FAS

Use of Attribution and Forensic Science in Addressing Biological Weapon Threats: A Multi-Faceted Study

A special report published by the Federation of American Scientists

Christopher A. Bidwell, JD and Kishan Bhatt

February 2016

About FAS

Founded in November 1945 by many of the scientists who built the first atomic bombs, the Federation of American Scientists (FAS) is devoted to the belief that scientists, engineers, and other technically trained people have the ethical obligation to ensure that the technological fruits of their intellect and labor are applied to the benefit of humankind. The founding mission was to prevent nuclear war. While nuclear security remains a major objective of FAS today, the organization has expanded its critical work to address urgent issues at the intersection of science and security. FAS publications are produced to increase the understanding of policymakers, the public, and the press about urgent issues in science and security policy. Individual authors who may be FAS staff or acknowledged experts from outside the institution write these reports. Thus, these reports do not represent an FAS institutional position on policy issues. All statements of fact and expressions of opinion contained in this and other FAS Reports are the sole responsibility of the author or authors.

Acknowledgements

This publication was developed under work supported by the Naval Postgraduate School (NPS) Project on Advanced Systems and Concepts for Countering WMD No. N00244-14-1-0054 awarded by the NAVSUP Fleet Logistics Center San Diego (NAVSUP FLC San Diego), with funding from the Defense Threat Reduction Agency (DTRA). It has not been formally reviewed by NPS. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of NPS, NAVSUP FLC San Diego, or DTRA. The authors are grateful for the opportunity to carry out this study and hope that the results will stimulate public debate among the academic, public policy, and non-governmental communities, as well as the public in general.

The authors would like to express their deepest gratitude to those who have supported this effort. The authors would like to thank Dr. Randall Murch and Mr. John Lauder for the wealth of expertise that they imparted in the planning and facilitating of the workshop and contributing written research. The authors also would like to express their sincere appreciation to all of the workshop participants of November 18, 2015 for their contributions of time and insight to help sort through a complex array of topics, as well as the staff at Middle East Scientific Institute for Security and the Royal Scientific Society in Jordan. Finally, we would like to thank the sponsors of this study at the U.S. Department of Defense, particularly the sponsors at Naval Post Graduate School, including Dr. Michael Malley and Dr. Clay Moltz, whom we thank for their valuable oversight and suggestions with regard to this effort. Additionally, the authors are grateful for editing support from Dr. Charles Ferguson, President of FAS, and editing and formatting support from Allison Feldman, FAS's Director of Communications and Community Outreach.

For more information about FAS or publications and reports, please call 202-546-3300, e-mail fas@fas.org, or visit www.fas.org.

Design, layout, and edits by Allison Feldman.

Cover Photo: © poba, iStock by Getty Images.

Table of Contents

Executive Summary

The threat from the manufacture, proliferation, and use of biological weapons (BW) is a high priority concern for the U.S. Government. As reflected in U.S. Government policy statements and budget allocations, deterrence through attribution ("determining who is responsible and culpable") is the primary policy tool for dealing with these threats. According to those policy statements, one of the foundational elements of an attribution determination is the use of forensic science techniques, namely microbial forensics. Unfortunately, using forensic science in an attribution setting is not a pure scientific endeavor. It involves the interplay among science, law, policy, law enforcement, public health, and the media communities. This convergence of different disciplines and professions all focused on reaching a common understanding of a suspicious activity is a difficult problem to work through in a domestic context, and even more so if a suspected BW event has transnational or global implications. In such instances, acceptance of an attribution determination would be dependent on how the leadership in other nations processes and accepts information that would be generated, how they would perceive the nature and the source of that information, and how their decisions regarding a response would be made. Consequently, how the attribution determination is made, and more importantly, how it is presented to foreign leaders, is critical if an investment in the science behind forensics is to pay off. This applies not only to cases wherein the attribution determination points to a guilty person, organization, or country, but also in situations wherein false accusations must be discredited.

This policy conundrum is exactly what is being played out in Syria today with regard to allegations of chemical weapon's usage with parties attempting to promote evidence that endorses their political objectives, while challenging the credibility of evidence that does not. Given such predicaments, this report explores the science-law-bureaucracy-media response dynamic for attribution determinations regarding potential manufacture, possession, and/or use of BW by walking through each of these elements individually, with a focus on the use of forensic evidence, particularly microbial forensics. This report explores the many challenges faced by policy makers in trying to convince others of the validity of an attribution determination and offers suggestions for improving the process.

Key points that this report makes are as follows:

- A good attribution capability is as valuable as a BW deterrence tool.
- A good attribution capability requires well developed science that not only meets scientific scrutiny but also legal scrutiny.
- Legal constructs act as a good lens to look at BW attribution evidence not just in the courtroom, but in the court of public opinion and in the minds of policy leaders.
- Forensic determinations, while based on science principles, require collaboration with other disciplines and communities, such as legal, law enforcement, public policy, public health, and communications.
- In order to be policy relevant, the science behind microbial forensics must be well accepted by the international science community, but more importantly, the non-science community.
- With regards to BW, microbial forensics is a useful policy tool, but must overcome general suspicions and unrealistic expectations towards forensic science in general.

Introduction

This report primarily focuses on the challenges of using attribution as a policy tool when addressing threats from the manufacture, acquisition, possession, and/or use of biological weapons (BW), emphasizing the role that forensics may play in establishing culpability. In the last 20 years, the U.S. Government has increased its focus on threats emanating from BW, especially after the terrorist attacks of 9/11 and the Anthrax attacks that followed shortly thereafter. The seriousness with which the U.S. Government treats this threat is reflected in recent budgets. Since 2001, the United States has reportedly spent over $60 billion dollars on biodefense.[1] Yet despite these investments, the *2009 National Strategy for Countering Biological Threats* (NSCBT) concedes that still "it is quite possible" that the United States "would not obtain specific warning of an imminent threat or imminent attack in time to stop it."[2] Additionally, a November 2015 report from the U.S. Government Accountability Office raised serious doubts as to the reliability of Homeland Security's $87 million a year BioWatch system – a system designed to rapidly alert authorities when a bio attack is occurring.[3]

The Policy Background

Given the limitations of prevention and early detection, two important approaches for reducing overall vulnerability to BW attacks are: (1) To improve response and mitigation capabilities should a BW attack occur; and (2) To ensure that those who are responsible can be held accountable through attribution. This is where the science of microbial forensics becomes an important component of government policy. The 2009 NSCBT highlights the importance of enhancing microbial forensics and attribution capabilities to generate "scientifically sound and statistically defensible" information that links a biological attack to its perpetrators.[4] To that end, the NSCBT includes a section on "Enhancing Microbial Forensics and Attribution" by ensuring synergy among experts in public health, agriculture, and law enforcement, as well as strengthening the National Biological Forensics Analysis Center (NBFAC) as the federal hub for bio attribution projects.[5] That broad policy paper was followed by the *National Research and Development Strategy for Microbial Forensics* that aims to develop a microbial forensics research agenda; promote interagency communication, coordination, and information sharing on research and development efforts; and enhance interagency education and training on microbial forensics and related topics.[6]

As these strategic policy documents focus on the use of microbial forensics as a key element of the attribution process, this report is heavily focused on the use of microbial forensics when talking

[1] Cole, Leonard A. "Bioterrorism: Still a Threat to the United States." *CTC Sentinel*. January 2012. https://www.ctc.usma.edu/v2/wp-content/uploads/2012/01/Vol5-Iss16.pdf.
[2] U.S. National Security Council, The White House. *National Strategy for Countering Biological Threats.* November 2009. http://fas.org/irp/offdocs/ppd/bio-strategy.pdf.
[3] Government Accountability Office. *Biosurveillance, DHS Should Not Pursue BioWatch Upgrades or Enhancements Until System Capabilities are Established.* Report. October 2015. http://www.gao.gov/products/GAO-16-99.
[4] Specifically, the NSCBT calls for establishing a nationwide research, development, and investment plan in microbial forensic science; maintaining a National Biological Forensics Analysis Center (NBFAC) to support local law enforcement agencies; and ensuring coordination among professionals in public health, law enforcement, and agriculture.
[5] U.S. National Security Council, The White House. *National Strategy for Countering Biological Threats.* Report. November 2009. http://fas.org/irp/offdocs/ppd/bio-strategy.pdf.
[6] National Science and Technology Council, The White House. *National Research and Development Strategy for Microbial Forensics*. Report. 2009. https://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/National%20MicroForensics%20R&DStrategy%202009%20UNLIMITED%20DISTRIBUTION.pdf.

about attribution. This strong commitment to the use of forensic tools by the U.S. Government was reaffirmed as recently as February 2014 in a White House report entitled *Strengthening Forensic Science: A Progress Report*, which highlighted the advancements in forensic understanding and its relation to policy.[7] This reliance on forensics by the policy community is neither new nor is it limited to bio threats. As will be discussed below, forensics is also a fundamental policy tool used in the case of nuclear attribution.

Given the findings of such national task forces, as well as policy decisions, the U.S. Government appears to be confident in the strength and potential for microbial forensics to play a large role in biosecurity efforts. This confidence has been the case across recent presidential administrations. In 2008, the Bush Administration published an executive summary of the Microbe Project Interagency Working Group (MPWIG) and a plan for advancing "genome-enabled microbial science across all agencies."[8] The plan called on the MPIWG to "promote development of techniques and criteria for microbial strain identification and attribution to distinguish natural from introduced pathogens and support the continued development of models of outbreaks that allow comparison of microbial forensics and molecular epidemiology paradigms."[9]

The Challenge

The laudable goals set forth in the NSCBT and subsequent national policy documents comprise a robust and ambitious domestic *national strategy*. However, an equally robust and ambitious *international strategy* for microbial forensics is necessary to help ensure that the "scientifically sound and statistically defensible"[10] determinations yielded will persuade audiences abroad to take action in support of an attribution determination – or be a willing participant in an investigation to attribute cause – or simply not condemn or interfere with U.S. Government actions in response to an attribution determination. This is the point where science, law, policy, law enforcement, public health, and public relations intersect most directly and where the difference between desirable certainties and available certainties, along with the limits of scientific inquiry, collide.

While microbial forensics is clearly an important factor in determining attribution, it cannot by itself be dispositive proof linking a BW attack, possession, or manufacture to a culpable person or entity. It is but one piece of a larger evidentiary mosaic. The story of the Federal Bureau of Investigation (FBI) enquiry of the 2001 Anthrax attack (often called the "Amerithrax Attacks") is illustrative. As part of the study, the FBI spent seven years and 600,000 investigator hours while consulting with 29 universities for scientific and technical support. Several accounts, including a 2011 PBS Frontline report, peg the FBI anthrax investigation as the United States' most expensive and complex investigation to date, costing $100 million over 10 years.[11,12] Still, a review of the evidence by the

[7] The White House. *Strengthening Forensic Science: A Progress Report.* Report. 2009. https://www.whitehouse.gov/sites/default/files/microsites/ostp/forensicscience_progressreport_feb-2014.pdf.
[8] The White House. *The Microbe Project, Interagency Working Group Coordination Plan*. Report. 2008. https://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/MPIWG%20plan%2012-17-08FINAL.PDF.
[9] Ibid
[10] Murch, Randall Steven. "Bioattribution Needs a Coherent International Approach to Improve Global Biosecurity." *Frontiers in Bioengineering and Biotechnology* 3, no. 80. 1 June 2015.
[11] Moughty, Sarah. "The Anthrax Attacks: 10 Years Later." *Frontline PBS*. 3 October 2011. http://www.pbs.org/wgbh/pages/frontline/criminal-justice/anthrax-files/the-anthrax-attacks-10-years-later/.

National Research Council concluded that it was "not possible to reach a definitive conclusion about the origins of the B. anthracis in the mailings based on the available scientific evidence alone."[13] (Of course, the FBI's case did not rely exclusively on microbial forensics evidence in reaching its conclusions, and there have been many advances in the field since then.)

As pointed out by many, the Anthrax Investigation was a case where the science was being developed as the investigation proceeded.[14] Similarly, the Department of Homeland Security's Undersecretary for Science and Technology, Tara O'Toole, MD, MPH, testified in 2011 to a Senate committee about the importance of microbial forensics (among other things) to biological defense programs. She explained that in the immediate aftermath of the 2001 Amerithrax episode, there was "no biocontainment lab, staff, or equipment singly dedicated to microbial forensic analysis and limited evidence handling processes, peer-reviewed analytical methodologies, or quality guidelines."[15] Dr. O'Toole cites the improved funding and architecture for such biodefense capabilities as a vital contributor to national security improvement, specifically through today's NBFAC, which supports bio crime investigations and has "developed sensitive and specific assay capabilities for more than 60 bacterial, viral, and toxic agents and has processed over 8,000 samples and completed 137 cases in support of Federal Law Enforcement agencies."[16]

As a result of its relative youth as a science discipline, the field of microbial forensics still faces numerous technical challenges due to the need to validate the totality of data collection and analysis methods used for investigating multitudes of potentially dangerous pathogens that could be used in a biological attack. In addition to the technical challenges inherent in gathering and analyzing forensic data, the field also faces practical challenges in communicating technical results to non-technical people – and that can be very difficult to overcome. Even assuming that microbial forensics can reach the level of sophistication and acceptance as Deoxyribonucleic Acid (DNA) evidence, transforming the data it yields into actionable tools for policymakers and public officials requires consideration as to how others will interpret it. Until this problem is solved, all the forensic science-based attribution efforts will not easily factor into policy decisions, especially those of foreign governments.

Nuanced and logically-sound methodologies have been proposed for synthesizing scientific information, intelligence, and open-source reporting to confirm or disprove accusations of WMD use.[17] The usefulness of microbial forensics to attribute an attack to a suspect will largely be a

---

[12] Trust for America's Health. *Remembering 9/11 and Anthrax: Public Health's Vital Role in National Defense*. Report. September 2011. http://healthyamericans.org/assets/files/TFAH911Anthrax10YrAnnvFINAL.pdf.

[13] National Research Council. *Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters*. Report. *The National Academies Press* p. 144 (2011). http://www.nap.edu/catalog/13098/review-of-the-scientific-approaches-used-during-the-fbis-investigation-of-the-2001-anthrax-letters

[14] The Center for Contemporary Research. *Anthrax in America: A Chronology of the Fall 2001 Attacks*. Report. November 2002. https://fas.org/irp/threat/cbw/anthrax.pdf.

[15] Department of Homeland Security. *Testimony of the Honorable Tara O'Toole, M.D. before the U.S. Senate Committee on Homeland Security and Governmental Affairs*. 18 October 2011. http://www.dhs.gov/news/2011/10/18/testimony-honorable-tara-otoole-md-mph-us-senate-committee-homeland-security-and.

[16] Ibid.

[17] Katz, Rebecca, and Burton Singer. "Can an Attribution Assessment Be Made for Yellow Rain? Systematic Reanalysis in a Chemical-and-Biological-Weapons Use Investigation." *Politics and the Life Sciences* 26, no. 1 (March 2007): 24-42. Katz's methodology assesses the reliability of each source of information (scientific information, intelligence, and open-source reporting) in combination with the strength of its association with a deliberate WMD attack as opposed to alternative explanations.

function of the degree to which non-U. S. Government entities and international leaders understand the science and regard the information it yields as credible. Understanding the science behind an attribution claim is a foundational challenge; moreover, developing a common understanding of what the science "actually says" poses an additional test.[18]

Without a doubt, geopolitics will play a role in shaping the responses of foreign leaders to U.S. Government concerns about possible BWC use and matters pertaining to culpability. In addition, social and cultural factors play a role in how political leaders, public health professionals, the media, and the general public react to scientific information and determine what type and amount of evidence is deemed sufficient to attribute the cause of a biological incident, be it naturally-occurring or man-made, and, if the latter, to an individual, group, or nation state. Conversely, and perhaps more likely, microbial forensics could serve to discredit false accusations that a naturally-occurring disease was the result of an intentional act by humans. Either way, epidemiological and microbial forensics will play a pivotal role in guiding policymakers on what to do in the wake of a suspected BW attack.[19] However, it should not be taken for granted that the rest of the world will take such evidence at face value. This caveat will be important to keep in mind if the U.S. Government (or any government) seeks to garner support for its scientifically-based conclusions and set the conditions for seeking retribution against alleged perpetrators.

To address the challenges outlined above, this report discusses the threat of biological weapons and reviews the general state of forensic science, with a particular focus on microbial forensics. It then addresses legal, policy law enforcement, public health, media, and communications concerns that interact with microbial forensics data. In addition, the report explores the link between BW investigations, attribution, and deterrence. Finally, it addresses how the results from microbial forensic evidence can be used in policy settings, both international and domestic, by answering key policy questions.

[18] Bidwell, Christopher and Mark Jansson. *Microbial Forensic Attribution, Where Science Meets International Relations*. Report. 31 March 2014. http://www.virtualbiosecuritycenter.org/wp-content/uploads/2014/07/FAS-Microbial-Forensic-Science-and-International-Relations.pdf.

[19] Budowle, Bruce, Schultzer, Steven, Breeze, Roger, Keim, Paul and Morse, Stephen. *Microbial Forensics, 2nd Ed*ition. Burlington, MA: Academic Press, 2011.

The Threat of Biological Weapons

Biological weapons are not a "new" concept in the history of war. They have been a threat to humankind for many years. One of the earliest known uses of BW occurred during the ancient Peloponnesian Wars between the Greek empires of Athens and Sparta, as was documented by Thucydides.[20] What is "new" is that since the mid-1990s, the world has significantly ratcheted up its attention to the threat of intentional use of BW agents to cause terror, harm, and societal disruption. This is mainly due to the fact that BW agents can now be altered to have more damaging effects, and furthermore are capable of being mass produced. Many attribute the public attention of that era to books and articles written by Ken Alibek[21] and Judith Miller,[22] which exposed the biological weapons complexes of the Former Soviet Union (FSU). The chemical attacks in the Tokyo subway in 1995, combined with the public revelation of a massive physical infrastructure in the FSU devoted to the manufacture of anthrax and other disease agents, caught the attention of many inside the U.S. Government and stirred up fears amongst the public. Working with other governments and non-governmental organizations (NGOs), the U.S. Government began to build an infrastructure to deal with the perceived threats from biological weapons. While the immediate and foreboding concerns over the former Soviet BW programs have dissipated, concerns remain over: (1) Programs that other "nations of concern" might possess; (2) well-resourced terrorist and insurgency groups that could pursue such programs; and (3) the potential for use by single individuals ("lone wolves").

Fears about BW in the early part of the 20th Century caused them to fall into the "prohibited" category of weapons whose consequences were so horrendous that they should not be used by civilized countries. The Geneva Convention of 1925 effectively codified this fear, as did the Biological Weapons Convention of 1972 (BWC) years later.

When thinking about BW, and how to address concerns about their use and possession, it is helpful to look at the recent experience of trying to attribute Chemical Weapon's (CW) use in Syria. Despite the watchful eyes of governments, journalists, and NGOs, not to mention a detailed Organisation for the Prohibition of Chemical Weapons (OPCW)/World Health Organization (WHO) report, commissioned by the U.N. Secretary General,[23] little usable, policy-relevant evidence has come forward to substantiate the allegations – and even the evidence that has been presented is being challenged in some quarters.

The key complaint from the OPCW/WHO report was that it failed to directly address the question of "who" (which party) deployed and used CW.[24] Part of this was due to the fact that those who made CW accusations (both the Syrian government and their anti-government foes) tended to be one-sided in their reporting. The inspection team limited their duties to determining solely whether

---

[20] Strassler, Robert B. *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian Wars.* New York, NY: Simon & Schuster, 2008.

[21] Alibek, Ken, and Steven Handelman. *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World - Told from Inside by the Man Who Ran It.* New York, NY: Random House, 1999.

[22] Miller, Judith, Stephen Engelberg, and William J. Broad. *Germs: Biological Weapons and America's Secret War*. New York, NY: Simon & Schuster, 2001.

[23] United Nations. *United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic, Report on the Alleged Use of Chemical Weapons in the Ghouta Area of Damascus*. Report. 21 August 2013. http://www.un.org/disarmament/content/slideshow/Secretary_General_Report_of_CW_Investigation.pdf.

[24] Gladstone, Rick, and C.J. Chivers. "Forensic Details in U.N. Report Point to Assad's Use of Gas." *New York Times*. 16 September 2013. http://www.nytimes.com/2013/09/17/world/europe/syria-united-nations.html?_r=0.

or not CW was used, as the U.N. mandate authorizing the investigation specifically prohibited the team from making an assessment as to "who" used CW.[25] The other hurdle was that the investigation essentially took place in an active war zone. Reports indicate that the inspectors were subject to sniper fire[26] and mortars landing near their hotel.[27]

In the Syrian CW case, there was a perceived political benefit in claiming to be the aggrieved party. This was true for both the pro-Assad factions and the opposition factions. Unfortunately, this situation put the United States, the United Nations, and most of its member states in the position of having to decide if the evidence offered by Hezbollah aligned forces was more reliable than contrary evidence supplied by Al-Qaeda or Daesh (ISIL) associated forces. This conundrum is not new, nor is it surprising. Since the signing of the U.N. Charter in 1945, no nation has ever been held conclusively responsible for possession or use of BW/CW, despite at least 12 United Nations Secretary General's Special Investigation Mechanism (UNSGSIM) reports involving hundreds of people and the expenditure of millions of dollars. While some reports have confirmed use, the politics of each case made direct attribution to the responsible party impossible.[28] This experience with the CW investigations and attempted attribution in the Syria case may be instructive in the BW context as there are recent reports in the media that ISIL has taken an interest in acquiring a BW capability.[29]

Other challenges associated with BW attribution have occurred in the domestic context. Twice in the last 14 years, there have been biological agents delivered to government leaders via mail (the 2001 Amerithrax and 2015 Mississippi cases).[30] In both cases, the law enforcement effort initially identified and prosecuted the wrong perpetrator. In the Amerithrax case, it was done in a very public way. Given this history, it is logical to assume that the credibility of the U.S. Government may be at risk when it comes to attributing the source of a biological or chemical attack. Complicating the task further is that the attribution concerns cross the traditional bureaucratic and administrative boundaries between the policy, medical response, and law enforcement communities.[31] The result is the existence of both overlaps and gaps in attempting to attribute the source of a biological incident. However, because none of the medical, public health, legal, policy, infrastructure, or response measures in place are fully effective to prevent a deliberate bio-attack from occurring, effective attribution and prosecution has become a very high priority for the U.S. Government, as it adopts an aggressive response to support a strategy of deterrence. Many foreign governments are not as aggressive about countering biological threats, but have recently recognized the need to be able to properly attribute an attack's source – if only to prevent a wrongful accusation against them.

---

[25] Kawashima, Yuta. "Timeline of Syrian Chemical Weapons Activity, 2012-2015." *Arms Control Association*. 8 May 2015. https://www.armscontrol.org/factsheets/Timeline-of-Syrian-Chemical-Weapons-Activity.

[26] Bennett, Dashiell. "U.N. Inspectors Fired On in Syria a, as Cameron Pushes Obama to Act." *The Wire.* 26 August 2013. http://www.thewire.com/global/2013/08/us-inspectors-fired-syria-cameron-pushes-obama-act/68701/.

[27] Makdesi, Marwan. "At Least Two Motar Bombs Hit Damascus near U.N. Team's Hotel." *Reuters.* 26 August 2013. http://www.reuters.com/article/us-syria-crisis-mortars-idUSBRE97P07320130826.

[28] Littlewood, Jez. *Investigating Allegations of CBW use: Reviving the UN Secretary-General's Mechanism*. Report. December 2006. http://carleton.ca/npsia/wp-content/uploads/CC3.pdf .

[29] Doornbos Harked and Moussa Jenan. "Found: The Islamic State's Terror Laptop of Doom." *Foreign Policy*. 28 August 2014. http://foreignpolicy.com/2014/08/28/found-the-islamic-states-terror-laptop-of-doom/

[30] Teague, Matthew, and Shashank Bengali. "Martial Arts instructor Arrested in Case of Poisoned Letters." *Los Angeles Times*. 27 April 2013. http://articles.latimes.com/2013/apr/27/nation/la-na-tupelo-poison-letters-arrest-20130427.

[31] Stone Bahr, Elizabeth. "Biological Weapons Attribution, A Primer." *Naval Post Graduate School*. June 2007.

Another related major concern comes from those biological threats that develop naturally. Effective BW attribution is important not only for the threats posed by manufactured weapons but also for naturally occurring disease such as Avian Flu, Middle East Respiratory Syndrome (MERS) Corona Virus, Escherichia Coli (E-Coli) 0157:H7 and Severe Acute Respiratory Syndrome (SARS). Correctly identifying the source of natural diseases is perhaps even more important given the frequency with which such outbreaks have occurred within the last 20 years and the impact those outbreaks have had on societal and national security policies. Furthermore distinguishing natural outbreaks from intentional use of BW will have a huge impact on how prevention and remediation actions are pursued.

The Uniqueness of the BW Threat

When thinking about BW, it is important to understand the anxiety associated with them. BW agents are unique among WMD in that an attack may not be noticeable. As humans, we may not be able to see, hear, taste, smell, or even feel an ongoing bio attack in real time. In other words, one can currently be subject to a biological attack and not even know it until days later. This is in stark contrast to a chemical, nuclear, or conventional attack. Furthermore, in order to observe the microbe, the primary attack modality, the use of a microscopes and advanced sensing equipment is required.

One of the consequences of the anxiety and inability to truly sense the onset of an attack is that evidence can be easily exaggerated in support of specious or unfounded claims. Thus, it may be more important to have the ability to rule out causes and explanations via attribution processes than to definitively prove the source of an attack. Evidence of exoneration is an extremely valuable tool for policy – especially from the stand point of the wrongfully accused.

The other factor that distinguishes BW from other WMD is that many of the causative agents of destruction are naturally-occurring and can cause harm without any manipulation from human. This means that naturally-occurring diseases in the environment can be falsely-attributed to an act of man. This has happened before (Kosovo conflict)[32] and could happen again.

All of the above identified factors point to the need for robust and believable attribution capabilities.

[32] Grunow, R. and E.J. Finke. "Differentiation of Natural and Artificial Epidemics." *Clinical Microbiology and Infection* 8, no. 8 (2002): 510. http://ac.els-cdn.com/S1198743X14626409/1-s2.0-S1198743X14626409-main.pdf?_tid=7cc859f6-d0f3-11e5-b7fe-00000aacb35f&acdnat=1455218169_f9402daead67ad075f1ff72ec823a1f8.

The Many Aspects of an Attribution Determination

Current policy documents indicate a reliance on microbial forensics as a tool for attribution. Recent U.S. Government budgets further support that premise. Consequently, the many aspects (technical and non-technical) of an attribution determination are explored below.

The Science Aspect – Forensic Science and Microbial Forensics

Forensic Science

As microbial forensics is a sub-set of forensic science, it is worth exploring the nature of the field. According to the American Academy for Forensic Sciences, forensic science is described as "any science used for the purposes of the law."[33] It is not empirical science; rather it is often a tool for measuring probabilities to identifiable degrees of certainty using scientific disciplines. It has often been referred to as "science for the courtroom." It is also more than a "pure" scientific or technical subject; forensic science is a multidisciplinary field that aims to provide objective analysis of evidence in legal proceedings using procedures from chemistry and biology, as well as other sciences.[34]

Communal inquiry and collaboration among experts are hallmarks of the process behind forensic science and investigation. As one forensic science text notes, "Individual scientists always work as members of a larger team."[35] Lawyers, policy experts, and judges are some of the key players in this larger team that interprets the information gathered by scientific specialists employing particular biological or chemical tracing techniques. Through coordinated efforts and cooperation among different disciplines, these experts from distinct fields are jointly-tasked with determining plausible and likely explanatory pathways of a problem.

While the forensic science process can yield consistent and reliable results, the credibility of forensic science is not universal across all settings. In 2009, the National Academy of Sciences (NAS) issued a report to the Department of Justice regarding the current state of forensics in the United States, finding "the depth, reliability, and overall quality of substantive information arising from the forensic examination of evidence available to the legal system varies substantially across the country."[36] In the courtroom context, William C. Thompson, a professor of criminology and law at the University of California at Irvine, notes that when used as a tool to prosecute criminal cases, "Excessive influence by police and prosecutors, who rely heavily on forensic science evidence to obtain convictions," may

[33] "What is Forensic Science?" American Academy of Forensic Sciences. 2016. http://www.aafs.org/students/choosing-a-career/what-is-forensic-science/.
[34] "What is Forensic Science?" Staffordshire University. 2016. http://www.staffs.ac.uk/schools/sciences/forensic/whatisforsci/whatisforensicsci/.
[35] James, Stuart H., and Jon J. Norby. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. Boca Raton, FL: CRC Press, 2003. https://books.google.com/books?id=KMfs_ezuWdMC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false.
[36] Committee on Identifying the Needs of the Forensic Sciences Community, National Research Council. *Strengthening Forensic Science in the United States: A Path Forward*. Report. *The National Academies Press* (2009). https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf.

make the objectivity of the findings tainted or suspect.[37] As objectivity is the *sine qua non* of credibility, using U.S. Government sponsored microbial forensics as an attribution confirmation tool can potentially suffer from this same credibility defect in the courts of law, as well as the courts of public opinion (both international and domestic). This is an important concern that needs to be considered when attempting to use microbial forensic results in a legal or policy setting.

Examples of Forensic Science

In his June 2015 article on bio attribution, Dr. Randall Murch identifies several core examples of forensic science. "Classical forensic disciplines include pattern analysis (e.g., fingerprint), biology (e.g., human DNA analysis), trace evidence (e.g., hairs and fibers), toxicology (i.e., drugs and poisons), digital evidence (e.g., computer media), and pathology (i.e., manner and cause of death). Validated techniques, methods, and protocols, which meet or exceed both scientific and legal standards, are required"[38] when using microbial forensic to advance a criminal or civil case, as well as when used in international policy decision making.

To be sure, many forensic science techniques involve analyzing crime scene objects and materials and performing comparisons with existing files in forensic databases. Forensic odontology, for example, is based on matching crime scene teeth marks to dental records on file. Consequently, the proper acquisition and handling of evidence, as well as active maintenance of centralized and comprehensive information hubs, are crucial to effective forensic attribution.[39]

Use of Forensic Science

Legal structures form the framework for interpreting the data that forensic scientists gather, treating this data as an important factor in decision-making. However, some forms of forensic data have limitations, especially when it comes to peer review. Prior to the 1984 discovery of DNA identification, use of fingerprint evidence was a foundational example of how the forensic science process was used in criminal trials. Matching a print taken at the scene to a particular suspect was understood to be a powerful indicator of whether or not that suspect committed the crime in question. Astoundingly, a PBS Documentary reported that "no peer reviewed scientific studies have ever been done to prove the basic assumption that every person's fingerprint is unique."[40] Furthermore, defense counsels' current use of numerous reports identifying unconscious bias among fingerprint examiners has reduced the credibility of such evidence in court.[41]

Conversely, the strength and accuracy of forensic DNA analysis has improved to the point where it has actually been used to exonerate people who had been convicted based on the conclusions from other, less reliable forensic techniques. Harry T. Edwards, a US federal judge and member of the committee that authored the 2009 NAS report, argued that "DNA is really the only discipline

[37] Thompson, William C. "A Setback for Forensic Science." *The Washington Post*. 8 May 2015. http://www.washingtonpost.com/opinions/a-setback-for-forensic-science/2015/05/08/540273f2-f350-11e4-84a6-6d7c67c50db0_story.html.
[38] Murch, Randall Steven. "Bioattribution Needs a Coherent International Approach to Improve Global Biosecurity." *Frontiers in Bioengineering and Biotechnology* 3, no. 80. 1 June 2015.
[39] Ibid.
[40] Jones, Jonathan. "Forensic Tools: What's Reliable and What's Not-So-Scientific." *PBS Frontline*. 17 April 2012. http://www.pbs.org/wgbh/pages/frontline/criminal-justice/real-csi/forensic-tools-whats-reliable-and-whats-not-so-scientific.
[41] Ibid.

among the forensic disciplines that consistently produces results that you can rely on with a fair level of confidence when you're seeking to determine whether or not a piece of evidence is connected with a particular source."[42] Given these more recent revelations and advances in understanding, DNA evidence has become preferential in the courtroom. The good news is that current microbial forensic techniques are based on many well-established DNA identification techniques, and as a result, its reliability may be perceived as similar to that of DNA evidence.

Microbial forensic research is saddled with the explicit task of precisely linking the microbes found at a scene to the microbes at a source based on unique and identifiable patterns of genetic polymorphisms. Similar to human DNA analysis, microbial forensic practitioners highlight particular loci at which individual strains among larger families of infectious agents differ in nucleotide sequence, and use that information to infer common identity and/or lineage. This can be a key element in establishing a connection between the source of a BW attack or biological outbreak event and its perpetrator or cause. In 2011, a Department of Justice report described the use of microbial forensics in the following way:

> Unlike human forensic analysis, disease-causing microbial pathogens of humans exhibit remarkable genomic diversity generated through a number of elaborate mechanisms, including high mutation and recombination rates, as well as diverse responses to selection. One major goal of microbial forensics is to use this genetic diversity to identify the source of a pathogen used to commit a crime.[43]

Thus, microbial forensics is a rapidly evolving tool for identifying pathogenic transmission routes, and its underlying scientific processes have been improving as more research is done to strengthen its role as an attribution tool.

The History of Microbial Forensics

Microbes are often of interest to both public health and bioterrorism investigations. Consequently, developing the ability to definitively link one microbial strain to another has been a top biosecurity and public health priority for some time. It's a critical component in the establishment of the cause of either a natural biological outbreak or BW attack. Microbial forensics is one of the primary emerging methods in the scientific-legal realm that is used to trace an infectious microbe to its origin, and it builds upon existing scientific processes. As the late Dr. Abigail Salyers, who was a microbiologist at the University of Illinois at Urbana-Champaign, writes, "Molecular techniques have been used for years to trace outbreaks of microbial diseases, a practice called *molecular epidemiology*."[44] Although it must withstand the same scientific scrutiny that molecular epidemiology is subject to, microbial forensics has the additional burden of overcoming the legal system's high evidentiary standards for claims of causality.

While it is a relatively new field, microbial forensics relies on existing (and rapidly evolving) biological and chemical processes that have developed over time. Virginia Tech's Dr. Randall Murch

---

[42] Ibid.

[43] Kshatriya, Priyanka et al. *Progress Towards Developing The Pathogen Tool Kit*. Report. May 2014. https://www.ncjrs.gov/pdffiles1/nij/grants/246954.pdf.

[44] Salyers, Abigail A. "Microbes in Court: The Emerging Field of Microbial Forensics." *Action Bioscience*. January 2004. http://www.actionbioscience.org/genomics/salyersarticle.html.

is renowned as one of the architects of microbial forensics technology. In a 2014 article, he writes that in 1996, the federal government launched an interdisciplinary biosecurity program to support a "new forensics investigative capability."[45] This U.S. Government program evolved into what is now termed *microbial forensics*.

The Future Promise of Microbial Forensics

The development of microbial forensics has likely benefited from historical progression in sequencing capabilities. Initial sequencing processes used what is known as the *chain termination method* when they first emerged in 1975. At that time, *Sanger sequencing* (named after Edward Sanger, the scientist who pioneered the technique) was revolutionary; experts considered it as the "gold standard for nucleic acid sequencing for the subsequent two and a half decades."[46] But in 1975, the technology was too inefficient and too expensive to use on a frequent basis for most average-resourced laboratories. Then, in in 2003, using chain-termination sequencing, the Human Genome Project was completed. It is still the largest and most prominent Sanger method-based project to date, costing the United States $3 billion and lasting 13 years.[47] While that type of project was clearly unfeasible for individual laboratories due to cost and duration, new sequencing methods using throughput technology have now caused the price of sequencing to plummet well within the potential for semi-regular use. A February 2014 article on the subject notes the increasingly rapid pace of sequencing technology: "In the past two decades, the speed of sequencing has leapt from around 10,000 bases per day per machine to more than 1 billion."[48] Such advances bolster hopes that microbial forensics can use such rapidly improving techniques from human DNA analysis en route to becoming an efficient, cost-effective tool to compare the genomic sequences of infectious agents collected at the crime scene and their purported origin. It is this speed of sequencing, coupled with reduced costs, that is making microbial forensics a viable tool for attribution.[49]

It is important to recognize that gradual advances in biology are not the only noteworthy historical steps. A 2008 study noted how high confidence analytical and Bayesian statistical methods could improve contemporary microbial forensics techniques. "Initially developed to express causal relationships in a probabilistic setting," the authors wrote, "Bayesian networks have become a well-established decision support tool used in many applications ranging from disease diagnosis to oil drilling."[50] As the scientific and mathematical communities continue to progress research in areas relevant to chemical and biological attribution, microbial forensics looks toward a future role in disease and bioterrorism investigations.

It should be noted that Bayesian inferences do not constitute empirical science, but are akin to mathematical formulas that can display a relationship match with a high degree of certainty. The

---

[45] Murch, Randall S. "Designing an Effective Microbial Forensics Program for Law Enforcement and National Security Purposes." *Archivum Immunologiae Et Therapiae Experimentalis* 62, no. 3 (2014): 179-85.

[46] Grada, Ayman and Kate Weinbrecht. "Next-Generation Sequencing: Methodology and Application." *Journal of Investigative Dermatology* 133, no. 8 (August 2013): 1. http://www.jidonline.org/article/S0022-202X(15)36383-1/fulltext.

[47] Ibid.

[48] Mole, Beth. "The Sequencing Future is Here." *Science News*. 6 February 2014. https://www.sciencenews.org/article/gene-sequencing-future-here.

[49] Wetterstrand, KA. "DNA Sequencing Costs: Data from the NHGRI Genome Sequencing Program (GSP)." *National Human Genome Research Institute*. 15 January 2016. www.genome.gov/sequencingcosts/.

[50] Jarman, Kristin H. et al. "Bayesian-Integrated Microbial Forensics." *Applied and Environmental Microbiology* 74, no. 11 (2008): 3573–3582. http://aem.asm.org/content/74/11/3573.full.

phenomenon seen through a Google search query is comparable to this: the results are fairly close to what is sought most of the time, but not all of the time. This is because Bayesian techniques are a model for describing potential relationships, but do not use actual evidence or established facts to reach a conclusion. In a legal context, probability is not equal to causation, but may be of great value to an investigation when trying to narrow down the myriad possible sources of a BW attack. Bayesian inference, like any inference, can be wrong.

Challenges to the Use of Microbial Forensics

In the fall of 2014, an article in the *National Academies in Focus*, a journal on biology and environmental studies, argued that microbial forensics faces "technologically challenging circumstances," including the "crucial need for the development of high-confidence methods to distinguish among natural, accidental, and deliberate disease outbreaks."[51] Another key limitation is in the lack of available genomic reference data; the article points out that "a more comprehensive database of microorganisms and their basic information has yet to be established."[52] To many observers, the absence of such a resource is one key obstacle; accumulating such a database on every infectious agent is a considerable task, and one that even after significant investment might not be fruitful. In contrast, a robust system of national DNA databases exists for forensic applications. As of December 2015, the United States had over 12 million DNA profiles in the National DNA Index System of the FBI Laboratory's Combined DNA Index System (CODIS).[53]

Drs. Bruce Budowle and Randall Murch, (two of the most prominent advocates for the use of microbial forensics) and others argue that microorganisms require a different type of database as opposed to human DNA, since "sequence similarity and/or genotypic match with microbes may only infer a common lineage instead of a unique identity."[54] Nonetheless, establishing a more comprehensive database is critical in order to strengthen microbial forensics and its conclusions, ultimately improving attribution capacity.

Still, linkage is not the equivalent of causation. For example, a June 2015 PBS Frontline report shows that DNA-based forensics focusing on human genetic material, while generally effective, are also not infallible, citing instances such as the Kumra murder investigation in 2012. In this case, DNA evidence implicated Lukis Anderson, a 26-year-old homeless man, who was documented as hospitalized at the time of the crime. After pondering how Anderson could have committed a seemingly impossible crime, investigators realized that the same paramedic team that brought Anderson to the hospital was the one that handled Kumra's body, allowing for the mixing of the former's DNA with the latter.[55] This incident illustrates the complexity of DNA evidence; while it is a stronger tool than other forensic techniques, the natural spread of genetic material can complicate source attribution. For example, to avoid such ambiguity, microbial forensics could confirm that the

[51] Anderson, Christina and Lauren Rugani. "The Promise of Microbial Forensics." *The National Academies in Focus* 14, no. 1 (2014): 5. http://search.proquest.com/docview/1619302435?accountid=13314.
[52] Ibid.
[53] Federal Bureau of Investigation. "CODIS-NDIS Statistics." 2016. https://www.fbi.gov/about-us/lab/biometric-analysis/codis/ndis-statistics.
[54] Budowle, Bruce et al. "Genetic Analysis and Attribution of Microbial Forensics Evidence." *Critical Reviews in Microbiology* 31, no. 4 (2008): 233-54. http://www.tandfonline.com/doi/abs/10.1080/10408410500304082?journalCode=imby20.
[55] Worth, Katie. "The Surprisingly Imperfect Science of DNA Testing." *Frontline PBS*. 24 June 2015. http://stories.frontline.org/dna.

strain of infectious agent that was found in one laboratory did not migrate there by way of shared delivery equipment to different facilities.

Furthermore, even supporters of microbial forensics point out some of its challenges. Budowle has acknowledged that it "may not be possible to uniquely identify a source based on genetics alone. Identifying the mutation/variant site that may have arisen in a subsequent passage is not easily accomplished without a costly whole genome sequence analysis."[56] Granted, whole genome analysis is becoming increasingly efficient and cost-effective, but in general, all of the aforementioned technological handicaps present potential challenges for microbial forensics to verify pathogenic linkages and origins.

Finally, many legal observers claim that forensic science is not always certain, and various media stories regarding wrongful convictions substantiate these concerns. Limitations in specific forensic methods also constrain what forensic evidence can be used to authenticate an allegation. The National Academy of Sciences studied the use of various forensic methodologies in 2005 and concluded that forensic labs in the United States need to be better resourced, have consistent and high standards for training, testing, and accreditation, and be allowed to operate with autonomy.[57] The complete story of what forensic science can or cannot prove more likely stems from the particular technique in use, the scientific scrutiny it faced over time in becoming an accepted methodology and the level of training of the forensic examiner.

The Legal Aspect – The Underlying Basis of Policy

Given the important distinction between empirical science and forensic science, not to mention its impact on legal models for establishing the validity of factual evidence, it is worth examining how the forensic sciences, particularly microbial forensics, are used in legal contexts. The legal aspect is important, as the law often acts as a paradigm framework through which attribution allegations are analyzed. It is important to note that the use of this framework is not only useful for examining evidence of attribution in a court of law, for which extremely high standards for conviction of a crime exist, but also as a comfortable fallback framework for analysis of complex problems. This methodology is likely to be used by national policy makers for two main reasons:

1. In the upper reaches of many national policy communities, there are often a large number of individuals that have legal training. Therefore, thinking within a legal framework may be helpful in addressing non-legal questions. Twenty-five (25) of the forty-four (44) Presidents of the United States were educated as lawyers, as were several modern Secretaries of Defense and Secretaries of State. Furthermore, even for those senior policy makers who are not legally trained, there is an acknowledgement that, given the preponderance of legally trained policy makers in most countries, a legal framework provides the most common framework for addressing complex situations. While it is not always consciously acknowledged, a legal

[56] Budowle, Bruce et al. "Genetic Analysis and Attribution of Microbial Forensics Evidence." *Critical Reviews in Microbiology* 31, no. 4 (2008): 233-54. http://www.tandfonline.com/doi/abs/10.1080/10408410500304082?journalCode=imby20.

[57] Committee on Identifying the Needs of the Forensic Sciences Community, National Research Council. *Strengthening Forensic Science in the United States: A Path Forward*. Report. *The National Academies Press* (2009). https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf.

framework often provides the mental infrastructure for communications between governments; and

2. When making an attribution allegation as part of a strategy for dealing with a biological problem, a reference to obligations under treaty law and international law can support a position more effectually than one that does not.

While use of a legal framework can be the fallback setting for analysis, intelligence analysis also plays a role. Legal assertions should not be confused with intelligence assertions, as both are steeped in different protocols for analyzing facts. Intelligence can be used to analyze uncertainty and can be arbitrary and evaluative of risk when "perfect knowledge" does not exist. Intelligence analysis employs methodologies that allow it to account for uncertainty and information gaps, whereas legalistic analysis draws upon establishing the existence of facts and does not easily account for speculation outside such facts.

The Use of Forensic Science in Law

Courts rely on forensic science as a form of evidentiary proof for a wide variety of crimes, including hit-and-run car accidents, homicides, and certain cases of sexual misconduct. Forensic science has particular methodologies to prove or disprove (with high confidence) the context surrounding accusations that a suspect committed a crime. For example, if person A is accused of murdering person B, human DNA found at the crime scene can tie person A to that location with a very high degree of certainty, based on the DNA found in residual hair or skin cell samples.

However, experts are quick to note that multiple sources of evidence should ideally converge toward a common result, with forensics being an important, but not standalone, contributor. In a journal article on science and society, European forensic biologist Mark Benecke said, "Wrongful convictions can only be made if DNA is looked upon as the only evidence."[58] The article goes on to paraphrase his position: "The integration of different sources of forensic evidence and their combination with investigative and legal procedures are even more significant than progress in any single field, such as DNA testing."[59] In other words, forensic science can help to prove legal guilt when used in conjunction with additional mechanisms of attribution and lines of evidentiary argument.

Although microbial forensics could become a key part of a wide variety of investigations, legal and medical investigators have yet to widely use the technique. Its use in the wake of the 2001 Amerithrax case serves as the most salient example to date. The FBI's investigation into the attacks put microbial forensics on public display, as it traced the linkage of the anthrax found at the attack sites to the lab of Army biodefense expert Bruce E. Ivins (who committed suicide as prosecutors prepared to charge him). Although the FBI officially closed the case in 2010 based on the microbial data discovered and other evidence, the *New York Times* reports lingering doubt from the scientific community over the investigation's methodology and conclusions.[60] Considering the amount of

[58] Hunter, P. "All the evidence." *EMBO Reports* 7, no. 4 (2006): 352–354. http://onlinelibrary.wiley.com/enhanced/doi/10.1038/sj.embor.7400669/.
[59] Ibid.

money and resources (discussed above) that were expended on this case, the result would seem unsatisfactory.

Admissibility of Evidence

It is not enough to treat the evidence as reliable. To be of value in a legal context, it must also be admissible. Were the case against Ivins to go to trial in a courtroom in the United States, the ability of the government to admit microbial forensic data as evidence supporting its case would be measured by the *Daubert* standard as articulated in the case of *Daubert v. Merrell Dow Pharmaceuticals, Inc.* 509 U.S. 579 (1993). This standard is codified in Rule 702 of the *Federal Rules of Evidence*.

Under the *Daubert* standard, evidence must be "relevant to the task at hand" and rest "on a reliable foundation." The factors that may be considered in determining whether the methodology (in this case, microbial forensics) is valid are: (1) Whether the theory or technique in question can be and has been tested; (2) whether it has then been subjected to peer review and publication; (3) its known or potential error rate; (4) the existence and maintenance of standards controlling its operation; and (5) whether it has attracted widespread acceptance within a relevant scientific community.[61]

In applying the *Daubert* test to microbial forensics methodology, it is likely that the science will be found to "relate to the task at hand" in most cases involving the attribution of an attack to a person or group. Furthermore, microbial forensics methodology has been referenced in peer reviewed journals,[62] thus meeting the "reliable foundation" test. Expert testimony would be required to establish factors 3-5. However, to date there have not been many court trials where microbial forensic evidence has been used and evaluated, thus, admissibility should not be assumed. Nonetheless, given its relationship to DNA evidence (which has been widely used in U.S. Courts), it is likely that microbial forensic evidence would be considered admissible.

Admissibility is not equal to proof, however. It is only the first step toward having the evidence relied upon. There is still the issue of keeping a proper chain of custody (verified hand-offs of any and all evidence found in the field), such as was the case with the anthrax contaminated letters that Ivins allegedly sent. In looking at a chain of custody, it is vital that each step or activity in the chain is properly documented and recorded, including: (1) Development of the sampling strategy (sizes, location, and method of collection used to obtain samples); (2) collection of the samples; (3) transportation of samples to the lab for analysis; (4) preparation of samples for comparative analysis; and (5) the process of analysis and comparison to known databases.[63] The chain of custody is of key importance not just in criminal cases, but in international claims of attribution. It is the most likely avenue of attack by those who would question an attribution claim.

It is important to note that chain of custody hurdles do not solely pose concerns under U.S. law, but in other legal systems as well, albeit with some variation. While the United States and some of its key allies, including Australia, Canada, and the United Kingdom, adhere to common law processes, other states rely on civil law legal systems. Still, others rely on different legal processes entirely (e.g.,

[61] See *Daubert v. Merrell Dow Pharmaceuticals, Inc.* 509 U.S. 579 (1993)

[60] Shane, Scott. "Expert Panel Is Critical of F.B.I. Work in Investigating Anthrax Letters." *New York Times.* 15 February 2011. http://www.nytimes.com/2011/02/16/us/16anthrax.html.

[63] Budowle, Bruce, Schultzer, Steven, Breeze, Roger, Keim, Paul and Morse, Stephen. *Microbial Forensics, 2nd Ed*ition. Burlington, MA: Academic Press, 2011.

Islamic law), so when it comes to international tribunals, there are completely different approaches to evaluating evidence. These differences can affect the way in which leaders in other countries might view evidence and associated chain of custody issues and should thus be accounted for in determining how best to approach particular countries with any attribution evidence. Failure to account for these differences may lead to unsatisfactory results.

Admissibility of Evidence in Different Legal Systems

Common Law Systems

In common law jurisdictions, there is the notion that "what is not explicitly prohibited is permitted." This is significant because it creates an adversarial dynamic with regard to the proffering of evidence. In a common law court, the adversaries make their strongest arguments using evidence that is most favorable to their position in an attempt to influence the decider of fact, be it a jury (or in some cases) a judge. The strategy and skill of the attorney in deciding what evidence should be used and how to present it can have a significant influence on the outcome. While the judge regulates the behavior, the attorneys drive the case.

Civil Law Systems

Diametrically opposed to common law, civil law systems (which are popular throughout Europe), operate under the premise that "what is not explicitly permitted is prohibited." This approach can affect what evidence gets introduced. If the judge is not specifically required to consider a particular type of evidence under a statute, then that evidence may not be considered. Also, there is a premium placed on the value of documentary evidence over witness testimony. Furthermore, the elements establishing a violation of the law must be spelled out more explicitly in the statute and the evidence introduced to prove such a violation must be specifically allowed per statute. Finally, a judge's role is more akin to an independent investigator, in that the judge chooses which documents to consider and witnesses to interview, thus more actively driving the overall process.[64]

Islamic Law Systems

Islamic Law is built upon the teachings of the Koran and is therefore considered infallible since it is considered "the word of the prophet." Islamic law systems place a high value on eyewitness testimony. This is not to say that scientific evidence will not be considered in Islamic courts; it simply means that if a form of evidence cited in the Koran should be used, then that evidence will take precedence. For example, in a recent ruling, the Council for Islamic Ideology (CII) of Pakistan, a country whose justice system is influenced by sharīʿah law, declared that DNA evidence could be used as primary evidence in a rape case, but that it could not stand alone as proof of guilt and must be accompanied by additional forms of evidence (such as the need for a confession or eyewitness testimony from four male witnesses).[65]

---

[64] Pejovic, Caslav. *Civil Law and Common Law: Two Different Paths Leading to the Same Goal.* Report. 2001. www.upf.pf/IMG/doc/16Pejovic.doc.

[65] "DNA test can't be primary evidence in rape cases: CII." *The Nation*. 24 September 24 2013. http://www.nation.com.pk/national/24-Sep-2013/dna-test-can-t-be-primary-evidence-in-rape-cases-cii. See also: Mushtaq, Hussain and Ammara Mushtaq. "Islamic Law: backing up forensic DNA evidence." *Nature* 563, no. 342 (2013). http://www.nature.com/nature/journal/v503/n7476/full/503342b.html.

International Tribunals

International Tribunals, such as the International Criminal Court (ICC), are where mass crimes of the highest order (e.g., genocide or wanton violations of the laws of war) can be adjudicated. Emphasis is placed on protecting witnesses (often victims) and having them get their version of the facts told. The court's fear is that these witnesses and/or their families will face retaliation in their home countries after testifying - thus there is a perceived need to protect them. This perception has led to criticisms that there is no check on wild allegations and no filter for various claims to be sorted through. Thus, the ability for the accused to effectively confront witnesses (a staple concept of Western legal systems) is limited in these cases.[66] While the United States is not a signatory to the ICC, it may cooperate in ICC investigations and may formally request one. An allegation of BW use may well be something that is best considered by the ICC and the U.S. Government should therefore be sensitive to its rules of evidence, as well as judicial attitudes if presenting microbial forensics in such venues.

The significance of knowing these distinctions is that use of microbial forensics or other attribution evidence associated with an allegation of BW possession or use will go through a legal gatekeeper, be it a mental one (in the mind of a policy decision maker) or an actual legal one. Keeping in mind the legal framework or reference point that the influencee will use in evaluating evidence offered will help ensure the persuasiveness of the case presented.

Civil Liability and its Role in Deterrence

The other area in which the law would come into play in the event of a bio attack or an accidental release scenario involves the notion of civil liability for damages by biotech and pharmaceutical companies. The threat these companies face is that if supplies, equipment, or microbes can be traced back to them, then they could be sued for damages under joint and several liability rules. (If a company is found only 1 percent liable for an event, they can be forced to pay 100 percent of the damages awarded.) Paying out civil judgments can be very expensive in terms of litigation costs, as well as payment of damage claims to victims. Depending on the amount of destruction and death involved in the incident, the monetary judgments can be quite high. This financial threat could effectively deter negligent behavior by certain companies with regard to their biosecurity and biosafety responsibilities. An additional consideration is that as legitimate businesses look to minimize litigation risks, they typically will turn to their insurance companies to provide protection or coverage for such risks. This gives the insurers leverage and can serve as a valuable regulation tool over the behavior of biotech and pharmaceutical companies. Insurers don't want to pay large judgments; therefore, they have the leverage to persuade companies to establish better biosecurity and biosafety monitoring procedures in order to prevent potentially damaging occurrences. Additionally, being linked to an attack or accident may have a damaging effect on the business's reputation, causing sales and profits to plummet.

When considering countries designated by the U.S. Government as state sponsors of terrorism (Iran, Sudan, and Syria), if material support for BW use can be traced back to them, there may be civil

[66] Crombs, Nancy. "Testimonial Deficiencies and Evidentiary Uncertainties in International Criminal Trials." *UCLA Journal of International Law and Foreign Affairs* 14, no. 1 (2009): 235. http://ssrn.com/abastract=1963227.

liability judgments. These are not insignificant. For Iran alone, there is currently an estimated $45 billion dollars in judgments against it for acts of terrorism using conventional weapons.[67] These claims will eventually have to be addressed before any relations can be normalized with the U.S. Government. This issue of "civil damage liability" became quite pronounced in the case of Libya before it normalized relations with the U.S. Government. In 2003, prior to normalizing relations, Libya (a former state sponsor of terrorism) was forced to pay over $2 billion dollars in unresolved claims.[68] The potential civil judgments that any of these currently designated state sponsors of terrorism would have for BW use could be significant and this liability would remain in place for an extended period of time, limiting a country's potential economic growth and its ability to normalize relations with the United States.

The Policy Aspect

Closely tied to the law dimension of microbial forensics is the policy element. While policy is not the equivalent of the law, policy decision making is often rooted in law, and more importantly, legal culture. The policy community can often take the sharp black and white aspects of the law and smooth (grey) the edges for political necessity. Policy is often the place where decisions must be made with incomplete knowledge and against multiple, competing priorities. Legal standards of proof are informative to the attribution determination, but not always a dispositive factor. The key challenge here is that a policy choice that relies on attribution evidence should not be completely inconsistent with the law.

The requirement for using evidence in an attribution context (and its use in decision making), can either be governed by the rule of law (highly structured) or the politics, policy priorities, biases, and circumstantial influences that exist with key individuals within each system (less structured). As the policy associated with an attribution allegation moves up the governmental chain, the influence of politics looms larger and the decision making process becomes less objective and more subjective. In open societies, these processes tend to be more transparent, with the media often weighing in, while in authoritarian societies, they are more opaque. When such legal or policy decisions impact transnational or international constituencies (such as transportation, finance, and agricultural businesses), the level of attribution complexity dramatically increases.

Within the policy community, it is not enough for the a government to know the source of a biological outbreak or attack. Whatever the source, the first priority is that the attack must first be contained. After that, the person(s) responsible need to be held accountable, not only to provide a sense of justice, but to act as a deterrent to others who may be contemplating an attack, now or in the future. At some point, action must be taken that will require evidence of attribution, in whole or in part, that must then be made public. In a domestic context, this task may be easily assigned to the law enforcement community to address. Fortunately, standards for collection and presentation in a domestic court of law are well-established and scientific techniques for proving attribution are well-defined and easily incorporated into present day domestic legal architecture. The remedies (jail time

[67] Hong, Nicole. "Terror Victims Eye Thawing With Iran." *The Wall Street Journal*. 2 August 2015. http://www.wsj.com/articles/terror-victims-eye-thawing-with-iran-1438556669.
[68] Congressional Research Service. *Libya: Background and U.S. Relations*. Report. 6 August 2008. https://www.fas.org/sgp/crs/terror/RL31258.pdf.

and restitution to victims) are also well-understood and agreed to by domestic society. In contrast, the policy choices and attribution decisions resulting from an attack by international actors (states, groups, or individuals) are much more complex and varied.

In an international policy context any government's attribution decision may be faced with the difficulty of the action that will be taken by another nation's leadership. This holds true even if the government is set on taking unilateral military action. While the U.S. Government may have the capacity to do so, in many instances, any unilateral action taken will still be subject to the consequences of taking an independent, as opposed to multilateral, action.

The range of possible actions the U.S. Government may take is varied. Relying solely on science or legalistic proof may not be enough to woo international partners into a coalition, or convince others not to interfere with U.S. Government policy. The degree of attribution proof required for the U.S. Government to produce a desired action by another sovereign nation can be scaled against the difficulty of the action requested. The firmer the requested action, the more attribution proof is needed. In addition, the strength of the relationship between the U.S. Government and the other relevant government(s) will affect the amount of proof required. Examples of difficult requests that foreign leaders are faced with are detailed below (roughly in descending order of difficulty):

1. Persuading a sovereign nation (friendly or neutral) to join in taking military action;
2. Persuading a sovereign nation (friendly, unfriendly, or neutral) to take domestic police actions (e.g., arrest of one of its own citizens);
3. Persuading a sovereign nation (friendly, unfriendly, or neutral) to change its behavior;
4. Persuading a sovereign nation (friendly, unfriendly, or neutral) not to interfere with the U.S. Government's or another nation's military actions;
5. Gaining a sovereign nation's (friendly or neutral) support for political action or sanctions; and
6. Asking a sovereign nation (friendly, unfriendly, or neutral) to take domestic regulatory actions.

When considering this matrix in terms of varying difficulty, it can be argued that a request to join the U.S. Government in taking military action against another nation would require a higher degree of attribution proof then would a request that a foreign nation simply update its domestic laws to ensure better levels of biosecurity and biosafety. For either request, it would be much easier to request that a long-term ally (such as the United Kingdom) join a military coalition or update its regulatory laws, than would be the case with a non-Western or third-world country.

One way to overcome this challenge is to ensure that scientific and political leaders in other nations understand the science behind an attribution determination – especially if the science is less established in the field. In the case of microbial forensics (a relatively "new" scientific discipline), a focused effort on promoting and explaining the science is vital. This can be accomplished through science engagement and science diplomacy efforts, both hallmarks of U.S. biosecurity strategy.[69] Even if the subject of microbial forensics and other attribution tools is not specifically addressed in

[69] Defense Treat Reduction Agency. *The Cooperative Biological Engagement Program Research Strategic Plan: Addressing Biological Engagement Through Research*. Report. 2009. http://www.dtra.mil/Portals/61/Documents/Missions/CBEP%20Research%20Strategy_FINAL_July%202015.pdf.

particular, the mere act of participating in multiple scientific engagements can build confidence and trust. Trust may become a very important asset after a difficult request to a foreign leader is requested and supporting evidence for an attribution case is offered. It is often at that point that a political leader will turn to his or her science advisor and ask if the evidence offered is credible. If that foreign science advisor has worked with U.S. scientists in the past, then the answer is more likely to be positive than if there was no prior interaction. A significant caveat here is that even if the scientific community believes the evidence offered is sound, decision makers will tend to discount forensic evidence that is inconsistent with other sources of information and their own assumptions.

The History of Forensics Use as a Policy Tool

The interest in the use and reliance of forensics by the U.S. Government in a BW policy setting should come as no surprise. Forensic attribution has been a key element of U.S. Government policy regarding nuclear deterrence for years. In considering the role of microbial forensics in deterrence and attribution, it is useful to consider the prefatory language of the Nuclear Forensics and Attribution Act. This language sets forth requirements that nuclear forensics should meet; the challenge of biological forensics is similar in many (though not all) respects. The opening paragraphs of the legislation state:

> The threat of a nuclear terrorist attack on American interests, both domestic and abroad, is one of the most serious threats to the national security of the United States. In the wake of an attack, attribution of responsibility would be of utmost importance. . . .
>
> (3) A robust and well-known capability to identify the source of nuclear or radiological material intended for or used in an act of terror could also deter prospective proliferators. Furthermore, the threat of effective attribution could compel improved security at material storage facilities, preventing the unwitting transfer of nuclear or radiological materials. . . .
>
> (6) In order to create a sufficient deterrent, it is necessary to have the capability to positively identify the source of nuclear or radiological material, and potential traffickers in nuclear or radiological material must be aware of that capability.

In addition, Congress proposed that international agreements and understandings should be among the measures to be pursued. The legislation thus states that it is "the sense of the Congress that the President should:

1. Pursue bilateral and multilateral international agreements to establish, or seek to establish under the auspices of existing bilateral or multilateral agreements, an international framework for determining the source of any confiscated nuclear or radiological material or weapon, as well as the source of any detonated weapon and the nuclear or radiological material used in such a weapon;
2. Develop protocols for the data exchange and dissemination of sensitive information relating to nuclear or radiological materials and samples of controlled nuclear or radiological materials, to the extent required by the agreements entered into under paragraph (1); and

3. Develop expedited protocols for the data exchange and dissemination of sensitive information needed to publicly identify the source of a nuclear detonation."[70]

Microbial forensics appears to be less well-developed and studied than nuclear forensics, thus the question of what can be done to give microbial forensics the same analytical, organizational, and legislative underpinnings that have strengthened nuclear forensics is highly relevant. In addressing concerns on the nuclear front, the National Technical Nuclear Forensics Center was established in October 2006 within the Domestic Nuclear Detection Office. According to the Department of Homeland Security's website, the Center has "three primary missions" identified by Presidential Directive and affirmed in the Nuclear Forensics and Attribution Act (Public Law 111-140), which President Obama signed into law on February 16, 2010. These missions are "to serve as program integrator and steward for the U.S. Government to ensure a ready, robust, and enduring nuclear forensics capability, to advance capabilities to conduct forensics on nuclear and other radioactive materials, and to lead the National Nuclear Forensics Expertise Development Program."

A similar approach to forensics in the biological arena should be considered. Without extensive technical study, appropriate legislation and a clear leading organization within the U.S. Government, the contribution of microbial forensics may be less credible as a deterrence tool.

The Public Health and Law Enforcement Aspects

In the rush to identify the cause of a biological outbreak, public health officials are primarily interested in knowing the characteristics of the microbes involved so they can begin both the process of treatment of victims and remediation (clean-up) of the contaminated areas. On the other hand, the predominant goal of law enforcement and the national security establishment is focused on whether or not there is an intentional act involved, and if so, who is responsible. Furthermore, even between law enforcement and the intelligence community, there is a manifestly different approach in obtaining and processing evidence.

In determining cause during an investigation involving a virus or suspicious pathogen, it matters what division of the government is doing the initial investigation. Within government circles, determining cause in suspected bio incidents is an inherently inter-agency activity, but more importantly, an inter-disciplinary one. A significant concern arises when an investigation initially focuses on one cause and then reverses course and focuses on a different cause as new information becomes available. Focusing on one cause and then suddenly switching gears and converging on another can result in the loss of vital evidence, as factors that initially seem inconsequential to a disease outbreak investigation may be very important to those looking at a deliberate bio attack scenario. While this problem has been recognized before, it persists because collaboration is often hampered by professional bias, as well as institutional/bureaucratic structures. The U.S. Government would be well-served by alerting and bringing in both public health and law enforcement personnel into any investigation of a suspected bio incident early on and then allowing

[70] United States Congress. *Public Law 111-140*. Report. 16 February 2010. https://www.congress.gov/111/plaws/publ140/PLAW-111publ140.pdf.

them to peel-off in their respective directions once the target of the investigation becomes more evident.

The Media Aspect

A key consideration regarding mass media outlets and BW attribution accusations is the fact that mass media can be on a different time schedule than policy decision making or scientific inquiry. We live in an era of 24-hour news cycles. With the advent of rapid-response social media outlets, reporting cycles can be boiled down even further (to 24 minutes). Within the realm of mass media, there is also a tendency to quickly identify villains and heroes in order for news to be more digestible or tell a more dramaturgical story.[71] Conceivably, in a crisis involving suspected BW attacks, the media could report a suspicious story that could then create an environment where policy makers must quickly respond to allegations, if only to prevent panic. Unfortunately, good policy decisions take time to develop, as facts need to be gathered and understood before consequential decisions can be made. Policy responses will take even more time to develop if they need to rely on scientific inquiry. In other words, the time clocks for these three different disciplines do not synchronize well. This can lead to intense confusion right at the time when cool, measured analysis and response are needed.

Expectations and the CSI Effect

Today, popular portrayals of forensic science can fuel both its expectations and its conflation with empirical science. Forensic science is often understood as strong evidence in courtroom settings, but in reality, many recent events and federal reports cast doubt on its objectivity. The expectations of forensic science capabilities stem from confusions with empirical science, a phenomenon of high expectations and confidence in forensics that some legal observers and media accounts have dubbed the "CSI effect."[72]

The "CSI effect" is a reference to a popular American TV show wherein criminal investigators use the latest science (or science that is currently in development) to solve a complex crime. It often promotes fanciful notions of scientific certitude as the show's writers attempt to compress difficult scientific concepts into a 60 minute show without going into the many nuances typically associated with the techniques (e.g., considering the cost of such investigations, and/or the financial resources available to conduct such an expensive inquiry). The "CSI effect" has become very influential, especially on people for whom their introductions to complex science come primarily from mass media. Courtroom lawyers and judges have complained in recent years that juries have come to expect an exactness, certainty, and conclusiveness in scientific evidence that is not obtainable in the real world.

In a policy context, the "CSI effect" can influence leaders (whom the U.S. Government may wish to sway) into similar thinking regarding unrealistic expectations concerning evidence presented to them. This can then make the use of technical analysis, such as that associated with microbial

[71] Bidwell, Christopher and Mark Jansson. *Microbial Forensic Attribution, Where Science Meets International Relations*. Report. 31 March 2014. http://www.virtualbiosecuritycenter.org/wp-content/uploads/2014/07/FAS-Microbial-Forensic-Science-and-International-Relations.pdf.

[72] Rath, Arun. "Is the 'CSI Effect' Influencing Courtrooms?" *Frontline PBS*. 7 February 2011. http://www.npr.org/2011/02/06/133497696/is-the-csi-effect-influencing-courtrooms.

forensics, a difficult sell. On the other hand, U.S. Government officials themselves may expect too much from forensic science, causing them to discount solid forensic evidence that is helpful to, but not comprehensively supportive of, policy objectives – "letting the perfect be the enemy of the good."

Finally, it should be remembered that forensic evidence requires professional interpretations and explanations in order to be understood. Forensics rarely produces a dramatic "ah-ha" moment, such as what happened in 1962 when Adlai Stevenson presented photographic evidence of missiles in Cuba at the United Nations. This lack of a dramatic effect can be another challenge for policy leaders trying to sell forensic results to a domestic or international audience.

Current Reporting on Shoddy Forensic Labs and Wrongful Convictions?

Another aspect of the media's influence on attribution is the recent spate of reporting on shoddy work in U.S. forensic crime labs. As noted above, the 2009 NAS report identified and commented on issues confronting forensic science, including the need for scientifically validated standards, consistent application nationwide, and strengthened oversight. Roughly concurrent to the release of the NAS findings, a study published in the Virginia Law Review examined trial transcripts for 156 people convicted, and later exonerated, of committing serious crimes, revealing that 60% of these cases relied on invalid testimony from forensic analysts summoned by the prosecution.[73] Moreover, the phenomenon was not localized to one laboratory or region; the authors write, "This set of trials included invalid testimony by 72 forensic analysts called by the prosecution and was employed by 52 laboratories, practices, or hospitals from 25 states."[74]

Recently, there has been a firestorm over the FBI's admission that, "Of 28 examiners with the FBI Laboratory's microscopic hair comparison unit, 26 overstated forensic matches in ways that favored prosecutors in more than 95 percent of the 268 trials reviewed."[75] Additionally, the Innocence Project, a legal activist organization dedicated to exonerating wrongly convicted people, published a list of 225 unlawful sentences that were overturned by DNA testing; over half of those cases involved what the group calls "unvalidated (*sic*) or improper forensic science" (i.e., use of untested disciplines or inaccurate statistics, failure to disclose exculpatory data, etc.).[76] Given these revelations, it appears likely that the broader context of forensic science and the criticisms it has faced could spill over into public perceptions of microbial forensics. Media reports of similar occurrences feed public suspicion of forensic testimony and can easily spread to international partners whom the U.S. Government is trying to influence with technical evidence of attribution.

These accounts of wrongful convictions, coupled with the 2009 NAS report and other documents, contribute to a political climate that can be skeptical of the empirical validity of forensic science. To

[73] Garrett, Brandon and Peter Neufeld. "Invalid Forensic Science Testimony and Wrongful Convictions." *Virginia Law Review* 95, no. 1 (March 2009): 1. http://www.virginialawreview.org/sites/virginialawreview.org/files/1-2.pdf.
[74] Ibid
[75] Hsu, Spencer. "FBI Admits flaws in hair analysis over decades." *The Washington Post*. 8 April 2015. http://www.washingtonpost.com/local/crime/fbi-overstated-forensic-hair-matches-in-nearly-all-criminal-trials -for-decades/2015/04/18/39c8d8c6-e515-11e4-b510-962fcfabc310_story.html.
[76] The Innocence Project. "Wrongful Convictions Involving Unvalidated or Improper Forensic Science that Were Later Overturned through DNA Testing." 29 January 2009. http://www.innocenceproject.org/causes-wrongful-conviction/DNA_Exonerations_Forensic_Science.pdf.

counter this suspicion, the FBI has gone out of its way to find methods of validating its technical laboratory work in the field of microbial forensics. In a 2011 press release, the FBI responded to a National Research Council (NRC) report, entitled *Review of the Scientific Approaches Used during the FBI's Investigation of the 2001 Anthrax Letters*. In the release, the FBI noted that the NRC committee "confirmed the value of the emerging field of 'microbial forensics,' and that the report findings highlighted its promise for future investigations."[77] Notably, the report also recognized "the FBI's unprecedented efforts to form outside partnerships within the scientific community and the value that its expertise can lend to a criminal investigation of this magnitude," illustrating federal willingness to work with academic, nongovernmental, and other private organizations to develop bio forensic capabilities.[78] However, it remains to be seen how effective this approach will be in establishing credibility in the future.

The Communications Aspect

One of the more nuanced and often overlooked aspects of any scientific issue is the way in which the science is communicated to the non-scientific community. Given that forensic science is indeed premised on collaboration among various groups (scientists, judges, lawyers, policymakers, and law enforcement personnel, to name but a few), the need for clear explanations is extremely important. The scientists, as well as the lawyers, must avoid overly-technical jargon, abbreviations, and using single words that might convey or represent a whole branch of thinking. Elizabeth Bass, Director Emerita of the Alan Alda Center for Communication Science at Stony Brook University, recently wrote:

> Blame "the curse of knowledge," as described in the book Made to Stick by Chip Heath and Dan Heath. The idea is that when you know something very well, it becomes hard to remember what it was like not to know it. You no longer recognize what is amazing or mysterious or funny or confusing about your work. You no longer can tell jargon - the specialized language of your field - from everyday talk. . . .
>
> As science gets more specialized, colleagues in neighboring fields become a lot like the public. They speak different languages, with different knowledge bases. Words like "transformation," "activation," and even "theory" mean different things in different fields (and something else again in everyday English). Does AI mean artificial intelligence, or artificial insemination?[79]

The problem is even more pronounced if one wants to communicate ideas out of his or her own culture or native language. As Nasser Bin Nasser, from Jordan's Middle East Scientific Institute for Security, points out in his recent article entitled, "A Social Science Perspective on International

---

[77] Federal Bureau of Investigation. *FBI and Justice Department Response to NAS Review of Scientific Approaches Used During the Investigation of the 2001 Anthrax Letters*. Report. *FBI National Press Office* (15 February 2011). https://www.fbi.gov/news/pressrel/press-releases/fbi-and-justice-department-response-to-nas-review-of-scientific-approaches-used-during-the-investigation-of-the-2001-anthrax-letters.

[78] National Research Council. *Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters*. Report. *The National Academies* (2011). http://www.nap.edu/catalog/13098/review-of-the-scientific-approaches-used-during-the-fbis-investigation-of-the-2001-anthrax-letters.

[79] Bass, Elizabeth. "They Won a Nobel Prize for What? Why Good Science Communication Counts." *Huffington Science*. 9 October 2015. http://www.huffingtonpost.com/the-conversation-us/they-won-a-nobel-for-what_b_8271184.html.

Science Engagement":

> [C]ulture is often a misunderstood and misappropriated concept for most policymakers. Admittedly, it is not something that is easy to capture, describe, or measure, which may explain why it is not a popular topic. Notwithstanding, there is growing evidence that cultural awareness can make a crucial difference to the prospective success of negotiations, inspections, and cooperative endeavors. The Central Intelligence Agency produced a report in 2006 that examined how a lack of cultural awareness among those involved in Iraq's inspection regime in the mid-1990s resulted in misinterpretation of the behavior of Iraqi officials, leading to an assumption that the exhibited behavior was that of denial and deception.[80]

For any policy recommendation, it is important that significant effort and money be spent on communicating the science behind an assertion. Without the ability to interpret the science and explain the results, the money invested in the science itself is of limited value.

[80] Nasser, Bin Nasser. "A Social Science Perspective on International Science Engagement." *FAS Public Interest Report* 68, no. 3 (Summer/Fall 2015). https://fas.org/pir-pubs/social-science-perspective-on-international-science-engagement/.

The Relationship Among Investigation, Attribution, and Deterrence Disciplines

Attribution, enabled by effective forensics, is but one element of deterrence. While it is certainly an important contributing factor, it is not the sole determinate factor. This challenge was effectively summed up by Dr. Jay Davis, former Director of the Defense Threat Reduction Agency, in an April 2003 article in the *Journal of Homeland Security:*

> Attribution, along with prosecution or retribution, is one of the greatest deterrent tools against terrorism. Exclusion, the opposite of attribution, is equally important in the highly charged environment after a terrorist event. . . . Several steps need to be taken operationally before an event occurs. The first step is to establish and train the organizations that will execute the attribution process. Another step is the frank and honest education of political decision makers. Preparing to communicate with the public is an essential step in operational preparation. Training and resourcing capabilities involves the creation of a common approach to dealing with events of different kinds.[81]

Even the most convincing attribution determination cannot enable deterrence if there is not a reasonable certainty of an appropriate punishing response, including the perceived presence of adequate resources to enable such punishment. In the case of BW, an important element of deterrence is the strength of public health infrastructure. A robust public health system can mitigate the advantages that might otherwise accrue to an adversary pursuing or using BW, just as well as the ability to attribute the source of an attack.

Secondly, in thinking about the deterrent effect of attribution, one might consider other national and international priorities beyond nonproliferation. The U.S. Government's national and international nonproliferation goals, while important, are often trumped by other national and international priorities. One example is in Pakistan, where U.S. interests in countering the Soviet Union's invasion of Afghanistan, and later the battle against al-Qaeda, took priority over well-known nuclear nonproliferation concerns.[82] When nonproliferation objectives are outweighed by competing national priorities, the notion of deterrence, even if supported by solid attribution evidence, becomes moot. This not only affects the proliferating country itself, but other potential proliferators who get the message that despite the lofty rhetoric, proliferation concerns may actually be a low priority in practice.

Finally, states are unlikely to pursue or use BW if they can meet their strategic objectives through other means, or if they believe that their strategic objectives would be threatened by negative international reactions to their pursuit or use of such weapons. In the end, deterrence, even if backed by strong bio forensics capabilities, would not be effective if a state or non-state actor pursuing BW believes that there will not be strong counteractions, or that their use of BW would be ineffective.

[81] Davis, Jay. "The Attribution of Nuclear Events." *Journal of Homeland Security*. April 2003.
[82] Frantz, Douglas, and Catherine Collins. *The Nuclear Jihadist*. New York, NY: Twelve, 2007.

Common Questions from the Policy Community

When it comes to the relevance of evidence needed for an attribution determination, there are many key policy questions that must be considered. Offered below is a summary of certain questions, along with some brief analysis.

1. *What quantity and quality of evidence is needed to support national or international engagements and international leaders' policy decisions regarding illicit intentions, research and preparation, testing, and delivery of biological weapons?*

   The evidence needed for a foreign leader to support a U.S. Government policy objective is directly dependent on that leader's internal process for making a decision. The legal process used within the particular country will be informative, but not dispositive. The more important consideration will be the amount of difficulty associated with delivering the support that is requested. In Washington slang, the question is what type and amount of evidence of malfeasance would the leader need in order to deliver on "the ask"? Variables will be many, but some of the primary concerns are: (1) The impact of the threat on the leader and country; (2) the nature of the relationship (positive or negative) with the U.S. Government at the time; (3) the amount of political capital that the leader would need to expend in order to deliver on the request; (4) how confident the leader is in the forensic evidence that is offered; (5) how confident the leader is of circumstantial evidence that is offered; (6) how the leader thinks his or her current allies and enemies will view the situation and respond to it (e.g. potential blowback); and (7) how the internal forces within the leader's country will accept the decision to support (economic consequences, other political factions, etc.).

   In considering the difficulty of "the ask," it would be most challenging for a leader to join the U.S. Government in a military strike or arrest of a foreign citizen. It would theoretically be less difficult if "the ask" were simply a request that any opposition to U.S. Government actions be tempered or restrained.

2. *What should policy makers expect (demand) of its national (international, if created) investigative forensics capabilities?*

   Establishing competence in the forensic process is the first step for the U.S. Government's policy community. Just as importantly, the perception of competence must be widely established within the international community. These expectations regarding competence should be considered in light of the domestic criticisms of the forensic community within the U.S. justice system. Organizations, such as The Innocence Project, continue to find cases where wrongful convictions were obtained that relied on faulty forensic evidence. The continuing stream of exonerations of criminals sentenced to long prison terms, and even death, through DNA analysis is both a curse and a small blessing on the legitimacy of forensic science. On one hand, the exonerations call into question the legitimacy of forensic sciences in general. Yet on the other, such pardons reinforce the use and legitimacy of certain types of forensic evidence, such as DNA. Fortunately, there is a similarity between

DNA and microbial forensic analysis that bodes well for the future acceptance of microbial forensics as a legitimate science going forward (which should, in turn, help legitimize BW attribution accusations in the future).

3. *What contribution can or should forensic science make to national and international policy decisions involving chemical or biological weapons?*

   As discussed above, forensics is not just a technical science endeavor; it has its place as a component of an attribution determination, which in turn is a component of deterrence, based on the idea that a potential acquirer or user of BW will fear the consequences of retribution if caught. The most significant aspect of a forensic determination may be that the results are consistent with other evidence used to make the attribution determination. If they are inconsistent, it should be an immediate red flag. Even if the forensic determination is kept secret or in classified channels, other inconsistent evidence tells the policy community that there is a hole in the attribution analysis. Discovery of such counter evidence would create mistrust of a government's overall attribution capability and make the believability bar higher for the next BW attribution determination.

   Even more important than supporting an attribution determination is the ability of forensic science to exonerate or cast doubt upon the evidence regarding a false or mistaken accusation. This would be critical in those instances where a natural disease outbreak is attributed to an intentional act of bio terrorism by a country or organization.

4. *How much reliance can (or should) be placed on forensic evidence and analysis for decisions related to attribution and holding perpetrators accountable?*

   As discussed above in question 3, forensic evidence must be consistent with other evidence, such as eye witness accounts, circumstantial evidence, discussions by alleged perpetrators, and photographic evidence. As non-scientists may be more familiar and comfortable with these other forms of evidence, the technical evidence offered may be the least probative factor in an attribution determination. Yet to be effective, the technical basis for an attribution determination (forensic evidence) must be easily understood. Furthermore, the science must be trusted by those technical people that a leader will rely upon in making a determination to act based upon the evidence offered.

5. *What is the robustness of international legal and policy mechanisms and are they sufficient to accept and properly use probative and acceptable forensic scientific results and conclusions?*

   International legal and policy mechanisms are as robust as the degree to which nations accept them as so. Fortunately, the use or possession of BW is considered to be taboo in the international community and thus, most nations accept restrictions on their own sovereignty in order to assure others of their compliance with treaties and to be certain that their neighbors are also in compliance. In this way, the taboo creates an international norm which most nations support. It should be remembered that those nations that have established BW, CW, and nuclear programs in the past 40 years, or have used BW/CW, have done so in

secret, hoping to avoid suffering the repercussions of doing so, such as ostracization and sanctions. This is further evidence that the norm is holding.

While the norm is helpful in reducing the number of countries to which the U.S. Government and others must be attentive, the problem remains that proving intentional use or possession of BW by the remaining outliers (both states and non-states) is still exceptionally difficult. This is primarily due to the fact that it can be hard to distinguish between a BW attack versus an accident or a naturally occurring disease outbreak. If involved in manufacturing BW, the dual use nature of the processes, equipment and byproducts can easily mask illegitimate intentions. Developments in the last several years in the field of forensics have made it easier to identify violators, but the discipline has yet to gain wide international acceptance.

6. *Can new or improved international legal or policy mechanisms be instituted and new scientific capabilities be established that would support internationally sanctioned investigations?*

The answer to this particular question varies depending on whether one is considering legal/policy mechanisms or scientific capabilities. On the science front, the landscape for the internationally sanctioned investigations has improved due to advances in forensics, especially in microbial forensics, where capacity is growing and costs continue to decline. On the policy front, the ability to prove "use" of BW has been well established through multiple UN investigations. However, despite these positive developments, determining "who" used BW remains a challenging problem, both technically and politically. Answering the "who" question not only requires more robustness in attribution methods, but also the political will by the policy community to try and answer the "who" question. This is by far the greater challenge.

7. *Could competent forensic investigative capability contribute to the deterrence of the acquisition, development, proliferation, and use of biological weapons?*

Deterrence is based upon the idea that a person wishing to do an act will refrain from doing that act if the perceived negative consequences of doing so are unacceptable. For a state actor with sovereign territory, this is a more prominent concern than for a non-state actor. The key factors in determining what is likely to deter an actor from acquiring a BW capability or using BW can be summarized as follows: (1) The likelihood of being identified; (2) the consequences of being identified; and (3) the willingness to absorb the consequences of being identified. This is matched against the desirability of the expected gain from using BW and the amount of risk the leader is willing to take to achieve his or her desired objectives. It is the first factor, the likelihood of being identified, where forensic investigation would have its most pronounced effect on deterrence.

Final Observations

Microbial forensics can be a viable tool for the policy community to use in addressing BW threats. However, the use of microbial forensics as a factor in establishing a BW attribution determination is likely to be more effective and viable if the underlying science is well understood (in both scientific and policy contexts) and trusted by those whom a government seeks to influence with such evidence. In order to obtain a desired policy outcome, the science first has to be "right," but more importantly, the science must be believed to be right by others, both friends and foes. One way of obtaining such believability is to ensure that the relationships among technical communities across the world are established before there is a crisis or a need to use forensic science results in order to support a policy objective. Interestingly enough this approach is what Congress proposed in the prefatory language of the Nuclear Forensics and Attribution Act. This could be accomplished through robust engagement on related scientific topics. Another way would be to accomplish this goal would be to encourage publication by scientists of primary and secondary methods of using forensic science techniques for making source and attribution determinations.