding methods used and conclusions reached in a discipline not within their general knowledge.[10] A simplified restatement is that a qualified expert may give their opinion to 1) help the court to understand evidence, or 2) to establish a fact in issue.[11] Scientists tend to perceive themselves as merely translators of findings into probabilities and not as educators. The forensic scientist must be able to impartially, credibly, and coherently communicate test results[12] and explain the methods and processes used to reach those conclusions to the finder of fact. Scrutinization of test results conforming with the gold standard in quality of laboratory procedures, methodologies, documentation, and results is also expected.[13]

The forensic scientist becomes an expert witness upon being qualified by the court. They apply general scientific theory or techniques to specific facts in order to formulate an opinion premised upon their knowledge, education, skill and training.[14] Scientific or technological evidence encompasses both testimonial and nontestimonial evidence presented by experts. The expert does not necessarily need to express an unqualified and absolute conclusion but is allowed to express an opinion. This privilege, in the words of L.T. Perrin, makes:

> experts … powerful witnesses. The expert is largely free of the restraints the rules impose on everyone else. Opinion testimony is not simply allowed, it is expected. Even opinions that embrace the ultimate issue are permitted. Personal knowledge is unnecessary. Testimony on matters of common knowledge is allowed. The expert is permitted to use hearsay in forming an opinion and to tell the jury about it. The structure of the rules of evidence provides the context to understand why experts are so attractive to lawyers.[15]

The movant[16] in legal proceedings must demonstrate the reliability of the test in order to satisfy due process and fundamental fairness. All cases involving criminal charges entail some aspect of scientific evidence and forensic science. Forensic science is generally considered reactive. In criminal prosecutions, law enforcement extensively

relies on scientific principles and technology as an integral part to advance its case. This interdependence is exemplified by the application and use of forensic DNA analysis for identification or breath alcohol testing devices in drunk driving prosecutions.

Success in the courtroom can require as much scientific acumen as it does legal knowledge in the current legal system. A paradox of scientific evidence is the participation of an attorney. Most lawyers and judges are generally scientifically unaware, if not uninformed. They are ill equipped and under prepared to handle the complexities of scientific evidence.[17] Their knowledge of science coincides with that of a layperson. Judges and attorneys must be able to understand and decipher scientific evidence. A science degree is not a judicial requisite even for appointment to the U.S. Supreme Court.[18] Understanding science, arguably, is part of the constitutional duty assumed by legislators, administrators, and judges in their respective roles[19] and prevailing professional norms.[20] Similarly, issues and questions of science will most likely be misunderstood by members of the legal system.[21]

ROLE AND ATTRIBUTES OF EXPERTS

The Role of the Expert Witness

The attorney - client privilege is designed to protect confidential communications between a client and their attorney. This privilege extends to expert consultants engaged by the attorney on behalf of the client. It is essential that the attorney maintain work product confidentiality,[22] provide all case materials, and discuss problem areas with the consulting and testimonial expert.[23]

Experts may be used in one of two capacities – consultation or testimony. They are classified into five general categories:

Layperson: Applies common sense and life-long experience.

Technician/examiner: Has limited and concentrated training; applies known techniques; works in a system and was taught in a system; examples include investigators and supervisors.[24]

Practitioner: Analyzes and interprets material and information.

Specialist: Is devoted to one kind of study or works with individual characteristics.

Scientist: Conducts original empirical research; conducts experiments to verify the validity of theories; designs and creates instrumentation and applied techniques; is published in their own field with peers; and advances their field of knowledge.

A consulting expert is a person who has been retained or specifically employed in anticipation of litigation, or in preparation for trial, but is not expected to testify at trial. The identity, theories, mental impressions, litigation plans, and opinions of a consultant are considered work product and are protected by the attorney-client privilege.[25]

A testimonial expert is retained for purposes of testifying at trial. The confidentiality privilege is waived, therefore all materials, notes, reports, and opinions must be produced through applicable discovery proceedings. If an expert relies on work product or hearsay as a basis for an opinion, that material must be disclosed and is usually produced through discovery.[26]

The expert witness performs two primary functions: (1) collecting, testing, and evaluating evidence and forming an opinion as to that evidence and (2) the forensic function of communicating that opinion and its basis to the judge and jury. A general rule of evidence is that witnesses may testify only to what they have personally observed or encountered through their five senses.

Expert witnesses are arguably "conduits of hearsay and other unreliable evidence."[27] In general, witnesses are not allowed to testify to their opinions, with several specific exceptions. One exception is the testimony of the expert witness whose opinion will be likely to aid the trier of fact in the search for the truth.[28] The expert, unlike other witnesses, may testify to ultimate issues that are mixed questions of law and fact.[29] The expert, however, may not give an opinion or state a legal conclusion regarding a question of law that is to be decided by the court.[30] Furthermore, an expert witness's opinion cannot be couched as possibilities or probabilities without articulating the underlying factual basis.

An attorney is prohibited from vouching for the credibility or truthfulness of any witness including an expert witness,[31] and cannot comment on the expert's compensation.[32] Witness credibility cannot be bolstered by having a prosecutor or a prosecution's expert witness express a personal belief that other witnesses provided truthful information, or by vouching for the witness's truthfulness in any other matter. This prohibition is especially important in summation arguments.[33]

Qualifications of the Expert Witness

The witness must be competent in the subject matter on which they are testifying. They may be qualified by knowledge, skill, practical experience, training, education or a combination of those factors.[34] Once competency has been verified, a witness's knowledge of the subject matter affects the weight and credibility of their testimony.

Minimally, the expert witness must know the underlying methodology and procedures employed and relied upon as a basis for their opinion.[35] Their background knowledge should include the "scientific method," state-of-the-art technology, literature review, education and experience in formulating a credible opinion.[36] There is no absolute rule, however, as to the degree of knowledge required to qualify a witness as an expert in a given field.[37] A fact or precipitant witness may be qualified as an expert witness, regardless of their protestations, due to their job description, employment or happenstance. Possessing requisite credentials alone is not enough to render expert testimony admissible. The testimony must be relevant and reliable.[38] A professional license or formal academic training is not required.[39] Previous court testimony, by itself, does not qualify someone as an expert witness.[40] However, lack of previous expert witness testimony is not a disqualification.[41] Prior judicial recognition of an expert's qualifications is normally a significant factor in the court's evaluation and determination of finding that the witness qualifies as an expert. The court's finding, however, that the proffered witness was a "paid expert liar in numerous other cases" is not an argument for determining the expert's qualifications.[42]

A debilitating invitation to blatant accusations and findings of inherent motive, interest, and bias exists if the proffered witness is required to testify based upon their job description or employment duties. This is a common problem with government employees used as expert witnesses.[43] Claims of intellectual dishonesty and inherent prejudice

may be insurmountable. An expert witness cannot have a conflicting interest in the outcome of the trial nor attempt to influence any aspect of it.

Crime laboratories are bound by legal and scientific standards and a code of ethics to foster integrity, honesty, competency, and public trust in their work. It is a violation of ethical canons, and substantive due process, for laboratory personnel to testify in criminal cases when the laboratory receives contingency fees should the defendant be convicted. Conscious and subliminal bias exist in crime laboratories especially when exclusively controlled by law enforcement.[44] This relationship creates a pro-prosecution culture, with scientists as an extension of law enforcement. No conviction means no fee and no fees means less funding. Therefore the laboratory's role is compromised if it has a financial incentive to produce a conviction. Public confidence in the justice system and integrity of evidence is paramount; it is eroded when fundamental fairness and trustworthiness are degraded or compromised.[45]

Prosecutors work closely with law enforcement and experts in forensic science to prepare and litigate their cases. The most common prosecution witness is a law enforcement agent ("Dr. Cop")[46] or government employee. The imprimatur of a governmental agency, laboratory, office, or title does not automatically make either the results or the witness's testimony inherently trustworthy, credible, and reliable.[47] A witness is not an expert merely because the term is part of their title or job description (e.g., Special Agent or Drug Recognition Expert). The terms "special," "expert," or "inspector" itself gives an instantaneous aura of authority and respect that implies a specific expertise beyond normal employment qualifications.[48] In the alternative, an expert cannot be called as a lay witness.[49]

The movant must provide complete and current information on the expert witness upon deciding to use one.[50] If there is noncompliance, opposing counsel will undoubtedly ask what the witness is trying to hide. The court, not the attorney or the witness, determines what information is discoverable and when it is discoverable.[51] All material is returnable to the court or movant.

An expert may be qualified but not competent to render a credible opinion:[52]

> In trial harm to litigants results from improper qualification of an incompetent expert or failure to qualify a competent expert … The incompetent expert is a vehicle for unreliable proof, while the latter denies the opportunity to present credible evidence.[53]
>
> In bolstering the credibility of an expert witness, attorneys will select as circumstances allow, witnesses with significant trial experience. Absent such a source, attorneys select from the community rather than classified advertisements. Trial tactics rather than reliability becomes the impetus for the selection of experts. Such tactics may influence selection of the less reliable witness.[54]

Most witnesses represent themselves truthfully. However, there are still individuals who "shade their background." Reliance on a person's resume or curriculum vitae for qualifying an expert witness is necessary to fairly evaluate the expert witness' qualifications. Resumes and curriculum vitaes that contain superficial or self-serving embellishments and professional achievements are particularly deceitful. Even though they are designed to appear impressive through a well written promotional presentation, some

expert witnesses equivocate regarding their qualifications. Other experts blatantly misstate and exaggerate their qualifications to the point of perjury.

The witness should not engage in self-promotion or enhancing of credentials, including their falsification. It is better for the witness to state their limitations than embellish or bolster their credentials with an expectation that they will not be discovered or questioned. Attorneys are expected to conduct a proper and thorough background investigation of the proffered witness by looking for material misrepresentations of their credentials. The witness's entire testimony could be tainted to a point of irrelevance, if not precluded, should any misrepresentations appear.[55]

The vast majority of expert witnesses testify truthfully. Nevertheless, there are experts, including both governmental and defense witnesses, who blatantly misstate or exaggerate their qualifications. Unfortunately, the "mountebanks"[56] are numerous enough for anyone to claim that prevaricating is a remote occurrence.[57]

Ethics and Intellectual Honesty

Ethics and scientific testimony are inextricably intertwined, because science is neutral and based upon facts. Intellectual honesty is an issue in scientific evidence. An expert witness can affect or infect evidence. The integrity of scientific evidence can affect the outcome of judicial proceedings. Ideological and personal beliefs can prejudice an expert witness's testimony. The application of forensic science in an impartial manner is integral to foster equal justice and promote fairness.

A pervasive bias exists in expert testimony in both private and public sectors. Experts whose livelihood depend on consulting and testimony learn to satisfy the purchaser of their services. Those who do not satisfy their principals will not get hired or remain employed.[58] Compensation contingent on the case's outcome or content of the expert's testimony is not permitted.[59] Experts may distort their view to suit the interests of their clients or employer, and in some instances even lie outright.[60]

Jurors regularly accord special weight to expert witness testimony. Judges and attorneys customarily believe jurors give more credibility to scientific evidence than to other types of evidence. Jurors normally believe the case would have been decided differently without forensic evidence. The extensive testifying experience of many experts makes them powerful and persuasive witnesses, capable of making or destroying a case. Testimony offered by expert witnesses is the most persuasive of all testimony.[61]

The predominant problems with forensic experts are credibility,[62] honesty, competency, quality of work, and neutrality. Forensic scientists must be independent neutral witnesses even if the government employs them. The ethical conduct of experts is a serious issue confronting the judicial system. An ethical forensic analyst has a professional obligation not to mislead the jury when presenting testimony at trial, and not to mislead the court when preparing forensic reports.[63]

Relativity applies to physics, not ethics. (Albert Einstein)

Scientific evidence is far superior to other types of evidence, such as eyewitness identification and confessions; it is also subject to misrepresentation. Data and results are not

self-explanatory. Adhering to and maintaining the fundamental principles and practices of forensic science protects the innocent and public safety while reducing miscarriages of justice. Typical misrepresentations include lying about credentials; submitting false laboratory reports; "data dredging";[64] tailoring testimony to fit facts determined by the investigation or at the behest of someone; presenting misleading testimony;[65] presenting biased testimony; misrepresenting the probative value of negative evidence with missing evidence;[66] presenting testimony founded on unproven scientific techniques;[67] and overstating statistics (overstated diagnosticity).[68] The most dangerous lies are those that most resemble the truth. Error, overstatement, or fraud by expert witnesses can often be exposed by careful examination and independent testing regardless of the scientific evidence being offered.

The Court in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[69] discussed the tenets of good science but did not address the dishonest and unethical forensic expert who participates in evidence shaping. Nor did the Court address how evidence shaping can affect the outcome of judicial proceedings. Evidence shaping is a colloquialism for misrepresenting scientific evidence through selective testing; selective reporting; biased interpretation;[70] overstatement of the significance of test results; lack of statistical uncertainty or error analysis; the ignoring or withholding of results inconsistent with a biased viewpoint; inappropriate collection and testing of evidence;[71] and fabrication of data.[72] Evidence shaping is also known rhetorically as "juicing the testimony."[73]

Evidence shaping encompasses bias, intellectual dishonesty, and fraud by the expert witness. It also involves performance, interpretation, and presentation of science deliberately designed to favor a particular viewpoint.[74] Fraud is not self-correcting; it is generally perpetuated (1) by laboratory managers who defer to a subordinate's intelligence, or (2) because the laboratory work conforms to a prevailing view, or (3) because of financial remuneration. When technicians or expert witnesses realize that nearly all cases are settled without going to trial, the temptation to minimize their efforts, time, and quality of work becomes powerful, and can result in sloppy and tainted or even biased results.[75]

There might be less temptation for some forensic scientists to skim the truth in their testing and testimony if courts and attorneys were scientifically aware. Evidence shaping sometimes results in gross miscarriages of justice through the presentation of convincing but false scientific testimony.[76]

Expert witnesses are responsible for their conduct including not making any material misrepresentations.[77] Forensic science service providers have an affirmative duty to correct and notify all parties of incorrect, unreliable, misleading, questionable evidence or findings, misstatements, breaches of ethical, legal, scientific standards or questionable conduct.[78] This corrective ethical duty exists regardless if the information or act was due to inadvertentance, negligence, mistake, misconduct, misapplication etc. There are no degrees of honesty.

Expert witnesses have the capacity to refuse a case on either a legal or an ethical basis. They must testify either completely or not at all if they accept a case. Communication and ethics are the cornerstone of credibility while integrity is paramount.[79] The forensic scientist cannot have an interest in the outcome of the trial. Providing testimony that implies more than the test can determine is a basis for an expert being deemed incompetent or acting as an advocate. There is no reason not to tell the truth. Anything less than the truth will forever impugn the witness's reputation.[80]

An expert cannot base an opinion, even partially, on illegally obtained or inadmissible evidence.[81] Furthermore, "the court must ensure that expert opinion testimony is in fact expert opinion and not merely an opinion given by an expert."[82]

Each witness is required to take an oath before providing testimony. The oath is a simple concept with a simple purpose, yet it can be so difficult to fulfill. It is the standard for integrity. "Do you promise or affirm to tell the truth, the whole truth, and nothing but the truth?" The oath speaks for itself. The witness promises to tell the truth. Not a portion of the truth, not shades of the truth, just the simple truth. It is a clear and definite concept.[83]

A forensic scientist as an expert witness is held to the standard of a reasonably prudent practitioner in the relevant scientific field. They can be sued for malpractice similar to a licensed professional based upon a duty owed to their clients (foreseeable plaintiffs). They may be also liable for resulting damages[84] including violations of a person's civil rights.[85] Use of false evidence, debunked science or repudiated expert witness opinions are a basis for challenging a conviction through a writ of habeas corpus and new trial.[86] It is relatively easy to convict an innocent person. Once an innocent person is convicted, it is practically impossible to get them out of prison.[87] A person wrongfully convicted in criminal matters cannot recoup their freedom.

> The measure of a man's real character is what he would do if he knew he never would be found out. (Thomas Babington Macaulay)

Demeanor

The demeanor of the expert is important. There are several general caveats to remember: be confident; be credible; speak with a steady cadence; be truthful; exercise common courtesy toward all parties including the judge and jury; and speak to the jury. Do not verbally duel or argue with an attorney while testifying or it will impair the expert's rapport with the jury.[88]

Expert witnesses are educators and communicators. As an educator, the expert witness must be aware of the jury's educational limitations and attention span. A good educator speaks to jurors rather than lectures at them. The expert should recognize the jurors' difficult job, and lack of familiarity with the subject matter, and with litigation in general.

The expert witness's demeanor, credibility, and communication skills are crucial to effective testimony. The expert witness must effectively and genuinely convey an aura of composure, humility combined with self-confidence, conviction, and integrity. Experts are held accountable by the jury. Experts should never ignore the jury or take its presence for granted as the jury receives a separate instruction concerning the expert's testimony and credibility[89] (Appendix A - Jury Instructions (Expert/Opinion Witness)).

Communication Skills

People are judged by the words they speak and their communication skills. Communicating with clarity is extremely important. Nothing is as frustrating to a jury or to a judge as not understanding what the witness is attempting to convey. Expert witnesses do not have to prove their intelligence, only their communication skills.

The misuse, miscommunication, misunderstanding and misrepresentation of forensic science can result in serious consequences for justice.[90] The forensic scientist should be careful to explain answers in lay terms that the jury can easily understand. The scientist should use the technical term and follow it up with an appropriate brief definition or explanation; in other words, communicate at two levels. Difficult scientific principles and esoteric concepts can be made readily understandable by practicing artful communication techniques. Experts would do well to hone their communication skills when addressing an attorney, judge or jury. Experts can render abstractions vividly and concretely by utilizing figures of speech, commonly used linguistic conventions, and other rhetorical devices such as metaphors, analogies, colloquialisms, and slang. This approach familiarizes the jury with the technical terms of art while explaining them in a simple and factual manner designed to neither offend the jurors nor be condescending.

The forensic scientist's testimony should be compelling and interesting. An effective and integral part of the testimony is developed through demonstrative evidence, the adult version of "show and tell" or "sharing" that children learn early on in elementary school. The use of visual aids is important when offering scientific evidence. Visual aids as demonstrative evidence can usually simplify confusingly abstract scientific testimony for the jury. Audiovisual aids are practical, efficient, and productive. This mode of communication is effective for two reasons: visual images help explain and define when mere words are insufficient; and they keep the jury's attention by varying the presentation.

Before testifying, expert witnesses should provide the court stenographer with a vocabulary list of technical terminology normally encountered in their testimony. The witness should then spell the troublesome or uncommon words during their testimony while simultaneously looking at the court reporter. This practice should facilitate an accurate stenographic record of the proceedings.

Clothing is a subliminal form of communication. Attire for the witness in court should be clean, neat, and presentable. The clothing must be comfortable, but not casual, and comport with regional dress codes and mores.

Observer Effects: Cognitive and Confirmation Bias

Even when the underlying forensic science discipline is valid and reliable, expert testimony by practitioners of the discipline may not be. Cognitive and confirmation bias can improperly taint and influence the examiner's perception and evaluation of the evidence. The same bias may affect the judge's perception regarding admissibility of expert witness testimony.[91]

Forensic science strives to avoid physical contamination of evidence, but not mental contamination which occurs as a result of cognitive and confirmation bias.[92] These natural biases may be generally defined as:

Cognitive bias: A pattern of deviation in judgement whereby inferences about other people and situations may be drawn from past experiences;[93]

Confirmation bias: The tendency to test hypotheses by looking for confirming evidence rather than potentially conflicting evidence. It usually occurs upon the loss of objectivity. It may also be known as "expectancy bias";

Contextual bias: The tendency for a consideration to be influenced by background information.

Different types of bias (human factors) can influence the outcome of forensic investigations, based upon, for example, pattern interpretation, impression evidence, handwriting, voice samples, medicolegal evaluations and assessments, and algorithms.[94] These biases can improperly sway the perceptual and cognitive judgements of forensic examiners and produce faulty conclusions regardless of intent.[95] Forensic scientists and laboratory directors must be cognizant of the potential for bias and institute internal procedures and protocols to minimize bias in forensic investigations.[96]

The admissibility of proffered expert opinion evidence tainted by bias can be challenged or impeached at trial.[97] Judges need to be mindful of the critical role of bias to avoid miscarriages of justice.

Pretrial Preparation

The only aspect of litigation an expert can control is preparation. If experts are not prepared, they should not go into the courtroom. The difference between the a successful and unsuccessful expert is preparation. (Practice the five Ps: prior preparation prevents poor performance.)[98]

Preparation is 90% of the trial. The capable expert witness acknowledges and understands this fact. Preparation includes the forensic scientist and attorney of record working together well in advance of trial.

By failing to prepare, you are preparing to fail. (Benjamin Franklin)

The expert's services should be sought and retained as early as possible in order for the expert to provide maximum assistance in the case. The expert can assist in developing a case history, propounding and responding to discovery, preparing demonstrative evidence, and interviewing witnesses.

Federal Rule of Civil Procedure (Discovery) 26(a)(2)(B), coupled with the *Daubert*[99] decision, requires disclosure of material when formulating the basis of an opinion and more extensive reports. The attorney must check the expert's report for accuracy and needs to monitor, if not control, the data an expert uses in forming an opinion. Therefore, the expert and the attorney must work closely together to make the expert's testimony more effective.[100]

The expert witness should be familiar with basic textbooks relied upon by attorneys when utilizing or confronting scientific evidence. Understanding the lawyer's thought process and perspectives will contribute to the witness's competency, effectiveness, and testimony.

The forensic scientist should maintain an accurate and current curriculum vitae in addition to having their voir dire qualifications written in a question/answer format (Appendix B - Qualifying Question Format Expert Witness). The expert witness should also prepare a series of written questions on the case's subject matter. The list format will facilitate a competent and effective presentation and minimize involvement in peripheral matters.

The expert must interview the attorney of record to be familiarized with the subject matter and testimony. The attorney must have a clear perspective and understanding of what tests and procedures the expert performed, including the results and opinions reached. If the attorney has not contacted the expert witness within a reasonable period

of time after retention, then it is necessary for the expert to contact the attorney in writing to initiate the interview.

It is essential that the attorney maintain work product confidentiality, provide all case materials, and discuss problem areas. Confidentiality is especially important when information is transmitted through nonencrypted electronic mail (e-mail), which is neither a privileged nor a confidential communication.[101] An expert who relies on a consulting expert's materials may convert work product into disclosable material.

TRIAL

A trial is a formal judicial examination of evidence and determination of legal claims in an adversarial proceeding. The claims are either civil or criminal. A defendant may waive their right to a jury trial and have the case adjudicated by the judge (bench trial). Otherwise, a jury decides factual issues for a determination of guilt or innocence. The judge decides questions of fact, rules of evidence and law.[102]

Trial Preparation

Being prepared and organized is essential to trial preparation. Experts must review and know all case materials. They must bring the entire original file to court, including, but not limited to, all personal notes, memoranda, file jackets, and formal reports. They must also have with them their current curriculum vitae, with photocopies of all applicable certifications, permits, and licenses, as well as a vocabulary list of terminology for the court reporter. They should provide a written outline of proposed testimony and demonstrative evidence to the attorney who requested their services. In addition, they need to know the location of the courthouse and must never be late to court.

Voir Dire

Voir dire[103] creates the standard for an expert witness's testimony and credibility. It is the first and foremost part of any examination process[104] and is the judge's and jury's first impression of the witness. Neither the movant nor the witness must take voir dire for granted or the proffered witness may not be properly qualified. Whether or not a witness is qualified as an expert can be determined only by comparing the area in which the witness has expertise with the subject matter of the witness's testimony.

The moving party must establish the expert's competency and knowledge in the profession and field[105] (not experience, education, or specialized training), subject to judicial approval, through examination of the expert's credentials. The tendered witness is not deemed an expert until so qualified by the court[106] (Appendix B - Qualifying Questions Format Expert Witness). A witness's knowledge of the subject matter affects the weight and credibility of their testimony once competency has been satisfied. Simply ask: Is the proffered witness qualified? Is the witness competent? Only when the judicial answer to those questions is yes will the witness be allowed to provide opinion evidence.

Credentials and competency are not the only criteria. The subject matter of an expert witness' testimony must be legally and factually relevant. A nexus must exist between the

scientific theory being offered and the evidence at trial. Failure to meet these threshold criteria will preclude or bar the expert's proffered testimony. Additionally, there must be a finding that the proposed testimony will affect the validity of the evidence.

Neither party should stipulate to the witness's credentials. A credential stipulation is usually a result of the expert being only marginally qualified - not as an effort to save time. The voir dire examination can be made to sound impressive, without substance to support qualifications and credentials. A proper qualifying voir dire should be able to survive a meticulous cross-examination of the proffered expert witness.

If there is a stipulation regarding the expert's credentials, then the proffering attorney should request that the judge recite the stipulation using the witness' biographical statement. The movant should still put the expert's curriculum vitae or resume into evidence to avoid any confusion or misunderstanding concerning the person's credentials and qualifications.

Direct Examination

Direct examination follows the witness's voir dire. It is through direct examination of witnesses, during their case-in-chief, that the parties principally place their case before the trier of fact. Communication skills and credibility are established during this phase of the expert's testimony.

All expert witnesses should be questioned in a manner that enables them to testify clearly and succinctly to matters within their area of knowledge and expertise. The pertinent facts should be elicited with open-ended, non-leading questions that do not suggest an answer. The use of demonstrative evidence through visual aids, such as charts, diagrams, experiments, and models, can emphasize or explain the witness' testimony.

Too often, incomplete testimony is presented either by the movant or expert witness which is epitomized by the paradigm conflict of "don't ask, don't tell." Frequently, the witness will omit exculpatory information and qualifiers and neglect discordant data, thereby emphasizing inculpatory information or neglecting probative exonerating evidence - essentially lying by omission.[107]

The expert witness relies on their knowledge, skill, training, and experience to relate their findings and opinion to the jury. The testimony should be kept simple, focused and understandable. The witness's demeanor should exude clarity and integrity. The use of plain, clear, concise, understandable speech cannot be overemphasized. Utilization of appropriate legal terminology is necessary when stating conclusions. Expressions and terminology involving frequency, individualizing statements or probability such as "consistent with," "could have," "highly likely," "very or highly probable," "practical certainty," "far more probable," "did come from," "match," "identification," "rare or unusual shared set of features" must be supported by empirical data and objective criteria.[108] The phrases "reasonable scientific certainty" or "to a reasonable degree of a discipline's certainty" or "practical certainty" are misleading, ambiguous, idiosyncratic, confusing and must not be used or implied.[109] No basis for certainty exists, especially when it is not known what the "certainty" is, its definition and/or its application.[110] The meaningless colloquialism was historically created and perpetuated by attorneys without a basis in law or fact.

The witness should exercise patience and explain technical terms and concepts without being patronizing, demeaning, or condescending. Too often the expert witness will use scientific jargon to sound smart, competent and to bolster their testimony, however the testimony should not be too technical. Save the technical aspects and jargon for cross-examination.

The witness's attire and demeanor contribute to their believability and respect. The appearance and demeanor of the witness are critical. The witness must convey a sense of believability to the judge and jury. Witness demeanor should demonstrate an interest in the subject matter of the testimony and respect for the seriousness of the proceedings. If the witness appears disinterested or annoyed with giving testimony, the jury will most likely be bored or annoyed with the testimony as well.

Cross-Examination

"Cross-examination is much more science and application of technique than it is art."[111] Cross-examination is the attorney's primary opportunity to give the jury reasons not to believe the opposing expert's testimony. Anticipated examination questions usually concern "who, what, where, when, how and why." It will predominately focus on issues of credibility - should this expert be believed? Impeachment is directed at the substance of the person's testimony or confronts the witness's credibility. The major spheres of expert witness examination are opinion testimony;[112] fallibility of methodology and result;[113] reproducibility of results; compensation;[114] integrity; and confirmation or cognitive bias. Areas within these domains susceptible to cross-examination may include inconsistent statements; transcripts of previous proceedings; motive; interest; bias; fees and compensation; omissions; treatises or other publications; experience; conviction of crimes; personal knowledge of facts; errors in the report; unknown facts; analytical tests not performed; lack of access to all relevant documents; probability or certitude; metrology (error analysis);[115] and absoluteness (Appendix C - Metrological Discovery Checklist (Basic)). Conflicts in the witness' testimony create doubt as to the expert's believability. If the forensic scientist has correctly and competently performed all the tests and examinations, has reached legitimate conclusions, is properly prepared for the trial, and testifies honestly, there is nothing to fear. The only apparent safeguard against an expert who gives a phony opinion is cross-examination[116] (Appendix D - Cross Examination: Debilitating Questions).

Maintaining Credibility During Examination

There are general rules an expert witness should follow to avoid appearing less than credible while testifying:

1. *Reasonable nervousness is okay.* Courtrooms can be intimidating places. Litigation is the attorney's domain and the courtroom their medium. Address fears and anxieties with your attorney. Complacency is problematic. Some nervousness generally strengthens the witness's credibility through unrehearsed spontaneity instead of routine perfunctory answers, even if the witness has been taught how to testify.
2. *Always tell the truth.* Do not compromise your integrity by committing perjury. The witness has more to lose by lying than by telling the truth. Never guess or

hedge an opinion, and never provide an answer the witness believes is best for the case unless it is the truth. The most common admonishment to a witness is "tell the truth." However, if the witness is told "do not lie" it is because they may be perceived as a liar.

3. *Listen to the question*. The witness must understand the terminology or the question that is being asked. A witness who does not understand a term or question should say so and request clarification before providing an answer. Rephrasing or repeating the question will usually make it more understandable. The same tenet applies if the questioner misstates the facts or a scientific principle as the expert knows it.
4. *Pause, then answer*. Listen to the question. Do not be rushed or coerced into answering. Take your time. Be careful. Collect your thoughts and think about the answer. Listen to any objections made by opposing counsel. The objections provide information on potentially damaging areas or how opposing counsel is attempting to mislead or discredit the witness' testimony. The witness should correct any misstatement contained within the question before answering it rather than answering the question and then attempting to qualify the answer.
5. *Admit mistakes and problems*. Do not evade the question. Candidly confront the problems and defuse harmful facts. All too often a witness, especially an expert, is reluctant to admit mistakes and problems even though admitting mistakes or problems can present an impression of credibility and honesty.[117]
6. *Admit limitations*. The witnesses should only answer questions if they know the answer. A witness cannot seek advice or assistance from their attorney while testifying. Experts are often too arrogant or too insecure to concede limitations of their knowledge and say "I do not know" to specific inquiries. By acknowledging limitations they would likely enhance their credibility. Admit any mistake, limitation, or problem or suffer the irreparable devastation of a perceived cover-up.
7. *Admit inability to remember*. If the witness does not remember or know something, they should say so without reservation. Do not guess or speculate. State only what is true. A vague answer will survive cross-examination but will be the witness' nemesis. A witness cannot be cross-examined on repeated answers of "do not know," "cannot remember," and "cannot recall," even though these answers will certainly be commented upon adversely during closing argument. Evasive answers will lower the witness' credibility with the trier of fact.
8. *Do not hedge or obfuscate*. The witness must be able to articulate, identify, and practically support their conclusions. If the witness is going to use any definitions or interpretations such as "match," "indistinguishable," or "identical," then the witness is obligated to objectively and empirically support the terminology and findings (conclusions) of their opinion. Terminology and phraseology vary in part because the starting point is never agreed upon.[118] Expert witnesses quite frequently hedge their opinions with obfuscatory words. Phrases such as "similar to," "could have," "might have," "compatible with," "consistent with,"[119] "physical observable characteristics," "instrumental techniques," "various chemical tests and analysis," "similar in all respects tested," "cannot be excluded as a source of…" are noncommittal and nondescript statements[120] designed to infer competency, credibility, and reliability. In reality, they can do the opposite. Reliance on bluffing, hedging, and obfuscation will adversely affect and impugn credibility and communication skills.

9. *Speak to the jury (or trier of fact)*. The jury alone decides the verdict. They assess the credibility of the witnesses and facts. Address the jury, not the lawyers, when answering questions and continually make eye contact with them. Do not take their presence for granted.
10. *Maintain a consistent attitude*. The witness should not overtly change their attitude between direct and cross-examination. Consistency in presentation is important. Be congenial, confident, and self-assured. Stay relaxed and maintain emotional stability, for it is the witness who controls the flow of their testimony and provides the jury with an opportunity to listen to the answers.
11. *Never argue with counsel*. Self-control is paramount. Opposing counsel's objective is to discredit the witness' testimony through any available means including assaults on temperament. Let the judge or witness' counsel control the opposing counsel's abusive conduct. Do not be antagonistic. Be personable and cooperative during both direct and cross-examination. Let the party's attorney rehabilitate any testimonial damage during their redirect examination.
12. *Answer just the question*. Do not volunteer information or embellish the answer. If additional information is necessary, it will be requested. Do not exaggerate. Too much explanation provides a basis for otherwise unexpected cross-examination and may also make the witness appear insincere or biased.

DISCOVERY AND DISCLOSURE

Discovery is the disclosure of evidence or information leading to additional evidence that is relevant to the case. The purpose of discovery is to eliminate surprises in both civil and criminal proceedings. Discovery minimizes miscarriages of justice and materially fosters the settlement of cases. Discovery is created by statute, by rule, from common law.[121] It is controlled by the courts. The five major devices for obtaining discoverable information are (1) written interrogatories; (2) depositions upon oral or written questions; (3) production of documents or objects or permission to enter upon land or property for inspection and other purposes; (4) physical or mental examinations; and (5) requests for admission of facts and genuineness of documents.

Available methods of pretrial discovery encompass the bill of particulars, selective motion practice (i.e., production of documents, objects, and tangible items), subpoenas, interrogatories, depositions, statutory and circuit court rules of procedure, and applicable case law. Discovery entails ascertainment of what was previously unknown. Being versed in the concepts and practices of discovery minimizes violations of the law and exposure to both civil sanctions and criminal prosecution.

The government has the duty to disclose exculpatory evidence even in the absence of a request for it if the evidence, considered as a whole, has a "reasonable probability" of affecting the result. The defendant does not need to show that the evidence will determine the result, but only that suppression of the evidence would undermine confidence in the outcome of the trial. The governmental obligation exists regardless of the good or bad faith of the prosecutor even if the police have failed to disclose the evidence to them.[122]

Federal Rule of Civil Procedure - Rule 26: Discovery and Depositions

Nothing is exempt from scrutiny or comment regarding the expert witness. Discovery relating to expert witnesses, scientific evidence and associated testimony is controlled, in part, by Federal Rule of Civil Procedure 26 (FRCP), the *Daubert* case,[123] state statutes, and local court rules. According to FRCP 26(a)(2)(B), before an expert witness can offer testimony that person must provide the following: a written summary opinion discussing the testimonial subject matter; a summary of the substance of facts and opinion; the basis for the opinion; reports; a list of all publications authored by the witness in the preceding 10 years; a record of all previous testimony, including depositions for the last 4 years; a disclosure statement;[124] a report signed by the expert and the disclosing attorney; and other items as required by the jurisdiction. A continuing duty exists to provide additional and corrective information once disclosure of the expert witness has been made, under FRCP 26(e)(10).[125] The movant is responsible for providing complete current information on the expert witness. Even though many states have adopted the text of the Federal Rules of Civil Procedure, including Rule 26, parties should consult their own jurisdictional rules of discovery and corresponding requirements.

The Federal Rule of Civil Procedure 26(b)(4) "is silent as to how the court should treat the request by a party to use an adverse party's designated expert at trial after the adverse party withdraws that expert's designation." A withdrawn expert may be called to testify by opposing counsel; this action is subject to judicial discretion on a case by case basis. Under Rule 26(b)(4)(D), consulting experts are not subject to discovery unless "exceptional circumstances exist." (e.g. timing, participation, evidence presented and prejudice.)[126]

Preservation of Evidence: Spoliation

Parties using and relying on physical evidence have a duty to keep and preserve the physical evidence from the date of collection until the resolution of judicial process. Whether the spoliation (destruction) of physical and electronic evidence, (for example, internet websites or media accounts)[127] is intentional or unintentional is irrelevant because of its integral evidential value.[128]

Destruction of the sample deprives the accused of "the opportunity to meet or dispute the [prosecutor's] test results by [his or her] own evidence of equal integrity and persuasiveness."[129] The defendant need only establish that the evidence's exculpatory value was apparent before it was destroyed and it might have been expected to play a significant role in the defense. The accused is unable to obtain comparable evidence in many cases.[130] Failure to preserve, keep and maintain evidence warrants a direct inference that the evidence was favorable to the aggrieved party.[131]

Failure to preserve evidence does not constitute a denial of due process when evidence of no apparent value to the defense is destroyed. An exception is when the criminal defendant can show bad faith on the part of the police. Fundamental fairness, however, prevents the movant or prosecution from introducing any test results based on the destroyed evidence where the accused has not been able to confront it owing to its destruction or withholding.[132]

Inadvertent destruction of evidence by the prosecution before independent testing is a violation of due process and warrants dismissal of charges. Bad faith is not required because

of the reliance on evidence to support a conviction. A defendant will not be able to contest whether the results are accurate without an independent analysis. The test is whether a defendant is able to establish a defense without the destroyed evidence.[133] Spoliation of evidence in civil proceedings warrants a presumption of negligence.[134] The presumption of negligence in criminal cases is a constitutional violation which warrants sanctions.[135]

A request for evidence is meaningless if the evidence does not exist. Simply, spoliation of evidence, regardless of intent, can substantially prejudice a defendant's ability to defend himself, and generally deprives the defendant of the right of confrontation and due process.

These stringent requirements and the rather drastic results for failure to adhere to them reflect the Court's interpretation of the underlying purposes and duty to preserve and disclose in *Brady v. Maryland*:[136]

> The purpose is not simply to correct an imbalance of advantage. . . [I]t is also to make of the trial a search for truth informed by all relevant material, much of which because of imbalance in investigative resources, will be exclusively in the hands of the government.[137]

The same Court stated:

> A criminal trial, like its civil counterpart, is a quest for truth. The quest will more often be successful if both sides have an equal opportunity to interview the persons from which the truth may be determined . . [T]he prosecution should not frustrate the defense in the preparation of its case.[138]

Subpoenas

Subpoenas are used in all stages of the judicial process in which testimony or production of material is sought including pretrial hearings and grand jury appearances.[139] A subpoena is a judicial writ enforceable by the issuing court. The word "subpoena" comes from the Latin meaning "under penalty." There are two types of subpoena: the *subpoena ad testificandum* and the *subpoena duces tecum*. The first is for the person, and second is for production of documents and records. Failure to comply can result in significant legal penalties: "The use of subpoenas to have compulsory process for obtaining evidence in the defendant's favor is guaranteed by the Sixth Amendment to the Federal Constitution and is applicable to state criminal proceedings."[140]

The subpoena cannot be vague or indefinite. In order to carry their burden, the proponent of a subpoena for documents must establish relevancy, admissibility, and specificity: "[T]he moving party must show that (1) the documents are evidentiary and relevant; (2) they are not otherwise procurable reasonably in advance of trial by exercise of due diligence; (3) the party cannot properly prepare for trial without such production and inspection in advance of trial and that the failure to obtain such inspection may tend to unreasonably delay the trial; and (4) the application is made in good faith and is not intended as a general 'fishing expedition'"[141] (Appendix E - Expert Witness Affidavit).

In the second type of subpoena, the subpoena duces tecum, the court, at the request of a party, commands a witness to personally produce at trial documentation or objects within their possession or control that are pertinent to the issues of the pending controversy.[142] The relevant language of a subpoena duces tecum usually states, "You are

commanded to bring any and all information, including but not limited to, ... in your possession, control or in that of your legal representative" (Appendix F - Subpoena Duces Tecum and Appendix G - Basic DNA Laboratory Report Subpoena).

Neither the prosecution nor the subpoenaed party can decide what information is discoverable or when it is discoverable[143] subject to the court's discretion. The subpoena is returnable only to the issuing party or court without interference, suggestion, or persuasion from the prosecution.[144]

The court, upon motion, may quash a subpoena for a person or documents if there is a clear showing the demand is unreasonable or oppressive.

Interrogatories

Interrogatories[145] are carefully drafted written questions seeking facts that form the basis of opinions and the sources of those facts relied upon in those opinions. They are a convenient, expeditious, inexpensive form of discovery. Interrogatories are instrumental in discovery.

Depositions

A deposition is a statement made orally by a person under oath before an examiner, commissioner, or officer of the court, but not in open court. This statement is reduced to writing by the examiner or by someone under their direction. It becomes public record upon being filed with the court. Too often the deposition is a battle of experts without direct judicial oversight.[146]

Any party related to the case may be deposed including adverse parties, independent witnesses, occurrence witnesses, expert witnesses, and percipient witnesses. The deposition may be conducted through various mediums (video, audio, telephonic) or in person. Depositions are frequently used to position information as a basis for settlement or resolution of issues. It can be a substitute for trial or a basis for impeachment evidence at trial. The deponent may be required to bring to the deposition any pertinent, non-privileged books, records, papers, recordings, or other such material. Depositions may be either used as a forum for discovery or preservation of witness evidence if the deponent becomes unavailable.

Most states have adopted rules that are substantially similar, if not identical, to the Federal Rules governing deposition practice and procedure.[147] A party to a criminal act may in certain circumstances make a motion for taking the deposition of a witness under the Federal Rules of Criminal Procedure.[148]

A deposition should be scheduled for a time at a neutral location convenient for the parties and witnesses involved. Usually, rooms are available at the court house for depositions, but the offices of an attorney are frequently used. Reasonable notice for the time of a deposition is required, and the person being deposed may request the court to change the time, date, and location.

The format of the deposition may vary, but generally the witness is questioned by both sides in the same order as at trial. The proponent directly examines the witness and then the opponent cross-examines.

The court may order the payment of expenses incurred by that witness when the government takes a deposition or when an indigent is deposing a witness. The deposition may be used at trial, in part or in its entirety, if the witness is unavailable or may be used for purposes of impeachment when the witness testifies.

THE LAW OF EVIDENCE

The Law of Evidence is a set of rules and principles affecting judicial investigations into questions of fact and for the most part controverted questions. Evidence is any matter, verbal or physical, that can be used to support the existence of a factual proposition: "The Rules of Evidence are founded in the charities of religion, in the philosophy of nature, in the truths of history, and in the experience of common life."[149] Its exclusionary purpose is to protect the jury from being misled.

There are two basic categories of evidence, direct and circumstantial. Within these general groups there exists three general types of evidence: testimonial, physical, and demonstrative. Any kind of evidence to be considered in a legal context must comply with the admissibility requirements of relevancy and materiality.

Direct evidence tends to show the existence of a fact in question without the intervention of proving any other fact: Is the evidence to be believed without inferences or conclusions from it? Direct evidence depends on the credibility of the witness. Circumstantial evidence is indirect evidence from which inferences or conclusions may be drawn. Circumstantial evidence depends on both the credibility and inferences from the witness.

Evidence may be testimonial (witness), physical (tangible objects and parts of the body) or demonstrative. Testimonial evidence is premised upon the witness's personal knowledge and relies on the person's five senses. Physical evidence is perceived as indisputable, scientifically sound and, most important, neutral. The value of physical evidence cannot be understated.[150] It is the silent, definitive witness. Physical evidence offers certainty, and certainty equals proof. The means by which physical evidence becomes proof is through forensic science.[151] It often involves submission of some tangible object that was directly involved with the situation or incident (documents, weapons, drugs, clothing, blood, hair, etc.).

Negative evidence is the failure to find evidence after looking for it. The common aphorism, "absence of evidence is not evidence of absence" is relevant. The significance of negative evidence needs to be explained when collecting, analyzing and reporting evidence. The evidence can be probative without being definitive - it may support inferences regarding the likelihood that a particular hypothesis is true without proving the hypothesis definitively (inductive inference).[152]

Demonstrative evidence serves as an audio-visual aid and is designed to assist the trier of fact in understanding the witness's testimony. It can include maps, models, x-rays, diagrams, computer graphics or simulations, or digital and electronic media.

Authentication

Authentication requires that the party offering contested evidence provide a basis for the fact finder to believe the item is what the proponent claims it to be. It requires also that the evidence be in substantially the same condition it was in when it was obtained

or seized. The principles of authentication apply to any physical items described in testimony or offered into evidence including witness statements. The most common form of authentication or identification of tangible objects (letters, documents, photographs, tools, weapons, etc.) is to simply have the witness identify them on the basis of their personal knowledge (what the witness saw, heard, tasted, felt, or smelled). The proponent must introduce evidence that is what its party claims it to be.

Evidence is susceptible to tampering, loss, substitution, degradation, or mistake and is not always capable of easy recognition. Therefore, the item must be authenticated. Aspects of authentication include the nature of the article; the circumstances surrounding its preservation and its custody; and the likelihood of alteration, degradation, contamination, or tampering.[153] The party offering the item as evidence must establish that its quality or condition has not substantially changed from its original state when obtained.

A complete independent historical accounting and rendition of the item must be documented to maintain the item's integrity - and not merely that it was subjected to change. Establishing the item's condition is accomplished through testimony of successive custodians, commonly called a *chain of custody*. This is typically established by having each person (each link in the chain) who has had contact with the item show: (1) the circumstances under which custody was taken; (2) the precautions taken to prevent alteration, degradation, contamination, or tampering; (3) that change or tampering has not occurred; and (4) the circumstances under which the person relinquished care, custody, and control of the item. If the physical evidence is fungible, not readily identifiable, or is of a type that might change in condition (e.g. narcotics), then it must be authenticated through a chain of custody. A short chain of custody significantly reduces the occurrence of problems. A serious or prolonged break in the item's accounting may render it inadmissible.

Safeguarding an item's integrity cannot be minimized especially in criminal cases. The chain of custody is used to assist in the identification and authentication of evidence that (1) it is what it purports to be and (2) it has not been substantially changed for any reason from its original state. If the item has been substantially changed, its value is reduced or negated since it may mislead or confuse the jury. Under these circumstances it is not admissible. It is necessary to establish that the item has been traced accurately and reliably through its chain of custody.

The Admissibility of Scientific Evidence

A proper legal foundation must be laid for its admission before any item can be considered as evidence. Both procedural rules and substantive law of evidence require a condition precedent to the admission of an item into evidence. Compliance with the item's condition is its legal foundation.

Admissibility is premised upon relevance and materiality. Relevance is the basic unifying principle underlying the evidentiary rules. It connotes the probative relationship between testimonial or tangible evidence. It also involves analysis of the relationship, often termed "materiality" or "consequentialness," between the factual proposition and substantive law. Evidence is relevant only if it (1) tends to prove or disprove a proposition of fact (probative value) and (2) is material to a charge, claim, or defense. Does the evidence have a tendency to make the existence of a fact more probable? Does the evidence have any probative value (that which tends to produce belief)? If the answer is yes, then it

is usually admitted as relevant evidence unless otherwise excluded by law or excluded due to being potentially prejudicial. Evidence that is not relevant is not admissible.

The rules of evidence and procedure apply equally to all witnesses. The primary procedural rules for scientific and expert evidence are governed by federal and state statutes, the Federal Rules of Evidence 701–706, and case law. They are applied through the seminal cases of *Frye v. United States*[154] and *Daubert v. Merrell Dow Pharmaceuticals, Inc*.[155] and others.

A predominant question in the area of scientific evidence is the criteria trial courts use to permit expert witnesses to testify regarding scientific, technical, or other specialized knowledge. The underlying assumption for this issue is that juries tend to believe almost anything a professed expert says. Therefore judges "should protect impressionable jurors from experts who lack objective credibility."[156] The U.S. Supreme Court has sought to resolve this question through rulings in three cases, commonly known as the "*Daubert* Trilogy." These cases consist of *Daubert*, *Joiner*, and *Kumho Tire*.[157]

Federal Rules of Evidence - Opinions and Expert Testimony

In most jurisdictions and under the Federal Rules, both lay and expert witnesses are permitted to render opinions. Federal Rules of Evidence 701-706 govern testimony by these witnesses. Specifically, Rule 702 addresses the admissibility of expert testimony. Rule 702 states, in part, the expert may testify in the form of an opinion or otherwise if: (1) provided that the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or determine the fact in issue; (2) testimony is based on sufficient facts or data; (3) the testimony is the product of reliable principles and methods; and (4) the witness has reliably applied the principles and methods to the facts of the case. This requirement is applicable to scientific and other forms of expert testimony.

Rule 702 Advisory Committee's Notes suggest additional standards for gauging expert reliability, including: (5) whether "maintenance standards and controls" exist; (6) whether the testimony relates to "matters growing naturally and directly out of research they have conducted independent of the litigation," or developed "expressly for purposes of testifying"; (7) "[w]hether the expert has unjustifiably extrapolated from an accepted premise to an unfounded conclusion"; (8) "[w]hether the expert has adequately accounted for obvious alternative explanations"; (9) "[w]hether the expert is being as careful as he would be in his regular professional work outside his paid litigation consulting"; and (10) "[w]hether the field of expertise claimed by the expert is known to reach reliable results for the type of opinion the expert would give."[158] Rule 702 is described as the "reliability test" for admissibility of expert evidence. Judges are supposed to evaluate and exclude unreliable or unvalidated evidence offered by the expert.[159]

SIGNIFICANT CASES

Constitutional principles and mandates affect court decisions on the admissibility of scientific evidence. Scientific developments, societal sophistication and court decisions have elevated the obligation of counsel to litigate forensic science evidence.[160] The Sixth

Amendment[161] and Due Process Clause (5th and 14th Amendments)[162] are emerging as sources of regulation to increase the reliability and validity of such evidence, while reducing flawed forensics, revealing wrongful convictions, publicizing crime laboratory scandals and exposing forms of "junk science"[163] or "pseudoscience" (e.g. bite mark impressions, comparative bullet lead analysis, hair morphology evidence, voice print identification, dog-scent lineups, bloodstain pattern (spatter) analysis, and Abel Assessment/Penile Plethysmography).[164] Junk science usually consists of flawed, unreliable, exaggerated, and sometimes fabricated testimony usually based on questionable methodology.

Frye v. United States

Frye v. United States focuses on the nature of the opinion through general acceptance in the scientific community for admissibility. General acceptance is defined as follows:

> Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well recognized scientific principle or discovery the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.[165]

Frye admitted scientific evidence that was generally accepted in the field. It did not, however, define the field in which the methodology must be accepted. Most courts were willing to consider the "field" of forensic analysis as an appropriate scientific community. Professor Margaret Berger observed,

> Because *Frye* emphasized "general acceptance" in a particular field, a well-organized group of expert witnesses in some instances became the "field." "General acceptance" by these experts then verified the reliability of the evidence.[166]

The *Frye* test, however, cannot distinguish between science and pseudoscience. Astrological forecasts are "generally accepted" in the "pertinent field" of astrology.[167]

Innate problems with *Frye* concern: (1) which applicable community accepts the technique, (2) whether the technique itself or the underlying principle and the technique are to be evaluated, and (3) the problem of judicial control over the admissibility of evidence versus the need to be open to new techniques and discoveries.[168] *Frye* does not guarantee the reliability of the test used. Some *Frye* states use a modified standard of relevancy to define "general acceptance" by requiring more than merely general acceptance by the users.[169]

Daubert v. Merrell Dow Pharmaceuticals, Inc.

The significance of emerging science and technology is germane to evidential standards of scientific evidence in natural, behavioral, and social sciences.[170] In courts of law, forensic testimony often goes unchallenged by a scientifically naive community. Forensic methods must be screened with greater care if equal justice is to be served.[171] The U.S. Supreme Court announced in *Daubert*[172] that the Federal Rules of Evidence supersede the common

law *Frye* test[173] for admission of scientific evidence. *Frye* required that a foundation for an expert's scientific evidence include proof that the theory and technique were generally accepted within the relevant scientific community. Admission of scientific evidence at the federal court level[174] depends on consideration of many factors, including the following nonexclusive criteria: whether the theory has been tested;[175] whether it has been subjected to peer review and publication;[176] its error rate;[177] whether there are standards for its operation; and whether it has widespread acceptance in the scientific community. A combination of these factors must help the trier of fact understand the evidence or decide the fact in issue.

An integral part of *Daubert* discussed the practice of "good science"[178] and the reliability of scientific results. Applying good methods to validate bad science should not be a basis for creating "good science." The threshold questions for admissibility include the following: Is the scientific evidence based upon good science? Was the science or forensic discipline developed "solely to solve crime?"[179] Is it reliable?[180] In determining the parameters of good science, the Court looked at how conclusions are reached, not which conclusions make sense. It also asked whether a hypothesis was generated and whether it was tested empirically.[181] *Daubert's* admissibility factors were formulated for Newtonian science[182] and are not typically applicable to nonscientific bodies of knowledge. But *Daubert's* reliability principles (empirical validation standard) are just as pertinent when nonscientific expert testimony is concerned.

The *Daubert* decision made judges "gatekeepers" of science[183] and of expert evidence in courts of law.[184] It has heightened the need for judicial awareness of scientific reasoning and methods. Evidentiary reliability is now based upon scientific validity.[185] The trial judge is assigned a "gatekeeping responsibility" to make "a preliminary assessment of whether the reasoning or methodology underlying the testimony is scientifically valid, and whether that reasoning or methodology can be properly applied to the facts in issue."[186] *Daubert* made it clear that trial judges should not reject what is worthwhile testimony to expert communities, and it implied that trial judges should adopt admissibility criteria that encourages expert communities to develop the best possible information on legally relevant issues.[187] The trial court's gatekeeping function applies to testimony by any expert."[188]

This "admissibility standard" of evidence demands an understanding by judges of the principles and methods that underlie scientific studies and of the reasoning upon which expert evidence is based. Peter J. Neufeld stated,

> Unfortunately, forensic evidence is not adequately tested in the crucible of court. But not only are judges ill-equipped to evaluate critically the reliability of scientific evidence; lawyers routinely fail to assess, much less challenge, the reliability of the particular test. The "crucible of the court" is therefore a meaningless safeguard."[189]

Two extraordinary procedures exist to assist judges in problems of expert evidence or complex scientific evidence: court-appointed experts and special masters. Court-appointed experts[190] can offer testimony at trial, can educate judges concerning fundamental concepts on which experts differ, and can assess the methodology on which the parties' experts are basing their opinions.[191] Special masters or magistrates[192] may be appropriate in extraordinary cases in which the demanding nature of scientific issues is combined with the need for special skill in fact finding. They may be appointed to conduct settlement negotiations that involve difficult scientific testimony or to manage the pretrial stages of cases that entail problems of expert testimony.[193]

Because the courts, in particular the trial judge, are now the gatekeepers for screening proffered reliable scientific evidence, scientific reliability must be defined. It has essentially two parts. The Supreme Court inquired whether the offered methodology or technique had a known error rate.[194] Accordingly, both the hypothesis and test results, and especially the error rates for those results, must be scrutinized in order to validate the hypothesis. Next, the Court asked whether susceptible standards existed for using the methodology, and if standardized procedures existed for reproducibility of the results. Simply, does a valid scientific methodology and process exist?

Common and anticipated challenges to expert evidence under *Daubert* are: (1) Is the expert qualified? (2) Is the expert's opinion supported by scientific reasoning or methodology? (3) Is the expert's opinion supported by reliable data? (4) Is the expert's opinion so confusing or prejudicial that it should be excluded pursuant to Federal Rule of Evidence 403?[195] On a motion to exclude expert testimony, the burden is on the proponent of the expert testimony, not the movant who is challenging that testimony. This is a significant advantage to the movant. The proponent must establish admissibility by a preponderance of the evidence.[196]

The rules of procedure at common law, in limited situations, permit circumvention of *Daubert's* formal regulations of evidence. This occurs through stipulations to facts, judicial notice based upon verifiable certainty,[197] and learned treatises. Parties cannot, however, stipulate to admission of scientifically unreliable evidence.[198]

The U.S. Supreme Court in *General Electric Co. v. Joiner* upheld the trial court's gatekeeping function, per *Daubert*, to determine the admissibility of expert witness testimony absent an abuse of judicial discretion.[199]

Kumho Tire Co., Ltd. v. Carmichael

The U.S. Supreme Court in *Kumho Tire Co., Ltd. v. Carmichael*[200] held that the general proposition of *Daubert's* reliability requirement applies to all expert opinions (technical and other specialized knowledge), not just to scientific ones. The Court stated any distinction between "scientific knowledge" and "technical" or "other specialized knowledge" is illusory and without support in the Federal Rules. Therefore, *Daubert* applies to all expert evidence and testimony regardless of whether it is "scientific" in nature. Furthermore, the trial court is not required to hold a "*Daubert* hearing" every time expert testimony is challenged. *Kumho* is applicable to both civil[201] and criminal cases.

Right of Confrontation - U.S. Constitution, Sixth Amendment

The U.S. Constitution and Sixth Amendment increasingly regulates the use of scientific evidence in criminal cases. The U.S. Supreme Court addressed the admissibility of laboratory reports and expert witness testimony in the following selected decisions. A constitutional distinction exists between admitting the expert's opinion and using the expert to introduce an underlying report produced by a third party as a basis to form that opinion.

Crawford v. Washington held out-of-court testimonial statements are inadmissible unless the witness is unavailable and the defendant had a prior opportunity to cross-examine the witness, regardless of reliability.[202]

Melendez-Diaz v. Massachusetts held a laboratory report (e.g., evidence affidavit or laboratory certificate) prepared for a criminal prosecution in lieu of court testimony is "testimonial" evidence subject to the Sixth Amendment's Confrontation Clause. It is not a business record.[203] Therefore, the defendant has a right to cross-examine the analyst who conducted the testing.[204]

Bullcoming v. New Mexico concluded the person who conducted the analysis and created the report must testify concerning its contents. A surrogate cannot fulfill this role unless the analyst is unavailable and the accused had a prior opportunity to cross-examine.[205]

Williams v. Illinois stated an expert may testify about non-testifying third party findings to form opinions, not merely report its results. This decision potentially makes it easier for the prosecution to present testimony in forensic science.[206] An important difference exists between *Bullcoming* and *Williams*. In *Bullcoming* the report itself was admitted into evidence, while in *Williams* the report was used as the primary basis for the expert's opinion. Introduction of formal laboratory reports alone is prohibited by the Confrontation Clause.

Seeking to remove confusion wrought by *Williams v. Illinois* Justices Gorsuch and Sotomayor dissented in *Stuart v. Alabama*. The dissenting justices believed a constitutional violation occurred. In their opinion the Confrontation Clause should require prosecutors to make the forensic analyst who conducted the analysis available for cross-examination when their work incriminates a defendant. Routine post arrest forensic reports are testimonial. The reports are prepared to secure a conviction. Furthermore, forensic evidence is a decisive part of criminal trials. The evidence can be manipulated and it is subject to error and contamination. "To guard against such mischief and mistake and the risk of false convictions they invite, our criminal justice system depends on adversarial testing and cross-examination."[207]

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Crime laboratory scandals, fraud, unsupported assumptions, invalid methods, high profile errors, flawed forensic DNA testing,[208] faulty forensic techniques and misleading trial testimony have contributed to wrongful convictions and exonerations. These problems have motivated a national movement to investigate and reassess the value of different types of scientific evidence.[209] The National Academy of Sciences Report[210] issued in 2009 (NAS Report) discussed endemic problems in forensic science disciplines. The NAS Report findings included a lack of necessary comprehension of science by judges and lawyers, vague standards for evaluation of non-scientific expert witnesses and adversity to change. It was severely critical of a law enforcement culture that induces wrongful convictions.[211] The National Academy of Sciences recommended the necessity for basic scientific research,[212] root cause analysis,[213] human factor analysis,[214] the need for validation studies on common techniques in comparative fields (e.g., fingerprint examinations, firearms (ballistics), tool mark identifications, questioned documents examination, hair analysis, bite mark analysis, digital/multimedia, accuracy and error rates etc.), and questioned claims of "zero error rates," "absolute certainty" and infallibility.[215] It is unreasonable to expect any human endeavor to be completely without error or not contemplate systemic error in forensic science. The legal system was chastised for its failure to establish either the validity of approaches or accuracy of conclusions used by forensic

science professionals.[216] The NAS Report made numerous recommendations for objectivity and accountability including standardization, improved rules governing courtroom scientific evidence and an oversight entity. Merely drafting new standards without validating empirical research is problematic. The obstinance of the status quo continues to ignore or contest the NAS Report. The NAS Report did not discuss international accreditation which improves the practice and management of forensic science through standards such as ISO/EIC 17020, 17024 and 17205 (relating to certification of personnel and laboratory accreditation).[217] In 2009 ISO 18385 was approved to minimize the risk of human DNA contamination in products used to collect, store and analyze biological material for forensic purposes (forensic grade standard).[218]

ORGANIZATION OF SCIENTIFIC AREA COMMITTEES FOR FORENSIC SCIENCE (OSAC)

The National Commission on Forensic Science (NCFS) and Organization of Scientific Area Committees for Forensic Science (OSAC) emerged as a result of the 2009 NAS Report. The National Institute of Standards and Technology (NIST) and the U.S. Department of Justice (DOJ) created a bilateral Memorandum of Understanding in 2013 in response to the NAS Report, and created OSAC and the NCFS within the DOJ jointly with NIST. The NCFS was created as a high level independent national policy advisory committee to provide recommendations to the DOJ.[219] The NCFS was funded through the DOJ. OSAC is administered through NIST.

OSAC's purpose is to strengthen the nation's use of forensic science by facilitating and promoting the development of technically sound forensic science standards for use by the forensic science and criminal justice community. OSAC is comprised of the Forensic Science Standards Board, Legal Resource Committee, Quality Infrastructure Committee, Human Factors Committee and five Scientific Area Committees.[220]

OSAC addresses creation and implementation of standards in a non-regulatory forensic science environment. The OSAC Registry publishes the standards and methods which define minimum requirements, best practices, standardized protocols, and related guidance. These standards assist in ensuring results of forensic analysis are reliable, reproducible and valid. The standards are posted for public comment as part of the development process.[221] OSAC does not have statutory or regulatory authority over forensic science service providers to enforce standards on the OSAC Registry.[222] The OSAC standards may become 1) effective upon adoption by a certifying agency, laboratory, a governmental body or funding bodies, or 2) become highly persuasive through policy or pattern and practice in the scientific and legal community. A viable incentive exists for crime laboratories to adopt OSAC standards as a condition for funding although they are not otherwise required to do so.

PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY (PCAST)

The President's Council of Advisors on Science and Technology (PCAST) is an administrative council charted to advise the President on science and technology. It is comprised of scientists and engineers. PCAST's report was written in response to President Barack Obama's request to determine "whether there are additional steps on the scientific side,

beyond those already taken by the Administration in the aftermath of the highly critical 2009 National Research Council report on the state of the forensic sciences, that could help ensure the validity of forensic evidence used in the Nation's legal system."[223]

PCAST released its report, "Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods"[224] on September 16, 2016. The well documented and researched report was issued to strengthen forensic sciences. It condemned endemic problems in forensic science disciplines. PCAST recommended all forensic techniques should be independently validated before being used in criminal investigations. Both the NAS Report and PCAST pointedly discussed the legal profession's failings concerning scientific evidence.

The PCAST recommended training forensic examiners; making forensic laboratories independent of police and prosecutors; and independently validating all forensic techniques before using them in criminal investigations. The report concluded several disciplines, including "feature comparison methods" (e.g. complex-source DNA, hair, latent fingerprints, firearms and spent ammunition, tool and bite marks, shoe prints and tire tracks, and handwriting) were not sufficiently validated.[225] Therefore, expert testimony concerning these disciplines should not be admitted at trial. Proclaiming evidence as "scientific" does not make it so.[226] Scientific validity and reliability are not determined or equated by conviction rate. The NAS and PCAST findings are an inconvenience to law enforcement and prosecutors. M. Chris Fabricant said, "Courts - like scientists - rely too heavily on precedent and not enough on the progress of science. At some point, we have to acknowledge that precedent has to be overruled by scientific reality."[227]

The Department of Justice (DOJ) through then Attorney General Loretta E. Lynch rejected PCAST's recommendations relating to investigations and prosecutions. The FBI stated the report makes broad, unsupported assertions regarding science and forensic science practice.[228]

On April 10, 2017 Attorney General Jeff Sessions terminated NCFS funding. The Commission expired on April 23, 2017 according to the terms of its charter. He also suspended the FBI review policy.[229] PCAST's recommendations were not implemented by the DOJ. Accordingly, scientific standards are determined by the DOJ which is not a scientific body. U.S. District Judge Jed S. Rakoff of New York, the only federal judge on the commission, said, "It is unrealistic to expect that truly objective, scientifically sound standards for the use of forensic science … can be arrived at by entities centered solely within the Department of Justice."[230]

Judges are known to periodically allow flawed science as evidence. Forensic science contributes to wrongful criminal convictions when it is misapplied. These misapplications are due to unreliable or invalid forensic disciplines; the method has insufficient validation; misleading and inaccurate proffered expert testimony; human error; and misconduct such as fabrication of results.[231] The courts should not allow unscientific work and testimony.

DEPARTMENT OF JUSTICE - PLANS TO ADVANCE FORENSIC SCIENCE

On February 21, 2018 the Department Of Justice announced its "Plans To Advance Forensic Science." The initiative is intended to implement additional quality assurance measures based on science-informed practices, enhance forensic capacity and efficiency,

and increase coordination and collaboration between the Department and state, local, and federal partners. The plan consists of four major parts:[232]

- Uniform Language for Testimony and Reports for use by Department forensic examiners to provide testimonial consistency and quality assurance;
- Initiation of Department-wide monitoring practices to ensure testimonial consistency and accountability by Department forensic examiners;
- To increase transparency, Department forensic laboratories supporting criminal investigations and prosecutions will begin publicly posting current quality management system documents and summaries of internal validation studies online; and
- The re-chartering of the Council of Federal Forensic Laboratory Directors, which will again begin meeting May, 2018. All executive branch agencies with forensic laboratories and digital analysis entities are invited and encouraged to join.

The DOJ's trend of diminishing the integrity of forensic science continued on December 4, 2018 when it disbanded the Science Advisory Board (SAB) for the Office of Justice Programs. The SAB was created to provide advice on science related issues in areas of criminal and juvenile justice.[233] (Appendix H - DOJ/Butts Letter - Dec. 4, 2018)

The courts establish practices and protocols for presentation of forensic scientific evidence. Judge Nancy Gertner (U.S. Dist. Ct. Mass.), for example, issued a Procedural Order directing how scientific evidence in criminal cases is to be presented in her courtroom. Judge Gertner adopted rules consistent with the NAS Report.[234] (Appendix H - Protective Order)

No absolute rule exists concerning the degree of knowledge required to qualify a witness as an expert in a given field. There is no stratagem in the courts that can cure scientists from preaching scientific nonsense or evidential manipulation as expert witnesses. However, the NAS Report and PCAST should provide guidance for rectifying problems in forensic science. Justice and science should not be distorted by political need. In the words of Albert Einstein, "The right to search for truth implies also a duty; one must not conceal any part of what one has recognized to be true."

CONCLUSION

The U.S. Constitution and corresponding laws of evidence are designed and intended to promote truth, equal justice, honesty, integrity, and freedom. Litigation, especially through the criminal justice system and Due Process Clause of the Fifth and Fourteenth Amendments, is premised upon defending constitutional law and corresponding inherent rights. The government must not prosecute and convict on less than all of the evidence.

Therefore, it is incumbent upon all people to rely on the legal safeguards to maintain, perpetuate, and protect these principles. People should always remember - freedom is only a word until it is lost.

DISCLAIMER

This chapter is intended to provide general information; it does not provide legal advice applicable to any specific matter and should not be relied upon for that purpose. Interested parties should review the laws with their legal counsel to determine how they will be affected by the laws.

APPENDIXES

APPENDIX - A

Jury Instructions: Expert/Opinion Witness

U.S. Constitution, Amendment VI, "In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial, by an impartial jury of the state and district wherein the crime shall have been committed ..."

Expert Witness

State (sample)

You are the sole judges of the believability of the witnesses and the weight to be given the testimony of each of them. In considering the testimony of any witness, you may take into account his ability and opportunity to observe, (his age), his memory, his manner while testifying, and interest, bias, or prejudice he may have, and the reasonableness of his testimony considered in the light of all the evidence in the case. *Illinois Pattern Jury Instruction 1.02 - Jury is Sole Judge of the Believability of Witnesses*

Federal (sample)

You have heard [an expert] give opinions about matters requiring special knowledge or skill. You should judge this testimony in the same way that you judge the testimony of any other witness. The fact that such a person has given an opinion does not mean that you are required to accept it. Give the testimony whatever weight you think it deserves, considering the reasons given for the opinion, the witness's qualifications, and all of the other evidence in the case. *Pattern Federal Jury Instructions for the Seventh Circuit: Criminal No. 3.07 - Weighing Expert Testimony; Civil No. 1.21 - Expert Witness.*

Opinion (Witness) Testimony

Federal (sample)

You have heard the testimony of________________, who testified as an opinion witness. You do not have to accept______'s opinion. In deciding how much weight to give it, you should consider the witness's qualifications and how he reached his conclusions. Also consider the other factors discussed in these instructions for weighing the credibility of the witnesses. Remembering that you alone decide how much of a witness's testimony to believe, and how much weight is deserves. *Pattern Federal Jury Instructions for the Sixth Circuit: Criminal No. 7.03 - Opinion Testimony.*[235]

Expert Witness Fees/Compensation

State (sample)

You're also instructed that the amount of an expert's fee is a matter which you may consider as possibly affecting the credibility, interest, bias, or partisanship of the witness. However, since all expert witnesses expect to be paid and are paid, you are instructed that there is nothing improper in an expert witness being paid a reasonable fee for his work and time in attending court and in preparing for attendance in ... court. *New Jersey Model Jury Charges (Criminal, Expert Testimony - Sept. 15, 2000)*

APPENDIX - B

Qualifying Questions Format for the Expert Witness

QUALIFYING QUESTIONS FOR THE EXPERT WITNESS

(Sample Expert Witness Voir Dire)[236]

---

1. Name.
2. Occupation.
3. Place of employment.
4. Present title.
5. Position currently held.
6. Describe briefly the subject matter of your specialty.
7. Specializations within that field.
8. What academic degrees are held and from where and when obtained.
9. Specialized degrees and training.
10. Licensing in field, and in which state(s).
11. Length of time licensed.
12. Length of time practicing in this field.
13. Board certified as a specialist in this field.
14. Length of time certified as a specialist.
15. Positions held since completion of formal education, and length of time in each position.
16. Duties and function of current position.
17. Length of time at current position.

18. Specific employment, duties and experiences (optional).

19. Whether conducted personal examination or testing of (subject matter/person/instrumentality).

20. Number of these tests or examinations conducted by you and when and where were they conducted.

21. Teaching or lecturing by you in your field.

22. When and where did you lecture or teach.

23. Publications by you in this field and titles.

24. Membership in professional societies/associations/ organizations, and special positions in them.

25. Requirements for membership and advancement within each of these organizations.

26. Honors, acknowledgments, and awards received by you in your field.

27. Number of times testimony has been given in court as an expert witness in this field.

28. Availability for consulting to any party, state agencies, law enforcement agencies, defense attorneys.

29. Put curriculum vitae or resume into evidence.

30. Your Honor, pursuant to (applicable rule on expert witness), I am tendering (name) as a qualified expert witness in the field of_______.

Note: This type of simple, thorough voir dire examination can be very effective. The suggested subject order and format of core questions must be tailored to each case. Discretion should be exercised, however, to keep the examination simple. The examination is not perfected until the last question is asked. The examination can be developed in a clear and concise manner, using simple, short, single-fact questions. The movant and witness must keep their objective in mind—qualify the person as an expert witness.

APPENDIX - C

Metrological Discovery Checklist (Basic)

(Uncertainty and Error Analysis)

Ted Vosk copyright 2016 [237]

I. Measurand – The quantity intended to be measured.

  A. Identify all samples/specimen obtained for purposes of, or which were subject to, forensic measurement.

  B. Identify the measurand of each of the forensic measurements performed. This includes:

    i. A full description/definition of the quantity intended to be measured by each analysis;

    ii. The matrix and sample that the quantity is part of;

    iii. Any algorithms used to define it;

    iv. Any diagrams used to describe it.

II. Methods and Equipment – Identification, Validation, Description.

  A. Identify the methods employed:

    i. In the collection, acquisition, transportation, transmittal and storage of samples/specimen;

    ii. To prepare samples/specimen for forensic measurement prior to the performance of such measurement;

    iii. To perform forensic measurement on samples/specimen.

B. Identify all instruments, equipment, containers, chemicals and reagents, as well as all software employed in the performance of the named methods. This includes:

   i. Make and model;

   ii. Lot numbers;

   iii. Version.

C. Provide all policies, procedures and protocols applicable or pertaining to:

   i. The performance of the named methods;

   ii. The care, use, maintenance and storage of the named instruments, equipment, containers, chemicals, reagents and software;

   iii. The reporting of results of forensic measurements.

D. All records and materials pertaining to the laboratory's validation or, if validated externally, verification, of the named:

   i. Methods. This includes:

      a. Analytical limits such as for detection and quantification;

      b. Inherent uncertainty;

      c. Range of measurement.

ii. Instruments, equipment, containers, chemicals and reagents for purposes of the use to which each was put;

iii. Software for purposes of the use to which each was put. This includes:

a. Software as purchased;

b. Software updates;

c. Software patches;

d. Internally coded data processing applications such as spreadsheets once coded for use.

E. All records and materials applicable or pertaining to:

i. Manufacturer/supplier instructions and specifications concerning care, use, maintenance and storage of the named instruments, equipment, containers, chemicals, reagents and software. This includes:

a. Expiration dates;

b. Maintenance schedules;

c. Environmental storage and operating conditions;

d. Recalls;

e. Patches/updates.

III. Calibration

A. Identify the specific reference materials used as calibrators, standards and controls for purposes of testing and/or calibration in this case;

B. Identify the methods employed:

   i. To calibrate instruments used in the forensic measurement of samples/specimen;

   ii. In the creation and/or certification of reference materials used as calibrators, standards and controls in testing and/or calibration;

   iii. To calibrate instruments used in the creation and/or certification of reference materials used as calibrators, standards and/or controls in testing and calibration;

C. Identify all instruments, equipment, containers, chemicals and reagents, as well as all software employed by the laboratory in the performance of the named methods;

D. Provide all of the laboratory's policies, procedures and protocols applicable or pertaining to:

   i. The performance of the named methods;

   ii. The care, use and maintenance of the named instruments, equipment, containers, chemicals, reagents and software;

   iii. Establishing the traceability of measured results.

E. For calibrations performed, and reference materials created and/or certified, by the laboratory, all records and materials pertaining to the laboratory's validation or, if validated externally, verification, of the named:

i. Methods;

ii. Instruments, equipment, containers, chemicals and reagents for purposes of the use to which each was put;

iii. Software for purposes of the use to which each was put. This includes:

a. Software as purchased;

b. Software updates;

c. Software patches;

d. Internally coded data processing applications such as spreadsheets once coded for use.

F. Provide all records and materials applicable or pertaining to:

i. The calibration of instruments used in the forensic measurement of samples/specimen. This includes any and all concerning:

a. Raw data, printouts and diagrams;

b. Range of calibration;

c. Any calculations performed, either manually, digitally or some other way;

d. Instrumental precision;

e. Instrumental bias;

f. Instrumental uncertainty.

ii. The creation and/or certification of reference materials used as calibrators, standards and controls

in testing and/or calibration. This includes any and all concerning:

a. Raw data, printouts and diagrams;

b. Any calculations performed, either manually, digitally or some other way;

c. Uncertainty in certified value.

iii. The calibration of instruments used in the creation and/or certification of reference materials used as calibrators, standards and/or controls in testing and calibration. This includes any and all concerning:

a. Raw data, printouts and diagrams;

b. Range of calibration;

c. Any calculations performed, either manually, digitally or some other way;

d. Instrumental precision;

e. Instrumental bias;

f. Instrumental uncertainty.

iv. Verification of all calibrations performed, and reference material values established, externally. This includes:

a. Raw data, printouts and diagrams;

b. Any calculations performed, either manually, digitally or some other way.

IV. Results

A. Provide all:

i. Results of forensic measurements performed in this case, whether or not reported;

ii. Raw data, printouts, diagrams and any other electronic, digital or mechanical data or graphs/diagrams/images generated or used during the course of the measurements performed;

iii. Bench notes, calculations or materials of any kind generated or used during the course of the measurements performed.

B. All records and materials applicable or pertaining to non-compliance with and/or deviation from documented procedures. This includes:

i. Quality Assurance/control reports;

ii. Permissions obtained to do so;

iii. Retests.

V. Traceability

A. Generally

i. Identify the methods employed to establish the traceability of measured results;

ii. All policies, procedures and protocols applicable or pertaining to establishing the traceability of measured results.

B. Specifically – This case.

i. Provide all records and materials applicable or pertaining to the traceability of the measured results in this case. This includes:

a. Full documentation of the chain of calibrations claimed to establish traceability;

b. Identification of each body relied upon as a link in the chain;

c. Documentation of/from each body;

d. Uncertainties at each link in the chain;

e. The national/international reference traceability being claimed.

VI. Uncertainty

A. Generally

i. Identify the methods employed to determine and report the uncertainty of measured results. This includes whether:

a. Frequentist or Bayesian methods are being employed;

b. Confidence intervals or coverage intervals are reported.

ii. Identify any software relied upon for the determination or reporting of uncertainty;

iii. All records and materials applicable or pertaining to the validation of methods for determining and reporting the uncertainty of measured results;

iv. Policies, procedures and protocols applicable or pertaining to the determination and reporting of the uncertainty of measured results. This includes:

a. Cause and effect diagrams;

b. Uncertainty budgets;

c. Algorithms relied upon;

d. Origin of values listed for Type A and Type B uncertainties;

e. Any sources of uncertainty not included and their values.

B. Specifically – This case.

i. Uncertainty of the results in this case;

ii. Random and systematic error;

iii. All data and values, including raw, published, assumed and otherwise, utilized to establish the values of Type A and Type B uncertainties and/or the overall uncertainty of the result in this case;

iv. The completed uncertainty budget relied upon;

v. All calculations performed.

VII. Accreditation and Quality Assurance/Quality Control

A. All records/materials applicable or pertaining to accreditation of the laboratory. This includes:

i. All accreditation certificates in effect for the laboratory at the time of the forensic analysis herein;

ii. The standards or requirements that served as the basis for laboratory accreditation;

iii. All organizations accreditation was sought from;

iv. Failed accreditation or accreditations not granted;

v. All findings, reports, corrective actions and other materials generated as part of the accreditation or reaccreditation process.

B. All records/materials applicable or pertaining to the laboratory's quality assurance/control program. This includes:

i. Quality assurance/control management, monitoring and reporting structure;

ii. Policies, procedures and protocols applicable or pertaining to quality assurance/control;

iii. In-house and independent/external proficiency testing;

iv. In-house and independent/external audits conducted of the laboratory or its work product;

v. What, if any, standards, guidelines and/or regulations are relied upon by the laboratory to ensure the quality of its work-product.

APPENDIX - D

Cross-Examination: Debilitating Questions [238]

Poignant Questions:

Q. Have you mislead or mistaken any fact in your testimony and report that you want to correct at this time?

Q. You agree that science is neutral and based upon facts?

Q. If a mistake or error exists in your (report, testimony, exhibits etc.), will you inform the court and both attorneys of it due to being unbiased?

Q. Have you reviewed and discussed your testimony with the attorney (who hired you) before testifying here today?

Q. Is this (named) method, procedure and instrument infallible?

Q. You agree that reasonable people in your field can have differing opinions?

Q. Your testimony is only your opinion and nothing more?

. There are other experts in this field.
. Reasonable people can disagree.

Q. How much are you being paid for your testimony?[239]

Q. Is there anything else about this case you want to tell the court?

Q. Would you openly share the information with the court or hide it for the benefit of one side?

APPENDIX - E

EXPERT WITNESS AFFIDAVIT
(sample)

AFFIDAVIT OF________________________, Ph.D.

I,______________, Ph.D., do on oath state, and if called to testify in court would state the following.

1. I am self-employed/employed by___________________at ________________, city, state, as a (toxicologist/ chemist/biochemist).

2. I have a doctoral degree in________________. My area of specialization is in organic chemistry, including medicinal chemistry and analytical biochemistry.

3. On_____________my scientific consulting services were retained by Mr./Ms.________________. Mr./Ms.______is the attorney of record representing________in case (caption)_______________.

4. I have reviewed the laboratory reports from _________ laboratories dated ______ for specimen number _________ regarding the analysis for THC-COOH metabolite purporting to belong to____________. The __________laboratory report only contains the test result of a enzyme multiplied immunoassay technique (EMIT) drug screen and a gas chromatography/mass spectrometry (GC/MS) assay on this specimen. No information regarding testing procedures, techniques, standards, methodologies etc. for the analysis of this specimen nor the preservation and storage of the sample was provided by _______laboratory.

5. Solely upon the EMIT drug screen and GC/MS test result from______laboratory, I am not able to render a competent opinion without information pertaining to the testing procedures, techniques, standards, methodologies, etc. relied on and required by experts in this field of science. Full information on the testing procedures, techniques, error analysis (metrology), standards, methodologies etc. employed is essential for understanding the entire analytical process. The test result alone, without additional information, is incomplete, unreliable and taken out of context.

6. Human urine specimens purporting to contain THC-COOH metabolite are susceptible to contamination and degradation if not properly collected, preserved, stored and analyzed.

7. Based upon my education, training, knowledge and experience as a (toxicologist/chemist/biochemist) the human urine specimen which is (give facts e.g.: liquified, two years and nine months old, currently at room temperature, dark amber brown in color, stored in a leaking bottle and whose contents emit an odor) is not suitable for accurate and reliable testing to determine the presence and amount of THC-COOH metabolite.

8. Affiant says nothing further.

Date: _________, 20____

__________________, Ph.D.
(Signature)

Subscribed and Sworn to before me on this ____the Day of _________, 20___.

____
Notary Public

APPENDIX - F

SUBPOENA DUCES TECUM

(sample)

(Initial Drug/DNA Testing/Trace Analysis Laboratory)

Rider - Subpoena Duces Tecum [240]

State of ______ vs. ___________, Defendant Case No. ______

From:_________________, Attorney for Defendant
Address of Attorney Date:___, 20_____

To: Person, laboratory & address

Any and all information in your possession, or that of your legal representatives pertaining to the above case and file #____, laboratory report #____, including but not limited to:

1. The actual employment and services contract between the ______, company or its agents, and____laboratory in effect from______to present. Also any information and documentation pertaining to termination, severance or nonrenewal of laboratory's obligations and services with the ______ company or its agents.

2. All complaints, reprimands, sanctions, penalties, claims, and legal actions against_______laboratory, its agents and employees, previously incurred and currently pending (regardless of status: administrative, regulatory, city, county, state, federal, consumer based, financial, civil, criminal etc.) relating to its work as a laboratory.

3. Name of person(s) who actually conducted the collection and analysis of the specimen, including their background, education, training, licensing, certification, experience and proficiency test results.

4. Laboratory guidelines and procedures for chain of custody documentation, quality assurance programs, choice of specimens, preparation of procedure manuals, extraction methods and proficiency testing (internal and external) and sample collection and transportation kit.

Subpoena Rider
People v. ___________, Defendant, Case no. ______
page two Date: _____, 20___

5. Laboratory accreditation and certification, including but not limited to:

a. Results of regular audit of policies, by internal and independent third parties.

b. Actual compliance with proficiency standards by independent third parties.

c. Laboratory manual and safety policies.

d. Actual results in their entirety of proficiency testing of laboratory employees, and laboratory, by outside agencies with unknown samples.

e. Names, addresses and telephone numbers of all agencies either certifying or not certifying the accreditation of____laboratory.

6. All licensing authorities (city, state, county, federal, professional etc.) including certificates of licensing, standards, regulations and compliance for and by________laboratory.

7. Policies of_____________laboratory conducting analysis and basis for threshold levels for determining positive intoxication levels, (quantitative level) of __________drug metabolite in human urine samples.

a. Laboratory criteria used and described in _______ laboratory's standard operating procedure manual for what constitutes identification of a drug and quantitative value for intoxication levels.

8. Equipment used or related to analysis of sample.

a. All maintenance, calibration reports, memoranda, customer advisories, bulletins, notices, inter-office memoranda, sales reports and purchase/lease agreements.

Subpoena Rider
People v. ___________, Defendant, Case no. ______
page three Date:___, 20___

b. General records for each piece of equipment used including serial number, make, model, date of installation, and any major update of the equipment (instrument).

c. Maintenance records of equipment used and recalibration records of the equipment after service call or other repair, from date of manufacture to present.

d. Operation, maintenance and repair manuals for equipment used in the sample analysis.

9. Actual standards and controls used and history of standard and controls.

a. Standard compounds, frequency of use, procedure for preparation of the performance standard, record of performance runs.

b. Standard operation manual specifying records and criteria for acceptable performance data.

c. Standards and controls used with equipment (ultra-violet, gas chromatography/mass spectrometry, infra-red spectrometry) calibration including sources, preparation, storage, stock and working standard, certification of solution's accuracy, quality control documentation of standards including its purity.

d. Calibration curve on all equipment used at time of analysis.

10. Number of blank test runs between each sample analysis and results of those blank tests.

11. Measurement of uncertainty associated with the results.

a. Explanatory note: Requests regarding uncertainty (metrology) associated with the result reported in this case refers to the uncertainty associated with the result reported including, but not limited to, any coverage/confidence intervals, margins of error, measures of precision and estimates of bias.

Subpoena Rider
People v. ___________, Defendant, Case no. ______
page four Date:______, 20__

b. The uncertainty associated with the result reported in this case;

c. Any algorithms utilized in the determination of the results uncertainty;

d. Any and all data relied upon for the determination of the results uncertainty including the specification of any constants relied upon;

e. Standard operating procedures maintained by the laboratory concerning measurement uncertainty;

f. Any and all data and written or digital information and communications possessed concerning the development of the method utilized to determine the uncertainty of results reported by your laboratory including any validation of the method that was performed;

g. Any and all written and digital information and communications possessed concerning the laboratory's accreditation including corrective action reports and responses.

12. All information necessary in order to independently, accurately and reliably reproduce the test results.

Certified duplicate copies will suffice in lieu of originals.

All information requested by this subpoena is directly returnable only to the court or attorney of record.

APPENDIX - G

<u>Basic (Initial) DNA Laboratory Report Subpoena</u>

<u>DNA Laboratory Report - Subpoena Duces Tecum</u>

Any and all laboratory, personal, miscellaneous notes, file jackets and file notes on parameters and conditions necessary to produce the tracings and results of police report #___________, Laboratory case #_______, and inventory #___________,. Also, any and all correspondences, communications, memoranda etc. (transcribed, recorded, taped etc.) related in any manner to this case, including but not limited to, its scientific tests, results, photographs, examinations, analysis and processing. Also, any and all information describing in detail the techniques, methods and procedures used, proficiency tests, including scientific literature and manuals relied on, so that the results can be reproduced. Also, when the actual analysis of the sample(s) was conducted (date, time and place), the results of all analysis (regardless of results) and the entire daily log records of instruments and equipment used in analyzing the sample(s) when it was analyzed.

APPENDIX - H

**Department of Justice/Jeffery Butts
Letter - Dec. 4, 2018**

U.S. Department of Justice

Office of Justice Programs

Office of the Assistant Attorney General

Washington, D.C. 20531

December 4, 2018

Dr. Jeffrey Butts
John Jay College of Criminal Justice
City University of New York
524 W. 59th Street, Suite 605BMW
New York, NY 10019

Dear Dr. Butts:

Thank you for your contributions to the efforts of the Office of Justice Programs (OJP) as a member of the OJP Science Advisory Board (SAB). Your commitment to advancing the scientific agendas of OJP has been most appreciated.

At this time, OJP has decided to bring closure to the SAB. OJP plans to continue to seek the advice of scientists and practitioners from across to country to provide input into the scientific activities and priorities of the OJP. This input will be sought through a variety of means, in particular through the efforts of the National Institute of Justice's Criminal Justice Requirements and Resources Consortium. This Consortium brings together researchers and practitioners from around the country to assess the highest priority research needs of law enforcement, courts, corrections and other components of the criminal justice system as well as criminal justice stakeholders. Furthermore, it supports the development of research-minded criminal justice practitioners. Additional efforts to assure ongoing communication between OJP and the science community will be developed as needs arise.

Again, thank you for your efforts in advancing the work of OJP.

Sincerely yours,

Matt Dummermuth

Matt Dummermuth
Principal Deputy Assistant Attorney General

APPENDIX - I

Protective Order - Trace Evidence [241]

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

GERTNER, D.J.

PROCEDURAL ORDER: TRACE EVIDENCE

March 8, 2010

In the light of the 2009 report to Congress of a Committee of the National Academy of Sciences,' NATIONAL RESEARCH COUNCIL COMMITTEE ON IDENTIFYING THE NEEDS OF THE FORENSIC SCIENCE COMMUNITY, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD (2009) [hereinafter cited as NRC 2009], this Court orders the following:

At or prior to the pretrial conference, parties are **ORDERED** to:

a) identify whether or not they seek to introduce trace evidence;

b) state whether or not either party seeks a Daubert/Kumho hearing prior to trial; and,

c) state the witnesses required for the Daubert/Kumho hearing and the exhibits that the parties seek to admit.

No later than two months before the pretrial conference, counsel must also indicate:

a) if counsel is appointed, whether expert funds are sought to deal with the trace evidence;

b) whether all discovery obligations under the Local Rules have been met or whether additional discovery required.

The NRC 2009 report, building on the writing of academic commentators, called for sweeping changes in the presentation and production of evidence of identification involving fingerprints, bullets, handwriting, and other trace evidence. The report noted that the forensic science disciplines exhibit wide variability with regard to techniques, methodologies,

> reliability, level of error, research, general acceptability, and published material.... Many of the processes used in the forensic science disciplines are ... not based on a body of knowledge that recognizes the underlying limitations of the scientific principles and methodologies for problem solving and discovery. ... [S]ome of these activities [encompassed by the term "forensic science"] might not have a well developed research base, are not informed by scientific knowledge, or are not developed within the culture of science.

NRC 2009 - 1-3.

While the report does not speak to admissibility or inadmissibility in a given case, it raises profound questions that need to be carefully examined in every case prior to trial: "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." NRC 2009 S-7.

The Report noted that these fundamental questions have not been "satisfactorily dealt with in judicial decisions pertaining to the admissibility" of evidence. Id. To be sure, the court's treatment of this evidence relates directly to the adequacy of counsel's treatment. See, e.g. Sturgeon v. Quarterman, 615 F. Supp. 2d 546, 572-573 (S.D. Tex. 2009) (defense counsel's failure to prepare a witness to testify about the unreliability of eyewitness identifications prevented defendant from presenting testimony that would have called into question the only direct evidence against him and was ineffective assistance of counsel warranting habeas relief); Richter v. Hickman, 578 F.3d 944, 946-947 (9th Cir. Cal. 2009) (en banc) (defense counsel's failure to conduct an adequate forensic investigation with respect to blood spatter, serology, and pathology comprised ineffective assistance

of counsel warranting habeas relief). See also United States v. Pena, 586 F. 3d 105 (1st Cir. 2009) (affirmed the court's decision not to hold a Daubert hearing on fingerprint testimony where counsel offered no expert or evidence.

In the past, the admissibility of this kind of evidence was effectively presumed, largely because of its pedigree -- the fact that it had been admitted for decades. As such, counsel rarely challenged it, and if it were challenged, it was rarely excluded or limited. But see United States v. Hines, 55 F.Supp.2d 62 (D. Mass. 1999) and United States v. Green, 405 F.Supp.2d 104 (D. Mass. 2005).

The NAS report suggests a different calculus -- that admissibility of such evidence ought not to be presumed; that it has to be carefully examined in each case, and tested in the light of the NAS concerns, the concerns of Daubert/Kumho case law, and Rule 702 of the Federal Rules of Evidence. This order is entered to accomplish that end.

SO ORDERED.

Date: March 8, 2010 /s/ *Nancy Gertner*

NANCY GERTNER, U.S.D.C.

END NOTES

1. Andre Moenssens, Fred Inbau, James E. Starrs, and Carol Henderson, *Scientific Evidence in Criminal Cases*, 4th ed. (Mineola, NY: Foundation Press, 1995), 1.
2. David L. Faigman, *Legal Alchemy: The Use and Misuse of Science and the Law*, (New York: W.H. Freeman & Co., 1999), 32.
3. Edward J. Imwinkelried and Robert G. Scofield, "The Recognition of an Accused's Constitutional Right to Introduce Expert Testimony Attacking the Weight of Prosecution Science Evidence: The Antidote for the Supreme Court's Mistaken Assumption in California v. Trombetta," *Ariz L. Rev.*, 33 (1991):59; Paul C. Giannelli, Edward J. Imwinkelried, Andrea Roth and Jane Campbell Moriarty, *Scientific Evidence*, vol.1, 5th ed, (New Providence, NJ: LexisNexis, 2012), ch. 4 and 5; Note, however, that in *Cray v. Thompson*, 58 F.2d 59, 66 (4th Cir. 1995), the U.S. Supreme Court declined to address whether as a matter of federal constitutional law what if any showing would entitle a defendant to private assistance. *Caldwell v. Mississippi*, 472 U.S. 320, 323–324 n.1 (1985).
4. Forensic science is the application of scientific principles and technological practices to the purposes of justice in the study and resolution of criminal, civil, and regulatory issues. Amer. Acad. of Forensic Sciences, *Policy and Procedure Manual*, (Colorado Springs, CO: American Academy of Forensic Sciences, 2017), 6.
5. M. Chris Fabricant and William Tucker Carrington, "The Shifted Paradigm: Forensic Sciences' Overdue Evolution From Magic to Law," *Va.J.Crim. L.,4(2016)*:1; Brandon L. Garrett and Peter J. Neufeld, "Invalid Forensic Science Testimony and Wrongful Convictions," *Va. L.Rev.*, 95 (2009):1; Michael J. Saks and Jonathan J. Koehler, "The Coming Paradigm Shift In Forensic Identification Science," *Science* 309, no.5736 (2005):892–895.
6. V. Miller and L. Callaghan, "A Lawyer's Pathway to Medical and Scientific Information: New Options for Bridging the Gap," part 2, *Shepard's Expt. and Sci Ev. Q.*, 2 (Fall 1994):379. "Understanding the language of science is synonymous with understanding science … it is differentiated from lay language by the use of certain grammatical features." For example, high information density, abstraction, technicality, specialized terms, authoritativeness. Leone Howes and Nenagh Kemp, "Discord in the Communication of Forensic Science: Can the Science of Language Help Foster Shared Understanding?" *Jorn. Language and Social Psychology*, 36, no.1 (2017):96, 101.
7. Faigman, *Legal Alchemy, supra,* n.2, at 26.
8. The rules of evidence formalized the roles of consulting and testimonial experts. Federal Rules of Evidence 701–706 and state equivalents.
9. Rafael E. Silva and Mary C. McMurray, "Lawyer-Scientist: Issues of Competency, Validation and Ethics," *Proceedings American Academy of Forensic Sciences*, 23 (2017):F27-832, https://www.aafs.org/wp-content/uploads/ProceedingsChicago2017.pdf; (accessed April 1, 2017); ABA Model Code of Prof. Resp. (1983), Canon 1, DR 1-102; Canon 2, EC 2-9; DR 2-101; Canon 9 (2010).
10. Judge Learned Hand wrote, "The whole object of the expert is to tell the jury, not facts but general truths derived from his specialized experience. But how can the jury judge between two statements each founded upon an experience confessedly foreign in kind to their own? It is just because they are incompetent for such a

task that the expert is necessary at all." Learned Hand, "Historical and Practical Considerations Regarding Expert Testimony," *Harvard L. Rev.* 15(1902),40, 54. Jennifer Laser, "Inconsistent Gatekeeping in Federal Courts: Application of Daubert v. Merrell Dow Pharmaceuticals, Inc. to Nonscientific Expert Testimony," *Loy. LAL Rev.*, 30(1996):1379, 1408 n.265.

11. Federal Rules of Evidence 702–706.
12. The expert witness must be disinterested and impartial. *State ex rel Collins v. Superior Court*, 132 Ariz. 180, 199, 644 P.2d 1266, 1285 (1982); *People v. Kelly*, 17 Cal.3rd 24, 38, 549 P.2d 1240, 1249, 130 Cal. Rptr. 144, 153 (1976). (Cases discuss voice print analysis and interest in use of technique and outcome of proceedings); *infra*, notes, 44, 45, 59, 110.
13. Gold standard is a colloquialism used in science for the accepted reference standard relating to purity, refinement, and precision when establishing a physical property's measurement or quantity. It is derived from the metallurgic standard for monetary systems.
14. Edward J. Imwinkelried,"Evidence Law Visits Jurassic Park: The Far-Reaching Implications of the Daubert Court's Recognition of the Uncertainty of Scientific Enterprise," *Iowa L. Rev.*, 81 (1995):55, 67.
15. L.T. Perrin, "Expert Witness Testimony: Back to the Future," *U. Rich. L.Rev.*, 29(1995):1389, 1410.
16. Movant is a generic term for the proponent of any issue, motion, or presentation of voir dire and witness in legal proceedings.
17. Interaction between science and law is not without controversy and frustration due to conflicts in terminology, methodology and attitudes. Andre A. Moenssens, Betty Layne DesPortes, and Stephen D. Benjamin, *Scientific Evidence In Civil And Criminal Cases*, 7th Ed., (New York: West Academic/Foundation Press, 2017), 2; Faigman, *Legal Alchemy*, *supra,* n.2, at xi-xii, 53–54, 64; Paul C. Giannelli and Sarah Antonucci, "Forensic Experts and Ineffective Assistance of Counsel," 48(6), *Crim. L. Bulletin,* Art. 8 (Nov./Dec., 2012):1360; Brandon L. Garret, "Validating The Right To Counsel," 70 *Wash. & Lee L. Rev.*, (2013):927, 955. "Do defense lawyers properly understand expert evidence or forensic evidence, and does the presence of that evidence tend to alter defense strategies, if so, how?"
18. John Wesley, "Scientific Evidence and the Question of Judicial Capacity," 25 *Wm. & Mary L.Rev.* 25(1893):675, 685.
19. Faigman, *Legal Alchemy*, *supra*, n.7, at 200.
20. *Strickland v. Washington*, 104 U.S. 335, 344 (1984) effective assistance of counsel (1) performance was deficient, and (2) errors deprive person of fair trial (but for conduct different results; *United States v. Hebshie*, 754 F.Supp.2d 89 (D. Mass, 2010) Ineffective assistance of counsel not contesting reliability of trace evidence and requesting a *Daubert* hearing.; *Maryland v. Kulbicki*, 577 U.S. 193 (2015). The U.S. Supreme Court held Maryland Court of Appeals impermissibly vacated conviction based upon ineffective assistance of counsel for failing to question comparative bullet lead analysis evidence that was considered valid at the time of the conviction, but later discredited and abandoned.
21. "Lawyers as a group evidence an appalling degree of scientific illiteracy, which ill equips them to educate and guide the bench in its decisions on admissibility of evidence proffered through expert witnesses. This scientific illiteracy is shared by a

large segment of the trial and appellate bench; many judges simply do not understand evidence based on scientific principles; even more tragically, they overlook important attributes indicative of reliability of evidence they reject, while ascribing positive properties to other evidence they accept which that evidence simply does not possess." James E. Starrs, "In the Land of Agog: An Allegory for the Expert Witness," *Journal of Forensic Sciences*, 30 no.2 (1985):289–308.

22. Lawyers must take reasonable efforts to ensure communications with clients are secure and not subject to inadvertent or unauthorized security breaches. ABA Comm. On Ethics & Prof'l Responsibility, *Formal Op. 477R: Securing communications of protected client information* (May 22, 2017); Confidentiality is especially important when information is transmitted through nonencrypted electronic mail (e-mail), which is neither a privileged nor a confidential communication. John W. Hall, "E-Mail and Confidentiality," *Champion*, 21 (June 1997):52; *American Civil Liberties Union v. Raw*, 929 F.Supp 824, 830–838 (E.D. Pa 1996) (discussing the open and decentralized nature of the Internet).
23. Confidentiality and Retainer: A expert hired by plaintiff was disqualified from testifying for defense, and defense counsel was disqualified for hiring plaintiff's former expert. Once a retainer has been accepted, returning it cannot erase acceptance of it, the significance of it, or the implications arising from it when expert later accepted a retainer from opposing counsel. *Cordy v. Sherwin-Williams Co.* et al., 156 F.D.R. 575, 583 (1994).
24. The technician has been taught to use complex instruments (gas chromatographs, infrared spectrophotometer, mass spectrometer) or even "simple" breath alcohol testing equipment as "bench operators" who have only a superficial understanding of what the instrument really does and how the readout is generated. Bench operators who qualify as expert witnesses are not competent to explain the instrumentation used unless it is established that they received the training and education necessary to impart a thorough understanding of the underlying theories. Andre A. Moenssens, "Novel Scientific Evidence in Criminal Cases: Some Words of Caution," *J. Crim. L. Criminol.*, 1 (Spring, 1993):1, 5–6.
25. *People v. Adam*, 51 Ill.2d 46, 280 N.E.2d 205, cert. denied 409 U.S. 948 (1972).
26. "A criminal defendant must … have access to the hearsay information relied upon by an expert witness. Without such access, effective cross-examination would be impossible." Although exhibits containing inadmissible hearsay may not be admitted into evidence, even though relied upon by an expert in formulating an opinion, the expert may still disclose the hearsay in testifying to the "facts and data" underlying the opinion, providing such hearsay was disclosed prior to testimony. *United States v. Lawson*, 653 F.2d 299, 302 (7th Cir. 1981).
27. Christopher F. Murphy, "Experts, Liars, and Guns for Hire: A Different Perspective on the Qualification of Technical Expert Witnesses," *Indiana L.J.*, 69 (1993):637. See also, Perrin, *Expert Witness Testimony, supra*, n.15 at 1401.
28. *State of Iowa v. Tyler*, 867 N.W.2d 136, 150–51, 162–164, 165 (Ia. 2015) Expert's testimony (forensic pathologist) and opinion must be based upon professional or medical knowledge (scientific, technical or specialized knowledge), not inferences or conclusions from various statements.
29. *Puente v. A.S.I. Signs*, 821 S.W.2d 400, 402 (Tex. Ct.App. 1991).

30. Ibid., at 400, 402; *Harvey v. Culpepper*, 801 S.W.2d 596, 601 (Tex.App. 1990); *Hall v. Baxter Healthcare Corp.*, 947 F.Supp. 1387 (D.Or.1996); *State of Iowa v. Tyler*, 867 N.W.2d 136 (Iowa 2015).
31. "ABA Model R. Prof. Conduct," sec.3-4(e)(2014). It is unprofessional conduct for an attorney to express their personal belief or opinion regarding the truth or falsity of any testimony or evidence or guilt.
32. Prosecutor's comments were not only improper, but so "egregious" as to "poison the jury's verdict" and require a new trial. *State v. Robert Smith*, 167 NJ 158, 770 A.2d 255, 271–275 (2001, NJ Supreme Court).
33. *Berger v. United States*, 295 U.S. 78, 88 (1934); *United States v. Modica*, 663 F.2d 1173, 1178–1179 (2d Cir. 1981) (describing the prosecutor's improper use of their own opinions in a summation). *State of Iowa v. Tyler*, 867 N.W.2d 136, 154–167 (Iowa 2015) role of forensic pathologist and witness credibility.
34. Expert witness criteria ideally should encompass: knowledge; reputation for honesty; objectivity; personal appearance; dignity; voice; modesty; even temperament; memory for facts without references; communication skills; humility, integrity; trustworthy; civility; and ability to teach and educate. All of these elements must be integrated for an effective and persuasive presentation of expert witness testimony. Carol Henderson and Kurt Lentz, "Expert Witnesses: Qualifications and Testimony," *Encyclopedia of Forensic Sciences*, 2nd Ed. (Jay A. Siegel et al. eds.) (Philadelphia, PA: Elsevier Academic Press, 2013); Robert Clifford, *Qualifying & Attacking Expert Witnesses*, Rev. 27 (Costa Mesa, CA: James Publishing, 2015).
35. States that have not adopted the Federal Rules of Evidence or the *Daubert* standard generally have similar rules or statutes governing expert witness qualifications and testimony.
36. Most forensic science testimony is actually "connoisseur testimony" designed as science. Ipse dixit of the expert. David E. Bernstein, "Expert Witnesses, Adversarial Bias, and the Partial Failure of the Daubert Revolution," *Iowa L.Rev.* 93(2008): 451, 459, 480, 481; *In re Lipitor (Hempstead v. Pfizer)*, 150 F.Supp.3d 644 (D.S.C. 2015).
37. Robert Byman, A.J. Stephani, and Glen Weissenberger, *Illinois Evidence Courtroom Manual*, 2013–2014 ed. (New Providence, NJ: LexisNexis), sect.702.4.
38. *Fuesting v. Zimmer*, 421 F.3d 528, 535 (7th Cir. 2005).
39. *Thompson v. Gordon*, 221 Ill.2d 414, 428–449, 434 (2006).
40. *Bogosian v. Mercedes-Benz of North America, Inc.*, 104 F.3d 472, 477 (1st Cir. 1977) Furthermore, "it would be absurd to conclude one can be an expert by accumulating experience in testifying." *Thomas J. Kliner, Inc. v. Lorillard, Inc.*, 878 F.2d 791, 800 (4th Cir. 1989) *cert. denied*, 493 U.S. 1073 (1990). The fact that a person has previously testified does not necessarily mean the witness is ethical, honest, competent, unbiased or impartial.
41. "Everyone must have their first day in court." *U.S. v. Locascio*, 6 F.3d 924, 937 (2nd Cir. 1993) *cert. denied*, 511 U.S. 1070 (1994).
42. *People v. Johnson*, 23 Ca. Rptr.2d 703, 712 (Cal.App. 1993); Margaret A. Berger, "Evidentiary Framework," in *Reference Manual on Scientific Evidence* (Washington, DC: Federal Judicial Center, 1994), 62. (available from the Federal Judicial Center, www.fjc.gov).

43. Gil Sapir, Mark Giangrande and Angela Peters, "Breath Alcohol Machines: Evidence Foundation Requirements in Illinois," *J. Marshall L. Rev.*, 22 (1988): 1, 19; *Ill. Dept. of Public Health-Breath Alcohol Analysis Technician*, spec., code 3150, position code 05170, effective April 1, 1985; *Ill. State Police Directive ENF-018*, "DUI Enforcement and Processing," Revised 09-14-99; Ill. State Police Position No. 5524, Breath Alcohol Unit Supervisor, effective August 1, 1998 (detailing the duties of Illinois State Troopers assigned to maintain breath alcohol testing equipment).
44. National Research Council, Committee on Identifying the Needs of the Forensic Sciences Community, *Strengthening Forensic Science in the United States: A Path Forward*, Aug. 2009; Roger Koppl and Meghan Sacks, "The Criminal Justice System Creates Incentives for False Convictions," *Criminal Justice Ethics*, 32 no.2 (2013):126, DOI: 10.1080/0731129X.2013.817070; International Organization for Standardization, ISO/IEC 17025:2017. *General Requirements for the Competence of Testing and Calibration Laboratories, 4.1.3*; *ASCLD/LAB Supplemental Requirements for the Accreditation of Forensic Science Testing Laboratories*, 2011 Ed., Append. B, Guiding Principles of Professional Responsibility for Crime Laboratories and Forensic Scientists, p.31; American Bar Association Model Rules of Professional Conduct, 2016, Rule 3.4(b); see also Restatement (Third) of the Law Governing Lawyers, § 117, cmt. D (2002); *City and County of Denver, Colo. v. Board of Assessment Appeals of State of Colorado*, 947 P.2d 1373, 1379 (Colo. 1997) reh'g denied (Dec. 2, 1997); American Bar Association Commission on Standards of Judicial Administration, 107 (1974); Michelle L. Behan and Gil Sapir, "Due Process and Ethics Violations: Crime Laboratories Cannot Be Paid for Convictions," *Proceedings American Academy of Forensic Sciences*, 25 (2019):F22-648; *supra*, note 12; *infra*, notes 45, 59, 111.
45. Seventeen states permit assessment of crime laboratory fees contingent upon conviction. Only Tennessee held this arraignment to be constitutional under its state constitution. *State of Tennessee v. Rosemary L. Decosimo*, No. E2017-00696-SC-R11-CD (Aug. 23, 2018). No other state has ruled on this revenue practice. The constitutionality however, does not change the ethics of whether this contingency fee should be permitted. A potential conflict of interest exists. Privately funded laboratories may conduct forensic analysis. Unlike government crime laboratories, private laboratories are generally liable for the work product. North Carolina exempts private laboratories from liability for law enforcement work. The 17 states are: AL, AZ, CA, FL, ID, IL, KS, KY, MS, MO, NJ, NM, NC, TN, VA, WA, WI; Sapir, *Due Process and Ethics Violations: Crime Laboratories Cannot Be Paid for Convictions*, *supra*, note 44; *infra*, notes 59, 111.
46. Police officers or federal agents are routinely qualified by on-the-job experience and personal observations. (connoisseur testimony) The courts are not as critical of police officers as other expert witnesses and they are routinely admitted as experts. Jennifer Groscup and Steven D. Penrod, "Battle of Standards For Experts In Criminal Cases: Police v. Psychologists," *Seton Hall L.Rev.*, 33(2002):1141, 1147–1149, 1151; Joelle Anne Moreno, "What Happens When Dirty Harry Becomes an (Expert) Witness for the Prosecution?," *79 Tulane L.Rev.* (2004):1; Mark Hansen, "Dr. Cop on the Stand: Judges Accept Police Officers as Experts Too Quickly," *ABAJ* 88(2002):31 (May 2002); *State v. Torrez*, 146 NM 331, 305 P.3d 944 (N.M. 2009). Their expertise is superficial compared to other experts. There is no requirement of scientific training. The less scientific police practices are, the

less reliable their knowledge or expertise. Ergo, the oxymoron "Dr. Cop." Rafael E. Silva, "Dr. Cop: The Need to Examine Validation & Reliability Standards for Specialized Law Enforcement Knowledge Testimony," *Proc. American Academy of Forensic Sciences*, 17(2010):E26-210, https://www.aafs.org/wp-content/uploads/ProceedingsChicago2011.pdf; (accessed Sept 6, 2015); Valena E. Beety, "Cops in Lab Coats and Forensics in the Courtroom." *Ohio St. J.Crim. L.* 13(2015):543; Brian R. Gallini, "To Serve and Protect - Officers as Expert Witnesses in Federal Drug Prosecutions." *Geo. Mason L. Rev.* 19(2011–2012):363; Anna Lvovsky, "The Judicial Presumption of Police Expertise." *Harv. L. Rev.* 130 no.8 (2017):1995.

47. The principal findings and recommendations of the Justice Department's report addressed "significant instances of testimonial errors, substandard analytical work, and deficient practices" including policies by the Federal Bureau of Investigation Laboratory." Justice Department Investigation of FBI Laboratory: Executive Summary," *Crim. L. (BNA)*, 61 (April 16, 1997):2017; "The [517-page Inspector General's] report provided plentiful evidence of pro prosecution bias, false testimony and inadequate forensic work … No defense lawyer in the country is going to take what the FBI lab says at face value anymore. For years they were trusted on the basis of glossy advertising." John F. Kelly and Phillip K. Wearne, *Tainting Evidence: Inside the Scandals at the FBI Crime Lab* (New York: Free Press, 1998), 3–4; Peter W. Huber, *Galileo's Revenge: Junk Science in the Courtroom (*Basic Books/Harper Collins Publishers: New York, 1991); Sabra Thomas, "Addressing Wrongful Convictions: An Examination of Texas New Junk Science Writ And Other Measures For Protecting The Innocent." Hous. L. Rev. 52(2015):1037; Sandra Guerra Thompson, *Cops In Lab Coats: Curbing Wrongful Convictions Through Independent Forensic Laboratories* (North Carolina: Carolina Academic Press, 2015); Matthew Clarke, Crime Labs Still In Crisis, *Prison Legal News*, April 2015, p.1 (https://www.prisonlegalnews.org/news/2015/apr/9/crime-labs-still-crisis/ (accessed April 30, 2017).

48. Police officers may call themselves drug recognition specialists (DREs), technicians, and evaluators. Cliff J. Vanell, "Is 'DRE' Extinct? Or What's in a Name?," *The DRE (Newsletter)* (September–October 1990):2. The International Association of Chiefs of Police (IACP) used the term "technician" for drug recognition police officer. However, on March 25, 1992, the Technical Advisory panel (to the IACP Highway Safety Advisory Committee) voted to change and use the self-proclaimed term "Drug Recognition Expert" thereafter. Cliff J. Vanell, "What's in a Name?," *The DRE (Newsletter)* (March–April 1992):10. The term "expert" is currently used in the latest training materials. If DREs call themselves experts—it is problematic.

49. It is possible for the same witness to provide both lay and expert testimony in a single case. The court however, should be vigilant to preclude manipulative conduct designed to thwart the expert disclosure and discovery process. FRE 701 Advisory Committee Note (2000 Amendment eff. Dec. 1, 2000).

50. Placing an expert's name on a case witness list without their knowledge and expressed consent, regardless of intent, is sanctionable by the court and state licensing bar.

51. Neither the subpoenaed party nor the prosecution can determine what information is discoverable. *People v. Harris*, 91 Ill.App.3d 1 (4th Dist. 1980); *People v. Briggs*, 519 NYS2d 294 (Brighton Town Ct. 1987). Nor can they determine when it is discoverable. *People v. Rogers*, 123 Ill.App.3d 780 (2nd Dist. 1984). Only the