Combating Biological Terrorism:

Roadmaps for Global Strategies

January 2018

Inter-University Center for Terrorism Studies

Potomac Institute for Policy Studies

International Law Institute — Est. 1955 — ILI

Center for National Security Law, University of Virginia

THE INTER-UNIVERSITY CENTER FOR TERRORISM STUDIES

Combating Biological Terrorism:
Roadmaps for Global Strategies

Table of Contents

901 North Stuart Street, Suite 200, Arlington, VA 22203

Tel. 703-562-4513, 703-525-0770 ext. 237 Fax 703-525-0299

yalexander@potomacinstitute.org www.potomacinstitute.org

www.terrorismelectronicjournal.org www.iucts.org

Cover Design by

Alex Taliesen

Introduction

Professor Yonah Alexander
Director, Inter-University Center for Terrorism Studies and Senior Fellow, Potomac Institute for Policy Studies[1]

An assessment of the contemporary global security outlook may cause one to recall the four horsemen of the apocalypse representing agents of conquest, famine, war, and death, and perhaps even ushering in the beginning of the end of the world. Indeed, preventing the proliferation of biological, chemical, radiological, and nuclear weapons has been a major priority for many nation states in the post-World War II era. Additionally, in the aftermath of 9/11, there has been a growing awareness globally of the potential dangers posed by terrorist groups who may resort to WMD. For example, the explosion of a nuclear bomb, the use of fissionable material as a radioactive poison, the seizure and sabotage of nuclear facilities, or the explosion of a "dirty bomb" is seen by many experts as plausible and by others as inevitable in the foreseeable future.

Since this report focuses on the dangers biological terrorism pose to individuals, communities, nations, and, indeed, perhaps even to the survival of civilization itself, it behooves humanity to beware of the nature and security implications of this potential challenge. A quick overview of biological terrorism consists of both natural causes as well as man-made operations. Among the broad range of characteristics frequently mentioned include viruses (e.g. Yellow fever, smallpox, Ebola), bacteria (e.g. plague, tularemia, anthrax, cholera), toxins (e.g. ricin, botulism), and rickettsia (e.g. Q fever, typhus).

The above list of agents selected at random is considered capable of spreading disease among humans, animals, or plants. Disease develops when people and animals are exposed to infectious microorganisms or to chemicals which are produced by such organisms. After an incubation period, during which organisms are multiplied, the disease may even cause death. Mention should also be made of a number of fungal pathogens, such as smut of wheat, that are capable of destroying crops as well as resulting in famine and other costly diseases.

Despite these types of classification of biological challenges, the historical and contemporary records provide extensive evidence regarding the nature, intensity, and health security implications of existing threats. This information also serves as a warning to beware of future catastrophic losses to human lives and economic costs to those societies affected by biological pathogen attacks.

For example, in the 14th century, the Black Plague wiped out 30-60 percent of Europe's population. Likewise, a century ago, the 1918 influenza pandemic, regarded as the deadliest in modern times, killed an estimated 50-100 million people worldwide. And the Asia flu, originated in China in 1957-1958, cost between one to four million lives.

More recently, the deadly Ebola outbreak presented a major health security challenge nationally, regionally, and globally. An eruption of this deadly disease in 2014 created unprecedented fear and anxiety over public safety, not only in parts of West Africa but the virus also seriously impacted the United States, Europe, and elsewhere.

By the time the epidemic ended, some 28,000 Ebola cases were reported resulting in some 11,315 deaths.[2]

Another health security threat is the Zika virus infection that is spread by mosquitos (that are also the vectors of many other diseases), sexually, and through blood transfusion as well as laboratory exposure. The disease causes microcephaly and many other birth defects. In addition, the cholera epidemic continues in war-torn Yemen where more than 400,000 cases were already recorded between April and July 2017.[3] This disease is caused by bacteria from water or food contaminated with feces.

In sum, the globalization of pandemic outbreaks of deadly infectious diseases are only a matter of time. The Centers for Disease Control and Prevention recently reported that during the 2015-2017 period, it has already "monitored more than 300 outbreaks in 160 countries, tracking 37 dangerous pathogens in 2016 alone."[4]

In light of this growing challenge, Bill Gates warned in a February 2017 Security Conference in Munich that "'by the work of nature or the hands of a terrorist,'… an outbreak could kill tens of millions in the near future unless governments begin 'to prepare for these epidemics the same way we prepare for war.'"[5]

A year later, Daniel R. Coats, Director of National Intelligence (DNI), in an open hearing of the U.S. Select Committee on Intelligence held on February 13, 2018 echoed a similar assessment on health security challenges. Director Coats elaborated:

> The increase in frequency and diversity of reported disease outbreaks—such as dengue and Zika—probably will continue through 2018, including the potential for a severe global health emergency that could lead to major economic and societal disruptions, strain governmental and international resources, and increase calls on the United States for support. A novel strain of a virulent microbe that is easily transmissible between humans continues to be a major threat, with pathogens such as H5N1 and H7N9 influenza and Middle East Respiratory Syndrome Coronavirus having pandemic potential if they were to acquire efficient human-to-human transmissibility.[6]

Director Coats further observed with a dire warning:

- The frequency and diversity of disease outbreaks have increased at a steady rate since 1980, probably fueled by population growth, travel and trade patterns, and rapid urbanization. Ongoing global epidemics of HIV/AIDS, malaria, and tuberculosis continue to kill millions of people annually.
- Increasing antimicrobial resistance, the ability of pathogens—including viruses, fungi, and bacteria—to resist drug treatment, is likely to outpace the development of new antimicrobial drugs, leading to infections that are no longer treatable.
- The areas affected by vector-borne diseases, including dengue, are likely to expand, especially as changes in climatological patterns increase the reach of the mosquito.

- The World Bank has estimated that a severe global influenza pandemic could cost the equivalent of 4.8 percent of global GDP—more than $3 trillion—and cause more than 100 million deaths.[7]

He also asserted in his testimony that "the threat of state and nonstate use of weapons of mass destruction will continue to grow" and that "some applications of biotechnologies may lead to unintentional negative health effects, biological accidents, or deliberate misuse."[8]

Biological Threats and Responses: An Overview

Aside from Mother Nature's diseases, another health security concern stems from biological weapons deployed by both state and non-state individuals and groups. Again, both historical and contemporary experience amply demonstrates that there are no limits to the evil intentions of perpetrators during war and peace periods.

Suffice to mention the 1346 case when bodies of Tartar soldiers who died of the Plague (a bacterial infection) were thrown over the walls of the city of Kaffa (currently located in Crimea) targeting the local residents. Similarly, English forces in 1767 used blankets contaminated with smallpox virus spread the disease among the native population during the French Indian War.

It was not, however, until World War I when chemical weapons (e.g. chlorine and mustard gases) were deployed by Germany causing 1.3 million casualties and 100,000 deaths that the international community subsequently began to consider some legal and diplomatic measures aiming to bring the challenge under manageable levels. Thus, in June 1925, the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare was signed in Geneva. Also, in April 1972, the Biological Weapons Convention (BWC) was opened for signature and three years later the BWC entered into force and by 2016 a total of 178 states are party to the treaty.[9]

Another noteworthy step was undertaken by the United Nations following the Gulf War. In April 1991, Security Council Resolution 687 established a Special Commission (UNSCOM) to eliminate WMD in Iraq, where the regime had developed a biological program that included the spread of typhoid, cholera, and anthrax. While concerns over current and future secret biological weapons programs of states such as Iran, Syria, and North Korea still exist, many countries are also continuing defensive research and development activities.[10]

Aside from such potential dangers, biological terrorism also stems from individuals and groups throughout the world. Among the proven biological incidents triggered by terrorists are the following cases, selected at random:

- In 1972, members of the Order of the Rising Sun (a neo-Nazi group) attempted to acquire an agent that causes typhus. They possessed 30-40 kilograms of bacteria for use on water supplies in major Midwest cities.
- A factory for making Clostridium botulinum culture was discovered at a hideout of the German Red Army Faction in Paris in 1980.

- The Animal Liberation Front in 1984 claimed to have contaminated Mars candy bars in the UK with rat poison.
- In 1986, salmonella was used by the Rajneesh religious cult in Oregon to contaminate salad bars in restaurants, resulting in 750 cases of food poisoning.
- Following the 9/11 attacks, anthrax letters were sent to various targets, including Senators Thomas Daschle and Patrick Leahy. 18 cases were confirmed and 5 people died.
- Al-Qa'ida terror network attempted to produce ricin, conducted tests on animals, and recruited operatives to conduct biological attacks (e.g. 2011 scheme to poison water at a tourist site in Spain).
- And in January 2016, Daesh (also known as ISIS, ISIL, Islamic State) planned to contaminate Turkish water sources with biological agents (e.g. Francisella tularensis, which causes tularemia or rabbit fever).

Although this partial record demonstrates a limited utilization of biological weapons by terrorists, it is possible that some changes in the geopolitical environment could provide perpetrators with incentives to escalate their attacks dramatically. "Just imagine what might happen in the aftermath of the anticipated collapse of Daesh…in Iraq and subsequently in Syria. Daesh leadership has promised to regain 'lost areas,' and its fighters and supporters are orchestrating their deadly attacks in dozens of countries in the Middle East and beyond, including the United States. Since the self-declared 'Islamic Caliphate' represents a territorial vision without borders, Daesh is likely to resort, without compunction, to a broad range of biological weapons in battles for regional and global dominance."[11]

Facing these and other potential biological threats, the U.S. government is spending billions annually to address the challenge. Thus far at least, federal efforts are incomprehensive and fragmented. Although the newly updated U.S. National Security Strategy released in December 2017 recognizes the need for a broader defense against WMD challenges as well as coping with the threats to public health, the issuing of a National Biodefense Strategy as called for by Congress has been delayed.

Other countries have also expressed concerns on the looming dangers. Thus, "the United Kingdom [has warned] that Daesh might weaponize Ebola, Germany hosted an international symposium on protection against biological warfare agents, Italy engaged its scientific community to deal with biological defense, and France performed a nationwide drill to prepare for biological attacks."[12] Additionally, some international bodies such as NATO are developing biodefense efforts through their centers of excellence to combat terrorism and other programs.[13]

In sum, to prevent a potential "Black Plague"-like disaster, it behooves all nations to recall the warning in Shakespeare's *King Lear*, "We make guilty of our disasters the sun, the moon, and stars: as if we were villains on necessity; fools by heavenly compulsion…" (Act 1, Scene 2).

Academic Context

The emergence in the post-World War II era of the "Age of Terrorism," coupled with the concerning escalation into a potential "Age of Super Terrorism" with all its

frightening implications has generated infinite diversified published and unpublished literature by governmental, inter-governmental, and non-governmental bodies. The purpose of this section is merely to outline selected academic programs relevant to biological terrorism issues that were undertaken by the Inter-University Center for Terrorism Studies, the Inter-University Center for Legal Studies, and the International Center for Terrorism Studies, and their earlier institutional structures during the past half-a-century. These activities consisted of seminars and publications seeking to provide insights into historical lessons learned, future potential threats, and offer recommendations for counter biological terrorism strategies by public and private entities.

To be sure, various academic initiatives have focused attention on the broader WMD challenges because of the linkages between biological, chemical, and nuclear challenges in terms of threats and responses. Thus, many of the seminars organized over the years in the United States and abroad have dealt with topics such as "Future Trends of Terrorism," "Mass Destruction Attacks," "Technology and Terrorism," "Preventing Super Terrorism," and "International Cooperation Against WMD." Other seminars focused on both "chemical and biological weapons" as well as specifically on "biological terrorism."

Several related WMD academic projects and publications are noteworthy. One project was developed by the "Task Force on the Prevention of Nuclear Terrorism," co-sponsored by the Institute for Studies in International Terrorism (ISIT) at the State University of New York and the Nuclear Control Institute (NCI) in Washington D.C. That effort resulted in the publication of two books: *Nuclear Terrorism: Defining the Threat* (Pergamon-Brassey's, 1986) and *Preventing Nuclear Terrorism* (Lexington Books, 1987). Both volumes were co-edited by Paul Leventhal and Yonah Alexander.

A second academic effort in this field was the 1988 formation of an international multidisciplinary project on "Preventing Super-Terrorism," administered by Professor Yonah Alexander, Director of the Inter-University Center for Terrorism Studies (IUCTS) at The George Washington University, and Professor Yuval Ne'eman, the Wolfson Distinguished Chair in Theoretical Physics at Tel Aviv University.

The purpose of this project, chaired by Professor Edward Teller of Lawrence Livermore Research Laboratory and Stanford University, was to both develop coherent counter-proliferation policies and increase governmental and public understanding of the risks of and responses to super-terrorism without providing sensitive information that could prove useful to potential perpetrators of terrorist acts involving weapons of mass destruction. An international task force of experts representing various disciplines and nationalities was responsible for formulating a critical analysis of the dimensions of the challenge and for developing a strategy to cope with it.

A third academic activity was the 2012 undertaking of a research project on a "WMD-Free Zone in the Middle East" (WMDFZME). This ongoing effort is administered by the IUCTS in cooperation with the International Center for Terrorism Studies (ICTS) at the Potomac Institute for Policy Studies (PIPS) in Arlington, Virginia, and the Inter-University Center for Legal Studies (IUCLS) at the International Law Institute (ILI) in Washington, D.C. The objective of this project is to organize a series of seminars and to conduct research with experts from both the public and the private sectors seeking to offer recommendations for ultimately achieving a Middle East free of WMD.

A more recent major academic initiative is the establishment of the bipartisan Blue Ribbon Study Panel on Biodefense, co-chaired by Senator Joseph Lieberman (former United States Senator and Attorney General of the State of Connecticut; the Democratic Vice-Presidential candidate in 2000; and currently Senior Counsel at Kasowitz, Benson, Torres, & Friedman LLP and Co-Chair of the Blue Ribbon Study Panel on Biodefense) and Governor Thomas Ridge (first Assistant to the President for Homeland Security, first Secretary of the U.S. Department of Homeland Security, former Governor of Pennsylvania, and currently Chairman of Ridge Global and Co-Chair of the Blue Ribbon Study Panel on Biodefense). Other panel members include former Secretary of Health and Human Services Donna Shalala, former Senator Majority Leader Tom Daschle, former Representative Jim Greenwood, and the Honorable Kenneth Wainstein. Established in 2014 with the institutional sponsorship of the Hudson Institute and the IUCTS and subsequently with the Potomac Institute for Policy Studies too, the Panel assesses the spectrum of biodefense efforts from preparation to recovery and is developing recommendations for the U.S. government to improve and optimize these efforts. It has already published three reports: "A National Blueprint for Biodefense: Leadership and Major Reform Needed to Optimize Efforts" (October 2015),[14] "Biodefense Indicators: One Year Later, Events Outpacing Federal Efforts to Defend the Nation" (December 2016),[15] and "Defense of Animal Agriculture" (October 2017).[16]

To be sure, other studies related to WMD concerns resulted from more extensive academic projects. These contributions appeared in publications such as *Terrorism: An International Journal* (Taylor and Francis, 1988-1991); *Terrorism: An International Resource File*, 1970-1990 (University Microfilm International, 1988-1991); *Technology Against Terrorism: Structuring Security* (Office of Technology Assessment, U.S. Congress, 1992); and *Super-Terrorism: Biological, Chemical, Nuclear* (Transnational Publishers, 2002), co-edited by Yonah Alexander and Milton Hoenig.

Some of the most focused publications on biological terrorism were initiated by PIPS and the IUCTS over two decades ago. A major book on *Countering Biological Terrorism in the U.S.: An Understanding of Issues and Status* co-edited by David W. Siegrist and Janice M. Graham was released by Oceana Publications, Inc. in 1999 as a special volume included in *Terrorism: Documents of International and Local Control* (edited by Yonah Alexander and Donald J. Musch).

Mention should be made of several other recent relevant publications. One is a report on "Reassessing the WMD Challenges: The Next Phase?" (May 2014) with the participation of Charles A. Duelfer (former Special Advisor to the Director of Central Intelligence for Iraq, WMD; leader of the Iraq Survey Group on WMD; and acting Chairman of the UN Special Commission on Iraq (UNSCOM); currently, Chairman of the Board, OMNIS, Inc.); Greg Gross (former Deputy Assistant Secretary of Defense and senior staff member, U.S. Senate; currently, consultant on foreign policy and military affairs); Michael Eisenstadt (Senior Fellow and Director, Military and Security Studies Program, The Washington Institute for Near East Policy); and Dr. Milton Hoenig (nuclear physicist).

The second publication is "Latin America's Strategic Outlook: Populist Politics, Health Concerns, and Other Security Challenges" (April 2017) that focuses *inter alia* on biological terrorism. Among the contributors to this report are Professor Gary Simon

(Director, Division of Infectious Diseases, Medical Faculty Associates, The George Washington University); Professor S. Gerald Sandler (Professor of Medicine and Pathology at Georgetown University Medical Center and Medical Director of the Blood Transfusion Service, MedStar Georgetown University Hospital); Dr. Asha M. George (Co-Director of the Blue Ribbon Study Panel on Biodefense); and Dr. Tara Kirk Sell (an associate at the Center for Health Security at the University of Pittsburgh Medical Center).

The third publication is a report on "Biological Terrorism: Past Lessons and Future Outlook" (June 2017) that includes a number of presentations delivered at past and recent seminars. The contributors include the Honorable Richard Danzig (Secretary of the Navy) and Professor Matthew Meselson (Harvard University) who participated at PIPS/IUCTS seminars in 1999 that focused on the threat of biological terrorism as well as Governor Thomas J. Ridge and Senator Joseph I. Lieberman (both co-chairs of the Blue Ribbon Study Panel on Biodefense) who spoke at an event on "International Cooperation in Combating Terrorism: Review of 2015 and Outlook for 2016" held on February 8, 2016, at the National Press Club.

Additional contributors to this report include Professor Rita Colwell (Distinguished University Professor at the University of Maryland, College Park and the Johns Hopkins University Bloomberg School of Public Health, and Senior Fellow at Potomac Institute for Policy Studies) and the Honorable Tevi Troy, PhD (CEO, American Health Policy Institute. Former Deputy Secretary, U.S. Department of Health and Human Services. Author, *Shall We Wake the President? Two Centuries of Disaster Management from the Oval Office)* who both participated at an event on "Preventing WMD Terrorism: Past Lessons and Future Outlook" held on March 23, 2017, at the Potomac Institute for Policy Studies are also included in this publication.

The fourth publication is a report on "Preventing WMD Terrorism: Ten Perspectives" (August 2017). It draws from two other major academic sources. Presentations by Dr. Rita Colwell, Kyle Olson, and Dr. Richard Weitz were made at a seminar on "Preventing WMD Terrorism: Past Lessons and Future Outlook" held March 23, 2017 at the Potomac Institute for Policy Studies and slightly edited for this publication. The contributions from David Albright Ambassador Bonnie D. Jenkins, Dr. Anthony Fainberg, the Hon. Charles A. Duelfer, Michael Eisenstadt, Dr. Milton Hoenig, and the Hon. Guy Roberts were made at earlier events organized by the IUCTS with its affiliated institutions and published previously in our reports and journals.

The current publication is a report on "Combating Biological Terrorism: Roadmaps for Global Strategies" that consists of four contributions made by Professor Rita Colwell, Professor S. Gerald Sandler, Dr. Norman Khan (Consultant, Counter-Bio LLC; former Director, Intelligence Community Counter-Biological Weapons Program), and Dr. Anthony Fainberg (former official at the Federal Aviation Administration and the Transportation Security Administration and currently a scientific advisor to the IUCTS). This latest academic effort draws from a seminar on the same topic held at Potomac Institute for Policy Studies on August 24, 2017 as well as continuing discussions with colleagues on the "Biological Terrorism: International Dimensions" project during 2017 and early 2018.

Acknowledgements

Some acknowledgements are in order. Deep appreciation is due to Michael S. Swetnam (CEO and Chairman, Potomac Institute for Policy Studies); General (ret.) Alfred Gray (twenty-ninth Commandant of the United States Marine Corps; Senior Fellow and Chairman of the Board of Regents, Potomac Institute for Policy Studies); Professor Don Wallace, Jr. (Chairman, International Law Institute); Professor John Norton Moore (Director of the Center for National Security Law and the Center for Oceans Law and Policy, University of Virginia School of Law); and Professor Robert F. Turner (Distinguished Fellow and Associate Director, Center for National Security Law, University of Virginia School of Law) for their inspiration and continuing support of our academic work in the field of global security concerns.

As always, Sharon Layani, Research Associate and Coordinator at the Inter-University Center for Terrorism Studies, deserves special gratitude for her professional research, publication support, and management of our team of interns during the Spring 2018 semester, including Lilli Abraham (The George Washington University), Julieta Barbiero (American University), Gabriella Garrett (Wichita State University), Gabrielle Labitt (University of Massachusetts Lowell), Hunter McWilliams (Skidmore College), Samuel Ridge (University of California, Berkeley), and Abdulrahman Sanee (University of California, Davis).

---

[1] This Introduction is derived from a knowledge-base developed by the author and his colleagues over the past half-century. Details on the research structures, methodologies, publications, and various relevant activities are provided in the "Academic Context" segment of this Introduction.
It should be noted that although the publication date on this report is January 2018, printing was postponed due to administrative and technical considerations. This delay provided an opportunity to incorporate some relevant data that became available in February 2018.

[2] "Ebola Situation Report - 30 March 2016." *World Health Organization*, 30 March 2016. http://apps.who.int/ebola/current-situation/ebola-situation-report-30-march-2016

[3] "Cholera in Yemen." Centers for Disease Control and Prevention Travel Notices. 14 August 2017. https://wwwnc.cdc.gov/travel/notices/watch/cholera-yemen

[4] Sun, Lena H. "The Trump administration is ill-prepared for a global pandemic." *The Washington Post*, 8 April 2017. https://www.washingtonpost.com/national/health-science/the-trump-administration-is-ill-prepared-for-a-global-pandemic/2017/04/08/59605bc6-1a49-11e7-9887-1a5314b56a08_story.html?utm_term=.de38cbc09f2a

[5] Selk, Avi. "Bill Gates: Bioterrorism could kill more than nuclear war — but no one is ready to deal with it." *The Washington Post*, February 18, 2017. https://www.washingtonpost.com/news/worldviews/wp/2017/02/18/bill-gates-bioterrorism-could-kill-more-than-nuclear-war-but-no-one-is-ready-to-deal-with-it/?utm_term=.6c9640e5bec6

[6] Coats, Daniel R. "Worldwide Threat Assessment of the U.S. Intelligence Community." U.S. Senate Select Committee on Intelligence, 13 February 2018. https://www.intelligence.senate.gov/sites/default/files/documents/os-dcoats-021318.PDF

[7] Ibid.

[8] Ibid.

[9] "Membership of the Biological Weapons Convention." The United Nations Office at Geneva. http://www.unog.ch/80256EE600585943/(httpPages)/7BE6CBBEA0477B52C12571860035FD5C

[10] See, for example, Hyun-Kyung Kim, Elizabeth Philipp, and Hattie Chung's "North Korea's Biological Weapons Program: The Known and Unknown" report published by Harvard Kennedy School, Belfer Center for Science and International Affairs, October 2017.

[11] Alexander, Yonah and Milton Hoenig. "Can we prevent ISIS's Doomsday Revenge?" *The Times of Israel*, December 21, 2016. http://www.timesofisrael.com/can-we-prevent-isiss-doomsday-revenge/

[12] Ibid.

[13] See, for example, the Centre of Excellence Defence Against Terrorism (COE-DAT) in Ankara, Turkey (http://www.coedat.nato.int/) or the Joint Chemical, Biological, Radiological, & Nuclear Defence Centre of Excellence (JCBRN Defence COE) in Vyškov, Czech Republic (https://www.jcbrncoe.cz/index.php).

[14] The 2015 report on A National Blueprint for Biodefense: Leadership and Major Reform Needed to Optimize Efforts" (October 2015) can be viewed at https://www.iucts.org/publications/reports/blue-ribbon-report-on-biodefense/

[15] The 2016 report on "Biodefense Indicators: One Year Later, Events Outpacing Federal Efforts to Defend the Nation" can be viewed at https://www.iucts.org/publications/reports/blue-ribbon-report-biodefense-indicators/

[16] The 2017 report on "Defense of Animal Agriculture" can be viewed at http://www.biodefensestudy.org/defense-of-animal-agriculture

Professor Rita Colwell

Distinguished University Professor at the University of Maryland, College Park and the Johns Hopkins University Bloomberg School of Public Health, and Senior Fellow at Potomac Institute for Policy Studies[1]

There have been positive developments in understanding bio-threats and how to identify the causative agents. Shortly after 9/11, the infamous anthrax incident occurred and an interagency group was formed to advise the FBI and the CIA. Dr. Norman Kahn, a participant in this conference, was a key scientist among the many with whom we worked in an advisory capacity to those federal agencies tracking down the perpetrator of the anthrax incident. Many of us can remember the anthrax bioterrorist action that resulted in several deaths and sickened many others. The anthrax agent was delivered in the form of a powder in letters posted in the Washington, DC area and in New England. The first victim to receive one of the letters was a reporter in Florida, to whom was sent a letter containing anthrax powder, the event comprising the initial incident.

The perpetrator, or at least the source of the anthrax, was identified using molecular biology and genomic tools. Over the 15 or more years since that anthrax bioterrorism event, a team which I led has been developing rapid and accurate tools to identify all microorganisms, bacteria, viruses, fungus and parasites, whatever the sample material, and to accomplish this quickly, using a method that is rapid, accurate, and actionable.

My team initially focused on microorganisms associated with human disease and wellbeing, but now includes agriculture safety and public health. It has been determined by many investigators over the past decade that the human body is comprised of more microorganisms than human cells, approximately 70-80 percent of the cells of human body are microbial. What is important to emphasize is that these microorganisms are predominantly beneficial in their action. Some species of bacteria in the human gut produce vitamins that the human body cannot synthesize. Also, microorganisms and their metabolites act to regulate our immune system and protect against invading microorganisms. Hence, our associated microorganisms are important to our wellbeing. And many microbial species are specific as to which part of the body they colonize. For example, those bacteria in the gut tend to be active fermenters. Those on skin are protective by having a wax-like substance in their composition that can act as a barrier to invasion by other, potentially pathogenic microorganisms. Although slow-growing, the skin bacteria serve as a first line of defense. In the oral cavity, saliva and mucosa also contain species of protective microorganisms.

In contrast, there are those microorganisms that are associated with disease, either by invasion of the body or direct causation of infectious disease. For example, certain bacteria on the skin can cause simple acne but more serious invaders of the gut cause ulcerative colitis and many other bacteria can infect wounds. Recent studies suggest that microorganisms may play a role in Parkinson's disease and other chronic diseases.

The history of the application of informatics and genomics to identify microorganisms can be considered to have begun in the 1960s, when computer programs were devised to identify microorganisms. At that time I was a student and wrote the first computer program for the IBM 360 to identify marine bacteria, employing

phenotypic characteristics coded to calculate similarity relationships among the bacteria. The computational capability of the IBM 360 in 1960, as crude a system as it was compared to today's computers, did allow identification of bacterial species. Since those early first steps, next-generation sequencing and bioinformatics employing laptop computers together now provide a foundation for a new field of metagenomics and microbiome analysis.

To identify agents of infectious diseases, such as was needed to be done in the case of the anthrax bacillus, circa 9/11, the bacteriological methods employed were tedious and laborious. The available microscopy and specific antibody based serological tests were generally time consuming and tedious. Mass spectrometry and, ultimately, genetic methods including the polymerase chain reaction (PCR) were subsequently developed, but culturing the suspected bacterial agents was still necessary.

In addition to difficulties in identifying a pathogenic agent, excessive use of antibiotics in the battle against disease-causing bacteria has led to wide-spread antibiotic resistance, adding to the complexity of identification and characterization of microorganisms. Fewer antibiotics remain active against common infectious agents today, with the consequence that many are becoming increasingly resistant to the most powerful antibiotics. Misuse of antibiotics has left us with multi-resistant microorganisms circulating in the general population, with projected consequences far into the future (Fig. 1). After completing my term as director of the National Science Foundation in 2004, I established a company, CosmosID, Inc., in 2007, focusing on bioinformatic methods for rapid, accurate, and actionable identification of bacteria, viruses, parasites, and fungi literally within minutes (Figs. 2 and 3).

The anthrax investigation took weeks before there was definitive identification of the agent that caused the death of the reporter in Florida. A total of six years passed before sufficient information was accumulated to determine the source of the anthrax and the perpetrator – the perpetrator committed suicide the day the FBI arrived to arrest him. We will never know the full details of his work, but what was clear was that we needed a method to detect bio-threat agents rapidly and accurately, whether in the food chain, hospitals, or water supply.

As mentioned above, the conventional laboratory workflow involving culturing the agents takes several days to weeks to isolate, test, and profile the organism. Isolates, once obtained in pure culture, can be identified within days. In contrast, by employing DNA and RNA sequencing (next generation sequencing), the time from sampling to sequencing, requires ca. 40 hours. Once the sequence is determined, the informatics tool identifies all bacteria, viruses, fungi, and parasites present in the sample within minutes and the identification is accomplished to the level of species and strain.

Other scientists are also developing similar tools. For example, Charles Chiu at the University of California, San Francisco, demonstrated the value of NGS/bioinformatics by identifying a pathogen infecting a young boy whose illness could not be diagnosed by routine methods. The boy had been hospitalized several times during a year long illness. When DNA was extracted from a blood sample and sequenced, the pathogen was identified as a *Leptospira* species, a spirochaete discharged in the urine of animals and transmitted via contaminated water. Penicillin treatment proved effective. However, a year of treatment had passed because spirochaetes are very difficult to culture and

identify using standard laboratory methods. Had the NGS/bioinformatics method been employed, treatment would have been possible months earlier.

A very useful example of the power of NGS/bioinformatics is our study in collaboration with colleagues at NICED in Kolkata, India, an infectious disease hospital that treats patients with cholera and enteric related diseases. The study compared standard microbiological methods and NGS/bioinformatics with stool samples from patients with severe diarrheal disease. That is, stool samples collected from patients were extracted to obtain DNA, which was analyzed using next generation sequencing (NGS) and informatics.

Ca. 20 samples were also obtained from healthy members of the community, which served as reference. All bacteria present in all samples from both patients and volunteers were identified to species level, including *Vibrio cholerae*. The discovery was that the illness for which the patients had been admitted to hospital involved more than a single pathogen. The NGS/bioinformatics method provided entirely new information, namely all bacteria present in the samples were identified and the infections rarely involved a single pathogen, usually several pathogens. Because the DNA of the entire sample could be compared directly with results obtained using standard bacteriological tests, mixed infections proved to be common by both approaches, a factor to consider in the future with respect to a bio-threat. Namely, like any infectious disease, a bio-threat may not involve a single agent, but a mixture of pathogens.

The DNA based method has proven consistent and offers a powerful forensic tool. Pathogens can be identified to species and strain. In addition, this elegant technique determines the presence of genes coding for antibiotic resistance, pathogenicity, and metabolic pathways.

A clear example of the need to identify, not only the species, but strains of a species was shown in a necrotizing fasciitis case.[2]

In a study of endocarditis, work done jointly with hospitals in the U.S., Sweden, and the Netherlands, identification of the pathogens involved in the infections, often difficult to identify using standard culture methods, were readily identified by employing NGS/bioinformatics. Various species of bacteria can cause endocarditis, including anaerobes and fastidious bacteria, which can be identified relatively easily and quickly employing NGS/bioinformatics.

Metagenomics (analysis of the entire microbial community) can provide comprehensive information about gut bacteria. As shown in Figs. 4 and 5, metagenomic data compiled for ten countries provide a composite composition for each country and bio-forensic patterns can be discerned. Diet, culture, genetics, and environment all play a role in creating the characteristic pattern of microbial species in the composite human gut flora of individuals in each country. This information is of bio-forensic value, allowing identification of the gut flora species common to a given population of any country.

To conclude, next generation sequencing, combined with bioinformatics, provides a valuable bio-forensic tool. The nearly two decades since the anthrax episode of 2001

has seen development of an identification system that can produce accurate and actionable results with a time period of 48 hours or less.

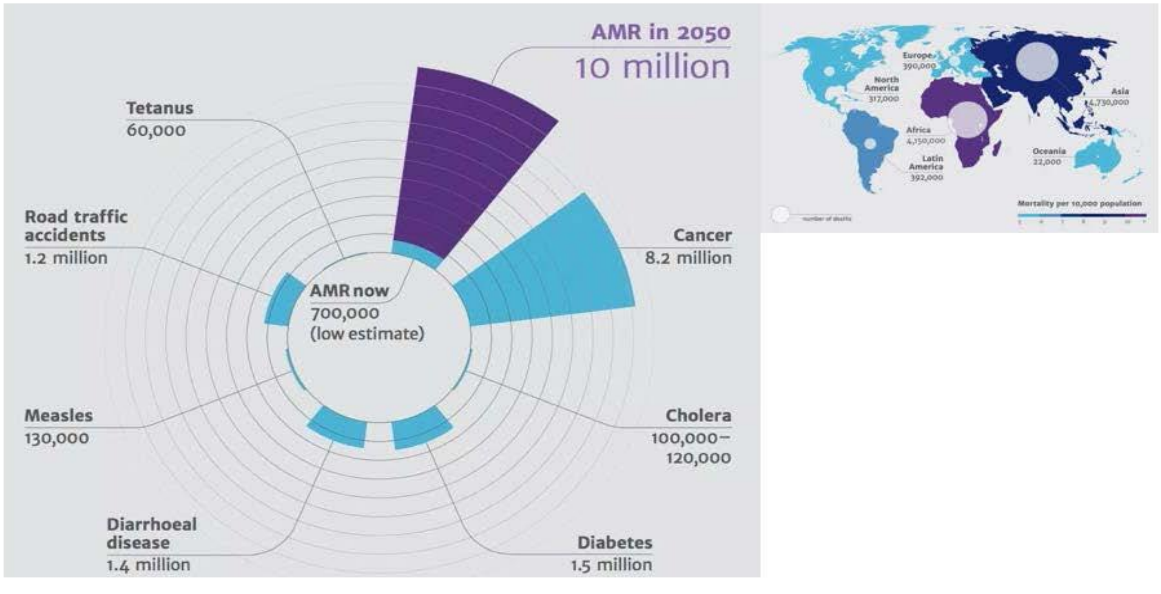
This is a capability that must be at the ready, because the next bio-threat may not be anthrax, but a more complicated threat and the power of this new tool will be critical. We must be vigilant and prepared to use this powerful new system of analysis to protect our country and the innocent throughout the world.

---

[1] Presentation at an event on "Combating Biological Terrorism: Roadmaps for Global Strategies" held on August 24, 2017, at the Potomac Institute for Policy Studies.

[2] Duraisamy Ponnusamy, Elena V. Kozlovaa, Jian Sha, Tatiana E. Erova, Sasha R. Azar, Eric C. Fitts, Michelle L. Kirtley, Bethany L. Tiner, Jourdan A. Andersson, Christopher J. Grim, Richard P. Isom, Nur A. Hasan, Rita R. Colwell, and Ashok K. Chopra. 2016. *Cross-talk among flesh-eating Aeromonas hydrophila strains in mixed infection leading to necrotizing fasciitis*. Proc Natl Acad Sci U S A. 2016 Jan 19;113(3):722-7. doi: 10.1073/pnas.1523817113. Epub 2016 Jan 5.

Figure 1. Prediction of Global Deaths from AMR by 2050.



The Wellcome Trust and the UK Department of Health (https://amr-review.org)

Figure 2. The next generation sequencing (NGS) and bioinformatics system for identification of microbial species.

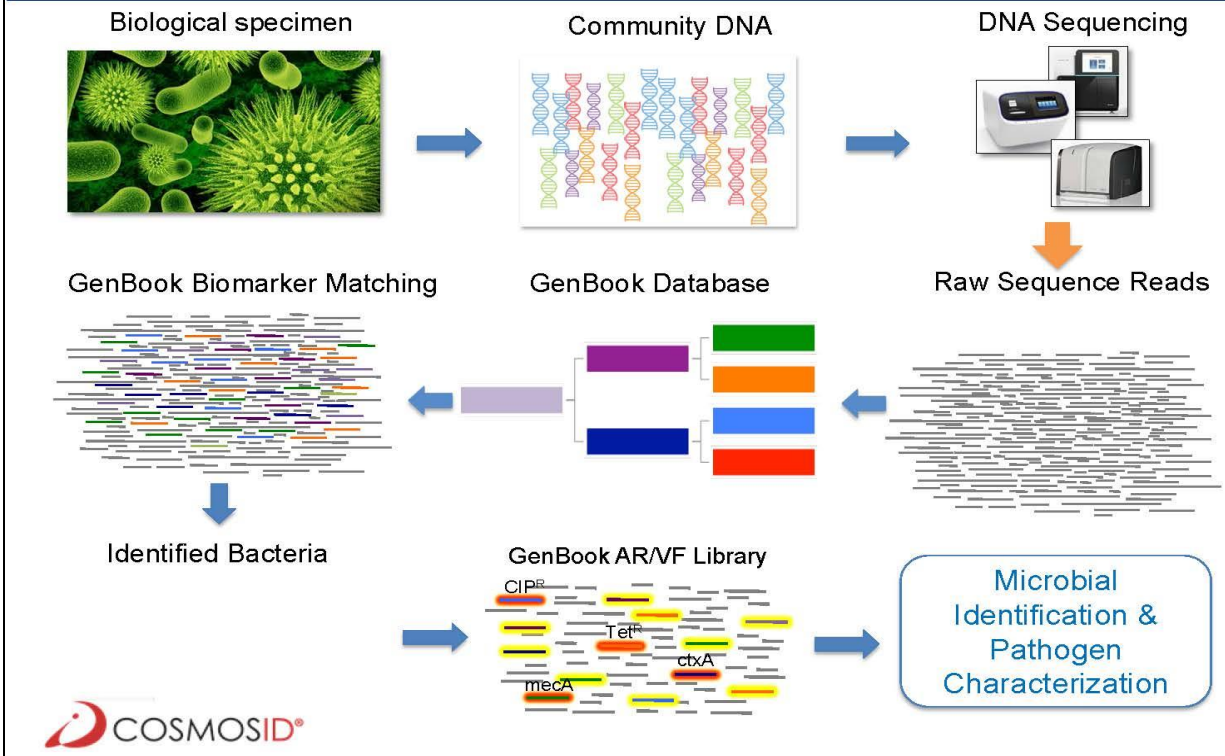
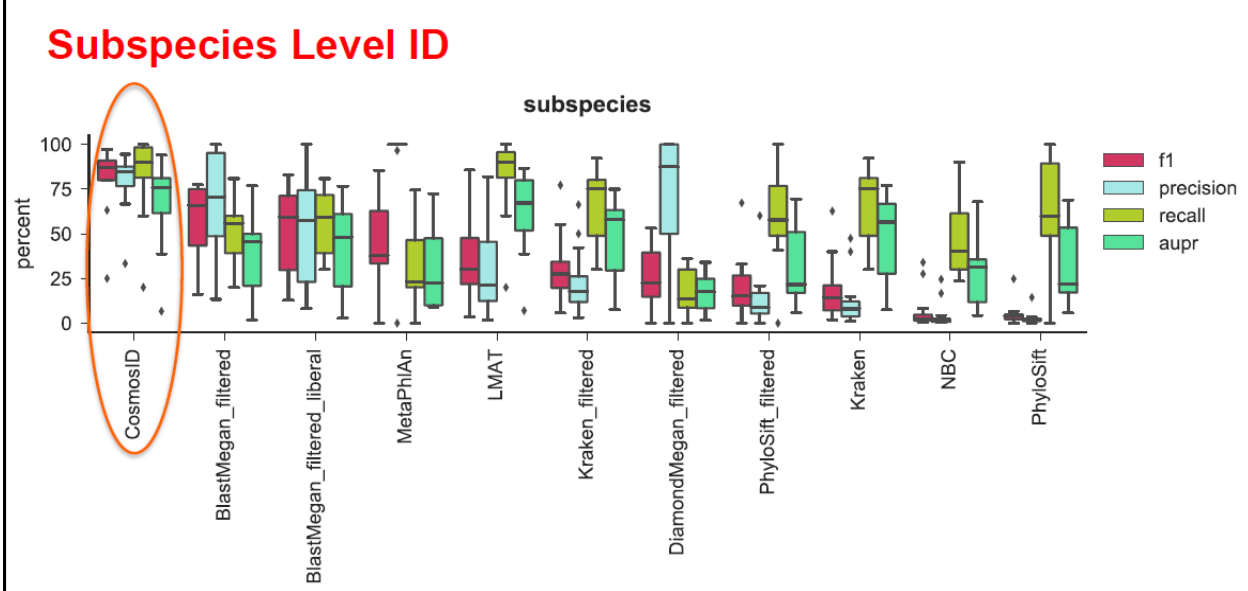


Figure 3. Accuracy of identification to subspecies. CosmosID Cloud Metagenomics – Performance.



McIntyre et al. Genome Biology (2017) 18:182
DOI 10.1186/s13059-017-1299-7

Genome Biology

Comprehensive benchmarking and ensemble approaches for metagenomic classifiers

Alexa B. R. McIntyre[1,2,3], Rachid Ounit[4], Ebrahim Afshinnekoo[2,3,5], Robert J. Prill[6], Elizabeth Hénaff[2,3], Noah Alexander[2,3], Samuel S. Minot[7], David Danko[1,2,3], Jonathan Foox[2,3], Sofia Ahsanuddin[2,3], Scott Tighe[8], Nur A. Hasan[9,10], Poorani Subramanian[9], Kelly Moffat[9], Shawn Levy[11], Stefano Lonardi[4], Nick Greenfield[7], Rita R. Colwell[9,12], Gail L. Rosen[13*] and Christopher E. Mason[2,3,14*]

Figure 4. Healthy Gut Microbiome Across Countries and Cultures.

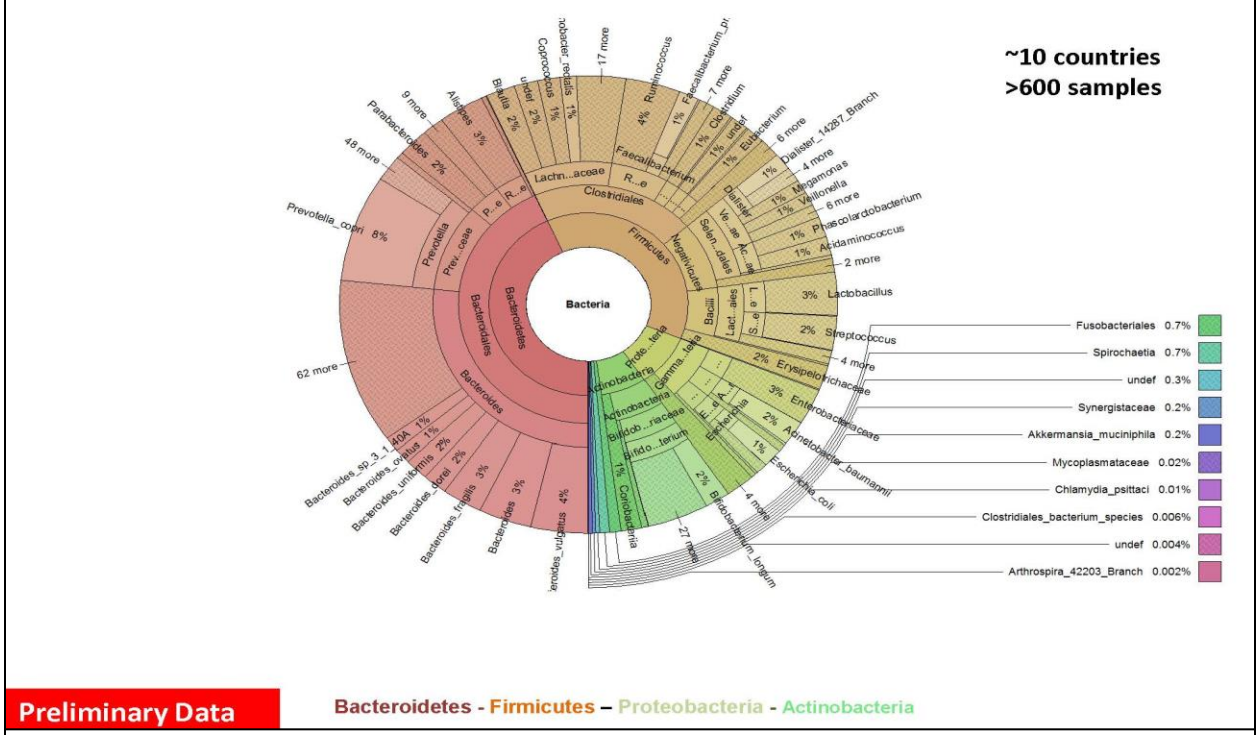
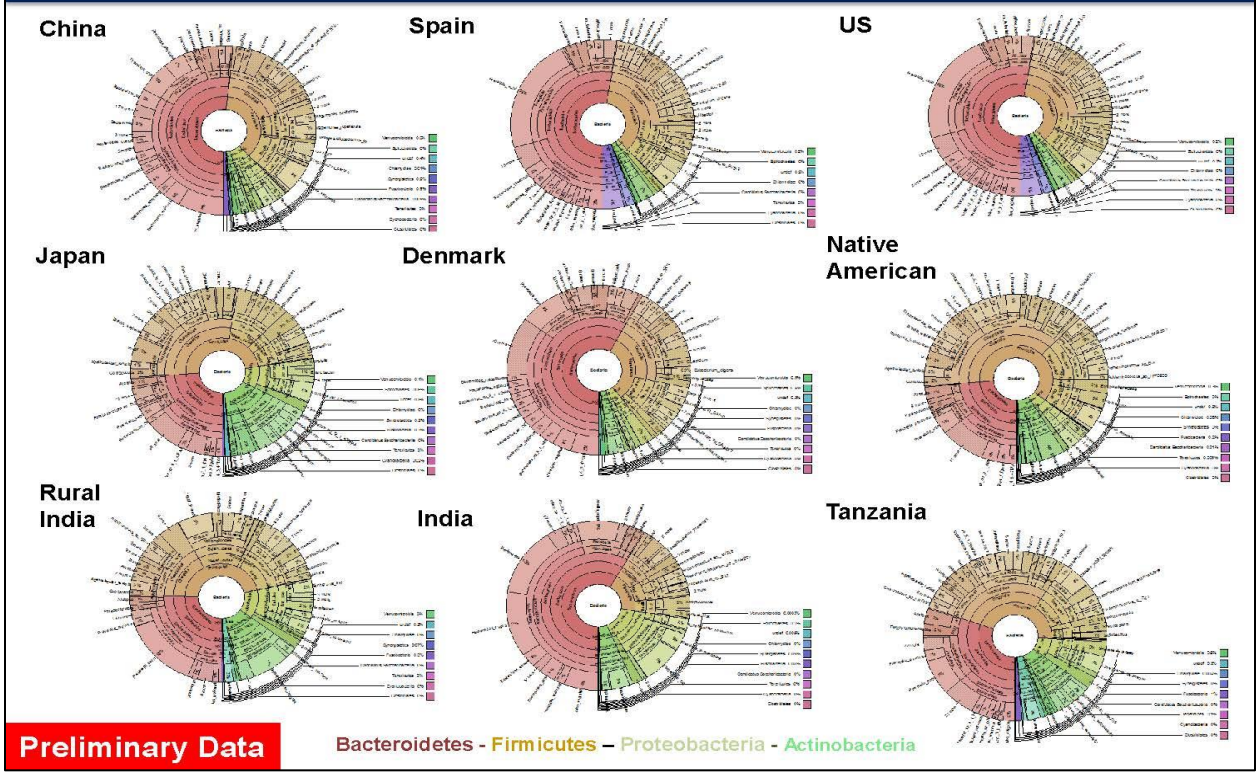


Figure 5. Healthy Gut Microbiome Across Countries.



Professor S. Gerald Sandler
Professor, Departments of Pathology and Medicine, Georgetown University; Medical Director, Transfusion Service, MedStar Georgetown University Hospital[1]

The title of this presentation is "What can the global blood transfusion experience contribute to today's discussion on bioterrorism?" A subtitle might be "Why *is* blood transfusion on the agenda at today's meeting?" I suggest that there are three reasons. One, there is an international network of what we in the blood transfusion discipline call "biovigilence," that is, daily monitoring and reporting of infectious complications of blood transfusion, including new "emerging" agents. That is probably the activity in my discipline of blood transfusion that caught the attention of Professor Alexander and his colleagues. The second rationale is that every day in the United States, blood centers test about 35,000 tubes of blood, that is, blood from 35,000 blood donors, for seven infectious agents. So that is quite a database of national data that is reported to the CDC. We have a national network of infectious disease data. Probably, the third rationale is the most pertinent. That is that there are about 300 transfusion services in medical centers in the United States, including mine at Georgetown University Medical Center, that have cesium-137 blood irradiators. If a hospital performs bone marrow or solid organ transplants, recipients must immunosuppressed to a degree that if a blood transfusion is administered and the blood donor's lymphocytes are transfused, too ("passenger" lymphocytes), the recipient can develop graft-versus-host-disease. That is, the immune system of the donor in the form of the passenger lymphocytes clones in the recipient and considers that person as immunologically foreign. The only way that graft-versus-host disease can be prevented is to irradiate the blood to be transfused (containing passenger lymphocytes) with a gamma irradiator. Those are the three topics from the discipline of blood transfusion that might be pertinent for our discussion on bioterrorism.

With regard to the international network, there is collaboration with the Health and Human Services, the American Association of Blood Banks, International Society of Blood Transfusion, and World Health Organization. This international network monitors for infectious agents, but our network is well-developed in the Western industrialized countries, and the action is elsewhere, in Latin America, in Africa, in other places. Our network for blood transmissible agents is not geographically located to monitor emerging infectious agents that may be suitable for bioterrorism.

With regard to the laboratory tests that are performed daily on donated blood, the question is whether these laboratory tests that are pertinent to detecting the categories of highly communicable agents that might be selected for a bioterrorist attack. In contrast to what a terrorist would be looking for – highly communicable infectious agents – the infectious agents we test blood for are not highly communicable: *Treponema pallidum*, the agent of syphilis, the agents of hepatitis B, hepatitis C, AIDS, West Nile fever, and the agent of Chagas disease. These are all infectious agents of very low communicability. A person needs to be transfused with a bag of 500 milliliters of blood, or to have to have sex with an infected person, or to be bitten by a mosquito to become infected. Our categories of infectious agents are not the ones that will interest a terrorist. The agents in our blood transfusion service databases do not spread the way a terrorist

wants to spread havoc. Our networks are in the wrong geographic locations and our infectious agents are not the ones of interest to terrorists.

Lastly, what is the relevance of our blood irradiators with cesium-137 for a discussion on bioterrorism? There are approximately 300 in blood transfusion services and community blood centers the United States. Each has in it about 2,000-6,000 curies of cesium-137, with a half-life of 30.2 years. If the wrong person obtained access to what is in my transfusion service, and blew it around downtown Washington, we could close the nation's capital for the rest of our lives, because it would not be safe from gamma irradiation. I would not be discussing this potential risk if the corrective action was not already well in place. Blood transfusion services in the United States are well into the process of converting to non-nuclear irradiators. We need about 25 gray (Gy) of gamma irradiation to inactivate passenger lymphocytes and prevent them from causing graft-versus-host disease. It would take about 20 minutes for the standard irradiator for patients to deliver that amount of gamma irradiation. That timing is not suitable for the turnaround time for a blood transfusion.

With the support of Department of Energy, Homeland Security and, particularly, the Nuclear Regulatory Commission, industry has done what industry can do. It has miniaturized non-isotopic gamma irradiators so we can get the equivalent of 25 Gy in about 5 minutes which is acceptable for a turnaround time. That is happening as we speak. The Department of Energy has provided funding so the cesium-137 core can be disposed of safely. We do not want to have 2,000-6,000 curies of cesium 137 washed down the sink or thrown out in the waste. I did not raise this topic in without realizing that the risk is rapidly being eliminated. Blood transfusion services are going to have nonnuclear the irradiators very soon. There is a few months back-log right now with the manufacturer, but that issue is not an issue for the future.

[1] Presentation at an event on "Combating Biological Terrorism: Roadmaps for Global Strategies" held on August 24, 2017, at the Potomac Institute for Policy Studies.

Dr. Norman Kahn
Consultant, Counter-Bio LLC; former Director, Intelligence Community Counter-Biological Weapons Program[1]

Most of the U.S. government resources that have been devoted to countering bioterrorism or bio-threats in general have focused on response, after the fact. What I am going to talk to you today is on the left side of the equation – the prevention side. How might one prevent an incident of bioterrorism? Since we are talking terrorism here, I am going to narrow it down and limit my remarks not to state-sponsored activities but to what is commonly called lone actor or lone wolf, or small groups.

I am going to read a quote from Nobel Laureate Josh Lederberg in 1998. "There is no technical solution to the problem of biological warfare. It needs an ethical human and moral solution if it is going to happen at all." And then he goes on to continue, "But would an ethical or moral solution appeal to a sociopath?" I would submit that the answer is probably no. And I would submit that the answer is also probably no when it comes to bioterrorism. If someone is going to do this, that person is not going to be swayed by ethical or moral suasion.

So how does one have a shot at preventing this? To me the answer is what I would like to call "deputizing the good guys". I am going to use a phrase throughout my talk: "bystander". I am going to define bystanders as a person or individuals who become aware that someone might be bent on perpetrating a bioterrorism event. I will give you an example or two of the potential efficacy of bystanders.

November 2012, Brunon Kwiecień, a Polish professor, a chemist by training, at Krakow's Agriculture University is arrested. Authorities at his home find detonators, a handgun, ammunition, and body-armor. And his plan was to get a truck, load it with four tons of ammonium nitrate – he had not yet obtained the four tons but that was his plan – and drive it into the Polish Parliament. But it never happened. He was arrested. He had been put under surveillance by Polish authorities.

Why did they put him under surveillance? His wife turned him in. It gets even more interesting. His wife turned him in because of the following. She was a biologist by training. He had been questioning her about what one could do with pathogens. What kind of harm could one cause with infectious agents and pathogens? She became concerned and alerted authorities. She thought he was bent on biological warfare, turns out he was not. But that is an example of a trained individual, trained in the sense of professional training, who was a bystander and made the decision to blow the whistle on someone. In this case it happened to be her husband.

I will give a more recent example. In October 2014, a Canadian by the name of Martin Couture-Rouleau ran down with his car and killed one person, injured another. They were both Canadian Armed Forces personnel. He was specifically targeting Canadian Armed Forces. Eighteen months before that event, he had converted to Islam. His personality changed, he grew a beard, he stopped wearing jeans, started wearing robes, started going to the mosque frequently. He decided he wanted to travel to Syria and aid the ISIS cause. In June 2013, just a couple of months after his conversion, his father became concerned and notified authorities that his son might pose a threat. His son

was bent on travelling to Turkey, but authorities confiscated his passport. And then the broader system tried to intervene. So besides his family, the imam at his mosque intervened, and Canadian authorities intervened and essentially counselled and held a number of discussions with him trying to dissuade him and get him off the path that he was on.

Just a couple of days before October 20, 2014, when he took his car and ran down those two Armed Forces individuals, he had a meeting with the Royal Canadian Mountain Police and he was able to convince them that he was no longer a threat. So in this case bystanders did intervene, a number of bystanders – the family, authorities, the imam – they all intervened but in this case it was not successful. But again, it points to the power of bystanders to prevent something.

What are my recommendations? For countering lone actor or small group bioterrorism, I think there needs to be the development of ethics-based programs for biologists, both students and practitioners, along the lines of the molecular bio equivalent of the Hippocratic Oath. And that needs to be done worldwide. And that has to include the ethical responsibility to report someone who is conducting themselves in a suspicious manner. Suspicious manner can be defined in lots of different ways but basically it is an anomalous behavior. It might not even be behavior in the lab but "something is not right here and it is making me nervous".

And the bystander system itself needs to be safe, accessible, and effective. It is a system that I am talking about, a sequence of steps. There have been publications on this but one thing that I have not seen are publications on the cultural aspect of a bystander system. In this country, you do have institutions that have personnel reliability systems in place. And that includes responsibility to flag someone like Bruce Ivins, for example. But if I transplant that system to South America, Southeast Asia, Africa, does it play out the same way or not? What are the cultural aspects of a bystander system that need to be considered so that what may be effective here is effective someplace else? You cannot make the assumption that the U.S. approach can be transplanted lock, stock, and barrel. Cultural aspects need to be researched.

My final recommendation is to develop and support these bystander-type systems worldwide. The cost is relatively cheap compared to the billions of dollars that this government has put into the response side of the equation over the past decade or more.

---

[1] Presentation at an event on "Combating Biological Terrorism: Roadmaps for Global Strategies" held on August 24, 2017, at the Potomac Institute for Policy Studies.

Dr. Anthony Fainberg
Former official at the Federal Aviation Administration and the Transportation Security Administration and currently a scientific advisor to the Inter-University Center for Terrorism Studies[1]

Reacting to 9/11, the public and the government of the United States developed a sudden, perhaps panicked, but nevertheless logical interest in understanding the terrorist threat, now clearly on its shores. Up to this point, the general view in the United States was that terrorism was certainly present – in some places, nearly omnipresent – in other parts of the world, notably the Middle East, but that international terrorism, at least, was not a domestic threat. Domestic terrorism did exist, usually in the form of an occasional pipe bomb, but was rare and generally had minor societal impacts over the previous half-century.

In the course of attempts by U.S. national security analysts and scientists to focus on terrorist threats and to try to anticipate what might happen next, thoughts naturally turned to the fearsome possibility of weapons of mass destruction (WMD) as a terrorist tool. WMD in this context is a term usually comprising nuclear, radiological, chemical, and biological weapons. After a year or two of consideration, it was generally agreed that radiological terrorism was probably of lesser concern than the other three categories, since casualties were likely not to be enormous, and most of the disruption and impact on the public at large would be economic and psychological instead.2 Chemical weapons were more of a worry, especially given the massive deaths (~5000) caused by Iraqi military's use of poison gases (thought to include tabun, sarin, VX, and possibly mustard gas) against Kurdish communities in Halabja, Iraq in 1988.

But among WMD, nuclear and biological weapons still give rise to the most worry and analysis among counter terrorism experts because of the enormous number of casualties that would arise from a successful attack. Even a small nuclear weapon in an urban area would likely cause tens or hundreds of thousands of deaths and many more injuries. The known effects of nuclear weapons used in war in 1945 constitute a proof of effectiveness. Regarding biological weapons, the verdict is less clear, although it is obvious that an infectious disease could affect millions over the course of weeks or months; the 1918-9 worldwide influenza epidemic was proof of that. Nuclear weapons furnish the public with a starker menace than biothreats; nuclear explosion effects are well known, assuming detonation. On the other hand, for biothreats, it is much more difficult to predict how well a successfully released agent would work in the field, even with preliminary laboratory testing. Environmental issues connected to dispersion, agent persistence and continued viability after release (considering living agents) are among the uncertainties to be considered.

In the 2000s, U.S. government agencies began to assemble a prioritized list of biothreats of concern, incorporating factors such as ease of production, effectiveness, viability outside a laboratory environment, infectiousness, and virulence. Potential countermeasures after release were separately considered. At first, about 10 agents were listed, and the number may have increased over the past decade. To prioritize the risks from the agents, if used by terrorists, one also had to estimate which ones a terrorist group (or what several distinct groups) would likely try to use operationally. The factors just mentioned would strongly play into this assessment.

In order to understand better what a terrorist group might do with bioweapons, and how successful they might be, it may be useful to start by consulting recent history. How have terrorist groups tried to use bioweapons over, say, the past several decades? Later, one could also consider recent developments in biology to estimate if and how these may affect the future use of bioweapons, by state as well as by non-state actors.

Only occasionally have terrorist groups in the United States attempted to use biological means of attack. For example, there were several efforts by individual political extremists to weaponize ricin, a biological toxin refined rather easily from castor beans. Because ricin is more effective as an assassination tool rather than to cause mass fatalities, these efforts were not successful as terrorist weapons. However, it has seemed that every few years someone in rural America is discovered exploring this possibility, usually with extreme right-wing political aims.

Probably the most widely reported (and slightly more successful) effort to use biological agents for political ends was the use of salmonella bacteria to infect a salad bar in Antelope, Oregon in 1992. This attempt by a bizarre, putatively religious movement, the Bhagwan Shree Rajneesh group, was intended to sicken just enough of the local population shortly before a local election to enable a takeover of the small town by the cult leaders. This attack, however, failed to achieve victory. Hundreds of people were actually sickened, but fortunately there were no fatalities. The cult eventually was forced out of the United States for this and other reasons, and its remnants are still in Pune, India.

A better-known biological attack in the United States was the case of the anthrax letters. Envelopes containing anthrax spores were sent shortly after 9/11 to members of congress and some journalists. About five members of the public eventually died from anthrax as a result of infections from the letters. More were sickened. Interestingly, the death rate, although high, was nowhere near the 90 percent level that had been bandied until then by most of the counter bioterrorism community. The perpetrator of this anthrax crime was attributed by the FBI to a mentally unstable scientist working at the U.S. Army Medical Research Institute of Infectious Diseases at Fort Detrick, Maryland, a biological research facility. However, some experts still express some doubt as to whether the guilty party was correctly determined. In any case, DNA analysis indicated that the anthrax strain used unambiguously came from Fort Detrick, in spite of rather crude written efforts in the letters to indicate that the attack was part of some Islamic plot.

Internationally, the best known and most effective sub-state chemical, not biological, terrorist attack was carried out by the Aum Shinrikyo cult in Japan in 1995. Sarin was released in the Tokyo subway, causing 13 fatalities and hundreds of injuries. An earlier release in the city of Matsumoto also caused casualties, including deaths. The cult was eventually broken up and its head is still in prison, possibly awaiting execution. This was, of course, not a biological weapon attack. But, a less well-known part of the story is useful in assessing the difficulties for groups with only limited, sub-state resources if they try to play with bioweapons. In fact, before the chemical attacks, the cult had tried to disperse anthrax in Kameido, Tokyo.3 It is noteworthy that in spite of the fact that the cult's membership did include people with advanced degrees in biology and chemistry, the type of anthrax used in this effort happened to be a non-virulent strain that had been isolated by legitimate disease researchers to help investigate the

bacterium. The terrorist group's bio experts did not figure this out. Therefore, no injuries, fatalities, or other consequences (beyond a reported unexplained bad odor) resulted from this abortive effort.

In another example of a sub-state terrorist group attempting to play the bioweapon card is al-Qa'ida. It attempted to develop and purify anthrax strains when it had safe and broad access to areas of Afghanistan given to them by their Taliban allies, who controlled the country until late 2001. Later analysis of their efforts indicated that they had managed to culture just a small amount but had made little progress towards weaponizing the agent.

The four examples just cited may indicate some things about attempts to use bioweapons for terrorist goals. First, the number of successful attacks was very low – zero, if one discounts the limited results of the anthrax letters. Second, even with some technical expertise available to the terrorist group, unexpected obstacles may frustrate terrorist designs. Third, up to the present, terrorists have chosen the simplest route, that is, to use available agents, rather than to attempt applying DNA manipulation techniques to make an already effective microbe more virulent, more transmissible, and more resistant to treatment. These conclusions indicate that terrorists seem to focus on the old standards, like anthrax, whose spores survive well in sunlight.

This conservatism among terrorists is worth mentioning since some well-respected experts in the early 2000s had expressed serious concern about the use of newly developed techniques in DNA sequencing and manipulation that could enable any smart and motivated high school student to develop an immensely effective bioweapon. This has not yet happened on the high school level, nor even on the level of sub-state terrorist groups. It is not that such cannot be done: yes, one could, in principle, arrange to insert into common gut bacteria genes that produce extremely effective toxins for dispersal among a target population. In fact, according to a former senior researcher, the Soviet Biopreparat laboratory, devoted to biological warfare in the 1980s, did attempt to modify anthrax DNA to create a more virulent product.4 But this endeavor is still far more difficult to accomplish instead of using a very effective existing agent, like anthrax or Yersinia pestis (plague) in respiratory systems. And even this has proven difficult for sub-state actors thus far.

I suspect that the real biothreats of this sort, that is, the use of genetically modified agents or the use of much more recently achieved techniques such as CRISPR (Cas 9 and others)5 in a bioweapon mode, is far more likely to come from the laboratories of a technologically advanced state than from someone's garage or the equivalent.

Some express concern that this and related techniques that can specifically target a known region of human DNA could be used to create a genetically targeted bioweapon. It is not certain at this point if such an approach to genetic weaponization is even possible, given the difficulties of using gene therapy for medical purposes in highly controlled clinical laboratories. But if so, the consequences could be extremely serious, especially if genetic changes could somehow be inserted into a human germ line, thus propagating the modification through the species as part of human DNA. How such an approach to a genetic bioattack would work is pretty murky, however. The most serious threat, through the germ line, even if feasible – and it is not certain that it ever could be outside a laboratory environment – could take decades to be effective and could, in

principle, be detected before having a major effect. If genetic modification were somehow accomplished against a target population's DNA in somatic cells, there would be the danger to the malefactor that his own supportive population could also be as seriously affected.

I would suggest that, given the current accumulation of a limited history of bioweapons research and bioattacks (which we did not have, say 25 years ago), and in view of many alarmist assessments of the future of bioterrorism in the early 21st century – assessments that fortunately have not yet panned out – it would be useful for an open, unclassified risk assessment of biothreats, considering both potential state and sub-state actors. It would be useful to prioritize threats and to do this in the open as much as possible, taking advantage of input from leading researchers in biological fields of interest. These should be put together with experts in terrorism and its recent history. Biological researchers would provide information not only on what is possible, but on what is likely. The goal should be to prioritize relative risks from standard, available bioagents and to do the same for future biothreats about which we have been warned or which can be imagined.

There could be at least two positive results of such an effort. First, resources could be more efficiently redirected to prevention and to countering possible threats to the United States and indeed the world. In addition, information from such research would also help in planning how to counter naturally occurring biothreats, such as a possible new and untreatable influenza outbreak in the world, or a broadly lethal mutated microbe that could appear, such as the epidemic of 1918-9 (a sub-type of avian H1N1) or the emergence of HIV/AIDS in the 1970s. Finally, it would improve the level of dialogue for the public to have in hand a set of realistic assessments of the risks of various biological threats to public health and safety. On the one hand, natural and quite possibly human-generated biothreats might have immense and overwhelming consequences, in a single country or in the world as a whole. On the other, just because a scientist or policy expert can imagine a horrible, detailed and super-lethal new threat does not mean that such a threat exists in the real world, either now or in the foreseeable future. We need serious experts to provide the rest of us with the fruits of their expertise so that planning on all government levels will be effective and affordable.

---

[1] Paper by Dr. Anthony Fainberg on "The Need For Biothreat Risk Assessments" (Spring 2018).

[2] For a detailed assessment, see Peter D. Zimmerman and Cheryl Loeb, "Dirty Bombs: The Threat Revisited," *Defense Horizons*, 38, January 2004, pp. 4-5

[3] H. Takahashi et al, "*Bacillus Anthracis* Bioterrorism Incident, Kameido, Tokyo, 1993," *Emerging Infectious Diseases* 10(1), January 2004, accessible at https://wwwnc.cdc.gov/eid/article/10/1/03-0238_article, last accessed July 4, 2017.

[4] K. Alibek with S. 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*, Delta, reprint edition 2000.

[5] CRISPR (Clustered Regularly Spaced Short Palindrome Repeats) Cas9 is a genome-editing technique adapted from certain bacteria, which have developed a natural ability, using a CRISPR portion of DNA to genetically attack invading viruses. Cas9 refers to an enzyme that is attached to a CRISPR segment of DNA that can be guided to a specific site in a DNA molecule. The enzyme then can cut the DNA at a specific site, allowing its modification. Other enzymes than Cas 9 can also be employed. Researchers hope to use this technique to attack certain diseases, such as cystic fibrosis or hemophilia, through gene therapy. But many biologists express concern that the technique could be used to create or exploit genetic weaknesses in a target population. See for example https://ghr.nlm.nih.gov/primer/genomicresearch/genomeediting, last accessed February 14, 2018.

Academic Centers

Inter-University Center for Terrorism Studies (IUCTS)

Established in 1994, the activities of IUCTS are guided by an International Research Council that offers recommendations for study on different aspects of terrorism, both conventional and unconventional. IUCTS is cooperating academically with universities and think tanks in over 40 countries, as well as with governmental, intergovernmental, and nongovernmental bodies.

International Center for Terrorism Studies (ICTS)

Established in 1998 by the Potomac Institute for Policy Studies, in Arlington, VA, ICTS administers IUCTS activities and sponsors an internship program in terrorism studies.

Inter-University Center for Legal Studies (IUCLS)

Established in 1999 and located at the International Law Institute in Washington, D.C., IUCLS conducts seminars and research on legal aspects of terrorism and administers training for law students.

International Advisory and Research Council

Honorary Chairman

*Prof. Edward Teller * Hoover Institution*

Prof. A. Abou-el Wafa	*Cairo University*	*Prof. Asher Maoz*	*Tel Aviv University*
Prof. Jayantha W. Atukorala	*Sri Lanka*	*Prof. Serio Marchisio*	*Instituto di Studi Giuridcic sulla*
Prof. Paolo Benvenuti	*Universita Di Firenze*		*Communita Inernazionale*
*Prof. Edgar Brenner **	*Inter-University Center for Legal Studies*	*Prof. Dr. Herman Matthijis*	*Free University Brussels*
Prof. Ian Brownlie	*Oxford University*	*Prof. Jerzy Menkes*	*Poland*
Prof. Abdelkader Larbi Chaht	*Universite D-Oran-Es-Senia*	*Prof. Eric Moonman*	*City University of London*
Prof. Mario Chiavario	*Universita Degli Studie Di Torino*	*Prof. Yuval Ne'eman **	*Tel Aviv University*
Prof. Irwin Cotler	*McGill University*	*Prof. Michael Noone*	*The Catholic University of America*
Prof. Horst Fischer	*Ruhr University*	*Prof. William Olson*	*National Defense University*
Prof. Andreas Follesdal	*University of Oslo*	*Prof. V.A. Parandiker*	*Centre for Policy Research*
Prof. Gideon Frieder	*The George Washington University*	*Prof. Paul Rogers*	*University of Bradford*
Prof. Lauri Hannikaninen	*University of Turku, Finland*	*Prof. Beate Rudolf*	*Heinrich Heine University*
Prof. Hanspeter Heuhold	*Austrian Institute of International Affairs*	*Prof. Kingsley De Silva*	*International Center for Ethnic Studies*
Prof. Ivo Josipovic	*University of Zagreb*	*Prof. Paul Tavernier*	*Paris-Sud University*
*Prof. Christopher C. Joyner **	*Georgetown University*	*Prof. B. Tusruki*	*University of Tokyo*
Prof. Tanel Kerkmae	*Tartu University, Estonia*	*Prof. Amechi Uchegbu*	*University of Lagos*
Prof. Borhan Uddin Khan	*University of Dhaka*	*Prof. Richard Ward*	*The University of Illinois at Chicago*
Prof. Walter Laqueur	*CSIS*	*Prof. Yong Zhang*	*Nankai University, China*
Francisco Jose Paco Llera	*Universidad del Pais Vasco*	*Deceased	

Director

Professor Yonah Alexander

Senior Staff

Sharon Layani
Lisa Winton

Senior Advisors

Michael S. Swetnam
CEO and Chairman, Potomac Institute for Policy Studies

Professor Don Wallace, Jr.
Chairman, International Law Institute

Technical Advisors

Mary Ann Culver
Alex Taliesen

Spring 2018 Internship Program

Lilli Abraham	The George Washington University	Hunter McWilliams	Skidmore College
Julieta Barbiero	American University	Samuel Ridge	University of California, Berkeley
Gabriella Garrett	Wichita State University	Abdulrahman Sanee	University of California, Davis
Gabrielle Labitt	University of Massachusetts Lowell		

Please contact the Inter-University Center for Terrorism Studies at the Potomac Institute for Policy Studies, 901 North Stuart Street, Suite 200, Arlington, VA 22203. Tel.: 703-525-0770 Email: yalexander@potomacinstitute.org, ICTS@potomacinstitute.org