S. HRG. 112–671

THE SCIENCE AND STANDARDS OF FORENSICS

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

MARCH 28, 2012

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

77–701 PDF WASHINGTON : 2013

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

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THE SCIENCE AND STANDARDS OF FORENSICS

WEDNESDAY, MARCH 28, 2012

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 2:35 p.m. in Room SR–253, Russell Senate Office Building, Hon. John D. Rockefeller IV, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. JOHN D. ROCKEFELLER IV, U.S. SENATOR FROM WEST VIRGINIA

The CHAIRMAN. Welcome, everyone. You don't see a lot of bodies around here, because we only allowed the two most intelligent, insightful members to be invited to this committee hearing, and so if you believe that, it'll be an easy hearing.

I don't get a chance very often to say that the Commerce Committee is working on truth and justice, but that's what we're doing today, and it's about using more science in our criminal justice system. It's about creating standards that judges, prosecutors, defense lawyers, law enforcement people and juries can trust.

This is the second hearing we've held. We had John Grisham at our first hearing, but what was interesting, and, Senator Boozman, you may remember this, is that—well, I'll get to that, because there was a more interesting witness who was here.

And we heard that there were many disciplines in forensic science, like ballistics, bite marks, even fingerprint analysis, and they're not based on peer reviewed science. And we heard that the forensic science community does not have the resources or sometimes the desire to conduct this type of research, and maybe it's just the money, but that's what—we can talk about all those things.

And most disturbing, and we heard that many forensic scientist disciplines lack what our witnesses call a culture of science, at the last hearing they said that. Too often, therefore, the conclusions that are reached are subjective and lack scientific validation and standards, and, thus, forensics comes under question.

Without properly analyzing evidence, it's hard for law enforcement people to apprehend, prosecute criminals, and it's more likely that our system will wrongfully convict people who are, in fact, innocent.

What's clear at this point is that we need more research and better standards in forensic science. Easily said, but you've got to have

the money to do it. And to be credible, this work needs to be performed by scientific experts outside of the law enforcement culture.

Today, we're going to talk with three leading scientists—I mean, you're all rock stars, even though you're not best selling authors. If you are, raise your hand and I'll duly recognize you. This is about leveraging the expertise of our Federal science agencies to force improvement in this process.

If our shared goal is to build a culture of science in the forensic science disciplines, the National Institute of Standards and Technology and the National Science Foundation are the two Federal agencies we will look to for guidance and for expertise. These two agencies will have become a link between the forensic science and the broader scientific research community.

NIST's work focuses on measurement science and standards of forensics, forensic science, the standards and the measurement. NIST scientists have decades of collaboration under their belts, with the FBI, for example, to improve their hardware and computer programs for fingerprinting screening and all kinds of things.

The FBI Criminal Justice Information Service—I love these things, FBI CJIS—which is based in West Virginia, houses the world's largest biometric database as part of the integrated automatic fingerprint identification system. You wonder why more people don't pursue science?

The FBI CJIS also hosts the Department of Defense's biometrics database that is fully interoperable with the FBI database and includes a broader array of biometrics data including fingerprinting, iris, palm, facial, voice and DNA.

This kind of collaboration between our science, those who practice it, and our criminal justice system will just have to grow and deepen. You know, the culture of science —many other cultures get in the way, too——jurisdictional, who's on top, who's in charge, all the rest of it, which is just classic behavior in our country and I guess everywhere in the world.

But we have to put our evidence standards on a solid scientific footing. That's the point. Putting more science into forensic science is one of the Commerce Committee's top priorities this year. It is for me and I know it is for Senator Boozman. I'm working on legislation that I hope to introduce in April that will apply to this.

My questions today will focus on the best way to apply the Federal Government's scientific knowledge and the resources to this problem, and I look forward to hearing your testimony, and I'm going to introduce you individually.

But I want to call on, now, Senator Boozman and point out that he is just—it's just like he has entered graduate school again. He has taken up the subject of forensic science on his own without any pushing, except from inside of his brain or soul, and he's interviewing everybody in sight and has kinds of group meetings and fora and things that are way beyond my capacity to understand. So I'm really proud that he's here, that he's our Ranking Member, and of him in general.

STATEMENT OF HON. JOHN BOOZMAN, U.S. SENATOR FROM ARKANSAS

Senator BOOZMAN. Thank you, Mr. Chairman. I think that we have had a lot of input from our very competent staffs that are working so hard on this issue. And it really is a very, very important issue, and I appreciate you bringing it to the forefront and allowing us to have these hearings.

As you know, I feel very strongly about this, not only because the field of forensic science is critically important to upholding our nation's criminal justice system, but also because the forensic sciences are a vital element in supporting homeland security and counterterrorism missions and protecting the safety of the public.

In our last forensics hearing, we discussed the many advances that have been made in the field of forensic science over the last two decades that have led to the prevalence of forensic evidence in our judicial system in court rooms, particularly in the realm of DNA technology and medical identifiers, which are widely relied upon by investigators, attorneys, judges and jurists throughout the judicial process.

We also discussed, in part, the recommendations made by the National Academies of Science Report of 2009 and the need for standardization in many specific forensic science areas, as well as hearing, as the chairman mentioned, from people like John Grisham on the tragedy that results from a wrongful conviction based on faulty forensic evidence.

However, as we are all aware, much of the surge of attention in forensic science has come from the Hollywood sets of popular television shows that portray the state-of-the-art forensic laboratories and the use of forensic evidence often as a central factor in their ability to solve crimes in a 60-minute segment.

This, of course, makes for good entertainment, but in reality, these shows grossly misrepresent what our system can accurately rely on in terms of the complexity and uniqueness of the various fields within the broader field of forensic science.

Today, I'm looking forward to hopefully hearing how we can bridge this gap between the basic scientific research in these fields and build a structure that will be accurate and reliable enough to hold up in a court of law in the most effective and efficient manner.

And while there is no doubt that greater peer review research efforts and basic scientific training are necessary to increase crime laboratory capacity and improve the accuracy, precision and reliability that are necessary to build this structure, we must accomplish this by leveraging building upon existing initiatives and expertise within the forensic community.

We must set our focus on strengthening forensic science to ensure reliable findings and improved judicial integrity, national security and public safety without completely reinventing the wheel, and I'm confident that we can all work together and do so.

Just this past week, as the Chairman mentioned, we had the opportunity to sit down in an informal setting with many of the leaders in the forensic community, including Dr. Gallagher, the Director of NIST who's here with us today, and we do appreciate you very, very much, as well as the representatives from NSF, and also the Director, Dr. Lob of NIJ, and the Director of the White House's

Office of Science and Technology Policy, Dr. Holdren. So we truly had an all-star cast and were able to discuss this, again, with myself and our staff who has worked so very, very hard.

The purpose of the meeting was to promote an honest dialogue to address the problems in the field of forensics and discuss proposed solutions in a manner that is often difficult to do during a formal committee hearing.

I was very pleased with the conversation. In fact, I base a large portion of my confidence so we can effectively achieve improvement in an efficient manner on the remarks during the meeting.

I think we all agreed that the best path forward was through better collaboration and coordination of our existing resources. Therefore, I'm very eager to hear the comments and suggestions from today's esteemed panel. I would like to thank all of you for being here today, and so I know your time is valuable, so let's get started. With that, I yield.

The CHAIRMAN. Thank you, Senator Boozman, very much, and you're too modest about yourself.

As I say, I want to introduce each of you, and, first, as it turns out, I'm looking at him, is Dr. Eric Lander, who is a world renowned expert in genomics. Dr. Lander is President and Founding Director of the—is that Eli Broad?

Dr. LANDER. Broad.

The CHAIRMAN. Broad, yes. That's him, though.

Dr. LANDER. That's him.

The CHAIRMAN. Yes, of Harvard and MIT. The Broad Institute propels the understanding and treatment of human diseases by studying their genetic underpinnings.

Dr. Lander is also a professor of biology at MIT. This is kind of impressive. I mean, I don't treat you guys as well, and I apologize, but, I mean, this is impressive.

Dr. Lander is also a professor of biology at MIT and a professor of systems biology at Harvard Medical School and Co-chair of the President's Council of Advisors on Science and Technology, which Senator Boozman just mentioned. So that's quite a lot.

And then Patrick Gallagher, right in the middle, is——I mean, this is an all-star cast. It really is. I mean, I think the last time I was at NIST was 20 years ago, and shame on me. And I drive by the National Science Foundation, but do I come in? No. Shame on me. I mean, the repository of knowledge and the depths of science and the eagerness in those institutions is extraordinary.

So Dr. Gallagher is the Under Secretary of Commerce for Standards and Technology and the Director of the National Institute of Standards and Technology, NIST, at the Department of Commerce. Does one beget the other?

Dr. GALLAGHER. After the COMPETES reauthorization bill of 2010, they are one and the same. Prior to that, I was just Director of NIST.

The CHAIRMAN. You see.

Dr. GALLAGHER. So this committee——

The CHAIRMAN. I helped advance your career.

Dr. GALLAGHER. You did. Thank you.

[Laughter.]

The CHAIRMAN. And, finally, we have Dr. Subra Suresh, who's the Director of the National Science Foundation, an enormous repository of knowledge.

And so, Dr. Lander, you're on.

STATEMENT OF ERIC S. LANDER, PH.D., PRESIDENT AND FOUNDING DIRECTOR, BROAD INSTITUTE OF HARVARD AND MIT; PROFESSOR OF BIOLOGY, MIT; PROFESSOR OF SYSTEMS BIOLOGY, HARVARD MEDICAL SCHOOL; CO-CHAIR, PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY (PCAST)

Dr. LANDER. Thanks very much, Chairman Rockefeller, Ranking Member Boozman, thanks for inviting me here today to talk about this issue of insuring quality and consistency in forensic science.

As you said, I have these other jobs. I direct this Broad Institute, worked on the Human Genome Project and direct the President's Council of Advisors on Science and Technology, but I think the real reason that I was asked to come testify today has to do with an experience I had 23 years ago in the first case in which DNA fingerprinting evidence was seriously examined in our criminal justice system.

I've given you some extended testimony, and I'm just going to try to summarize and describe the key points here.

The CHAIRMAN. Feel free, we're not pressed here.

Dr. LANDER. OK. Well, 23 years ago, I got invited to testify in a case in New York called the *People* v. *Castro,* and in that case—it was a murder case in the Bronx—the defense asked me, because I was a human geneticist, if I would look at the DNA fingerprinting evidence. I did this reluctantly and *pro bono,* but, in the end, I agreed to look at it and to testify and, as much as I was a DNA scientist, the evidence itself was appalling.

There were no standards for declaring when two DNA bands matched. There were no standards for declaring when some nonmatching band could be ignored or should be counted as a nonmatch. There were no real standards for declaring the probability of a match. And testing labs were giving, blithely, numbers like one in 10 billion for the chance of a match, when, in fact, when you probed underneath it, there was no real evidence to support those claims.

That was just the first year or so of DNA fingerprinting, but it was a situation where you had a world class technology developed by molecular biology, but it was being applied in a way that lacked standards.

Well, it was a fascinating case. It was a 15 week, pretrial hearing in the Bronx, and near the end of it, something very unusual happened. Well, unusual for the legal system, maybe not for science.

All the witnesses who had testified on behalf of the defense got together with all the witnesses who had testified for the prosecution, in the middle of the case, without any of the judges or lawyers, and we spent a day reviewing the evidence with each other as scientists would do.

We later found out this isn't the sort of thing that usually happens in the legal system, but it's very typical for scientists. And, at the end of the day, all the scientists who had testified for the

prosecution agreed that the evidence was appalling and agreed to switch sides and testify for the defense.

The end of the day, the judge really had little choice but to declare that DNA fingerprinting was, in principle, a powerful technology, but, in practice, had been applied so sloppily that it couldn't be admitted.

This gave rise to a lot of consequences. I had the tremendous honor to then work together with the FBI's crime lab, in particular, a wonderful scientist called Bruce Budowle at Quantico, on trying to set standards for this.

I served on this National Academy committee that was organized on DNA fingerprinting in the early 1990s, and within about 5 years, based on the efforts of many people working together in the law enforcement community and the scientific community, and bringing very different perspectives, but talking to each other, DNA fingerprinting was put on a firm foundation, the firm foundation it's on today, where it is amazingly sensitive and highly accurate, but it wasn't an accident. It was the result of real robust collaboration between two cultures.

Now, at the beginning, I've got to say, the law enforcement community had serious worries that we were going to have, you know, scientists running around and producing, you know, all sorts of things that would disrupt the use of DNA fingerprinting in the courts.

What ended up happening was exactly the contrary. That collaboration made the technology stronger for prosecutors, made it easy to use for cold cases and for identifying perpetrators of rapes and murders, and it made it more powerful for the defense as well.

In the end, it wasn't a question of being a tool for the prosecution or the defense. It was a tool for truth, and that made a big difference. When we get the truth wrong, we both risk convicting an innocent person, and we risk having a perpetrator still running around on the streets. So the defense and the prosecution have a common interest in getting this right.

Well, the power of DNA fingerprinting, as it became a highly accurate technology, had another unexpected consequence. For the first time, we could go back and look and we, not that I myself was involved, but, we, as a community, could go back and look at past cases and see where we got things wrong.

What we'd call it in science is false positives. Think, times you thought you'd made a match, but, in fact, DNA now revealed you were wrong. And you could then begin to ask how did that happen. How did you make that mistake?

Well, it turns out that in about 60 percent of cases that were examined forensic science had been used in these cases that involved wrongful conviction. So people could go back and ask what was wrong with this forensic science.

On a notable case, there was an honorably discharged veteran who was convicted of murder in Arizona based on bite marks. A forensic examiner said his bite marks matched the bite marks on the neck of the victim, and he was convicted of murder.

He was later exonerated, based on DNA evidence, and the real perpetrator was found, who, incidentally, committed another attack on a girl 20 days after the first case. Had we been able to finger

the right person at the right time, we would have not only avoided convicting an innocent person, but caught a guilty person.

Another case in New York, a rape and murder, where someone was tied to that rape and murder based on hair analysis and soil analysis and fabric print analysis, where an examiner said that they were similar. Well, DNA evidence, 20 years later, set that person free as absolutely innocent, and it points out that hair analysis can be wrong.

And the FBI has found, in a study it did, about one in eight of the matches that were detected in the study were later found to be non-matches, based on DNA evidence, fabric analysis, bite mark analysis. In all of these cases we often lack objective standards for declaring what's a match. What features do you want to declare to be matching? What features can you ignore? What probabilities can you attach?

Well, as you already said, in 2009, the National Academy of Sciences issued an important and a thoughtful report about how to strengthen forensic science, and it pointed out that there are issues. There's nothing wrong with there being issues about a science. Everything has problems. We need to know about what its problems are, so we can make it better.

But the academy recognized that with regard to many of these technologies, they said, and I quote, "The simple reality is that the interpretation of forensic evidence is not always based on scientific studies to determine its validity."

Sometimes, like in the case of fingerprints, there's a lot of information about them, but we still don't have the studies that tell us about our ability to truly match fingerprints, when you have variability on the surfaces it's been put on, when you have partial prints. You get a match based on some criteria, but there still aren't really objective criteria. And there are two notable cases, one involving the Madrid bombing, when fingerprint evidence pointed to the wrong suspect.

So we know that the error rate is not zero. We know it's not perfect. It is not necessary to have a perfect technology. The goal is to have a technology where we understand what it's good for and what its weaknesses are, so we can weigh evidence appropriately.

So, as I say, the big issue is often having a good method for declaring whether things really match or don't match and having a good way to attach probabilities, and that just takes science.

What's the solution to all this? Based on my experience with DNA fingerprinting, based on what I saw 23 years ago, I know what the solution is. It is getting a collaboration between the scientific community and the law enforcement community working together.

The National Academy was unambiguous in its report. This can't be done within the Department of Justice alone. Now, there's nothing wrong with the Department of Justice. There are fantastic public servants there, but the people who are practicing a technology and using it day by day in law enforcement can't be the people who can stand back and objectively say what's wrong with it, what are the problems with it.

You can't have the same community both be the advocacy users and the skeptics about a technology. It's a marriage of the users

and independent skeptics working together that make things better.

How do we fix it? Well, look, in my opinion—and I'm going to emphasize, despite co-chairing the President's Council, I'm here today as an individual. I'm not speaking on behalf of the administration, but I'll give you my opinion about it, which is that we need a partnership between the DOJ and these two agencies here, NIST and NSF.

With regard to setting the standards in forensic science, there's no doubt that the DOJ clearly has an essential role in identifying the most important needs and in promoting the widespread adoption of standards.

But there's also no doubt in my mind that NIST should clearly take the lead in identifying where our gaps in research are, where the weaknesses are, and in developing and proposing specific standards and best practices for measurement, for analysis and for interpretation. The two agencies need to work together, but each needs to lead in its own respective domain.

There are many ways one can organize to do that through appropriate task forces led in one or the other agency, and I'm not going to suggest how to micromanage that, but we clearly need clear and crisp processes that will accomplish those two distinct but complementary goals.

With regard to research—forensic science research—we need a robust scientific research agenda to develop the most important body of empirical evidence to be used, the most effective technologies to be used.

So the NIJ provides some limited funding for forensic science research, and that's a good thing, but I think the NSF has a critical role to play in supporting basic research underlying forensic science. The setting of that agenda must surely be a collaboration between the law enforcement community that says here are the things we desperately need and the scientific community that says here's how we can find those things out.

So I'm going to say for both NIST and NSF, I don't want to create unfunded mandates. I hope, in fact, that both of these agencies will proceed to do this, and I hope they will have the additional resources necessary to be able to do these well, because this serves justice overall, prosecutors, defense, and, most importantly, the whole American people.

So, in any case, in closing, based on my experiences of a very successful situation 23 years ago, I think it is possible to bring together these two cultures. I think we can make tremendous strides in advancing the quality of forensic science.

I am sure there are people today in the law enforcement community who will worry about how will all this science weaken the tools. I think they may have it backwards. I think if this collaboration happens it will strengthen the tools. These tools will become more powerful by being better understood. They will become cheaper to use. We'll be able to use them in local jurisdictions. They will make them efficient, will make them reliable. I think that is a win for everybody.

I'm pleased to see the activity in both the executive branch that I've gotten to observe in my role as the Chair of the President's

Council, and here with this committee's own interest and its attention in the legislative branch to these important problems. And with everybody's continued attention, I think we can enlist the full power of science in the service of justice.

Thank you.

[The prepared statement of Dr. Lander follows:]

PREPARED STATEMENT OF ERIC S. LANDER, PH.D., PRESIDENT AND FOUNDING DIRECTOR, BROAD INSTITUTE OF HARVARD AND MIT; PROFESSOR OF BIOLOGY, MIT; PROFESSOR OF SYSTEMS BIOLOGY, HARVARD MEDICAL SCHOOL; CO-CHAIR, PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY (PCAST)

Chairman Rockefeller, Ranking Member Hutchison, and Members of the Committee:

Thank you for inviting me here today to speak to you about an issue of tremendous importance for our nation and our justice system: ensuring the quality and consistency of forensic science relied upon in criminal proceedings.

My name is Eric Lander. I am the President and Founding Director of the Broad Institute of Harvard and MIT, which was the leading contributor to the International Human Genome Project a decade ago and works today at the forefront of genomic medicine. I am also the co-chair of President Obama's Council of Advisors on Science and Technology (PCAST), which is the external scientific advisory group to the White House. I want to emphasize, however, that I am not here today to represent the Administration's position. Rather, I have been asked to testify based on a longstanding personal interest that traces back 23 years, to my involvement in the earliest days of DNA fingerprinting.

Today, we consider DNA fingerprinting to be the gold standard for forensic science. It's a staple on television in the fictional crime-solving on "CSI" and on "Law and Order"; and in reality, it is a technology with amazing sensitivity and near-flawless accuracy.

But, this wasn't always the case.

In 1989, I participated in one of the first DNA fingerprinting cases in the United States—a New York case called *People* v. *Castro.* Because DNA fingerprinting was such a new technology and I was a molecular geneticist with expertise on the human genome, the defense asked me to review the evidence and to testify in a pre-trial hearing on the admissibility of the DNA evidence. I did so reluctantly and insisted on doing so *pro bono.*

To make a long story short, the evidence turned out to be appalling. There were no objective standards for declaring when two DNA bands matched; for deciding when non-matching bands could be ignored as "noise"; or for calculating the probability of a match. The testing labs were issuing breathtaking statements that particular DNA patterns had frequencies of less than one in 10 billion—in effect, asserting that they were unique, despite the lack of any rigorous support for these claims.

The pre-trial hearing lasted for 15 weeks. Near the end, the scientific experts who had testified for the defense and the prosecution took an unusual step—unusual, at least, for the legal system. We decided to have a one-day joint scientific meeting to review the evidence together, without the lawyers or judges.

At the end of the day, the scientific experts for the prosecution agreed with those for the defense that the DNA evidence was unacceptable. They decided to switch sides and testify for the defense. Needless to say, the judge excluded the DNA evidence—deciding that DNA fingerprinting was reliable in theory but not as practiced.

It was a triumph of the scientific method and the scientific culture.

Following the case, I worked with others to ensure that we had reliable standards for DNA fingerprinting. I had the pleasure to work closely with extraordinary public servants in the FBI's Crime Lab, including Bruce Budowle, of the FBI's unit at Quantico. And, I served on the first of two committees assembled by the U.S. National Academy of Sciences on DNA fingerprinting. Sometime later, I also agreed to serve on the Board of the Innocence Project.

Within about five years, DNA fingerprinting was put on firm foundation—through a robust collaboration of law enforcement on the one hand and independent scientists on the other. It was the alchemy of rigorous scientific attention that turned DNA fingerprinting from base metal into the gold standard it is today.

At the beginning, the law enforcement community had serious concerns about inviting independent scientists to set standards because they worried that it might weaken DNA fingerprinting as a law enforcement tool. In fact, DNA became a

stronger tool for the police and prosecutors—making it possible to revive cold cases, to catch serial rapists and murderers. And, DNA also became a stronger tool for the defense to protect those who were wrongfully accused.

In the end, DNA became a tool not for the prosecution or for the defense, but for the truth, which is the main goal. When we fail to find the truth, we may fail society in two ways—by locking up an innocent person and by leaving a criminal free to commit more crimes.

The power of DNA fingerprinting had another unexpected and very important consequence. For the first time, it gave us a way to revisit old cases and to prove that some people had been wrongfully convicted—to prove that hundreds of people in jail were actually innocent; to prove that at least 17 people who had been on death row were actually innocent; and to infer that, in all likelihood, at least some people who had been executed were actually innocent.

Because many of these wrongful convictions involved forensic science, it became important to ask how the forensic science testimony could have been wrong. The goal here is not to point fingers. The goal is to identify errors, understand the reasons and improve the science so that it is accurate. That's how science advances in research labs and in clinical labs. And, it is how science must advance in the justice system.

We have learned a lot, both from legal cases and from scientific studies, about the need for improving forensic science.

A paper by Garrett and Neufeld in 2009 reported that, in 137 cases where transcripts of forensic testimony were available and a convicted person was later exonerated by DNA evidence, roughly 60 percent involved problematic forensic testimony.

The cases included ones like that of an honorably discharged veteran who was wrongly convicted of murder in Arizona based in part on a comparison of a Styrofoam impression of his teeth with bite marks on a murder victim's neck. DNA testing eventually led to the veteran's exoneration in 2002. (In fact, the actual perpetrator went on to attack a young girl 20 days after the murder, a crime that might have been prevented had the police had the right suspect.)

In another illuminating case, a man was convicted of rape and murder in New York, in part on the basis of hair analysis, soil comparison, and fabric print analysis. The forensic expert reported similarities of hair, soil and fabric prints from the man's truck and from the crime scene and victim. Yet, there were no empirical data on the frequency of those materials, so no way to know how common such characteristics or "matches" might be. DNA testing eventually exonerated the man nearly 20 years after his conviction.

In 2009, the National Academy of Sciences issued an important and thoughtful report about strengthening forensic science. It cited serious issues with the analysis and interpretation of forensic evidence.

It cited, for example, an FBI study that found that ⅛ of hair samples said to "be associated" based on microscopic comparison were subsequently found to come from different people based on DNA analysis.

It noted serious issues with bite marks, tool marks, and fiber comparisons, including the lack of objective standards and the lack of meaningful data and databases from which the probability of matches can be inferred. It identified issues with fingerprints, whose evidentiary value depends importantly on the quality of the latent fingerprint image and for which fully validated analysis methods are still needed.

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

I should emphasize that the problem is often not with the technology per se. As we saw with DNA fingerprinting, it is often that there is a lack of serious scientific standards for analysis and interpretation—that is, (1) methods for deciding that two

samples are similar matches and (2) methods and databases for attaching meaningful probabilities to such similarities. Without scientific standards for measurement, analysis and interpretation, expert opinion is not scientific and thus not meaningful in court.

What is the solution? As it was with DNA fingerprinting, the answer lies in drawing on two cultures—the criminal justice community, which understands most fully the needs for and uses of forensic evidence, and the independent scientific community, which understands most fully the principles of rigorous scientific analysis.

The National Academy of Sciences report was unambiguous that the task could not be accomplished within the criminal justice community alone. In particular, it concluded that "advancing science in the forensic science enterprise is not likely to be achieved within the confines of the [Department of Justice]". The National Academy report went so far as to recommend the creation of an independent National Institute of Forensic Sciences, within or associated with a science-based agency.

For my part, I think that it may be possible to achieve these goals through a partnership between the DOJ and two science-based agencies, NIST and NSF. But, it will be important that the partnership have clear and complementary roles.

[1] With respect to standards for forensic science:

DOJ clearly has a central role in (i) identifying the most important needs for forensic measurement, analysis and interpretation, and (ii) promoting the widespread adoption of good standards for forensic science throughout the justice system.

NIST clearly should take the lead in (i) identifying research gaps and weaknesses in forensic science and (ii) developing and proposing specific standards and best practices for forensic measurement, analysis and interpretation.

The two agencies should actively engage the other in the work, but it is important that the distinct activities have distinct leadership. Scientific standards should be based on robust input from the broad scientific community—not simply the input of forensic scientists or practitioners. As emphasized in the report from the National Academy of Sciences, scientific standard-setting should be led by a science-based agency such as NIST, not units within DOJ. Conversely, the adoption of standards requires the perspective of practitioners. It should be led by DOJ.

In my opinion, the partnership between NIST and DOJ should be formalized through appropriate advisory committees or task forces with assigned responsibilities.

[2] With respect to forensic science research:

We need a robust scientific research agenda to support the development of a body of empirical knowledge on the validity of technologies and methods. This would greatly help the cause of advancing the status of forensic science.

While the National Institute of Justice (NIJ) provides some support for forensic science research, the program has very limited funding and engages a very limited scientific community—both in its grantees and its peer reviewers.

I believe that NSF has a critical role to play in supporting basic research underlying forensic sciences. The NSF engages the full breadth of the U.S. scientific community in both research and peer review.

For both NIST and NSF, I do not want to create unfunded mandates. I believe that some additional funding will be required to NIST and to NSF to carry out these roles with respect to forensic science.

In closing, based on my experiences with the evolution of DNA fingerprinting, I believe it is possible that by bringing together the two cultures of science and justice, we can make large strides in advancing the quality of forensic science.

Again, I speak only for myself here. But, I am pleased to see that both the Executive and Legislative branches have become increasingly attentive to the issues of ensuring quality and consistency in forensic science. I am very hopeful about the various activities underway in both branches—including an ongoing process within the National Science and Technology Council, discussions in recent months among representatives of the departments and agencies that have equities in forensic science, and the interest of this Committee. With everyone's continued attention, we can enlist the full power of science in the service of justice.

Thank you.

The CHAIRMAN. Thank you, and you've given me some questions to ask you.

Now, we should go to you.

STATEMENT OF PATRICK D. GALLAGHER, PH.D., UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY, U.S. DEPARTMENT OF COMMERCE

Dr. GALLAGHER. Thank you very much, Mr. Chairman and Ranking Member Boozman, for your leadership on this topic, and I want to include Senator Udall, and——

The CHAIRMAN. Yes, I forgot to introduce him. He's from some state.

Senator UDALL. A very important state.

The CHAIRMAN. New Mexico, right? And he's just pure gold. And he was the third person who was admitted to this august dais today. There'll be no more.

Dr. GALLAGHER. As an Albuquerque native, I'm a little bit biased.

The CHAIRMAN. Oops.

[Laughter.]

Dr. GALLAGHER. But I have to agree.

It's a real pleasure to be here today and to discuss the role of measurement science and forensics. As you know, NIST has a specific mission and that mission is to define a uniform scientifically based national system of measurement and to support those who have to use that system of measurement, whether it's industry or whether it's other Federal agencies, or practitioners.

The scientific basis for accurate measurements using the most rigorous, soundly defensible and universally accepted science that gives accurate, reproducible and reliable measurements underpins any system like this.

The hallmark of NIST mission in measurement science is that there is a scientific basis for every measurement, and a well-defined system of traceability to that basic unit of measurement, so that the uncertainty and precision of the measurement can be defined and understood.

NIST also supports the quality and integrity of the measurement system, including forensic measurements, and this includes services like providing validation of methods, performing primary calibration services, providing calibration artifacts, such as Standard Reference Material, standards data and supporting laboratory accreditation programs.

In the context of this mission, NIST has always played a role in supporting forensic science. In fact, as early as 1913, NIST was the nation's *de facto* criminal forensic science laboratory. And it was NIST, then the National Bureau of Standards, that the FBI turned to in 1932 to help them establish their laboratory and train their scientists in the principles of forensic investigation.

In fact, it was an NBS scientist whose analysis of the ransom letters from Charles Lindbergh helped lead to the conviction of that kidnapper.

Today, by comparison, the range of measurements used by our law enforcement community is extraordinarily broad. There are nearly 400 forensic laboratories in the United States. More than 90 percent of those are at the state and local level, not the Federal level, and they are dedicated to some aspect of forensic science.

The NIST programs provide a wide range of services to support these laboratories across a broad range of measurements, including

chemical analysis, biological, radiological and nuclear detection and analysis, fire and explosives analysis, gunshot residue, latent fingerprint analysis, biometrics, digital evidence and many other areas.

Our laboratory program validates the performance of measurements and provides services to help laboratories and practitioners assure the equality of those measurements, so that forensic specialists can reliably, routinely and repeatedly provide the services they are called upon to provide.

In the area of forensic science, NIST is perhaps best known for our work in DNA. One of NIST's researchers, John Butler, is a leading expert in this area and has worked developing a new DNA analysis approach which uses smaller fragments of DNA than ever before, was essential in helping to identify many more of the victims of the September 11 attacks——

The CHAIRMAN. Did he go to Stanford?

Dr. GALLAGHER. John Butler?

The CHAIRMAN. Yes.

Dr. GALLAGHER. I'd have to look at his bio.

The CHAIRMAN. Yes. Because I may know him. I'm just—I'm sorry. Just struck me.

Dr. GALLAGHER. The NIST work in DNA profiling, testing helped establish the methods and support the methods now routinely used across all crime labs to match individuals to evidence samples.

The FBI requires that forensic DNA labs use this Standard Reference Material to calibrate equipment before any of the data can be entered into the National Criminal DNA Data base. The National Institute of Justice also requires that crime laboratories it funds use the same methodologies and tools.

Our work in DNA analysis is the gold standard in forensic science, and what makes that true is the scientific rigor and grounds of that work. The measurements are so precise that a DNA sample for any one individual can be accurate to a very high level. No other area of forensic science has achieved that level of precision. And what we stand ready to do is to bring our measurement science expertise and approach to many other areas of forensic science.

NIST is working to identify sources and to develop standard procedures for minimizing the chance of error in impression analysis, a very difficult area, including fingerprints and ballistics.

We also have a technical working group on biological evidence preservation. Some of the resources NIST has developed in this field include databases such as our latent print database, our short tandem repeat DNA, Internet database and the world's largest database of literature related to DNA research.

We also have expertise in cell phone and computer forensics including the recovery of deleted files and logs.

Of course, with growing demand in this area, our budget request for 2013 included a specific increase in this area.

Mr. Chairman, this measurement science and standards role, our expertise and our dissemination of both the research and the tools to support the practice of measurement is a key part of our mission. We look forward to aligning this, so that it can support the forensic science community.

And I want to thank you, once again, for this opportunity to discuss this with you.

[The prepared statement of Dr. Gallagher follows:]

PREPARED STATEMENT OF PATRICK D. GALLAGHER, PH.D., UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY, U.S. DEPARTMENT OF COMMERCE

Chairman Rockefeller Ranking Member Hutchison, and Members of the Committee, thank you for the opportunity to appear before you today to discuss the importance of forensic science. The Department of Commerce's National Institute of Standards and Technology (NIST) has a long history of collaboration in the area of Forensic Science. In the Fiscal Year 2013 (FY 2013) budget NIST has requested $5 million for an initiative that will enable NIST to create a strategic program to broadly address the most critical issues in Forensic Science today.

NIST's Role in the Forensic Sciences

NIST was founded with a specific mission—to define and advance a uniform, scientific, national system of measurement to support industry and other Federal agencies. This system of measurement is underpinned by NIST's measurement science research. This scientific basis for accurate measurements using the most rigorous, soundly defensible, and universally accepted science gives accurate, reproducible, and reliable measurements. In this context, Forensic Science has always been part of NIST, since much of Forensic Science is about forensic measurements.

Measurement and forensic scientists are bound by mutual interests in accuracy and uncertainty, a quantifiable expression of the quality of our measurements. NIST works to resolve the uncertainty as it pertains to all types of applied sciences. Resolution of uncertainty will lead to the accuracy that is necessary in many applications, including Forensic Science. Some of the other areas NIST has measurement expertise in that have applicability in Forensic Science are dimensional analysis, chemical and material analysis, DNA, structural fire analysis, radiation signatures and digital data.

One of the founding principles for NIST is establishing traceability in the marketplace for measurement. The work NIST does with measurement standards and their traceability to NIST research provides the crucial framework for measurement.

Justice can, in some instances, quite literally hang on a single thread, or in the parlance of forensic scientists, a single fiber. Forensic scientists are under a tremendous amount of pressure to not only get it right but also to explain methodologies and results to a judge and jury. NIST can and does provide metrics to help define the resolution of methods and the veracity of the results.

The next piece of the NIST mission is our role in standards. NIST's measurement research allows NIST to inform the standards function and make sure that the standards are realistic and scientifically valid, in this case for use in labs and the field. For NIST to perform our standards role well, we must have independent measurement science research in the appropriate disciplines of forensic science.

The Past, Present and Future of Forensic Science Measurement and Standards at NIST

NIST has supported forensic science throughout our history. In fact, from 1913 until the Federal Bureau of Investigation (FBI) hired its first scientist in 1932, NIST was the Nation's de facto criminal forensic science laboratory. Our involvement in the forensic sciences originates with Wilmer Souder—one of the Nation's best and least known criminologists to whom the FBI turned in 1932 to help them establish their lab and train their scientists in the principles of forensic investigation.

Souder's interest in forensic science began in 1913, when famed document examiner Albert Osborn sent some precision measuring devices to NIST for calibration. By the 1930s Souder had become a pioneering expert in the identification of questioned documents, handwriting, typewriting, bullets, cartridge cases, and firearms. In his nearly 40 years at NIST, he assisted almost 1,000 Federal investigations of crimes, including extortion, forgery, kidnapping, murder, bootlegging, and theft.

Perhaps most famously, Souder was among the handwriting experts whose analyses of the ransom letters helped to convict Bruno Richard Hauptmann for the kidnapping and murder of Charles Lindberg, Jr.

NIST continues this long history of work in support of law enforcement. We have worked with the Department of Justice, the Department of Homeland Security, and the Department of Defense toward the development of standards for body armor, nonlethal weapons, and explosives detection technologies, among others.

In the area of forensic science, we are perhaps best known for our work in DNA analysis. One of our researchers, John Butler, Ph.D., Leader of the Applied Genetics Group, literally wrote the book (actually, he wrote four books with another on the way) on forensic DNA typing. Butler's work, developing a new DNA analysis approach which uses small fragments of DNA, was essential in helping to identify the victims of the September 11, 2001 attacks on the World Trade Center.

NIST continues its work to further improve techniques for identifying severely degraded DNA and advance the state-of-the-art for forensic DNA typing. NIST also produces Standard Reference Materials for calibration and quality control for forensic science and genetics laboratories throughout the United States and the world. NIST's work in genetic kinship analysis made it possible for police in California to catch a killer known as the "Grim Sleeper," who had been at large for more than 20 years.

The FBI already requires that forensic DNA labs use NIST's Standard Reference Materials (SRMs) for quality assurance before they may enter their data into the national criminal DNA database. The National Institute of Justice (NIJ) also requires that the crime laboratories it funds use these SRMs.

Many broad aspects of NIST's work have applicability in forensic science. Measurement is the comparison of a known to an unknown, and NIST's job is to supply forensic science labs with as many knowns as possible by actively offering our measurement expertise and continually working with the community to help them do their jobs more effectively.

Some of the resources NIST has developed that are used in the field include databases such as our mass spectroscopy database and our latent print database. We also have expertise in cell phone and computer forensics, including the recovery of deleted files and logs. Additionally we have fire research and arson investigation expertise that have provided assistance in major investigations such as the World Trade Center building collapses, the Rhode Island nightclub fire, and the Chicago high-rise fire, as well as an extensive array of fire modeling software. We've been performing fire research for a very long time. We have provided guidance in fire research by initiating the compilation of best practices, resulting in the 1980 publication of the Fire Investigation Handbook, and through this publication, entered into a close partnership with the National Fire Protection Association.

NIST is working to identify sources and develop standard procedures for minimizing the chances of error in impression analysis, including fingerprints and ballistics. We also have a technical working group on biological evidence preservation.

The work done by the NIST can help to establish a more solid scientific basis for comparing samples and interpreting the types of evidence mentioned earlier. A more scientific basis for comparison will give the forensic science and law enforcement community a better understanding of how well those interpretations can be trusted. The goal is to provide a vocabulary that will help define the limits of certainty so police officers and forensic scientists can testify before a jury and say this evidence came from that suspect with a quantified confidence.

There are nearly 400 labs in the U.S. dedicated to some aspect of forensic science. These labs operate under a variety of standards, mandated at the state or local level and that may be unique to each department.

There is, of course, much to be said for expertise, but even experts can make mistakes. This is why standards are important. Standards unite our efforts and help us to speak with one voice. They bolster trust. They set a minimum level of performance, a baseline for defining success, and a vocabulary for expressing degrees of confidence with consistency and objectivity.

Measurement Science and Standards in Support of Forensic Science in Fiscal Year 2013

The $5 million initiative proposed in Fiscal Year 2013 request will enable NIST, in coordination with DOJ, to create a strategic program to oversee and manage standard development in forensic science.

Forensic science must deal with an incredibly wide range of interdisciplinary fields, from DNA sequencing to electron microscopy to the visual matching of patterns like footprints or tool marks. Often evidence samples are degraded, incomplete, or available only in very small amounts, which also presents challenges for developing the full range of measurement tools required for ensuring confidence in results.

In 2009, a committee of the National Research Council (NRC) made a number of important recommendations for strengthening the public's trust in forensic science findings. The recommendations included strong support for improved measurement and validation methodologies, development of additional forensic science standards,

and dissemination of best practices to strengthen the precision and reliability of forensic science analyses.

NIST's work in advancing forensic science led the NRC to explicitly name NIST as one of several Federal agencies that should collaborate on developing new forensic science measurements and standards. Working with NIJ and other agencies through reimbursable funding, NIST has measurement science research under way in chemical, biological, radiological, and nuclear detection and analysis; fire and explosives analysis; gunshot residue, latent fingerprints, and many other areas. NIST's work in DNA profiling and testing, for example, helped establish the methods now used by all crime laboratories to match individuals to evidence samples.

With the requested $5 million initiative, NIST will be able to develop state-of the art measurement science and standards as the basis for forensic disciplines and technologies. Working with stakeholders, NIST has identified critical areas of investment that will be complementary to current research. It will also provide practitioners with analyses in disciplines that require more research in the near term, including areas in which quality control is acknowledged as the most pressing issue, and in which significant investment in human capital or equipment is necessary to make an impact. Examples of priority program areas in this new initiative include: new reference methods and technologies for understanding crime scenes and identifying criminals, including the uncertainty and standards associated with those techniques; improved calibration systems, reference materials and databases, and technology testbeds for ensuring reliable and accurate forensic science practices; and development of rigorous training programs.

A major outcome of this initiative will be to strengthen the utility and reliability of forensic science evidence in the courtroom. This work also has the potential for significant cost savings for the U.S. justice system by reducing the number of mistrials and appeals related to questions about forensic science analysis. One economic analysis of cost savings from forensic DNA testing alone estimated a cost savings of $35 for every dollar invested; the same analysis predicted that if DNA testing were fully utilized the United States could expect a $12.9 billion annual savings in prevented crime.[1]

NIST anticipates additional impacts to include new, innovative forensic science technologies; increased use of documentary standards and measurement services by the forensic science community; and the creation of reference materials, reference databases and new calibration services to improve the consistency of the implementation of forensic science across the Nation.

In conclusion, public trust in the justice system relies on the validity and certainty of evidence presented to the courts. Increasingly, that evidence is gathered and analyzed with innovative forensic science technologies. Any time a new technology is developed, accurate measurements, standards, and uncertainty estimates are needed to ensure that the technology works as intended.

That is where NIST's expertise in the forensic sciences is critical, and our Fiscal Year 2013 request will build a stronger forensic science program at NIST.

Thank you again, for the opportunity to testify today, I would be happy to answer any questions you may have.

The CHAIRMAN. Thank you very much.

Dr. Suresh.

STATEMENT OF DR. SUBRA SURESH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. SURESH. Thank you, Mr. Chairman, Ranking Member Boozman, Senator Udall, thank you so much for inviting me to testify today.

Mr. Chairman, I also want to take this opportunity to thank you again for your support of science, and also of the National Science Foundation.

As you well know, NSF supports basic research and education at the frontiers of knowledge in all fields of science and engineering and at all levels of education, science and engineering education.

[1] Butler, John. "Fundamentals of Forensic DNA Typing," Academic Press 2009, p.261.

Many of NSF's activities contribute directly to building the human capital, the infrastructure and advanced methods needed to ensure the vigor and vitality of the forensic sciences.

NSF supports significant basic research that may be applied in forensic settings. Supported research investigates the effectiveness of currently employed forensic science approaches and explores potential applications of cutting edge theory and technologies.

NSF awards across the foundation support training and activities and programs which directly address the need of the 21st century forensics workforce.

A search of recent NSF awards shows that the foundation has supported 147 awards just in the period 2009 to 2011 that contribute to the strengthening of the forensic sciences. So in keeping with my One NSF philosophy, each of the foundation's seven directorates contributes to this effort.

The awards represent many facets of NSF activity including basic research awards, major research instrumentation, small business innovation research, student support, as well as workshops.

Just in this period from 2009 to 2011, more than $50 million of research has been awarded to institutions in 36 states and in the District of Columbia, large and small colleges and universities, EPSCoR states, minority-serving institutions, community colleges and small businesses.

Let me provide you with just a taste of our activities in support of the forensic sciences. Our data analysis also shows that there are more than 200 current awards that are supported by NSF.

With support from the Social, Behavioral and Economic Sciences Directorate, or SBE, researchers at the University of Arkansas are investigating how to overcome obstacles to the assessment of likely age changes in facial features.

An award by the Computer and Information Science and Engineering Directorate is using computer approaches to handwriting examination, which contributes to the scientific analysis of documents of questioned authorship.

NSF has long used workshops to identify cutting-edge opportunities for future directions. In fact, after the NRC report was published in 2009, NSF-supported workshops including one on cognitive bias and forensic science, that was at Northwestern University and another one on nanoscale science and technology for forensics.

NSF supports activities designed to achieve excellence in U.S. science education. Students participate in supported research and thereby gain skills that are transferable to crime labs.

Some awards specifically expose students to research in a forensic setting. A project at Tuskegee University, Auburn University, as well as Mississippi State University provides occupational training to America's veterans in digital forensics.

Other awards, including one at Arkansas State University, capitalize on the popularity of shows such as CSI to engage students in science.

NSF provides funding for small business innovation research to stimulate technological innovation in the private sector, and a number of awards support commercial development of technologies applicable to forensic settings.

Likewise, investments in infrastructure provide databases and instrumentation used in forensic applications and research.

NSF also works collaboratively with other agencies. The award that supports training of veterans was made in coordination with the Department of Veterans Affairs.

Our science staff serves on the National Science and Technology Council Subcommittee on Forensic Science, and SBE, our Directorate on Social, Behavioral and Economic Sciences, is developing a memorandum of understanding with the National Institute of Justice to facilitate support of relevant forensic sciences.

So, in summary, NSF has supported and is committed to continue supporting the basic sciences that form the foundation for forensic applications, to collaborate with other mission agencies and to support science education opportunities necessary for the 21st century, especially in the area of forensic sciences.

Thank you, Mr. Chairman. I'll be happy to answer any questions.

[The prepared statement of Dr. Suresh follows:]

PREPARED STATEMENT OF DR. SUBRA SURESH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Introduction

Chairman Rockefeller, Ranking Member Hutchinson, and distinguished Members of the Committee, thank you for inviting me to participate in this hearing on "The Science and Standards of Forensics."

I am pleased to have the opportunity to discuss the National Science Foundation's (NSF) investments that strengthen the forensic sciences in the United States.

As you well know, NSF supports research at the frontiers of knowledge across all fields of science and engineering (S&E) and all levels of S&E education. Its mission, vision and goals are designed to maintain and strengthen the vitality of the U.S. science and engineering enterprise. In this role many of NSF's activities contribute directly to building the human capital, infrastructure and advanced methods needed to ensure the vigor and quality of the forensic sciences.

NSF is supporting significant basic research that may be applied in forensic settings both in the near and longer term. Supported research investigates the effectiveness of currently employed forensic science approaches and also explores potential applications of cutting edge theory and technologies. Activities in NSF's Education and Human Resources Directorate, as well as in basic science directorates, support training programs and activities which directly address the need for a 21st century forensics workforce.

A search of the NSF Awards Abstracts Database identifies 210 active awards using the search-term "forensics." Each of the Foundation's 7 directorates is represented in this sample of awards. Of these awards, 147 were made in the years 2009–2011 and several awards have been made thus far in 2012. The awards represent many facets of NSF activity including basic research awards, Major Research Instrumentation, Small Business Innovation Research, Doctoral Dissertation Improvement awards, Research Experience for Undergraduates, and Workshops. For 2009–2011alone, the awards total in excess of $53 million and awards were made to institutions in 36 states and the District of Columbia. Awards were made to large and small universities, state and private universities, minority-serving institutions, small liberal arts colleges, community colleges and a number of small businesses. Awards have also included collaborations with international scholars.

After a brief discussion of background issues I will provide you with a number of examples of our activities in support of the forensic sciences. I will also point to several actions currently underway at the Foundation that should enhance our contribution to this effort.

Background

In 2009, the National Research Council (NRC) published "Strengthening Forensic Science in the United States: A Path Forward." The report was prompted by the Senate's concern in 2006 that ". . .there exists little or no analysis of the remaining needs of the (forensic science) community outside the area of DNA."

The NRC report goes on to indicate areas where it determined there to be significant challenges facing the forensic science community:

- lack of mandatory standardization, certification, accreditation
- disparities between local, state and Federal laboratories
- insufficient funding for instrumentation
- unacceptable backlogs

The most significant comment that has direct relevance to NSF is that

> . . . forensic science . . . research, education, and training lack strong ties to our research universities. The forensic science system is underresourced also in the sense that it has only thin ties to an academic research base that could support the forensic science disciplines and fill knowledge gaps (pg 15).

Further, the report advocates for investment in research:

> . . . of the various facets of underresourcing, the Committee is most concerned about the knowledge base. . . . [There are] fundamental limitations in the capabilities of forensic science disciplines to discern valid information from crime scene evidence (pg 15; emphasis added).

Activities at NSF that contribute to Strengthening Forensic Science

Workshops

NSF has long used workshops and other small gatherings of scholars and members of relevant communities to discuss cutting edge ideas and to identify and investigate gaps in knowledge and to propose future directions. In the area of forensic science, NSF has supported several workshops in the recent past; the NSF awards database lists 11 active awards containing the key words "forensic science" and "workshop."

Two recent examples:

> In direct response to a recommendation of the NRC report that research on human observer bias be encouraged, the Behavioral and Cognitive Sciences Division of the Social, Behavioral and Economic Sciences (SBE) Directorate supported "Cognitive Bias and Forensic Science" at Northwestern University in September, 2010. The workshop brought together lawyers, forensic scientists, and academic researchers in the area of cognitive bias to examine the role that psychological factors may play in forensic pattern recognition. The report of the workshop is available at *http://www.law.northwestern.edu/faculty/conferences/workshops/cognitivebias/*. In line with the workshop goal to ". . . convert general theories and testable hypotheses into concrete research proposals" attendees continue planning the development of joint research projects.
>
> The Division of Electrical, Communications and Cyber Systems/Directorate for Engineering (ENG) supported a workshop in August 2011 on "Nanoscale Science and Technology for Forensics" at the University of Connecticut. "The workshop assembled key experts from nanotechnology areas (optoelectronics, materials, fabrication, engineering and medicine) to focus on applications in forensic science." This multidisciplinary meeting was designed to advance identification of future research needs and to promote new collaborations. The workshop also established recommendations for the development of programs for training graduate and undergraduate students to become the next generation of forensic scientists and engineers. A special effort was made to include student attendees.

Training Activities

NSF supports numerous activities designed to achieve excellence in U.S. science, technology, engineering and mathematics (STEM) education at all levels and in all settings (both formal and informal) in order to support the development of a diverse and well-prepared workforce of scientists, technicians, engineers, mathematicians and educators, as well as a well-informed citizenry. This is certainly the case in the realm of forensic science. Many students participate in NSF supported research and thereby gain exposure to the conduct of research and some of these students ultimately focus their attention and career in a forensic science. In addition, there are a number of awards that specifically expose students to research in a forensics setting.

Some awards capitalize on the popularity of shows such as CSI to engage students in science. One example is an award to Arkansas State University titled "CSI: Classroom Student Investigations" that was supported by the Division of Research on Learning in Formal and Informal Settings/Directorate for Education and Human

Resources (EHR). This project ". . . uses the popularity of the Crime Scene Investigation television show . . . to train teachers in forensic science topics and use that training in their science classrooms to stimulate and encourage middle and upper school students in science topics generally." Upon completion, the project will ". . . examine the impact on students' interest in STEM careers in classrooms of participating teachers and examine how participation in the program affects participating teacher implementation of reform based pedagogy and technology."

Other basic research projects, while not focused on educational goals, include capacity building components. With support from the Division of Mathematical Sciences of the Directorate for Mathematical and Physical Sciences (MPS), researchers at Michigan State University are investigating modeling and computational issues in fingerprint analysis. A central question in fingerprint analysis is the individuality of a person's prints. The whorls, ridges and valleys present complex data that lead to the assumption of uniqueness. But in a legal setting, there are significant questions as to what constitutes a match when comparing a latent print from a crime scene and those of a defendant. These researchers are developing computational models for addressing the question of uniqueness and this may significantly impacts how fingerprint evidence is reported and used for the identification of individuals. Graduate students working with the principal investigators will be equipped with the analytic, computing and methodological skills that are necessary to perform high level forensic research.

Basic Research

Numerous basic research projects have potential applications in forensic science. Questioned Documents analysts attempt to extract information from a document utilizing as many sources as possible, including handwriting analysis. A recent Early Concept Grants for Exploratory Research (EAGER) award by the Division of Information and Intelligent Systems/Computer & Information Science and Engineering (CISE) to a researcher at SUNY Buffalo is using computer approaches to "Automatic Identification of Writer Accent and Script Influences in Handwriting." The investigator is testing hypotheses with respect to handwriting analysis by examining and analyzing the written works of native and non-native writers of a particular script or alphabet.

One of the most recent awards, supported by the Division of Behavioral and Cognitive Sciences of the Social, Behavioral and Economic Sciences (SBE) Directorate, uses GPS to track vultures. Vultures arrive early in the process of decomposition of human remains and leave few clues to indicate their scavenging activity. This can greatly complicate medico-legal death analysis. This doctoral dissertation improvement award seeks "to establish a predictability model of likely vulture scavenging habitats using remote sensing techniques and spatial and temporal statistics," the results of which could have significant implications for the practice of forensic pathology.

The Division of Chemistry (MPS) awarded funds to a researcher at the University of Iowa to use surface enhanced Raman scattering (SERS) for the detection of small molecules without the use of traditional receptor—based surface chemistry. If successful, this process could provide new means of detecting trace levels of drugs and biomolecules and thereby enhance the sensitivity of forensic investigations.

The Division of Social and Economic Sciences (SBE Directorate) funded researchers at the University of Arkansas, in collaboration with researchers at the University of Central Lancashire in the United Kingdom, to assess current methods of forensic age progression (assessing likely age changes in facial features), including identifying factors that influence the accuracy of age progression methods. The PIs will also explore novel methods for creating and presenting age progressed images that may improve the accuracy of forensic identifications.

Data and Scientific Infrastructure

Forensic scientists benefit from access to large databases as they attempt to analyze and interpret crime scene evidence. NSF has supported a variety of data infrastructure projects in recent years that generate valuable resources for forensic practitioners. These projects also include support for the training of future scholars.

The Division of Behavioral and Cognitive Sciences (SBE) continues to fund the **Al**lele **Fr**equency **D**atabase (ALFRED) at Yale University. This database currently houses information on human genetic variation on a global scale –ALFRED now has data on 663,602 genetic polymorphisms, 714 populations and more than 37,000,000 frequency tables (one population typed for one site). These data are invaluable for investigating human population structure, migrations and relationships, and can also be utilized by forensic scientists.

The Biology (BIO) Directorate's Division of Biological Infrastructure supports The Human Impact Pollen Database at the University of Massachusetts, Boston. This searchable digital image database of pollen from plants that are associated with human activities is critical for investigating both past and current human-environment interactions. This on-line database provides value for a variety of disciplines including forensic identification.

The NSF also provides Major Research Instrumentation (MRI) grants to support the development of specialized laboratories or the acquisition of cutting-edge equipment that facilitates research and training opportunities at U.S. institutions. Several such awards have supported forensic science research and training in recent years.

The Office of Cyberinfrastructure provided MRI support to Jacksonville State University for the development of a cybersecurity laboratory facility to facilitate research and training activities in digital forensic methods of analysis, among other relevant areas.

Civil, Mechanical and Manufacturing Innovation in the Directorate of Engineering provided MRI support to Southern Illinois University at Edwardsville for the acquisition of a 3D laser scanner and associated modeling software that promote research and training on high resolution photographic and three-dimensional coordinate data which is often used by forensic scientists in the analysis of crime scenes. The instrumentation is being used to test new modeling and analytic approaches for investigating forensic sites in a multidisciplinary context.

Finally, the Division of Chemistry/Directorate of Mathematical and Physical Sciences has provided MRI support to Cleveland State University for the purchase of a triple quadrupole/linear ion trap liquid chromatograph mass spectrometer system. he instrument will support a wide range of research and training activities, including the ante- and post-mortem forensic analysis of drugs and other specimens.

Small Business Innovation Research

The NSF provides funding for Small Business Innovation Research (SBIR) to stimulate technological innovation in the private sector and to increase the commercial application of federally supported research results. A number of awards in recent years have supported the development of materials, algorithms, and instrumentation that have significant implications for the practice of forensic science. Two examples are provided below.

SBIR support was recently provided to DNA Polymerase Technology Inc. for the development of novel enzymes that can aid the rapid detection of pathogens via DNA detection and amplification. The processes explored may aid forensic practice, where the acquisition of small amounts of DNA in the context of inhibitors can present challenges to identification.

NSF support was also provided to Deurion, LLC for SBIR development of Surface Acoustic Wave Nebulization (SAWN) for use with mass spectrometers. SAWN provides a means of ionization outside of the laboratory with significant portability and ease of use. This technique may improve law enforcement's ability to collect and analyze crime scene materials.

Human Resources

In addition to funded research, training and workshops, NSF has invested significant human resources in support of the forensic sciences.

The National Science and Technology Council's (NSTC) Committee on Science established a Subcommittee on Forensic Science in direct response to the NRC report. NSF has been represented on the subcommittee since its inception. The individual who attends the Subcommittee meetings also co-Chairs the Research, Development, Testing and Evaluation (RDT&E) Interagency Working Group (IWG). An NSF program officer also serves on this working group.

NSF has provided input in numerous areas including discussions about:

- conducting merit-based peer review,
- identifying and prioritizing research opportunities,
- designing survey instruments for assessing current practices and needs,
- judging validity and reliability in laboratory sciences

Over the past several years SBE/BCS science assistants also aided in the design of the Subcommittee's website (*http://www.forensicscience.gov/iwg.html*) and supported the Interagency Working Group on Outreach and Communication.

Near and Longer Term Activities

Collaborating With Mission Agencies

The NSF continues to work with other agencies to identify opportunities for advancing the forensic sciences. As the recent past indicates, many investigator-initiated projects directly address scientific questions of importance in forensic settings.

NSF continues to be represented on NSTC Subcommittee on Forensic Sciences and on its RDT&E IWG. The IWG has assessed the state of the science in a number of forensic settings (*e.g.,* latent print analysis, questioned documents, fiber analysis, odontology) and is preparing annotated bibliographies and other documents that will help to elucidate foundational aspects of the forensic sciences and encourage further scientific inquiry.

The NSF's Directorate for Social, Behavioral and Economic Sciences is developing a Memorandum of Understanding with the National Institute of Justice regarding research, development, and evaluation of social and behavioral sciences as they pertain to legal and forensic matters. Activities undertaken via the MOU will foster information-sharing about the most promising areas of research in the social and behavioral sciences, and serve as a catalyst to identify synergies and opportunities for future collaboration.

Coordination within NSF

As clearly documented above, NSF invests significant human and financial resources in advancing the forensic sciences. In order to better coordinate our efforts going forward, we are planning to convene an internal group of appropriate program officers to share information regarding support for activities with obvious forensic applications.

Another potential activity that could benefit the forensic sciences would be the issuance of a Dear Colleague Letter (DCL) that notifies researchers of the Foundation's interests in supporting activities with potential applications to the forensic sciences. Such a DCL would draw the attention of academic and forensic communities to the potential for utilizing forensic settings as test-beds for asking basic research questions. Some psychology researchers, for instance, have already begun to utilize forensic laboratories as settings for asking basic questions about human cognition and decision making. The DCL could be designed to encourage collaborative, interdisciplinary teams (to include basic and applied forensic scientists) to develop scientific proposals around the relevant questions. Likewise the DCL could encourage the use of forensic settings for development of new methodologies and instrumentation.

In keeping with the philosophy of OneNSF, the Foundation could develop a crosscutting panel to review a set of proposals that focus on aspects of forensic science emanating from a number of relevant basic science directorates. Such an interdisciplinary approach that brings together basic researchers and practitioners would create new knowledge, stimulate discovery, and address a range of complex problems.

NSF continues to develop a multi-year plan of Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE). This activity responds to issues raised in a variety of publications and to perceptions in the research community that NSF does not always provide good opportunities for comprehensive review and support of unsolicited interdisciplinary research. The current INSPIRE activity provides funding for high risk/high reward research that brings together ideas and approaches that cross intellectually distinct areas of science. Given the strong potential for coordinating the interests of basic scientists and the forensic science community through such opportunities, we have encouraged the development of interdisciplinary partnerships that address forensic science issues under this umbrella.

Summary

In summary, NSF is committed to supporting the basic sciences that form the foundation for forensic applications. Many of the projects funded in recent years will strengthen the forensic sciences both through support of research with obvious application to forensic settings and, in the longer-term, through as yet unimagined scientific and technological developments. In keeping with the NRC's recommendations, research in the behavioral and social sciences will also inform the forensic community regarding the impact of cognitive biases on the evaluation and utilization of forensic information.

The forensic sciences are also strengthened by NSF's support of many other activities. As a general statement, involvement of students in supported research will help to ensure a skilled scientific workforce for the 21st century and provide important training opportunities that will ultimately improve the practice of forensic science. The Small Business Innovation Research program will help to spur eco-

nomic growth with projects that improve the precision and operability of instrumentation and processes in forensic laboratories. Major Research Instrumentation and database development activities will also assist in building infrastructure for pursuing forensic-related opportunities. And NSF will continue to provide human and financial resources in the years ahead to coordinate and collaborate with other Federal agencies as we work to improve the practice of forensic science.

Mr. Chairman, this concludes my remarks. Once again, thank you for the opportunity to appear before you today on this topic. I would be happy to answer any questions you may have.

The CHAIRMAN. And thank you, Dr. Suresh.

Let me just start with questions, and this can be freewheeling. The Mr. Grisham that I mentioned before was at our December hearing, but I thought, frankly, the best testimony came from a former Federal prosecutor named Geoffrey Mearns. You know him? I just met him that one meeting, and he is a member of the National Academy of Sciences committee that reviewed the state of forensic research or science.

At the Department of Justice, Mr. Mearns prosecuted many high-profile cases, including the Oklahoma City bombing.

As a prosecutor, he said, and I just totally identify with this—he said he always assumed that evidence used in a courtroom was based on objective scientific analysis. I mean, why wouldn't he?

But after studying the issue as part of the National Academy's review, he told us his faith was shaken. Mr. Mearns testified that he came to realize that there was not nearly enough genuine science to validate many forensic science disciplines.

So, Dr. Lander, you mentioned in your statement sort of bands of human genome.

Dr. LANDER. Yes.

The CHAIRMAN. And then you also mentioned hair follicles. Now, let's go to the hair follicles, since I can relate to that a little more easily. How can one mess that up scientifically?

Dr. LANDER. So look under a microscope at two hairs that might come from the same person or might come from different people. What are you going to look at? The color? The width? The curliness or frizziness?

You can think up a whole bunch of features that might describe a hair. So which ones do you pay attention to? Which ones might you ignore as having to do with the conditions under which the hair was found? Is this really the same color of brown or not?

Well, you could imagine a forensic examiner with complete honesty saying, look, in my experience, these things are very, very similar. That's, indeed, the experiment the FBI ran when they looked at things and asked, when people said they're really very similar, in my expert judgment.

You can imagine someone testifying in a courtroom. In my judgment, these really must have come from the same person. But then the FBI ran an experiment where they got the DNA off the bottom of the hair and found one time in eight, even when concentrating on certain features they thought matched, the hairs didn't match.

Look, the same is true for fingerprints. Now, it's much better technology, but you run a fingerprint here, there are all these wiggly patterns. What wiggles are you matching and what wiggles are you ignoring? Now, it's usually not on a perfectly flat surface. It's not like when you get your fingerprints done by the FBI. It's

on some funny surface. So it's never going to match exactly. How close is close enough?

It's actually the same thing as we found 23 years ago with DNA. When we said, in that case 23 years ago, Do the bands line up? Well, they don't line up perfectly. They're always a little different. How different is too much? How much is the inherent noise in the technology?

That's what NIST is so good at. NIST looks at the same things a hundred times, a thousand times and says, what's the inherent variability? And if it's more than that, we shouldn't really trust it.

Many things that we think are obvious, actually, well, they're not so obvious, especially if you're going to apply them thousands of times, and one percent of the time you're wrong, that's still an awful lot of wrong identifications.

The CHAIRMAN. But, now, a lot of that, and going to Senator Boozman's appropriate reference to NCIS and CSI, et cetera, actually, in their defense, in West Virginia, at our two universities, which do a lot of forensic science, I mean, students are just pouring into those programs. So, you know, they get some credit for that, if, in fact, they do, but I'll give it to them for the moment.

But those aren't done by people. Those are done by computer software, and all of a sudden, match comes up. So it isn't a human observation. It's a computer observation. Help me understand that.

Dr. LANDER. Well, if you have your samples analyzed on CSI, the computer does it and it just says match. In reality, it's often a human who's doing it, a human who's deciding which features matter. And even when it's a computer doing it, there's someone who wrote a computer program to determine whether things match.

The CHAIRMAN. But was it for that particular science decision?

Dr. LANDER. Well, it depends. In the case of DNA, that case I told you about 23 years ago, someone had a computer program. They measured the bands by computer. They measured the distance and said it differed by this much, and the computer determined was it significant. It was how many standard deviations apart was it.

The problem wasn't the ruler. The problem was whether that difference was a significant difference or not. The ruler was fine. The calculation was fine, but the inference of significance was what's wrong.

So the best computer in the world wouldn't help. There was no data underlying it to tell you that two things that were the same must be this close, and if it's farther apart than this much, they can't be matching. You need a database underlying it or when there are many features, you need to know which ones to choose.

We can fool ourselves by using the computer, by pretending we're being objective, by choosing some things and then ignoring what's really the heart of the matter. Do we have data underlying it to tell us whether this match is really significant?

The CHAIRMAN. Well, but then you have left me with two problems, and then I'll turn it over to Senator Boozman. You have an apparent imperfection of human decision-making.

Dr. LANDER. You do.

The CHAIRMAN. Which could go on eternally.

Dr. LANDER. Yes.

The CHAIRMAN. And as the day wears on or as his or her years wear on, it could get worse. And then you have a computer. And most people—it's sort of like robotics at an automobile plant. You look at the robotics and you say, they must be doing it exactly right, because when there's a problem, at least at Toyota, you know, it'll say, problem, and then a robot will come in and fix the problem, machine to machine.

And so it just buttresses this belief that science has to be exact. There's some form of way of getting at science, forensic science which it has to be exact, but you're giving me no hope.

Dr. LANDER. No, no. Let me restore your hope, Mr. Chairman.

The CHAIRMAN. OK.

Dr. LANDER. I want to restore your hope. I'm saying just because it's done by a computer or a machine doesn't make it right, but that doesn't mean it can't be right. That is what we have places like NIST for. What you do is you measure something hundreds of times. You empirically validate how much variation there is, and then you build that into the computer program.

My objection isn't to the computer program. My objection isn't to the human. My objection is to either of them proceeding in the absence of data, measurement data. It may sound boring to measure things carefully under many different conditions, but it is the heart of accuracy. DNA works because it's been done so many times that we know the problems that arise.

Let me fully restore your faith in the ability to get it right. You've just got to concentrate in advance on getting it right. So when we have bite marks and someone testifies that this bite mark is the same as that bite mark, but there are no studies that show how much human dentition varies, how well a mark is transferred from your teeth to a neck, there are no such studies, you should be worried about that.

But if NIST had decided to go into the bite mark business and had carefully evaluated that across a couple of hundred subjects under many different necks that were available for biting, you might be able to put real legs under it.

You can put legs under almost anything if you go to the trouble of doing it or at least you will know how accurate it is. It is all about that collaboration.

The CHAIRMAN. Yes, and then the sad thing is what we started with and that is that people tend to believe that if it's being introduced as evidence in a court, it's just got to be true or else it just wouldn't be there.

Dr. LANDER. So, therefore, it's our job as scientists, as lawmakers to make sure that it is true by providing that scientific foundation for it.

The CHAIRMAN. Thank you, sir.

Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Chairman.

And so I agree, you have to have the collaboration to get that done, and then, you have the good science to back it up.

With just the pure science, how do you get that into the field? You know, this isn't like pure science in the sense of creating some sort of scientific breakthrough that you're going to market and perhaps make many, many dollars out of it.

When we're talking about bite marks and things like that, the commercial aspect would not be very great. How do we get that from your laboratory where there's a breakthrough made out in the field to the small town policeman?

Dr. SURESH. OK. Let me take a stab at that. In fact, I want to go back to the chairman's question to Dr. Lander. You know, the level of uncertainty that you have in DNA interpretation is no different from the level of uncertainty we have in any scientific experimental work. So let me give you an example that we all know.

Whenever we develop new materials—for example Alcoa, not too far from West Virginia, designs a new material and Boeing puts that into a plane. It's a 20 year process.

So what does Alcoa do? They design a material outside of Pittsburgh in their research center, and they make the material in Davenport, Iowa. And they do a lot of testing, and they pull the material, they twist the material, they bend the material, they break the material, and they give the material to Boeing.

Boeing doesn't believe anybody else's data because human lives are involved in flying a plane. They do their own in-house testing. And in order to make sure that the testing is reliable, and the interpretation of the testing is reliable, there are standards, which have come into existence thanks to the work of NIST.

There is a whole organization called American Society for Testing and Materials that over the course of many, many decades has established standards. If you want to pull a piece of metal, what are the standards by which you do your experiment? Those standards are established by NIST and various professional societies. And it's that kind of validation of scientific data that needs to exist for the interpretation of DNA. That's what is lacking. That's where the scientific method comes in.

So, historically, what NSF has done is fund the research at universities that work with industry and create the basic scientific data. Agencies like NIST come in and help develop the standards. These, too, are then adopted by industry and that becomes the bread and butter of how the industry develops a new material and puts it into service. I think it's that kind of a scientific method that needs to be established in forensics.

So to your question, Mr. Boozman, with respect to how do we bring it to the attention of people, we can, with these standards, with these new tools and technologies, we have a variety of things in place. I can only speak for NSF here.

If there are basic scientific discoveries, we can have engineering research centers that work with industry. We have small business innovation research. We have partnerships for innovation. We have innovation research. These are all programs that NSF supports.

Those kinds of programs, the SBIR program, which is not just at NSF, it's in nine Federal agencies, can help take the basic scientific discoveries and help translate them into commercial practice for small businesses, entrepreneurs, bring them in touch with venture capital community.

And the program we launched last year, the NSF Innovation Corps, is another attempt by NSF to bring that kind of thinking from basic discoveries to the marketplace to the community.

Senator BOOZMAN. Go ahead.

Dr. GALLAGHER. I didn't want to take your time, but just very quickly, you asked sort of two questions. One is how do you set priorities, and that happens at the junction between the world that's practicing forensics and the scientific world. It's really at that interface that those priorities merge, work and science most contribute.

The other part of your question was interesting, because there's an impression that putting science in forensics is tantamount to putting scientists everywhere.

We're not talking about putting Ph.D. research scientists in every criminal jurisdiction across the United States. What we're saying is that the tools they use should have a basis in science. And so, in fact, this can be built into the process they use, into the laboratory tools they use, the technology they use, and their methodology.

Senator BOOZMAN. No, and I agree, and guess my concern is that it's going to take money to get that to small town Arkansas or wherever, and it's just very difficult right now. Something we need to do.

The Chairman talked about the human factor that comes in and there's always a human factor, whether it's the judge or the jury or whomever.

We can take some of that out by accreditation and certification which, to me, is very important. Can you all comment about that where you guys think we need to go in that regard?

Currently, you've got some crime lab certification, but talk about the need for perhaps some higher degrees in the science of forensics.

Dr. GALLAGHER. So the human factor really has, again, a couple of different elements. One of them has to do with the methods that you are using, whether making the measurement, handling the sample or interpreting the information that comes from your measurement. Those can be standardized, and those standards are based on science. That's kind of where the science gets put in.

And so you develop standard operating procedures for laboratory personnel. You develop specific specifications for equipment. You develop standardized analysis tools.

What accreditation and certification do is they're basically the quality control system that's placed on that system to give the system the assurance that the laboratory is following those procedures, that those people have the skills that they need to have to do what they're being asked to do, that the technology that they bought is compliant with and meeting the specifications. And that's a very important part of the system, because it basically shows that we're following our own process and that it's about quality control.

Senator BOOZMAN. And the things that are in place now, perhaps with some strengthening, are they adequate as far as the accrediting agencies that we have?

Dr. GALLAGHER. The take-home message I got, certainly, from the National Academy report, is that it's the disaggregation of our system that's really interesting. So we have areas where it's quite strong, where, in fact, the data—for example, DNA data is not put into the CODIS, the national DNA profile database, unless those

standards are met. So there's what we call conformity assurance. There's a process in place to make sure that people follow that and that the data has some integrity.

In other areas, the systems are weaker or they're not uniform across the U.S. And so one of the big messages in there was getting much more systematic about the quality control as well as the methods.

Senator BOOZMAN. One last thing that's related to that, in talking to some of the crime lab folks, some of them are advocating for an independent entity, an office of forensic science within DOJ to coordinate all of this. And I have been very impressed with the collaboration. I think it's been good, and it was really much greater than what I thought.

Do we need a group like that combined with maybe a group of the guys out in the field some sort of panel there to make sure that the collaboration continues and somebody's responsible?

Dr. GALLAGHER. Certainly, in my opinion the answer is yes, that most of the progress we saw in DNA, for example, came from the intersection of the world of science with the practicing world of criminal forensics. You can't really have one without the other. I mean, having a beautiful scientific basis for something that can't be deployed and implemented and practiced or has no meaning in the field is not going to be that useful.

So I don't know what the structures look like, but there is no question that the ability to convene and have the appropriate mechanisms where the scientific and the standards deployment and the practitioning community can talk together, and the communication needs to work both ways, the science coming into the process and also the priorities coming out of the practicing field back into the world of science. So that's a key part, I think of any solution we're talking about.

Dr. LANDER. If I can comment very briefly on that, yes, I think it's a good idea to have such an office in Justice, but is it enough? No office of forensic science sitting at DOJ will be a substitute for the kind of scientific work that has to go on with regard to standard setting. So an office at the DOJ can play an incredibly important role in promoting the adoption of standards throughout the country, identifying needs, accreditation. Only the DOJ can do that.

But it's tasking it with the wrong mission to ask it to be the independent scientific body that sets those standards. So as long as there is strength at both places, and they, as Dr. Gallagher said, communicate about the needs and then the ways to address those needs, I think we're in fine shape.

Senator BOOZMAN. Thank you, Mr. Chairman. I apologize to Senator Udall for running a little bit long.

STATEMENT OF HON. TOM UDALL,
U.S. SENATOR FROM NEW MEXICO

Senator UDALL. Well, I thank both of you and thank the panel. This has been a very good panel. I attended the last hearing, and I thought it was excellent. And I appreciate, Chairman Rockefeller, you showing such an interest in this.

I remember last time the National Academy of Sciences report. I think that came out in 2009, is that correct? And that report, I think it was called Strengthening Forensic Science in the United States, A Path Forward, had some very concerning conclusions in it, state of forensic science, the lack of scientific foundation behind forensic science disciplines, lack of standards in laboratory techniques, and it went on and on and on.

I'm wondering, in the opinion of the panel, since the report came out, and you would think a report like this would kind of shake things up a little bit and move the ball down the road, have there been concrete accomplishments that, in your mind, Dr. Lander, you've followed this for a long time, 23 years it says in your testimony, Mr. Gallagher, same question.

I don't know, Mr. Suresh, if you feel you want to answer on that, or is this just a report that sits there and gathers a lot of dust and nobody listens to it? What's the——

Dr. LANDER. Well, let me first say, with regard to the 23 years, I became involved 23 years ago in this case and have been interested in this since then. It's not a field that I have worked in continuously there. I have other things I do, but, as an observer, I'll answer your question.

That 2009 report was deeply disturbing. It really did point out, as the chairman said, that there are a lot of areas where our evidentiary foundation is a lot weaker than we thought. I frankly would have thought it might have provoked more action.

I think, though, it has not sat on the shelf and gathered dust either. I think we're in the process in these couple of years of digesting a worrying conclusion and figuring out what to do. I think we've taken long enough to figure out what to do. I think it's clear that the what-to-do involves this collaboration with real responsibility tasked in science agencies and real responsibility tasked in DOJ, and it's time to act.

Were this to go on for a lot longer without meaningful structural response, I would be quite worried, but I think it's been a good process. I know here in the legislature and in the executive branch and out in the field, both of scientists and forensic labs trying to think about how to proceed. One shouldn't go too quickly to jump to a solution, but one shouldn't go too slowly either. It is time to act.

Dr. GALLAGHER. So I think the honest answer to your question is it probably depends upon how you're looking at it. The academy report had sort of two elements to it. One was a structural recommendation to form a new agency, and within that structure it called for a whole list of specific areas to be addressed.

And, of course, the problem I think we ran into was that the structural solution was the only one in the report and it wasn't one that was viable or deemed viable.

So the question is in addressing a structural solution that answers the problem without falling to a new agency, that is probably not something that's done yet. It's been very active, but it's fair to be impatient.

However, if you look at the 15 or 16 areas underneath, they have spurned probably the most active interagency process I have seen in my 18 years of government. In fact, what's striking is it's much

broader than just Federal involvement. We have representatives from state crime labs and other experts involved directly in the Federal interagency process, and they've made a lot of progress in addressing certification requirements and a whole list of other things, so that once the structural answer is put on the table, we're ready to roll. And so it's kind of mixed.

Dr. SURESH. I can point to three or four different activities that are evolved or continuing to evolve in response to the NRC report. One is the two workshops that I mentioned, one on cognitive bias. The other one is on nanotechnology and forensic science. These workshops were organized and supported by NSF in response to NRC report. So that's the first one.

The second is, I mentioned in my opening remarks the memorandum of understanding that's in the works between NSF and NIJ, and that's something that's a direct outcome of the NRC report.

The third is the activity that is part of the National Science and Technology Council Subcommittee on Forensic Science, and there are several possibilities there. One is to develop a White Paper that summarizes recommendations to achieve the goals of the NRC report. The other one would be to create a prioritized national forensic science research agenda. A third would be to draft a detailed strategy for developing interoperability standards. At least a discussion is taking place through NSTC. So those are four tangible outcomes following the NRC report.

Senator UDALL. Thank you.

And I think, Chairman Rockefeller, your efforts here at the Committee, I think, have spurred things to move along. And I think we need to get to the point where we get an organizational part of this, as you just talked about, that's really going to come to grips with it and take advantage of all the energy that's going on out there in this respect. Thank you very much. Thanks for your attention.

The CHAIRMAN. You were a prosecutor.

Senator UDALL. I was a prosecutor. That's correct, both at the, at the Federal level, I was Assistant United States Attorney and prosecuted criminal cases.

I was thinking the same thing that you said. I always had the impression when we went into court that the judge was the arbiter over the science. And you had the sense that, you know, and the rules all say that, that the judge, he makes sure that the best scientific information comes in, and whenever it's fingerprint evidence or whatever.

And you get the sense as a prosecutor, well, that's up there with the judge, and if he lets it in, then it's all going to be fine. And, as a prosecutor, you're working with the law enforcement people and they're doing the same thing they've done day after day and have been allowed to do.

And so it's kind of a shock when you read the kinds of things in this report that, whoa, this is very different than the sense of prosecuting a case. I mean, you really need to look behind.

And I'm glad we're doing this, because I think it's important, very important. So thank you for your work on this, Chairman Rockefeller.

The CHAIRMAN. No, but that's interesting that you have that same——

Senator UDALL. Yes.

The CHAIRMAN. It hinders us enormously as policymakers.

Senator UDALL. Yes.

The CHAIRMAN. If you, as a prosecutor, had that feeling about a judge, and then one could start doing an analysis of juries. Not allowed to do that because that's called the American system. They have a right to be wrong, right? You don't have a right to be wrong.

Senator UDALL. Well, and the juries, Chairman Rockefeller, my understanding, talking with some of my old friends that have stayed in prosecution, is the juries are watching these crime shows so much now that the crime shows are impacting what juries think should be produced by prosecutors in the courtroom. And if they don't produce all the fancy things that they see on television, they think there's something wrong with the case and they think there's reasonable doubt there and they throw the case out. So, I mean, we have another problem there when it comes to juries.

The CHAIRMAN. Is that why you ran for the Senate?

Senator UDALL. I got out of all that business. No, it isn't exactly why I loved it, but it's a tough business, the prosecution arena, and trying to get focused on, and the obligation as a prosecutor, different from a defense attorney, is to do justice. And so you know in the daily activities that you carry out that's the ethical obligation on you, and the idea that the science isn't quite there on some of these techniques is pretty disturbing.

The CHAIRMAN. It is. It is.

Senator UDALL. Yes.

The CHAIRMAN. But that's valuable stuff.

Senator UDALL. Yes.

The CHAIRMAN. I'm going to ask sort of a weird question, a catch-all, and I hope it comes out the way I hoped it would, but it may not.

Dr. Suresh, you have a pretty decent budget, and you spend approximately $50 million over 3 years on forensics? See, now that's two-tenths of a percent of your budget. I would appear to be critical, but I'm sort of setting the scene here, OK?

You've done, in fiscal 2010, 13,000 awards, and I'm trying to figure out each of the three of you or the two of you, how do we sort of pull this whole thing together? It means that you have to have the proper funding, but if you have the proper funding you've got to use the proper amount of funding of that proper funding for forensics.

And the EPSCoR program, which I'm thoroughly familiar with, gets it out into the New Mexicos and the West Virginias and the Arkansases, and before it all went to Harvard, Yale, Princeton, Stanford. I remember that fight with Dr. Eric Bloch. It was not pleasant.

Then NIST, NIST, I look upon as NIST is being kind of the decider. NIST is right. Others can make mistakes, but NIST doesn't make mistakes, because you do what Dr. Lander said. You just keep pounding away at the science until you've got the genome bands or they're too close or they're not close enough, but you figure that out and you do that. Am I right?

Dr. GALLAGHER. That's right. And——

The CHAIRMAN. Don't answer the question.

Dr. GALLAGHER. Yes. That's right.

The CHAIRMAN. I'm still formulating. I'm formulating my question. I'm not sure how it's going to come out.

And then I go to Dr. Lander, and anybody who's a deputy to your boss has to be a perfect person. I think John Holdren's one of the great people in government. He doesn't have to do it, you know. He just does it because he loves it. So you're kind of pointing to those two and saying, well, let's make this happen.

And then we run into what I've run into so many times when I was Governor, the county law enforcement system, the city law enforcement system, the FBI law enforcement system, the intelligence community. There are 18 different agencies of the Federal government that collect intelligence.

And, after 9/11, the first law we passed, to our everlasting shame, but thank God we did it, was to allow the CIA to talk to the FBI. They were not allowed to talk up until that time. And in that story is a lot of the 9/11 Commission tragedy, because the dots were there and they could have been connected, but they weren't because they couldn't talk.

So that means that people have to give up stovepipes. They have to be willing to share. Sharing is not a human characteristic. In government, it's sort of miserable, and I think in corporate life it probably is, too. I don't know that. In families, it's often very hard, you know, to share. In other words, to give up to get to the desired result.

So I want each of you to figure out a way, tell me how we get to the point. Because, in the meantime, until all of this is put in place, until the—I mean, I'm still trying to get over the software thing, because if you can't trust software, what you're saying is you can't trust people. If you can trust people, you can trust software. But then I've got to get through people and software before I can relax, and, in the meantime, we're sending people to prison or sending them to the chair or we're not.

Dr. LANDER. We're not catching them.

The CHAIRMAN. We're not catching them, right.

So how is this puzzle put together in a way which is practical? Actually, I don't insist on that, because, I mean, people are just, in the intelligence community, beginning to share. They're beginning to share. We're finding that now in cybersecurity, still. In the Senate, we have committees that won't share with each other because they're jockeying to hold on to their jurisdiction. So something gets dropped.

I mean, human behavior is not admirable. So how do we put this thing together?

Dr. LANDER. I'm happy to start here.

The CHAIRMAN. OK.

Dr. LANDER. Happily, I think this is simpler than many of the situations you referred to, Mr. Chairman. The ability to light the fires of excitement in the scientific community is really pretty great.

The Human Genome Project, a clear agenda was put out by this Congress in the late 1980s. It said, we need to get the sequence of

the human genome. We could somehow get the sequence of the human genome. It brought into science a generation of young people, myself included, who said this was exciting. People identified that agenda as important.

The single most important thing in marshaling science behind some public purpose is the clear setting of an agenda. And that isn't as hard as it seems. If the law enforcement community and these science agencies came together in an appropriate structure, some advisory committee, some task force, some something, which was tasked with identifying where are the biggest gaps in forensic science. What are we missing right now to write the software that we need or build the machines? And you state that clearly to the scientific community, you unleash the minds of a new generation.

So we have problems with hair. Great. Let's get that out in front of the scientific community. And what you're going to find is labs in West Virginia and kids in Berkeley, and, you know, older scientists in Maine who are going to say, oh, is that really an important problem? Let's get on the web a database of 10,000 hairs and let's set an X prize, a challenge, who can get the best program to identify those hairs.

It'll turn out probably to be cheaper than you imaged because when you unleash that creativity around each of these problems, we're going to see software, we're going to see clever new methods.

Right now, what smart young scientist coming along knows to think that these are really important problems that our government cares about?

I think if you got NIST and NSF together with DOJ in an appropriate structure setting that scientific agenda, you would see tremendous returns on that investment, because it isn't about government stovepipes. In the end, it's about unleashing creative energies. They'll write applications to the NSF saying, oh, I want to work on this. I'd put their energy there.

Get a clear agenda out there about our greatest needs. And that's where the DOJ is crucial. The DOJ will know. The prosecutors will know what are our greatest needs right now.

NIST will be able to say, in order to do that, what science might we have. NSF will be able to talk to its community and say, we have funding mechanisms for really meritorious applications. And you, your committee and the Congress, will be able to supply an appropriate amount of funding to make sure it gets done, I hope.

The CHAIRMAN. But you would have the final definition.

Dr. LANDER. I would have a clear agenda out there. If you state an agenda of the worthy challenge problems, in this country, the scientific community rises to meet challenges.

The CHAIRMAN. But, then, it puts its results, in whatever fashion, into the hands of NIST as the dispenser.

Dr. LANDER. Indeed. Yes. So then the mechanism to go from scientific discovery to the setting of standards must pass through NIST. You don't want the kid in Berkeley or the scientist here or there turning them into the standards. That's what we have NIST for.

The CHAIRMAN. Right.

Dr. LANDER. But you need the science underlying it. You then need NIST to turn it into standards, and you need the DOJ to be

able to turn that into promoting the adoption across our justice system.

The CHAIRMAN. Dr. Gallagher, what forces the community at large, God, I'm over time, by a lot. What forces the world at large, the legal world at large?

Senator UDALL. You're the chairman.

Senator BOOZMAN. He's never over time.

The CHAIRMAN. You can't leave, Tom. You're a prosecutor.

Senator UDALL. I will stay here for 5 minutes.

[Laughter.]

The CHAIRMAN. I am undeterred.

How do you get the NIST exactitude standard out to where it will be understood in Albuquerque and Welch, West Virginia, and accepted in those places? Because they have their own, you know, the state has its own labs. Maybe the county has its own labs. I mean, counties do, don't they? They have coroners and forensics. They have that stuff, larger ones, at least.

Dr. GALLAGHER. I have two senses about this problem. One is that this problem is not as difficult, in my opinion, as some of the ones you alluded to. In fact, I remember during my confirmation we were talking about cybersecurity, and I told you NIST had to work with NSA and DHS, and you said, oh, my gosh. But, in fact, that's working actually quite well. And I think, in this case, I have to say, in my opinion, a multiagency answer is probably better than the single agency answer that was in the academy.

And the reason for that is if you map it across two agencies, let me just focus on NIST and the Department of Justice, the focus of NIST will be on the integrity of the measurement. And we're not really influenced by the application of it.

Whereas, the whole role of the Department of Justice is to apply that measurement to prosecute crime and to promote justice. Those are complementary roles, and, in fact, if you combine them into one place, they could actually create tension, which is part of what we see in the system right now.

So this is a case where NIST being the technical non-regulatory, the nerds, in support of the people who have to apply it is actually a good construct. And you asked the right question, which is, "OK. NIST does its work and let's say we've articulated that this appears to be the right basis for doing this measurement, and here's how we recommend that it's done. How do you drive it into practice?"

And it's a combination of carrots and sticks. You have to facilitate the adoption. In other words, you have to put it into the language, bake it into the technology, make it consumable by the people who have to do these measurements.

The other thing is that you have to force the adoption, in some sense. Somebody has to be the adopter-in-chief, and, in this case, we have this very complicated Federal, state and local problem.

My view is that the Federal adoption actually is a huge ingredient here, that if the Department of Justice becomes the adopter for the Federal law that it's going to have an enormous impact on the states and local jurisdictions. And we can facilitate that adoption if we've brought the state and local participants in from the

beginning, so they see their own involvement in the process as well.

And I know the Department of Justice shares that view with me. So we bring them along from the beginning and then the Department of Justice can manage the requirement-setting on the Federal side, and that will, I think, have a very profound impact on adoption.

The CHAIRMAN. OK. Well, in sheer embarrassment I go to Senator Boozman, hoping that Senator Udall won't leave. He is.

Senator BOOZMAN. And I'll yield to you if you've got a question or comment. Go ahead.

Senator UDALL. No, no. Well, I just want to thank both of you. I know you're taking a real interest in this, and this is such an important issue. I think back to doing prosecutions and you'd call experts. You know, you'd get an expert. Everybody'd say, well, you need an expert in whatever it was. Let's just say hypothetically hair. And an expert would go out, and you'd get the best one, and then everybody would say, well, whatever he says, it's going to go into evidence and it'll get into evidence on your criminal case.

Well, what you all are telling me, and what this report is opening my eyes on is that it may well be he was a very, very good expert, but the real question is did he really have the depth of science to back it up? And that's what I think we're exploring today, and I think it's very important.

So that's just my final comment. I apologize to Senator Boozman for stepping out on him, but I really appreciate both of you——

The CHAIRMAN. No, he insisted that you ask a question.

Senator UDALL. Yes. Yes.

The CHAIRMAN. I was the one who was arguing.

[Laughter.]

Senator UDALL. Well, you're both very generous. Thank you.

Senator BOOZMAN. Thank you, Tom.

Secretary Gallagher, if I'm understanding, then we potentially have an entity that gives guidance and helps collaborate, the scientific community and the Federal Government, the standards community, all of that gives guidance out. And then what you're saying is we don't need to federalize this, but the reality is that as we come up with good science, if the Federal Government adopts certain things in their jurisdiction, then it will follow that that will upgrade the whole level, and so I think that's a good point.

Unlike watching CSI or similar shows where generally, the first person there is the coroner, and in probably half of our states, those people are elected with no training whatsoever and no accreditation. Where does that fall into all of this?

Dr. GALLAGHER. So I'm going to give you a short answer and then promise to follow up, because I'm also not an expert in the medical-legal area, but that has been actually a key discussion point within the NSTC process. And there's, in fact, a specific subgroup that's looking at qualification standards and practices within that community. And I'd prefer to get back with you on that one, so I don't attempt to——

[The information requested follows:]

In June 2009, Office of Science and Technology Policy (OSTP) Director Dr. John Holdren signed the Charter of a new Subcommittee on Forensic Science, under the

National Science and Technology Council (NSTC) Committee on Science, to address the concerns raised by a congressionally mandated study by the National Research Council (NRC) of the National Academies on the status of forensic science in the United States. The NRC report, entitled "Strengthening Forensic Science in the United States—A Path Forward," was published by the National Academies Press on February 17, 2009 (NRC Report). Among a host of other concerns with forensic science practice, the NRC Report was critical of the status of the medicolegal death investigation in the United States:

> "What also is needed is an upgrading of systems and organizational structures, better training, the widespread adoption of uniform and enforceable best practices, and mandatory certification and accreditation programs. The forensic science community and the medical examiner/coroner system must be upgraded if forensic practitioners are to be expected to serve the goals of justice." [NRC Report, p. 15]

The NSTC Subcommittee on Forensic Science Accreditation and Certification Interagency Working Group has been tasked to analyze the issue of medicolegal death investigator certification. We anticipate its recommendations will be submitted to the NSTC's Committee on Science in the fall for consideration.

Senator BOOZMAN. No, I appreciate it, and, again, you all can comment if you like, but it does seem like that's an integral part of the whole thing, that it's something else. And I think our crime labs would also like some advice and input in that regard, because it makes it very difficult, especially in our smaller communities where many times that entity is looked to, and, yet, in many of our states there's no training at all.

Well—yes, sir.

Dr. SURESH. I just wanted to add a couple of points to the comment that the chairman made about NSF's ongoing investments. The 147 projects or so amounting to about $50 million that I mentioned were identified by doing a search with the term forensics. So there is a lot of funding that NSF provides which feeds into this, but it's not directly aimed at forensic science.

For example, we fund genetics and genomics research in our Biological Sciences Directorate. The basic discovery there has a lot of potential implications for forensic science. So that's background basic research.

Likewise, in the computer and Information Science and Engineering Directorate, there is a lot of funding that goes into data analytics, image processing. Those kinds of things have huge implications for the development of forensic science within the NSF context.

So if I were to look at basic science funding with the implication for forensic science, it's likely to be a lot more than $50 million. So I just wanted to mention that.

Senator BOOZMAN. Good. Again, thank you all for being here. Your testimony today has been very, very helpful to me. And we do appreciate the collaboration that we really are seeing. Again, I was really very pleasantly surprised in the sense that I knew that some of that was ongoing, but I think we really are. However, we all have some frustration that we haven't perhaps outwardly moved as far forward as we'd like to on the 2009 report.

But I think that it appears that there has been a lot of work behind the scenes that really is moving in that direction.

And this, as the Chairman has pointed out so many times, is such a high stakes thing, and this is so important that we get this right. But we have to get it right so that it'll transfer again down

to the small communities in Arkansas and West Virginia where they just don't have the resources.

In fact, we could probably have another hearing, Mr. Chairman, just on the backlog now of the crime labs dealing with stuff that we all agree that they're dealing with in a very appropriate manner, but the backlog, in some cases, is tremendous because of lack of resources.

So thank you, Mr. Chairman.

The CHAIRMAN. OK. And thank you.

Can I just ask one more question, and that is I've got to restore some semblance of confidence in something called software, and, at this point, it's crash landed in my mind, because it's written by people.

And, on the one hand, I'm thinking of those, you know, when you Google typography and then you can make valleys disappear and turn into mountains or go back 1,000 years and get what it was like then, and just absolutely amazing things, which take tremendous disciplined brain power, and yet those are written by humans, but, on the other hand, those aren't case specific. They're just general information.

So to make software appropriate to individual cases that come up and so that somebody doesn't get put away for the wrong reasons, can software be developed for that?

Dr. LANDER. Sure. Software is just rules made faster. There's nothing a piece of software can do that you couldn't do yourself with a pencil and paper and enough time. They are just the embodiment of rules in a machine.

The problem is rarely with the software. It's with the choice of rules you put in there. Put good rules in there, good search rules in Google, you get good search results. Lousy search rules, you don't find what you want on the web. Put good rules there about those matching DNA bands or about hair, you'll get good matches and a statement about how good those matches are. Now, there's a 20 percent chance it's wrong or a 1 percent chance it's wrong or a one-in-a-million chance it's wrong.

Don't worry about the software. I'm confident that good software can be written. It's all about the rules. Rules come from the knowledge. If we get the knowledge right, then NIST will be able to write standards, which are those rules, and then the software folks will be able to produce the software you want. We trace it back there to the real source of the issue.

The CHAIRMAN. My confidence was restored, which probably is a good point to end the hearing on.

Thank you all very, very much for being patient and very edifying.

[Whereupon, at 4:02 p.m., the hearing was adjourned.]

A P P E N D I X

PREPARED STATEMENT OF THE NATIONAL DISTRICT ATTORNEYS ASSOCIATION (NDAA)

Chairman Rockefeller, Ranking Member Hutchison, members of the Committee, thank you for allowing us to submit a "Statement for the Record" for this important hearing on behalf of the National District Attorneys Association (NDAA), the oldest and largest professional organization representing over 39,000 district attorneys, state's attorneys, attorneys general and county and city prosecutors with responsibility for prosecuting up to 95 percent of all criminal cases in the United States.

During the hearing a question was posed to the effect of the leverage which may exist whereby any standards adopted federally could be "forced" upon the states. The choice of words may have been unfortunate. Nevertheless it makes a point about the nature of the collaboration that must exist if such an effort is to be successful. The collaboration must not be solely limited to NIST, the NSF and the Federal forensic community. As pointed out, there are an estimated 400 forensic laboratories in the United States and approximately 380 of those laboratories are State and local laboratories while the remaining labs represent Federal and private forensic laboratories. NIST, the NSF and our Federal partners in the forensic community all have a role to play in this effort, but none greater than that of state and local laboratories that are charged with analyzing evidence in what accounts for over 95 percent of the crimes committed in this country.

This collaboration can be performed successfully, as evidenced by the DNA Advisory Board within the Department of Justice which had participants from NIST and other Federal, state and local partners. That effort and the lessons we learned can be duplicated here as well.

During the hearing, Senator Udall posed the question whether since the release of the 2009 National Academy of Sciences report there had been any concrete accomplishments toward improving the state of forensic science. It should not be overlooked that the legislation requesting such a study was sought and supported by the forensic science community. We can be proud to report that their have been significant accomplishments and those efforts actually predate the report itself. The National Academy report singled out for particular criticism three forms of analysis—serology, bite mark and microscopic hair analysis. Most of the exoneration cases which identify forensic science as a contributing factor involved those forms of analysis. Most of those cases occurred prior to the existence of forensic DNA typing in 1985 or its ready availability in this country around the mid 1990s. However, their use by the forensic science community has been extremely limited for a number of years.

Consider, for example, microscopic hair comparison that Dr. Lander testified to, where certain physical characteristics were compared. He testified that it was subsequently determined in a study that in approximately 1 out of 8 comparisons examiners would reach a conclusion that there was a "match" between known and questioned hairs. Using mitochondrial DNA testing it was determined that in170 hair examinations, 1 in 8 hairs believed to match did not come from the same source. That study was conducted by scientists from the FBI and the Forensic Science Initiative of West Virginia University. That study was published in 2002. Thereafter, microscopic hair comparison has been limited to serving as a "screening" test for purposes of identifying cases in which mitochondrial testing of evidentiary hairs would be appropriate.

Forensic odontology has long been utilized within the forensic community, most notably as a method of identifying human remains. Bite mark evidence is another aspect of the work of a forensic odontologist. The most noteworthy case in which bite mark evidence was used was in the prosecution of Ted Bundy in the state of Florida. However, with the advent of DNA profiling, bite mark evidence has been relegated largely to those cases in which a swab for saliva in the area of the bite mark has not yielded DNA sufficient for testing. That has been considered best practice since at least 1997. As reference, please see *Manual of Forensic Odontology,* 3d. Ed. American Society of Forensic Odontology (revised 1997).

Serology has likewise been relegated to use as a screening tool within the forensic laboratory almost from the day forensic DNA profiling became readily available within this country. The science of serology is interesting however because it is well researched and its limitations are well known within the scientific community. It continues to be used today in hospitals across the country. It is well validated.[1] The reason that serology has been replaced for evidentiary purposes is that it lacks the powers of discrimination between individuals that DNA testing provides. A simple blood type, for instance, may only narrow the range of potential suspects to approximately 40 percent of the population. The problem with the serology cases was not the science so much as the competence or integrity of the scientist, the prosecutor or the defense counsel.

The commitment of the forensic science community for reliable science is evidenced by its investment in the accreditation process. Three organizations currently accredit forensic laboratories within the U.S.[2] Virtually all public laboratories are accredited today. ASCLD–LAB has accredited an estimated 380 such laboratories, Federal, state, local, private and international. Most of those laboratories were accredited before 2009. The National Academy report recommended accreditation to a recognized international standard for accreditation (ISO 17025). Accrediting bodies in this country were in the process of accrediting laboratories to that standard before the Academy report was published. An estimated 180 labs are already accredited to that standard by ASCLD-LAB with the remainder in the process of becoming so accredited.

It is NDAA's belief that non-DNA forensic science disciplines have been demonized in recent years because their reliability is not up to the "DNA Standard" seen on popular television shows like CSI. Unfortunately, real world examples of cases tried on television are few and far between. Some cases have DNA, but most cases do not. As stated on the Innocence Project's website (*www.innocenceproject.org*), since 1989 there have been 289 post-conviction DNA exonerations in the United States. While NDAA agrees that even one wrongful conviction of an innocent person is too many, this number needs to be taken into proper context to gain an accurate portrayal of the state of forensic science in America's criminal justice system.

In the United States there are, at minimum, 10 million cases per year (not including traffic offenses) where serious crimes have been committed. This means since 1989 there have been at least 220 million cases in America involving serious crimes: while 289 post-conviction exonerations are of real concern to NDAA, in reality these wrongful convictions occurs less than one-hundredth of 1 percent of the time in America's courtrooms.

Many stakeholder groups point to these 289 post-conviction exonerations and reactively conclude that America's use of forensic sciences in the courtroom is suspect and the system is irreparably broken. NDAA could not disagree more with this notion; it is important for us to remember that the vast majority of the time during criminal cases—more than 99.99 percent of the time—the prosecutor properly serves justice and gets the case right. That said, NDAA fully supports improvements to forensic science and agrees that Federal resources be used to improve the quality and reliability across all forensic science disciplines.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO ERIC S. LANDER, PH.D.

Good Science Leads to Good Law Enforcement

Question 1. The crime writer John Grisham was the most famous witness at our December hearing. But I thought some of the best testimony came from a former Federal prosecutor named Geoffrey Mearns, who was a member of the National Academy of Sciences' committee that reviewed the state of forensic science. At the Department of Justice, Mr. Mearns prosecuted many high-profile cases, including the Oklahoma City bombing.

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[1] Some confusion exists within the general public with respect to the terms "validated," "invalidated" and "unvalidated." Validated, as Dr. Lander described it, is that process of testing and retesting in order to identify the limitations of the reliability of a technique or measuring system. Invalidated means that something has been tested and the results of testing show the conclusions to be unreliable. Unvalidated means that there is a lack of sufficient testing necessary to render a conclusion as to the reliability of a measurement, test or conclusion. Unvalidated and invalidated are not synonymous. Testing and being found to be true or false is one thing, never being adequately tested is something completely different.

[2] Forensic Quality Services, American Society of Crime Laboratory Directors-Laboratory Accreditation Board and A2LA.

As a prosecutor, he said he always assumed that evidence used in the courtroom was based on objective scientific analysis. But after studying the issue as part of the National Academy's review, he told us his faith was shaken. Mr. Mearns testified that he "came to realize that there was not nearly enough genuine *science* to validate many forensic science disciplines."

In your testimony, you talk about how law enforcement officials were at first reluctant to work with you on developing standards for DNA testing. Can you explain how you convinced them that scientific standards were good for our criminal justice system?

Answer. The change was driven by necessity. Law enforcement officials had originally rejected as unnecessary a proposed study of DNA forensics by the National Academy of Sciences. Then a high-profile case revealed serious flaws in the practice of DNA fingerprinting, with both prosecution and defense witnesses ultimately agreeing on the problems. Law enforcement officials then became concerned that these findings might jeopardize the use of DNA fingerprinting, and then agreed that setting higher standards was desirable.

The recent NAS report on problems with forensic science should have been a similar wake-up call. But there has been continuing resistance.

Question 2. Can we have a fair justice system while we are waiting for the science of forensics to catch up?

Answer. Yes, but . . .

The justice system can be fair *provided that* the reliability of forensic testimony is accurately described. For some forensic disciplines (such as bite marks), this would involves telling juries that the evidence is scientifically unsupported and thus unreliable. For others (such as hair analysis), it would require telling juries that errors occur at an appreciable frequency (10 percent in an FBI study) and thus the evidence is not definitive.

For too many forensic technologies, we don't know how to evaluate the evidence: we don't know the rate of false positives and false negatives.

The integrity and fairness of our justice system is threatened when we lack standards, but we allow witnesses to tell juries otherwise.

It may be best to exclude certain classes of evidence until the science and standards catch up.

Scientific Analysis Reduces the Chance of Bias in the Criminal Justice System

Question 3. The National Academy of Sciences report makes a very interesting point about how human error can creep into forensic science. It discusses a concept called "contextual bias," which means that a forensic analyst's conclusions can be influenced by what he or she knows about the suspect or the facts of the case. The report isn't suggesting that anybody is acting with intentional bias, but it does suggest that a more independent and rigorous scientific approach could minimize this problem. What steps do scientists take to limit the possibility of "contextual bias" in your work? Can you also explain why this is an important issue in the field of forensic science?

Answer. In most scientific situations (not involving forensic testimony), scientists take a variety of precautions to guard against contextual bias.

These may include "blinding" themselves to the identity/characteristics and to the changes or treatments given to research subjects. For example, in a clinical trial to evaluate a drug, a scientist will not know until after concluding an experiment which group of patients is the control group that did not get the drug and which group of patients is the treatment group that took the drug. This will prevent the scientist from being biased toward observing the responses in patients that the scientist hopes to see. This is so critical that unblinded clinical trials are considered suspect.

Scientists also follow objective, verifiable methods to test their hypotheses against available data. They try only to draw conclusions that are supported by the data, and to be cautious not to overstate their results.

Their studies, before publication in journals, typically undergo a peer-review process.

And, it should be possible for other scientists to replicate any experiment, and they should draw the same conclusion. Only when science has been independently replicated can it be truly considered sound.

Forensic evidence presented as scientific findings in criminal trials often differs in important ways from the process that scientists use in conducting studies and publishing their results in peer-reviewed journals. For example, forensic experts do not necessarily "blind" themselves to the identity of the accused or the facts of the

case, and are not required to demonstrate the accuracy of methods on a larger sample. In criminal cases, scientists present evidence that is not typically peer-reviewed.

Prizes and Challenges in Forensic Science

Question 4. The America COMPETES Reauthorization (P.L. 111–358) gave broad authority to Federal agencies to use prizes and challenges as drivers for stimulating private industry and individuals to solve problems of national importance; certainly the forensic science community is facing concerns of national importance. What specific problems in forensic science do you think are best suited for a prize or challenge?

Answer. Prize competitions involving the broader public could be an excellent method to address the challenge of (i) determining the best analytical methods to evaluate specific kinds of forensic data and (ii) determining the accuracy of those methods (which is critical for evaluating their use in courts).

It might be ideal to focus on the 5 most important forensic technologies, as determined by DOC and DOJ and reflected in the NAS report. (Examples could include hair, bite marks, bullet marks, and fingerprints.)

Question 5. How would you recommend structuring such a challenge so that we achieve the best possible results in the most timely manner?

Answer. For each type of forensic evidence selected, DOJ/FBI could contract with an external party to prepare a very large set of samples (many thousands) including associated digital data that could be shared without limitation and physical specimens that could be shared with qualified parties.

The samples should reflect the wide range of conditions under which evidence is encountered. (For example, for a fingerprinting sample set and dataset, the FBI should collect and offer fingerprints that include partial prints from many kinds of surfaces, and the full range of type of fingerprints collected in criminal cases and beyond.)

Information about which samples actually match would be known but withheld.

Competitors would be challenged to develop methodologies that would be tested relative to known "right answers". (Crime labs could participate in the competition, as well as scientists and technologists.)

A contest advisory board would be selected by the NAS, based on input from FBI and NIST, to oversee the competitions.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO ERIC S. LANDER, PH.D.

Question 1. I am concerned about the effect of delays in DNA and other forensic analysis in criminal cases—delays in forensic analysis can prevent law enforcement from apprehending criminals or delay exoneration of innocent persons. Can you comment more on this?

Question 2. From your perspective in the scientific community, what factors contribute to delays in analyzing forensic evidence?

Question 3. Do you believe standards are a way to reduce the delays forensic analysis?

Answer. [Dr. Lander believes he has insufficient knowledge to answer these questions usefully.]

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO ERIC S. LANDER, PH.D.

Question 1. Your testimony indicates that DNA forensics was not widely accepted by the practitioners of forensic science? Today it is widely accepted in the law enforcement and forensic community. What specifically changed, in the community of practitioners, to make this happen?

Answer. The change was driven by necessity. Law enforcement officials had originally rejected as unnecessary a proposed study of DNA forensics by the National Academy of Sciences. Then a high-profile case revealed serious flaws in the practice of DNA fingerprinting, with both prosecution and defense witnesses ultimately agreeing on the problems. Law enforcement officials then became concerned that these findings might jeopardize the use of DNA fingerprinting, and then agreed that setting higher standards was desirable.

The recent NAS report on problems with forensic science should have been a similar wake-up call. But there has been continuing resistance.

Question 2. The scientific working groups (SWGs) are currently active within the DOJ. I understand some SWGs are more active than others. How do you feel about SWGs with NIST oversight, with the both practitioners and scientists in this group? How do you think the individuals should be chosen?

Answer. [Dr. Lander believes he has insufficient knowledge to answer this question usefully.]

Question 3. Do you feel that current ISO standards for forensics are inadequate? Please give specific examples.

Answer. [Dr. Lander believes he has insufficient knowledge to answer this question usefully.]

Question 4. Do you think that we need advanced level degree programs in the science of forensics? What are your thoughts about the current education level and accreditation system for practitioners? In your opinion, what are the current needs in this area?

Answer. [Dr. Lander believes he has insufficient knowledge to answer this question usefully.]

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO DR. SUBRA SURESH

Forensic Science Pipeline

Question 1. A healthy forensic science pipeline supports basic research, development of practical applications, as well as training of students and practitioners. I am particularly interested in education of students because the Bureau of Labor Statistics projects a 20 percent increase in jobs for forensic science technicians alone by 2018.

Dr. Suresh, your written testimony describes activities NSF is supporting to expose students to forensic science research. However, as I understand it, there are no Ph.D. programs in forensic science. How does this contribute to the fundamental problems in forensic science research?

Answer. The National Science Foundation supports basic research and education in all fields of fundamental science and engineering. Many of the research projects that are supported contribute to scientific advances that ultimately contribute to the scientific basis for forensic analysis. While many awards are made to senior research personnel, a significant number of awards are made each year directly in support of doctoral research by students with forensic science interests that will advance the application of science in forensic settings. For instance, an award was made to Louisiana State University in support of doctoral student's research titled "Using GPS to Track Vultures in Texas." As the student explains in the application for funding, understanding the behavior of vultures over time and space and its relation to decomposition of remains, will improve the efficiency and accuracy of forensic estimation of time-since-death. Other doctoral research is less obviously tied to forensics, but nevertheless advances those sciences. An award to an anthropology doctoral student at Johns Hopkins University titled "Environmental Effects on Human Cranial and Postcranial Sexual Dimorphism" will contribute valuable data that can assist forensic scientists in determining the sex of skeletal remains.

Often science and engineering doctoral students conduct research while supported by awards made in support of their mentors, and many research projects supported across the foundation are budgeted to assist in supporting graduate students. Thus, a collaborative research project on nuclear data measurements and radiation detector development, funded at Duke and North Carolina A&T State Universities, contains funds for support of undergraduate, graduate and post-doctoral students. This research may advance nuclear forensics, an increasingly important area in countering terrorist threats, and is but one example of basic research that holds promise for forensic application and contributes to workforce development. Examination of high impact publications in the forensic sciences shows that authors of most frequently cited articles are based in basic science research programs. Clearly, students and senior researchers in these basic science settings provide results and methodologies that inform the forensic sciences.

Question 2. Your written testimony points out that the Foundation's forensic science awards are spread out over all seven directorates. Is this a good thing? Would a specific forensic science program at NSF help to consolidate the work and attract additional worthy research proposals?

Answer. A crucial strength of the National Science Foundation is that it supports basic research in all fields of science and engineering. Scientists submit research proposals to standing programs, or increasingly to interdisciplinary programs, and

the proposals are reviewed via high quality merit review. Through its gold standard merit review process, NSF brings research to bear on a number of timely national problems.

The forensic sciences constitute an exceedingly diverse set of investigatory areas ranging from anthropology to zoology. While there certainly are some challenges within forensics that could, or already do, benefit from collaboration across the traditional academic stovepipes, many of the forensic sciences are quite distinct in their theoretical bases and methodological approaches. Creation of a forensic science program which received competing proposals in, for instance, analytical chemistry and forensic anthropology would bring very different research projects into competition with each other.

NSF does utilize a wide array of mechanisms in support of cutting edge, transformative research and several of these have already been applied to proposals with forensic science significance. Co-review of proposals that intersect two or more standing programs is a long-standing practice within the foundation and awards which contribute to the forensic sciences have been made with the support of several programs. Programs in three divisions across two directorates supported a project ("Cyber-Enabled Chemical Imaging: From Terascale Data to Chemical Imaging") that will assist in providing detailed information on the chemical composition of substances found on surfaces—a capability of significant utility in forensic analysis. Additionally, many programs are by their very nature interdisciplinary in character. The Law and Social Science, a program with roots in a number of social and behavioral sciences including sociology and psychology, is supporting research on overcoming obstacles to the successful use of forensic age progression. This research utilizes information and theories from anthropology, computer science, developmental sciences and psychology with an ultimate aim of improving the utility of this forensic technique.

However, we are aware that more can always be done. Subsequent to publication of the National Academy's report *Strengthening Forensic Science in the United States: A Path Forward" (http://www.nap.edu/catalog.php?record_id=12589)*, the Social, Behavioral and Economic Sciences Directorate (SBE) supported a workshop on cognitive biases in forensic examination. SBE, possibly in conjunction with the Computer and information Sciences (CISE) directorate, is considering another workshop in the area of human and computer recognition of patterns in forensic settings.

As stated in Dr. Suresh's testimony of March 28, 2012 NSF might also issue a:

> . . . Dear Colleague Letter (DCL) that notifies researchers of the Foundation's interests in supporting activities with potential applications to the forensic sciences. Such a DCL would draw the attention of academic and forensic communities to the potential for utilizing forensic settings as test-beds for asking basic research questions. Some psychology researchers, for instance, have already begun to utilize forensic laboratories as settings for asking basic questions about human cognition and decisionmaking. The DCL could be designed to encourage collaborative, interdisciplinary teams (to include basic and applied forensic scientists) to develop scientific proposals around the relevant questions. Likewise the DCL could encourage the use of forensic settings for development of new methodologies and instrumentation.

We are also considering the establishment of internal communication mechanisms, such as a Sharepoint site. This would allow staff to share information on awards, workshops, publications etc. about research with forensic science significance supported across the foundation. Such exchanges of information would stimulate coordination and collaboration. Coordination and collaboration is not confined to internal activities. Several program staff have served on the NSTC Subcommittee on Forensic Science. A number have already discussed opportunities for joint support of research with the National Institute of Justice, the FBI and Department of Defense.

Thus, there are many current activities, and others which are under consideration, that are investments in the forensic sciences and which serve to attract high quality research projects.

Question 3. What are your thoughts about how applying the scientific method can reduce the possibility of contextual bias in the criminal justice system?

Answer. The National Science Foundation has begun to address the issue of contextual bias and supports basic research in many relevant areas, including human cognition and decisionmaking as it may relate to the forensic sciences. It is well known within the psychological research literature that individuals are susceptible to certain biases and preconceptions in the perception and interpretation of stimuli, and in the decision processes that lead to such interpretations. The NSF's Directorate of Social, Behavioral, and Economic Sciences (SBE) has supported research

in this area through its programs in Perception, Action, and Cognition; Social Psychology; Economics; Decision, Risk, and Management Sciences; and Law and Social Sciences.

In response to the National Academy's report on forensic science, the Division of Behavioral and Cognitive Sciences (SBE Directorate at NSF) sponsored a workshop to explore the role of cognitive bias in forensic examiner decisionmaking. The goals of this workshop included stimulating basic research projects among researchers who may not have considered the interplay between behavioral science and forensic science, as well as identifying applied research projects that might improve communication and decisionmaking by forensic examiners. Participants offered important recommendations for translating basic research on countering cognitive biases including (i) assessment procedures that shield investigators from contextual information that may bias their decisions and (ii) the use of evidence "lineups" that require discrimination of a source from that of distractor samples, or tasks that require examiners to consider factors that might lead to decisions supporting both a "match" and a "non-match" of a sample. Participants noted (i) that additional research would be required to successfully translate and refine procedures that might prove most effective in the forensic science context, and (ii) that collaboration between behavioral scientists and forensic practitioners would be an important determinant of success in this context.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO DR. SUBRA SURESH

Question 1. Has the current administration formulated a consistent policy position regarding the science and standards of forensics? If yes, please state; if no, when will this policy be announced?

Answer. The National Science Foundation supports basic research in all areas of science and engineering except for the medical sciences. Through its gold-standard merit review process, the Foundation identifies the highest quality research for support, both in traditional academic areas and novel areas which are 'high-risk, high-reward. Establishing administration priorities in science lies with the Executive Office of the President's Office of Science and Technology Policy. Therefore, OSTP would be the best source of information on the administration's policy in forensic science and standards.

Question 2. It is my understanding that the National Science Foundation is currently funding research in forensic science, although spread out in several directorates and not underneath one single category of 'forensic science.' Could you please give me a scope of the projects that are currently funded? One of the recommendations of the National Academies Report is more 'coordination' of the underlying science in this area; what practical benefits, from the NSF standpoint, do you expect to see from this coordination?

Answer. A crucial strength of the National Science Foundation is that it supports basic research in all fields of science and engineering except medical science. As stated in Dr. Suresh's testimony of March 28, 2012, all Directorates have funded basic research with implications for forensic science. While a description of each award is beyond the scope of this response, these awards encompass the variety of mechanisms offered by the Foundation, including standard awards to scientists at academic institutions, doctoral dissertation research grants, research experiences for undergraduates, and major research infrastructure awards. The awards also cover a variety of forensic sciences, including forensic anthropology, DNA and trace analysis, digital forensics, and the various comparative forensic sciences such as fingerprinting and forensic authorship identification.

Within each Directorate, scientists submit research proposals to standing programs, or increasingly interdisciplinary programs, which are reviewed via high quality merit review. The forensic sciences constitute an exceedingly diverse set of investigatory areas ranging from anthropology to zoology. Some topics could, or already do, benefit from collaboration across the traditional academic stovepipes. However, many of the forensic sciences are quite distinct in their theoretical bases and methodological approaches. Creation of a forensic science program that receives competing proposals in, for instance, analytical chemistry and forensic anthropology would bring very different research projects into competition with each other. This might well result in a reduction in support of the best ideas and projects across the various fields that forensic scientists draw upon and inhibit the connection between the forensic sciences and the underlying basic research in, for example, chemistry.

Nevertheless, increased coordination of NSF's contribution to forensic science research is possible. For example, proposals that intersect two or more standing pro-

grams can undergo "co-review" by these programs—a mechanism that has been used to support awards that contribute to the forensic sciences at NSF. However, we are aware that more can always be done. Subsequent to the National Academy's report on forensic science, the Behavioral and Cognitive Science Division of the Social, Behavioral and Economic Sciences Directorate (SBE) supported a workshop on cognitive biases in forensic examination. SBE, possibly in conjunction with the Computer and information Sciences Directorate and the United Kingdom's Home Office, is considering another workshop in the area of human and computer recognition of patterns in forensic settings. As stated in Dr. Suresh's testimony of March 28, 2012, NSF is also considering the creation of a Dear Colleague Letter (DCL) "that notifies researchers of the Foundation's interests in supporting activities with potential applications to the forensic sciences. Such a DCL would draw the attention of academic and forensic communities to the potential for utilizing forensic settings as test-beds for asking basic research questions." NSF is also considering the establishment of internal mechanisms, such as a Sharepoint site, to inform program officers of research with forensic science significance supported across the foundation and thereby stimulate coordination and collaboration.

Coordination and collaboration is not confined to internal activities. Several program staff have served on the NSTC Subcommittee on Forensic Science. Additionally, a number of program officers have discussed opportunities for joint support of research with the National Institute of Justice, the FBI, and Department of Defense.

We believe in the importance of NSF's continued contributions to basic science that informs development of the forensic sciences. The mechanisms described above could promote further coordination in this area and provide critical knowledge that could improve the efficacy of forensic practice in the years ahead.

Question 3. As you know, the fiscal situation in this country is very tight. The NSF has many scientific priorities, but the demand for basic forensic science research will increase. With limited resources, how would you prioritize which areas of forensics will get priority in terms of basic science research?

Answer. The National Science Foundation recognizes that we face difficult choices in the face of increased demand for research support and constrained resources. In making these choices, we will rely on advice and guidance from our Advisory Committees and community-based decisionmaking through the merit review process and other mechanisms.

NSF supports basic research in all fields of fundamental science and engineering. Many of the research projects that are supported contribute to scientific advances that ultimately contribute to the scientific basis for forensic analysis. Advances in virtually all areas of science, ranging from anthropology to zoology, may immediately, or downstream, lead to important applications in the forensic setting. As noted in the response to the previous question, the National Science Foundation identifies the most promising projects through the use of a merit review system that is held high esteem around the world. Indeed, last month NSF hosted representatives from more than 50 countries for the first Global Summit on Merit Review.

NSF review processes provide for submission of research proposals by individuals or teams of scientists. The proposed activities are then reviewed and assessed against the criteria of Intellectual Merit and Broader Impacts, as well as additional, applicable criteria such as the integration of research and education. The most compelling projects may then be recommended for funding.

The merit review system ensures that the highest quality projects are funded. Any specific proposal may have immediate or downstream applications in one or more areas of forensic science. NSF has traditionally listened closely to its research communities and frequently learns through proposals submitted by investigators about their cutting-edge interests. Projects are supported that best demonstrate their relevance based on two agency-wide criteria: intellectual merit and broader impacts.

All NSF scientific staff members are continually involved in activities such as outreach to scientific communities, attendance at scientific meetings and conferences, sponsorship of workshops, and interactions with colleagues in agencies with legal and forensic missions. Such efforts allow NSF staff to monitor trends, identify opportunities and set priorities in concert with the many basic research communities that ultimately inform forensic practitioners. In addition, workshops may be funded with the purpose of examining trends in research, identifying gaps and needs, and recommending priorities.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO PATRICK D. GALLAGHER, PH.D.

NIST and Forensic Science

Question 1. NIST has an outstanding reputation for doing cutting edge work in technology, measurement science, and standards, and your written testimony nicely outlines NIST's long and rich history in forensic science. My question to you is simple: with NIST's credentials in forensic science going back almost 100 years, why do we still have a problem today?

Answer. As outlined in the NAS report, the issues that plague the forensic science community are complex. The NAS report describes the practice of forensic science in the U.S. as highly fragmented, both across jurisdictions and across disciplines. Other contributing factors include the lack of uniform oversight and the limited funding available for basic research and standards development.

There are approximately 400 Federal, state and local government crime laboratories and more than 90 percent of them fall under state and local jurisdictions. There are great disparities among them with respect to funding, oversight, personnel certification, and laboratory accreditation. For example, the accreditation of crime laboratories in the U.S. is still voluntary for Federal laboratories and for crime laboratories in 46 of the 50 states. The main barrier to uniformed practices of crime laboratory practices across the U.S. is state sovereignty, which limits the role that the Federal Government can play in the development and enforcement of forensic science regulations.

Each forensic science discipline applies a unique subset of principles from traditional sciences to draw conclusions about evidence collected in a case. The quality as well as the degree of foundational scientific rigor underlying the practice within each discipline has correctly been described as uneven at best.

Although NIST has a rich history in forensic science, its contributions have only sought to address the specific needs of other Federal agencies and industry with which it has partnered to date. However, as outlined in my testimony, our work has a broad impact on the forensic science disciplines with which we have worked. As a leader in measurement science, standards, and technology, NIST is a logical choice to partner with other agencies and professional organizations on a national initiative to lead the U.S. toward improving the practice of forensic science in the United States. We look forward to partnering with other Federal agencies with complementary core strengths to collectively contribute to the future of forensic science.

Scientific Analysis Reduces the Chance of Bias in the Criminal Justice System

Question 2. The National Academy of Sciences report makes a very interesting point about how human error can creep into forensic science. It discusses a concept called "contextual bias," which means that a forensic analyst's conclusions can be influenced by what he or she knows about the suspect or the facts of the case. The report isn't suggesting that anybody is acting with intentional bias, but it does suggest that a more independent and rigorous scientific approach could minimize this problem. What are your thoughts about how applying the scientific method can reduce the possibility of contextual bias in the criminal justice system?

Answer. Applying the scientific method is just the beginning of resolving the issue of contextual bias in the practice of forensic science. As we have seen in a number of recent studies, sources of contextual bias are numerous and the solution is multilayered. In addition to the appropriate triage of facts and information selectively provided to the forensic science practitioner, there are also processes and procedures for quality assurance that must be built into the technical review of the first scientist's analytical findings. For example, the practice of requiring a technical reviewer to reexamine only those cases where the original examiner has made a "match" between questioned evidence and a suspect in a fingerprint case must be prohibited if we wish to achieve true objectivity. The reviewer who has the expectation that only cases with "matches" will reach her desk for review inevitably has contextual bias built into the process. One solution is to forward a variety of outcomes to the reviewer including cases with exclusions and inconclusive outcomes in addition to cases with "matching" outcomes.

NIST has been actively studying the issue of contextual bias and other human factors issues. In collaboration with the NIJ, NIST convened an expert working group to do a scientific assessment of the effects of human factors on forensic latent print analysis and to develop recommendations to reduce the risk of error. The recently published report, *Fingerprint Analysis: Improving the Practice through a Systems Approach,* (*http://www.nist.gov/manuscript-publication-search.cfm?pub_id=910745*) is the result of a 2½ year study. It was composed of forensic science practi-

tioners, psychologists specializing in contextual bias, statisticians, prosecutors, defense attorneys, academicians and accident prevention specialists. The working group also created a process map (*http://nij.gov/nij/topics/forensics/evidence/impression/latent-print-flowchart.htm*) that illustrates the latent print examination process, and the report details steps in that process where human error risks could be minimized.

The Expert Working Group on Human Factors in Latent Print Analysis and its recently published report serve as an excellent model for the other forensic science disciplines. NIST will begin a new panel evaluating the human factors issues in questioned documents analysis in the coming months. Many forensic science disciplines would benefit from implementing this model to identify and help limit the potential for contextual bias.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO PATRICK D. GALLAGHER, PH.D.

Question 1. What working relationship between exists between NIST and DOJ? Do both agencies agree on the clear division of appropriate responsibilities regarding this problem? Could you outline, to date, some of these activities and briefly tell us what progress this synergy has produced? What problems do you anticipate with this type of inter-agency, "inter-cultural" collaboration?

Answer. NIST and DOJ enjoy a decades old history predating World War II of successful collaborations in criminal investigations and supporting the development of the original FBI Laboratory. During the intervening years, DOJ and NIST have partnered on technology and standards development in many areas of public safety, including emergency response involving law enforcement agencies, fire departments, emergency medical teams, corrections and forensic science communities worldwide. DOJ and NIST have numerous formal agreements in place articulating the respective roles and responsibilities of the two agencies. The synergistic relationship between our two agencies is an excellent example of leveraging the core strengths of each agency to produce deliverables with benefits to public safety communities that exceed what either agency could generate on its own.

One example includes the response by the U.S. Attorney General to the 2003 premature field failure of recently issued body armor that was penetrated by a standard round from a handgun that the body armor had been certified to stop. In response, the AG created the Body Armor Safety Initiative. Under a subsequent agreement, NIST undertook research to measure and characterize the root causes of these failures and developed testing methodologies to insure that such failures did not occur again. The research and collaboration between NIST and DOJ, with practitioners and relevant stakeholders, led to the revised standard for body armor (NIJ Standard 0101.06), which included testing for environmental conditions that had led to the 2003 failure and a more robust conformity assessment and accreditation program for the independent laboratories conducting body armor testing and certification.

The impact of that ongoing collaboration is enormous. Ballistic-resistant body armor has been credited with saving the lives of more than 3,000 police officers.

Another example resulted in the research and development of new technology to permit DNA identification of a substantial proportion of the human remains recovered from Ground Zero at the site of the World Trade Center disaster on September 11, 2001. There were more than 20,000 bits of human tissue and bone recovered, some no larger than a fingertip, and most were badly decomposed or partially incinerated. The severely degraded condition of these human remains made it extremely difficult for the forensic biology laboratory of the New York City Office of the Chief Medical Examiner (OCME) and its collaborators to obtain interpretable DNA profiles from these human fragments using conventional DNA methodologies in practice within crime laboratories in 2001. DOJ and NIST collaborated and funded applied DNA research to develop at NIST a new set of DNA reagent molecules called "Mini-STRS" that would enable scientists to go back and identify successfully much more of the partially degraded DNA samples than ever before. The result was a dramatic improvement in the proportion of fragments of human remains that could be identified and associated with the known reference DNA standards of the victims or members of their families.

The impact of that ongoing collaboration between DOJ and NIST is also enormous. The result of that giant leap forward in forensic DNA testing capability contributed significantly to the subsequent identification of more than 1,600 victims who perished at the WTC disaster on 9/11, many by DNA testing alone.

There are dozens of other similarly significant synergistic outcomes of the successful collaboration between NIST and DOJ in the world of testing, accreditation and

standards development including such forensic science disciplines as fire investigations, drug detection, biometrics, firearms/ballistics, and genetics (DNA). This partnership benefits from the mutual exploitation of the core strengths in each other's agency to the benefit of the entire public safety community and society.

Question 2. The area of forensics is not only interesting scientifically, but also very important since the stakes are high. On the one hand, we have issues of measurement, but on the other hand we have judicial and legal issues. Could you outline some of the unintended consequences you and DOJ have encountered so far?

Answer. As noted above, NIST and DOJ enjoy a decades old history of successful collaborations in criminal investigations and supporting the development forensic science standards and technology. There has been much mutual discussion about the current status of forensic science practice in the United States and the impact on judicial and legal issues. NIST and DOJ are keenly aware of current issues and challenges and our partnership affords us an effective view of matters from both scientific and legal perspectives. NIST has subject matter expertise in scientific measurement, technology and standards development and DOJ has subject matter expertise in judicial and legal issues as well as the practice of forensic science. In response to your request to characterize the "unintended consequences" NIST and DOJ have encountered so far, it is accurate to describe the collaboration quite to the contrary—highly attuned to the needs of the forensic science community, in large measure attributable to the experience and expertise resident within our agencies as well as both agencies' long history of outreach with state and local subject matter experts throughout the Nation. As a matter of current operational practices, NIST and DOJ routinely collaborate heavily with state and local agencies in the formation of technology and standards development and identifying current challenges to forensic science practitioners and members of the criminal justice community.

Although one cannot foresee all possible further contingencies, the boots on the ground in both organizations are career professionals and both camps are keenly sensitive to the needs of the Nation's forensic science community and value the input of state and local stakeholders to provide the necessary guidance to inform our day-to-day decisionmaking.