Recent NIST Activities to Strengthen Forensic Science

John M. Butler, PhD
National Institute of Standards and Technology

Cedar Crest College
5th Annual Forensic Science Leadership Lecture
October 8, 2015
O.J. Simpson: Helped Bring DNA Testing to Knowledge of the General Public
The World’s Largest Classroom
Dr. Robin Cotton in May 1995 teaches >1 billion people watching the O.J. Simpson Trial about DNA
Progress Since 1995…

Almost 8 weeks needed to get results

Now <8 hours to get results

O.J. Simpson DNA testing was performed with RFLP
# Forensic DNA Typing Textbooks Have Set the Standard for the Field

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>335 pages</td>
<td>688 pages</td>
<td>520 pages</td>
</tr>
<tr>
<td>Publication</td>
<td>Jan 2001</td>
<td>Feb 2005</td>
<td>Sept 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aug 2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oct 2014</td>
</tr>
</tbody>
</table>
Background Information on NIST

- Started in 1901 with roots back to the Constitution
- Name changed to National Institute of Standards and Technology (NIST) from National Bureau of Standards in 1988
- Primary campus in Gaithersburg, Maryland (just outside of Washington, D.C.)
- Part of the U.S. Department of Commerce
- >3,000 employees and >2,000 associates
- Supply >1300 reference materials
- Defines official time for the U.S.
Types of Standards

physical (measurement) standards

Certified reference material to aid with calibration of measurements

http://www.nist.gov/srm/

documentary (technical) standards

Specific requirements for the operation of a laboratory related to management system and competence

http://www.nist.gov/srm/
U.S. Innovation Agenda – NIST has an increasing role

Examples of NIST Programs Addressing National Priorities:

- Advanced Communications
- Advanced Manufacturing
- Climate Assessment
- Cybersecurity
- Energy
- **Forensic Science**
- Healthcare
- Nanotechnology
NIST’s Early History in Forensic Science Research

• 1913 - Wilmer Souder was asked to calibrate some precision measuring devices sent to him by famed handwriting expert Albert Osborn.

• By the 1930s – Souder was recognized as a pioneer researcher in questioned documents, handwriting, typewriting, ballistics, and firearms.

• Souder was instrumental in setting up the FBI Laboratory, which opened in 1932

*NIST began work with fingerprints in the 1960s and with DNA in the 1990s*
Dr. Wilmer Souder: Early Handwriting Expert

• **National Bureau of Standards** (1911-1913, 1917-1954)
  – His PhD research at the University of Chicago 1913-1916 on the photoelectric effect led to Robert Millikan receiving the 1923 Nobel Prize in Physics

• Chief of the NBS Identification Laboratory (est. ~1921) and Dental Research Laboratory (est. 1919)

• Based on notebook records recently rediscovered, he served as a Federal expert in hundreds of handwriting, typewriter and ballistic identification cases during the 1920s through the 1950s

• Helped set up the FBI Laboratory in 1932 and provided training to the FBI and other forensic labs in document examination and ballistics

• Testified for the prosecution in the Bruno Hauptmann (Charles Lindberg baby kidnapping) trial in 1935

• Active member of IAI and IACP and many other scientific organizations

*NBS changed its name to NIST in 1988*
Typewriting casework received from the Department of Justice – Charles Appel (first FBI Laboratory employee) on October 28, 1933 (10-28-33)

All [material returned] to Appel on October 30, 1933 (10-30-33)

Convicted on Appel’s testimony
HANDWRITING TESTIMONY IS ENDED

DULL EVIDENCE HAS TIRED JURY; STATE CHANGES STRATEGY

Parade Of Experts Links Hauptmann With The Notes

FLEMINGTON, N. J., Jan. 16.—Albert D. Osborn, son of a previous witness, today was the seventh government expert to charge the writing of the Lindbergh notes against Bruno Richard Hauptmann, accused as the murderer of Charles A. Lindbergh, Jr.

Osborn, 40, added the weight of his handwriting knowledge in declaring at the start of his testimony that the hand that wrote the ransom notes also wrote Hauptmann’s application for an automobile license and the “request” writing done after his arrest.

Harry E. Cassidy, government handwriting expert from Richmond, Va., identified writing in the Lindbergh ransom notes as that of Hauptmann.

Cassidy became the fifth expert to link the man accused of the murder to the writing of the letters which led to Col. Lindbergh’s payment of $50,000 for the return of the child he never saw alive again.

Wilmer Souder, of the U. S. Bureau of Standards, considered one of the government’s greatest investigators of handwriting and documents, followed Cassidy and delivered a scholarly pronouncement regarding his opinion that Hauptman tried to disguise his handwriting when he composed the ransom demands.

The defense moved today to strike out the testimony of Morton Maish, Wyoming, O., thumb guard manufacturer, who swore yesterday that metal thumb guards would not corrode when exposed to the air. The motion was denied.

The state has more handwriting experts ready to testify that Hauptmann’s heavy hand penned the crudely disguised writing in the ransom notes.

It decided to withhold them because it felt the jury was tired of scientific testimony and wanted sensations. Justice Thomas W. Trenchard, tired of repetitions and long cross-examinations, asked that the trial be speeded up.

It has been a wearisome, but necessary performance. When the first Osborn talked to the jury, he obtained close attention for two reasons. First, because he was the first of the experts to declare the ransom letters were written by Hauptmann; second, because he gave an entertaining lecture on handwriting, and few in his large audience had ever heard anything like it.
The National Bureau of Standards’ Identification Laboratory (1935)
One of the Nation’s First Forensic Laboratories

Dr. Wilmer Souder:
Photo taken April 11, 1935

Photo re-discovered August 5, 2015 in the National Archives
“The honest expert never looks upon the outcome of his work as a result of luck, the reward of a game, or victory in a battle of wits. He has built his qualifications through hard work. He establishes his conclusions through exacting procedures; he presents his testimony in the face of keen opposition and asks no favor beyond an honest consideration of the facts disclosed. Having done so, he has fulfilled the high obligations of his profession.

“Justice is sometimes pictured as blindfolded. However, scientific evidence usually pierces the mask.”

Co-lead with DOJ

National Commission on Forensic Science

NIST Point-of-Contact (POC): John Butler

A federal advisory committee for the U.S. Department of Justice

http://www.justice.gov/ncfs

Organization of Scientific Area Committees

POC: Mark Stolorow & John Paul Jones

NIST-administered effort dedicated to identifying and developing technically sound, consensus-based documentary standards and guidelines

http://www.nist.gov/forensics/osac/

NIST Forensic Science Research Program

POC: Sue Ballou

SIX FOCUS AREAS

1. Ballistics and Associated Tool Marks
2. Digital and Identification Forensics
3. Forensic Genetics
4. Toxins
5. Trace
6. Statistics

http://www.nist.gov/forensics
NCFS and OSAC: 
U.S. Efforts to Strengthen Forensic Science

• National Academy of Sciences (NAS) report issued in Feb 2009

• White House Subcommittee on Forensic Science (SoFS) operated from July 2009 to Dec 2012

DOJ/NIST Partnership (announced Feb 2013)

1. NCFS (National Commission on Forensic Science)
   • First meeting held February 3-4, 2014 in Washington DC

2. OSAC (Organization of Scientific Area Committees)
   • 542 members named; first public meetings held in Feb 2015
National Commission on Forensic Science

A Federal Advisory Committee for the U.S. Department of Justice

http://www.justice.gov/ncfs
National Commission on Forensic Science (NCFS)

www.justice.gov/ncfs

NCFS Leadership

Sally Q. Yates
Deputy Attorney General
DOJ Co-Chair

Willie E. May
Director of NIST
NIST Co-Chair

Nelson A. Santos
Vice-Chair (DOJ)

John M. Butler
Vice-Chair (NIST)

32 voting and 8 ex-officio members

Next meeting (8th): December 7-8, 2015
Vice-Chairs of the National Commission on Forensic Science: John Butler (NIST) and Nelson Santos (DOJ)

Photo taken before our AAFS 2015 talk regarding the National Commission on Forensic Science
February 3-4, 2014 was the first meeting of the National Commission on Forensic Science

First meeting was not webcast but future ones will be

37 Commissioners + DOJ/NIST Leadership Team (with ~100 public attendees)
Timeline for Commission Activities

Federal Advisory Committees exist on a 2-year renewal cycle

New Commission charter signed on April 23, 2015

Includes digital evidence

- Commission membership named (January 10, 2014)
- *First* Commission meeting (February 3-4, 2014)
- *Second* Commission meeting (May 12-13, 2014)
- *Third* Commission meeting (August 26-27, 2014)
- *Fourth* Commission meeting (October 28-29, 2014)
- *Fifth* Commission meeting (January 29-30, 2015)
- *Sixth* Commission meeting (April 30-May 1, 2015)
- *Seventh* Commission meeting (August 10-11, 2015)
- *Eighth* Commission meeting (December 7-8, 2015)
Organization of Scientific Area Committees (OSAC)

- A NIST-administered effort begun in 2014 in collaboration with the U.S. Department of Justice
- Involves >500 subject matter experts in more than 20 different forensic disciplines
- OSAC goals are to identify and develop technically sound, consensus-based documentary standards and guidelines to improve the practice of forensic science

http://www.nist.gov/forensics/osac/index.cfm
# Listing of Scientific Working Groups (SWGs) as of 2013

<table>
<thead>
<tr>
<th>Scientific Working Group (SWG)</th>
<th>Topic (Forensic Discipline)</th>
<th>Start</th>
<th>Sponsor</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 SWGDAM</td>
<td>DNA</td>
<td>1988</td>
<td>FBI</td>
<td>swgdam.org</td>
</tr>
<tr>
<td>2 SWGMAT</td>
<td>Materials (Trace)</td>
<td>1992</td>
<td>FBI</td>
<td>swgmat.org</td>
</tr>
<tr>
<td>3 SWGFAST</td>
<td>Friction Ridge (Fingerprints)</td>
<td>1995</td>
<td>FBI</td>
<td>swgfast.org</td>
</tr>
<tr>
<td>4 <strong>SWGDRUG</strong></td>
<td>Controlled Substances</td>
<td>1997</td>
<td>DEA</td>
<td>swgdrug.org</td>
</tr>
<tr>
<td>5 SWGIT</td>
<td>Imaging Technologies</td>
<td>1997</td>
<td>FBI OTD</td>
<td>swgit.org</td>
</tr>
<tr>
<td>6 SWGDOC</td>
<td>Document Examination</td>
<td>1997</td>
<td>FBI</td>
<td>swgdoc.org</td>
</tr>
<tr>
<td>7 <strong>SWGDE</strong></td>
<td>Digital Evidence</td>
<td>1998</td>
<td>FBI OTD</td>
<td>swgde.org</td>
</tr>
<tr>
<td>8 SWGGUN</td>
<td>Firearms &amp; Toolmarks</td>
<td>1998</td>
<td>FBI</td>
<td>swggun.org</td>
</tr>
<tr>
<td>9 SWGFEX</td>
<td>Fire Debris &amp; Explosives</td>
<td>1998</td>
<td><strong>NIJ</strong></td>
<td>swgfex.org</td>
</tr>
<tr>
<td>10 SWGSTAIN</td>
<td>Bloodstain Pattern</td>
<td>2002</td>
<td><strong>NIJ</strong></td>
<td>swgstain.org</td>
</tr>
<tr>
<td>11 SWGTREAD</td>
<td>Shoeprint &amp; Tire Tread</td>
<td>2004</td>
<td>FBI</td>
<td>swgtread.org</td>
</tr>
<tr>
<td>12 SWGDOG</td>
<td>Dog &amp; Orthogonal Detector</td>
<td>2004</td>
<td>FBI</td>
<td>swgdog.fiu.edu</td>
</tr>
<tr>
<td>13 SWGGSR</td>
<td>Gun Shot Residue</td>
<td>2007</td>
<td><strong>NIJ</strong></td>
<td>swggsr.org</td>
</tr>
<tr>
<td>14 SWGANTH</td>
<td>Anthropology</td>
<td>2008</td>
<td>FBI</td>
<td>swganth.org</td>
</tr>
<tr>
<td>15 SWGTOX</td>
<td>Toxicology</td>
<td>2009</td>
<td><strong>NIJ</strong></td>
<td>swgtox.org</td>
</tr>
<tr>
<td>16 FISWG</td>
<td>Facial Identification</td>
<td>2009</td>
<td>FBI OTD</td>
<td>fiswg.org</td>
</tr>
<tr>
<td>17 SWGDVI</td>
<td>Disaster Victim Identification</td>
<td>2010</td>
<td>FBI</td>
<td>swgdvi.org</td>
</tr>
<tr>
<td>18 SWGMDI</td>
<td>Medicolegal Death Investigation</td>
<td>2010</td>
<td><strong>NIJ/FBI</strong></td>
<td>swgmdi.org</td>
</tr>
<tr>
<td>19 SWGGEO</td>
<td>Geological Materials</td>
<td>2011</td>
<td>USACIL</td>
<td>swgggeo.org</td>
</tr>
<tr>
<td>20 SWGWILD</td>
<td>Wildlife Forensics</td>
<td>2011</td>
<td>USFWS</td>
<td>wildlifeforensicscience.org/swgwild</td>
</tr>
<tr>
<td>21 SWGSPEAKER</td>
<td>Voice Analysis</td>
<td>2012</td>
<td>FBI</td>
<td>swg-speaker.org</td>
</tr>
</tbody>
</table>
Organization of Scientific Area Committees (OSAC)

Forensic Science Standards Board (FSSB)

Legal Resource Committee (LRC)

Quality Infrastructure Committee (QIC)

Human Factors Committee (HFC)

Biology/DNA SAC
- Biological Data Interpretation and Reporting Sub
- Biological Methods Sub
- Wildlife Forensics Sub

Chemistry/Instrumental Analysis SAC
- Fire Debris and Explosives Sub
- Geological Materials Sub
- Gunshot Residue Sub
- Materials (Trace) Sub
- Seized Drugs Sub
- Toxicology Sub

Crime Scene/Death Investigation SAC
- Anthropology Sub
- Disaster Victim Identification Sub
- Dogs and Sensors Sub
- Fire and Explosion Investigation Sub
- Medicolegal Death Investigation Sub
- Odontology Sub

Digital/Multimedia SAC
- Digital Evidence Sub
- Facial Identification Sub
- Speaker Recognition Sub
- Video/Imaging Technology and Analysis Sub

Physics/Pattern Interpretation SAC
- Bloodstain Pattern Analysis Sub
- Firearms and Toolmarks Sub
- Footwear and Tire Sub
- Forensic Document Examination Sub
- Friction Ridge Sub

Currently 131 affiliates (from >1300 applicants) are assisting with task

SAC = Scientific Area Committee
Sub = Subcommittee
NIST Forensic Science Research
NIST Forensic Science Research Efforts

Assisting the forensic science community through:

• Scientific and technical advances
• New analytical tools and supporting infrastructure
• Scientific validation of currently applied instrumentation and methods
• Evaluation of models, methods, and standards
• Performance and validation studies to define and estimate error rates
Forensic Science Research Program

Goal:

To advance the use of scientifically valid methods and techniques to improve the understanding of uncertainty and error in forensic evidence analysis
Forensic Science Research Program

Objectives:
1. Provide tools, reference materials, and techniques to support existing validated methods and technologies
2. Initiate new projects to strengthen existing measurement methods and technologies
3. Obtain feedback from community through outreach and education on potential needs/gaps/projects

Common Themes
- Error and Uncertainty
- Data and Information
- Algorithm Development
- Method Validation
- Training
5 Year Goal: Assess new technologies and genetic markers for forensic applications and support the deconvolution and interpretation of complex DNA mixtures through software exploration and inter-laboratory studies.

Impact: Developers of STR typing kits have made changes on beta versions of their next-generation STR typing kits due to NIST research and have released new DNA typing technologies incorporating NIST’s reference materials. Crime laboratories have used NIST’s data in the creation of their DNA protocols.
5 Year Goal: To produce scientifically valid and objective measurement methods with error rate reporting that ultimately support a conclusion of identification for ballistic evidence, including laying the groundwork for use in court proceedings.

Impact: Research results have been adopted by crime labs and industry such as the FBI and Sensofar. State and federal crime labs are working to implement and validate recent advances in error rate reporting. The NIST standard bullets and cartridge cases have sold widely and are used throughout the world for quality control and training.
Digital and Identification Forensics

5 Year Goal: Provide standards and measurement to improve the quality, efficiency and understanding of digitally-based forensics focusing on digital evidence tools, latent prints and biometric databases.

Statistical Methods

5 Year Goal: To make identifiable contributions to statistical methods for forensic science applications in the following areas:

1. study of statistical frameworks for evaluating evidence
2. development or deployment of improved statistical models and methods for different applications
3. development and use of appropriate uncertainty assessments for forensic test results
4. use of reproducible research approaches in forensic science research.

Impact: Working towards effective incorporation of statistical methods in forensic science through:

• training sessions,
• demonstrating the incorporation of approved methods in software, standards or guidelines for the forensic analyst and
• outreach to the community through publications and presentations
Drugs and Toxins

5 Year Goal: To establish a validated metrology infrastructure for confident drug identification and quantification. To produce scientifically valid and objective measurement methods with well defined uncertainties.

Impact: Development of:

- rapid identification approaches for new designer drugs;
- mass spectral database and reliable methods to allow identification and uncertainty evaluation for drugs of abuse.
- a marijuana breathalyzer test system to determine level of intoxication instead of use.

AM-2201, a synthetic cannabinoid
Trace Evidence

• **5 Year Goal:** To produce scientifically valid and objective measurement methods and uncertainties to support a conclusion on the comparison and origin of trace evidence.

• **Impact:** Move from subjective observation based conclusions to measurement based conclusions with calculable uncertainties.

• Develop methods, reference materials and databases that allow crime labs to rigorously and reproducibly measure and accurately interpret polymers (e.g. paints & fibers), particles & surfaces (e.g. gunshot residue & ambient particle populations), and arson vapor evidence.
NIST Forensic Science Center of Excellence (FSCOE)

- NIST has committed to invest $20M over 5 years in the FSCOE

- **Goals:** (1) improve the statistical foundation for **pattern evidence** (fingerprints, firearms, tool marks, etc.) and **digital evidence** (computer, video, and audio analyses) and (2) develop education and training on **probabilistic methods** for practitioners and other relevant stakeholders

- **Awardees:** A consortium effort led by Iowa State involving Carnegie Mellon, University of California-Irvine, and the University of Virginia
• **432 participated** from >35 states and 11 countries
• 2 keynote speakers (Brandon Mayfield & Steven Wax)
• 8 world-renowned plenary speakers
• 42 sessions across 8 technical tracks
  – 105 individual platform presentations
  – 9 panels
  – Symposium concluded with a **moot court presentation**

http://www.nist.gov/director/orals.cfm
Science Magazine reported on the NIST-organized Forensic Science Error Management meeting.

SCIENCE AND THE LAW

Forensic labs explore blind testing to prevent errors

Evidence examiners get practical about fighting cognitive bias

By Kelly Servick

Shaken by revelations of unreliable results in crime labs, some forensic scientists are urging their colleagues to adopt a basic research practice: the blind experiment. Last week, at the first International Symposium on Forensic Science Error Management in Arlington, Virginia, nearly 500 scientists, lab managers, and other practitioners confronted the factors that lead them to make mistakes. A key problem, many said, is that people who evaluate evidence from crime scenes have access to information about a case that could bias their analysis.

Science. His presence at the meeting, organized by the National Institute of Standards and Technology (NIST), was one sign of the field’s eagerness for reform after a decade of humbling revelations. A 2009 report from the National Research Council concluded that many forensic disciplines lacked a firm foundation in science and produced inconsistent, unreliable results.

In response, NIST and the Department of Justice assembled both a national commission on forensic science to suggest policies that will strengthen the field and 24 discipline-specific expert committees to make practical recommendations to more than 400 U.S. labs.
Biannual Conference to Showcase NIST Research

November 28-30, 2012 at NIST
- **52 presentations** covering DNA, firearms and toolmarks, fire research, trace sampling, drug analysis, computer and multimedia forensics, fingerprints, facial and speaker recognition
- Presentations and video are available for downloading and viewing

December 3-4, 2014 at NIST
- 20 presentations & 30 posters

U.S. initiatives to strengthen forensic science & international standards in forensic DNA

John M. Butler*

National Institute of Standards and Technology, Gaithersburg, MD, USA

- This review article covers recent U.S. activities to strengthen forensic science including the formation of the National Commission on Forensic Science and the Organization of Scientific Area Committees

- DNA documentary standards and guidelines from organizations around the world are also included

Butler, J.M. (2015) U.S. initiatives to strengthen forensic science & international standards in forensic DNA. *FSI Genetics* (volume 18, pp. 4-20)
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Article Title (Invited Review Articles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Butler</td>
<td>U.S. initiatives to strengthen forensic science &amp; international standards in forensic DNA</td>
</tr>
<tr>
<td>Titia Sijen</td>
<td>Molecular approaches for <strong>forensic cell type identification</strong>: on mRNA, miRNA, DNA methylation, and microbial markers</td>
</tr>
<tr>
<td>Manfred Kayser</td>
<td><strong>Forensic DNA phenotyping</strong>: predicting human appearance from crime scene material for investigative purposes</td>
</tr>
<tr>
<td>Chris Phillips</td>
<td>Forensic genetic analysis of <strong>bio-geographical ancestry</strong></td>
</tr>
<tr>
<td>Robin Cotton &amp; Matthew Fisher</td>
<td><strong>Properties of sperm and seminal fluid</strong>, informed by research on reproduction and contraception</td>
</tr>
<tr>
<td>Claus Børsting &amp; Niels Morling</td>
<td><strong>Next generation sequencing</strong> and its applications in forensic genetics</td>
</tr>
<tr>
<td>Erica Romsos &amp; Peter Vallone</td>
<td><strong>Rapid PCR of STR markers</strong>: applications to human identification</td>
</tr>
<tr>
<td>Peter Gill et al.</td>
<td><strong>Genotyping and interpretation of STR-DNA</strong>: low-template, mixtures and database matches – 20 years of research and development</td>
</tr>
<tr>
<td>K. Gettings et al.</td>
<td><strong>STR allele sequence variation</strong>: current knowledge and future issues</td>
</tr>
<tr>
<td>Just, Irwin, Parson</td>
<td><strong>Mitochondrial DNA heteroplasmy</strong> in the emerging field of <strong>massively parallel sequencing</strong></td>
</tr>
<tr>
<td>Toni Diegoli</td>
<td>Forensic typing of short tandem repeat markers on the <strong>X and Y chromosomes</strong></td>
</tr>
<tr>
<td>Ogden &amp; Linacre</td>
<td><strong>Wildlife forensic science</strong>: a review of genetic geographic origin assignment</td>
</tr>
<tr>
<td>Maria Brión et al.</td>
<td><strong>Massive parallel sequencing</strong> applied to the <strong>molecular autopsy</strong> in sudden cardiac death in the young</td>
</tr>
</tbody>
</table>
NIST Forensic Science Efforts

National Commission on Forensic Science (NCFS)

Department of Justice FACA co-led by NIST setting policy

Organization of Scientific Area Committees (OSAC)

NIST-administered >540 members of the community establishing standards and best practices

NIST Funded Internal Research Programs

~$7.5M/year invested

NIST Forensic Science Center of Excellence

CoE: ~$4M/year invested for 5 years (2015-2020)

International Symposium on Forensic Science Error Management

432 participants (11 countries)
Some Advice to Students…
Value of Personal Preparation

• Importance of self-education (continuing education) – READ, READ, READ! … I have never had a single class on molecular biology (or statistics)!

• Importance of skills in oral and written communication (I took a class in public speaking while an undergraduate at BYU)
In the fields of observation chance favors only the prepared mind.

Louis Pasteur
(1822-1895)
The Importance of Hard Work

Thomas Alva Edison (1847-1931):
“There is no substitute for hard work.”

I am grateful to my parents for teaching me the value of hard work and the importance of self-education.
President Calvin Coolidge

- Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent. The slogan “Press on” has solved and always will solve the problems of the human race.
Mark Twain (1835-1910)

• Always do right. This will gratify some people, and astonish the rest...
Men give me some credit for genius, but all of the genius I have lies in this. When I have a subject in mind, I study it profoundly, day and night it is before me. I explore it in all its bearings. My mind becomes pervaded with it. The result is what some people call the fruits of genius, whereas it is in reality the fruits of study and labor (as quoted in Sterling W. Sill, The Upward Reach, p. 125).
If you want to be a technician, performing tests on requests, then just focus on the policies and procedures of your laboratory. **If you want to be a scientist and a professional**, learn the policies and procedures, but go much further and learn the philosophy of your profession. **Understand the importance of why things are done** the way they are done, the scientific method, the viewpoint of the critiques, the issues of bias and the importance of ethics.


www.nist.gov/forensics

301-975-4049  john.butler@nist.gov