INTER-UNIVERSITY CENTER FOR TERRORISM STUDIES

HOSTS A SPECIAL FORUM:

A LAB OF ONE'S OWN:

FIGHTING BIOTERRORISM, CHOLERA, AND COVID - 19

FEATURED SPEAKER:

Distinguished Unviersity Professor Rita Colwell

COMMENTERS:

Dr. Vinton G. Cerf
Vice President and Chief Internet Evangelist for Google

Dr. Norman Kahn
National Security Consultant

EDITORS:
Professor Yonah Alexander
and Professor Don Wallace, Jr

DECEMBER 2020

Inter-University Center For Terrorism Studies

Potomac Institute for Policy Studies

International Law Institute — Educators, Advisors, Publishers

Center for National Security Law, University of Virginia

NOTICES

The Special Forum is a collection of observations, research, policies, and comments on current medical research related to COVID 19; medicine; sports; legal considerations to exposure claims and liability mitigation; and international political perspectives.

This special forum featured a conversation with Professor Rita Colwell, one of the leading scientists in America as well as a world-renowned academic for her exceptional contributions to global health and security concerns. She discusses Covid-19, pandemics, and policies in context of her latest highly acclaimed book *A Lab of One's Own: One Woman's Personal Journey Through Sexism in Science* published by Simon & Schuster in August 2020.

The publication may be found here:

https://www.simonandschuster.com/books/A-Lab-of-Ones-Own/Rita-Colwell/9781501181276

Video of the full conference may be found here:

http://ili.org/about/news/1251-iucts-host-prof-rita-colwell-a-lab-of-one%E2%80%99s-own-fighting-bioterrorism,-cholera,-and-covid-19.html

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SPECIAL FORUM:

"A LAB OF ONE'S OWN: FIGHTING BIOTERRORISM, CHOLERA, AND COVID – 19"

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A LAB OF ONE'S OWN:
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I. PREFACE

PROFESSOR YONAH ALEXANDER AND PROFESSOR DON WALLACE, JR.

EDITORS

The national, regional, and global spectrum of biological challenges is limitless. Throughout recorded history, these safety concerns stem essentially from two inevitable sources of enduring actual and potential dangers to individuals, communities, societies, and civilizations.

The first critical threat is caused by Mother Nature's disasters, such as earthquakes, cyclones, and infectious diseases. The second concern is man-made menaces, including violent radicalism, terrorism, and war. The key question is whether the United States and the International Community are prepared to identify, prevent, and counter current and future biological threats.

This Preface of the current report on "A Lab of One's Own: Fighting Bioterrorism, Cholera, and COVID-19" (December 2020) offers an overview of the national and global implications of biological challenges, both natural and man-made, as well as providing a brief academic perspective.

MOTHER NATURE AND MAN-MADE BIOLOGICAL THREATS

Biological agents are micro-organisms too small to be seen with the naked eye and can include bacteria, viruses, and fungi. Some of the most serious viral agents are those that produce, for example, smallpox and yellow fever. Bacterial agents can induce the plague and Anthrax.

Biological threats are difficult to control as they require a delivery system, or "vector," that can make distribution difficult and dangerous. Furthermore, it seems likely that if terrorists were to use a biological weapon, they would probably choose a bacteriological rather than a viral or rickettsial agent due to available countermeasures as well as the difficulty of cultivating viruses.

In addition, toxins, the poisonous byproducts of micro-organisms, plants, and animals, fall somewhere between biological and chemical agents as they are non-living substances. Toxins are relatively easy to manufacture and extremely virulent. Botulinum toxins, for example, can be more toxic than some nerve agents on an equal-weight basis.

Moreover, many agents are considered capable of spreading disease among humans, animals, or plants. Disease develops when people and animals are exposed to infectious micro-organisms 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 is capable of destroying crops as well as resulting in famine and costly diseases.

Despite the wide array of biological challenges, historical and contemporary records provide extensive evidence regarding the nature, intensity, and health security implications of existing threats. These massive data sources also serve as a warning to beware of future catastrophic losses to human lives as well as political, social, economic, and strategic 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, the 1918 influenza pandemic, regarded as the deadliest in modern times, killed an

estimated 50 million people worldwide, about 675,000 of them in the United States. Additionally, the Asian flu, originated in China in 1957-1958, resulted in the death of some one to four million people.

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

In fact, the Ebola virus reappeared in the Congo at different times during 2018-2020. Similar outbreaks as well as other contemporary health security challenges are anticipated in the future.

Mention should be made of the Zika virus infection that is spread by mosquitoes (which 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. Another grave humanitarian concern is the cholera epidemic that has occurred in war-torn Yemen where more than 100,000 cases have been recorded by World Health Organization (WHO) sources, a quarter of them children. This disease is caused by bacteria from water or food contaminated with feces.

Supplementing Mother Nature's biological threats are man-made intentions and capabilities to deploy a wide range of weapons against perceived or actual adversaries in the struggle for power within and among nations. From the dawn of history to modern times numerous theologians, philosophers, politicians, military strategists, scientists, academics, and other participants and observers of the world's security concerns have underscored the continued trends toward mass destruction capabilities.

In sum, to prevent a potential "Black Plague"- like disaster as well as man-made threats, 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 compulsions…" (Act 1, Scene 2).

Bill Gates similarly asserted 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."[1]

COVID-19 AND AN ACADEMIC CONTEXT

COVID-19 alarmed the world in 2019 and 2020 because similarities with the SARS (the acute respiratory syndrome) some 17 years ago, which killed almost 800 people. On March 11, 2020 the WHO declared the escalating biological threat a pandemic and two days later registered 8,710,703 COVID-19 cases, which had resulted in a total of 225,817 deaths. By the end of January 2021, the United States registered 24,438,723 COVID-19 cases resulting in a total of 406,147 deaths. During the same period the pandemic confirmed 46,832,000 cases with a total death toll of 2,075,000 worldwide.[2]

Many questions have arisen during the past year ranging from the exact origin of the pandemic in China, to whether the worst is yet to come, to what are the best response practices to prevent the next potential outbreaks.

In view of the expanding biological threats that pose continual and unprecedented security challenges to the United States and abroad, we organized a total of six Zoom conferences in 2020: "Combating Global COVID-19: From Isolation to International Cooperation" (March 26, 2020); "Combating

[1] Avi Selk, "Bill Gates: Bioterrorism Could Kill More Than A Nuclear War – But No One Is ready To Deal With It." The Washington Post. February 18, 2017.
[2] The statistical data is drawn from the John Hopkin's University global COVID-19 data, February 9, 2021.

Global COVID-19: A Preliminary Assessment of Past lessons and Future Outlook" (April 14, 2020); "Global COVID-19 and the Economy: Costs, Lessons, and Future Outlook" (May 20, 2020); "Global COVID-19 and Energy: Threats and Responses" (June 25, 2020); "COVID-19 and Sports: Threats and Responses" (July 30, 2020); and "A Lab of One's Own: Fighting Bioterrorism, Cholera, and COVID-19" (November 17, 2020). The videos of the six are accessible at the ILI website (www.ili.org).

Additionally, three publications drawn from the 2020 Events have already been released. The first is a Monograph on "Global COVID-19 and Sports: Exposure Claims and Liability Mitigation Considerations" published in September 2020.

The abbreviated version of the Monograph is incorporated in a slightly edited and updated, Report on "Global COVID-19 and Sports: Threats and Responses" published in October 2020. That report consists of contributions by invited interdisciplinary panelists including Distinguished University Professor Rita Colwell (University of Maryland College Park and Johns Hopkins University Bloomberg School of Public Health); Dr. Richard B. Reff, MD (Orthopedic Surgeon and Sports Medicine Specialist); Carl Francis (Director of Communication at the National Football League Players Association); Chalana Damron, Tom Gies, Kristof Roox (attorneys at Crowell & Moring); Ambassador (Ret.) Charles Ray (a former U.S. diplomat and military officer); and Ambassador Pjer Simunovic at the Embassy of Croatia.

The three publications are available to view at: http://ili.org/about/news/1243-iutcs-and-ili-host-ambassador-s-forum-global-covid-19-threats-and-responses.html.

The Report on "Combating Global COVID-19: From Isolation to International Cooperation" (November 2020) consists of contributions by invited interdisciplinary panelists at our Ambassador's Forum on "Combating Global COVID-19: From Isolation to International Cooperation" that was held on March 26, 2020 via Zoom conferencing and hosted by the International Law Institute (ILI) at the Inter-University Center for Terrorism Studies (IUCTS). Speakers at this Ambassador's Forum included Dr. Roberta DeBiasi (Chief of the Division of Pediatric Infectious Diseases at the Children's National Hospital); Dr. James Giordano (Professor in the Departments of Neurology and Biochemistry at Georgetown University Medical Center); Ambassador (Ret.) Charles Ray (Former U.S. Ambassador to Cambodia and Zimbabwe); Ford Rowan (Chairman of the National Bureau for Counter-Terrorism at the U.S. Department of State); Dr. Daniel Gerstein (Former Acting Undersecretary and Deputy Undersecretary for the Department of Homeland Security); Dr. Richard B. Reff, MD (Orthopedic Surgeon and Sports Medicine Specialist); and Dr. Tevi Troy (CEO of the American Health Policy Institute). This event is available at: https://www.ili.org/about/news/1094-ili-hosts-"combating-global-COVID-19-from-isolation-to-international-cooperation"-conference.html.

The current Report on "A Lab of One's Own: Fighting Bioterrorism, Cholera, and COVID-19" is a slightly edited transcript of the initial Zoom conference held on November 17, 2020. Featuring a conversation with our friend and Distinguished University Professor Rita Colwell in honor of her latest acclaimed book titled "A Lab of One's Own: One Woman's Personal Journey Through Sexism in Science," published by Simon and Schuster in August 2020. Her compelling and inspiring memoir/manifesto, written in collaboration with Sharon Bertsch McGrayne is indeed an exceptional contribution to global health and security concerns.

Participating in the November 17, 2020 discussion with Professor Rita Colwell are our two commentators, Dr. Norman Kahn (National Security Consultant) and Dr. Vinton G. Cerf (Vice-President and Chief Internet Evangelist at Google).

The full report is accessible at: http://ili.org/about/news/1251-iucts-host-prof-rita-colwell-a-lab-of-one%E2%80%99s-own-fighting-bioterrorism,-cholera,-and-covid-19.html .

ACKNOWLEDGEMENTS

At this time, we wish to express our deep appreciation to ILI members Robert Sargin, Gourgen Karapetyan and Emma Andrews for their guidance and support in producing this report and facilitating the six Zoom conferences on COVID-19 concerns.

Additionally, appreciation is extended to Mythili Kotagiri [Rutgers University graduate], and Kathryn Hamilton [the Catholic University of America graduate] who participated in the IUCTS Internship Program in 2020.

II. PRESENTATION: A LAB OF ONE'S OWN: FIGHTING BIOTERRORISM, CHOLERA, AND COVID-19

Distinguished University Professor Rita Colwell

Thank you for your kind introduction Yonah. I've chosen to focus on the anthrax letters, because it's a story that has not been told, and took place almost entirely in a classified environment. The anthrax bioterrorism incident has been reported by other authors, but the particular story in my book, "A Lab of One's Own", is unique and describes how men and women worked together, informally, to address a national threat. It begins with my connections to the US intelligence community, the 17 government intelligence organizations, including the CIA, in the late 1960s. I was an Associate Professor at Georgetown University at the time and elected president of several international biological organizations. Some of these organizations had held a few of their governance meetings in South Africa during the time of apartheid and others in Czechoslovakia before the fall of the Berlin Wall, as well as other interesting places around the world. I did a lot of my research in South America as well. I published many manuscripts about my research on cholera, which I had begun as a graduate student working on marine bacteria and had made the discovery that the causative agent of cholera is a marine bacterium native to the aquatic environment. My work on cholera, and the associated travels led me thinking about the potential of microorganisms causing pandemics, like cholera, as a weapon, a weapon of mass destruction. Biological weapons and biological attacks should be of interest to those agencies serving to protect our country.

In the late 1990s, I contacted John Phillips, a PhD chemist and Chief Technical Officer of the CIA, who later became Chief Scientist for the entire intelligence community. I asked John if there was a committee that addressed bioterrorism. And he said, no, there wasn't any, currently. And my next question was, shouldn't there be one? He agreed, but after that discussion months went by. Several of my colleagues and I began advocating for a database of human pathogens because at that time such information was rudimentary; it was pre-sequencing. We did not believe there was much activity at the CIA on the topic. However, in January, 2001, I received word from John Phillips, an excellent scientist and effective administrator, that he had obtained funding from Congress to begin a major research and development program for countering chemical and biological terrorism. John invited me to join the advisory board for the program. I accepted, but, from the first week of January, 2001, there was no further word for another nine months.

I had been appointed Director of the National Science Foundation by President Clinton in 1998. At 8:45 a.m. on the morning of September 11, 2001, I was in my office at the National Science Foundation in a meeting with two staffers from the White House, discussing the upcoming NSF budget to go before Congress, that is, the budget coming out of the White House to go to Congress. Suddenly, one of my staff knocked on the door and came into the room to say that a plane had just crashed into the World Trade Towers in New York. I turned on the TV in my office just as the second plane crashed into the World Trade Center. An hour later, we learned a third hijacked plane had crashed into the Pentagon, not far from the NSF office in Arlington, Virginia. And a fourth plane was over Pennsylvania, racing toward the White House. It was surreal. As a side comment, I wasn't able to make contact with the White House until 11:30 that morning, two hours after the crashes. I needed to inform my staff, then about 1,500 in number. At 9:00 a.m. I asked for access to the PA system for the building and learned the emergency PA system control was located in the basement of the building. And the keys to the PA control room were in the possession of the Arlington, Virginia, Fire Chief who was, by then, at the Pentagon. Thus my first action that day, was to order the locked door to be forcibly opened so I could inform my staff and give them permission to return to their homes if they wished to do so.

Three weeks later, on October 5, the committee on bioterrorism held its first meeting at CIA headquarters. The nation was now on high alert after the 9/11 attacks, and on October fifth, sixth and seventh we had a very intense workshop on chemical and biological terrorism. There was a press release from the White House shortly thereafter that brought terrifying news. A Florida man, Robert Stevens, had died from

inhalation anthrax, a very dangerous infection of the lungs that spreads very quickly throughout the body. He was the first US anthrax case since 1975 and, until 2001, only one of 18 cases in the 20th century. Every member of the biological threats committee at the CIA knew a great deal about *Bacillus anthracis*, referred to as "anthrax". And our first reaction, quite normally, was to conclude that this anthrax case was the work of a rogue nation since the anthrax death occurred right after the 9/11 incidents in New York and Washington. We figured the perpetrator was either a homegrown terrorist group or a crazy individual. Given the timing, so soon after 9/11, the committee, I, others on the committee, and many in the government, assumed it was the work of Al-Qaeda in a follow-up to the World Trade Center and Pentagon attacks. There was some logic to that hypothesis. When President Bush was briefed on Stevens' illness, it was assumed to have been part of a major biological weapons attack. Government health officials moved quickly to assure the nation that there was no need for concern. Secretary of Health and Human Services, Tommy Thompson repeated six times on national television: "the Stevens illness was an isolated case." He suggested Stevens might have become ill from drinking stream water during a hike in North Carolina. That misinformation was unfortunate because it made the government look uninformed and rather clueless.

I will not go into detail here about anthrax, except to say that it affects primarily large grazing animals, e.g. cattle, sheep, goats, pigs, elephants, and, in northern Canada, bison. This bacterium spends most of its existence in soil, usually in a dormant state, a sort of hibernation. When an animal grazes on grass growing in soil containing *Bacillus anthracis*, it can breathe the spores into its nose and become infected.

My being the first microbiologist to direct the National Science Foundation proved fortuitous. I had the unique opportunity to bring scientific expert expertise to respond to this terrorist attack. The NSF funds science and engineering research, but does not itself operate research laboratories. I quickly offered John Phillips and the intelligence community assistance from NSF to address the challenge of the anthrax attack. John and I were able to have the CIA assist in financing, publicly and with no strings attached, scientifically worthy projects that the NSF did not have sufficient funds to support but were of interest and could provide useful information for the CIA. Funds were transferred to NSF to support grants to enhance scientific capabilities of the country. One of the programs of interest had funded Larry Page and Sergey Brin a few years earlier, for example, and they went on to found Google as graduate students working on a search engine.

In 2001, I knew we needed to sequence the anthrax bacterium if we were to track the perpetrator. This was very early in DNA sequencing. Craig Venter had published the sequences of two bacterial genomes, *Mycoplasma genitalium* and *Haemophilus influenzae*. And his team was embarking on sequencing the very large genome of *Bacillus anthracis*. We learned early on in the anthrax investigation that the anthrax that had killed Stevens was a particular strain that had come from the U.S. This particular bacterium was a home grown strain.

After admission of Stephens to the hospital on October 2, by October 12, 10 days later, the situation had dramatically changed because the office of a U.S. Senator and an NBC news anchor received letters containing powder. One letter had a misspelled warning "This is next, Take penacilin now, Death to America, Death to Israel, Allah is great". Three days later, Senator Tom Daschle's secretary opened a letter containing powder but, alerted by the prior incident, she held the envelope at arm's length. That quick action saved her…and enough powder for testing. Subsequently more anthrax letters sent through the mail made it clear that we had a very dangerous situation. Late one evening I called Claire Frazier, who had taken over as President of The Institute for Genomic Research, TIGR the company Craig Venter had founded. I tried to be circumspect, if a proposal to sequence *Bacillus anthracis* was sent to NSF it would be received and reviewed very quickly, within two weeks, following an internal review. Apparently, Claire didn't quite get the point. But did after a series of anthrax letters appeared, Claire called and asked if there would be funding for sequencing of *B. anthracis*. After an accelerated review, NSF made funds available on October 26, 2001, and sequencing was begun with Claire Frazier and Timothy Reed at TIGR serving as principal investigators. By this time, it was determined that this was an Ames strain from the United States and not developed by Al-Qaeda, a homegrown strain. Microbiological research at Fort

Dietrich and other laboratories, notably by a very talented technician, Teresa Abshire, contributed significantly to this conclusion. Terry Abshire realized there were mutations in colonies that appeared on the growth medium she used to grow the Anthrax bacterium in her laboratory at Fort Detrick. Resulting from her work, sequencing proved critically important and vital to the government investigation.

On December 18, 2001, Ari Patrinos, an administrator in the Department of Energy, where the Human Genome Project had been launched, organized a meeting of agency administrators, which was held in Dr. Tony Fauci's office at NIH. Again, a few weeks passed after the meeting and my impatience led me to call Dr. Fauci. My argument to him was that it was critical to sequence the strains that used as a bio-weapon and to do so quickly. My background, as a microbiologist who had written a computer program, as part of my PhD thesis, to analyze and identify bacteria, made it clear to me that we really had to work fast to sequence the Bacillus anthracis strains before changes would occur during culturing in the laboratory. During the meeting that Ari Patrinos had helped organize in Dr. Fauci's office at NIH, a quick consensus was reached that the country needed a database of genetic information on pathogenic microorganisms.

As a side note, Ari was very pleased with the meeting. He often kept two sets of notes, one in English that snoopers might read over his shoulder and the other a transcript in his native Greek… for his eyes only. After the meeting, Patrinos wrote in Greek that he was very happy with the outcome of the meeting.

It was after that December 18, 2001 meeting that I called Tony and said, look, I am ready to run this committee. He said, fine. Tony delegated Maria Giovanni, a genome scientist and his deputy as his representative to the committee. Jack Marburger, Science Advisor to President Bush, assigned Rachel Levinson as the OSTP and White House liason. I realized very quickly this could not be the usual governmental committee. If officially appointed, the committee would have a presidential directive, i.e., formal organization and responsibility. But if an official committee, it would be subject to FOIA, the Freedom of Information Act, and the FBI or CIA could not participate because they would be in the process of conducting a criminal investigation. Minutes of the committee meetings would have to be made public. Thus, at the first meeting early in 2002, we agreed we would keep no minutes, no public hearings, and would work voluntarily without official appointment.

The committee met every week, for three years, on Friday afternoons in a room in a building adjoining the NSF headquarters, where there was a room for conducting classified work. Every Friday afternoon at one o'clock we met in that room for one hour. We always stayed on schedule since representatives from the FBI laboratory in Virginia would have to deal with busy traffic if the meeting ran over. We decided the committee was a research team and declared it the National Interagency Genome Sciences Coordinating Committee (NIGSCC). With representatives from every agency, e.g., NIH, DOD, EPA, USDA, NSF, FBI, CIA, etc…with a total of 17 government agencies represented. The first priority was anthrax.

At the meetings we planned and organized funding for building a library of sequences of all dangerous pathogens, notably those that could be used as a threat by a bioterrorist. The list comprised category A, those pathogens of severe danger, e.g. anthrax, smallpox, etc. Category B, those that could create serious damage to public health, e.g. Salmonella and Shigella spp., and category C, pathogens, including animal and plant pathogens that could cause serious economic damage. I won't provide all the details here but do so in my book that was published in August, 2020.

This team of experts worked collaboratively and included experts. Bruce Buddole, the FBI's DNA scientist who did the most to modernize the FBI forensics laboratory. Bruce took time from identifying victims of 9/11 to help in this study. We all worked together over the next five years determining the sequence of *Bacillis anthracis* strains and building a national database. This collaborative effort assisted the FBI in identifying the source of Anthrax used as a weapon in the 2001 Anthrax attack in the United States. It took more than five years to accomplish the task but it was successfully completed and the source of the anthrax was determined.

III. INTERVIEW: DR. NORMAN KAHN AND PROFESSOR RITA COLWELL

KAHN: Yonah, thank you very much. I am absolutely honored to participate in this celebration of the publishing of Rita's sterling memoir. During the course of my career I had the pleasure of working with Rita on numerous occasions and I learned much and I benefited greatly from her experience and expertise. So Rita, I'd like to follow up on the comments that you just gave by posing a few questions to you on the intersection of bioscience and national security. And I'd like to start off with a two-part question. What are your thoughts regarding the national security implications regarding the recent advances in genetic engineering, such as CRISPR, specifically what threats can you foresee in terms of misuse by states and also by malicious groups or individuals? And then part-two: what do you think we might do to mitigate the threat?

COLWELL: A good question because there is much concern about bioengineered organisms. But Mother Nature does a much better job in producing bio-threats. To the second part of your question, there is not a lot we can do to mitigate the threat, but we need to look for anomalous activities, especially insider threats. It is important, for example, to be aware in a large pharmaceutical company of behavior of an individual that might suggest such activity. The loner who may be a potential bioterrorist is not easy to identify. However, the possibility that an individual can work on his or her own to genetically engineer a bioterrorist weapon is slim. Consider the work involved in CRISPR engineering, for example. CRISPER is a tool used to engineer an organism and requires both sophisticated scientific knowledge and laboratory apparatus. However, it is not difficult to grow anthrax for someone with rudimentary knowledge and equipment. Thus, it wouldn't likely be a bioengineered organism that is used as a weapon but rather a culture prepared by someone with ability to prepare a culture of bacteria in a kitchen. Thus it would be wise to look for anomalous situations, anomalous purchases of supplies of a suspicious nature.

KAHN: Generally speaking I think your comment that there's a fair amount of sophistication required to do genetic engineering whether it's CRISPR or otherwise, is an excellent point. My concern would be an individual like a Bruce Ivins, someone who actually has the appropriate skill set to do relatively sophisticated work. I look at the intersection of intent and capability: if your intention is really bad but your capability is really low, nothing serious is likely to happen which I think is your point. My concern is someone on the high end; imagine a competent virologist who for whatever reason goes off the reservation and at that point you have a problem.

COLWELL: I agree, the key would be anomalous behavior.

KAHN: As a follow up on that before I get to my next question, in terms of minimizing or mitigating this kind of threat, where do you place the importance of ethical training of scientists?

COLWELL: That is absolutely key, and I am pleased that several scientific organizations, including the National Academy of Science, the national Sigma Xi honorary society, and many physical science and engineering societies have developed codes of ethical conduct and proposed statements on being a scientist, what is expected, and what actions and activities are unethical. Ethical training is critical, especially for young scientists entering their careers.

KAHN: I couldn't agree more. Next question: addresses the potential of behavioral modification through biochemistry. What are your thoughts on the risk that such modification may pose in terms of societal influence or disruptions? Is that something that ought to be a concern?

COLWELL: That is what I would call the greatest danger of the 21st century, because we now know from studies of the microbiome, that there is an amazing influence of microorganisms in the gut and their metabolism on the brain. In fact, some now consider the gut microbiome to be another organ of the human body. Some compounds produced in the gut include those that influence whether your mood will be good or bad, whether you will feel ill, anxious, etc. Someone could produce an array of chemicals to

modify the behavior of an individual or a crowd. I know that sounds a bit pseudoscientific, but it is not out of the realm of possibility. Mood control and understanding potential applications of social behavioral science are critical. We have underinvested in research in the social behavior and economic sciences. We need to understand human behavior, not to control, but to understand and provide wellness for individuals and populations.

KAHN: Rita I've got one more question for you if I may. This is a much broader question and it brings into play the whole idea of the bio-economy as it relates to national security. And what I'm thinking about here is the reality that a strong national security posture is predicated among other things on a strong economy. So how do you think we stack up to our competitors when it comes to the development of our bio-economy and the investments we're making?

COLWELL: I believe strongly that we must understand and learn from the effects of significant disparities between rich and developing nations. There is a wide chasm between the ultra-rich and the ultra-poor. This chasm creates dissonance in society and needs to be addressed and fixed. Both a strong economy and technical capability are vital for our nation. My book discusses sexism and misogyny and makes the case that you don't fight a war with half an army. You do not deal with technological competition with half the brains of the country. The Y-chromosome does not carry genes that code for intelligence. It is critical to mobilize the entire workforce regardless of sex or gender or race. All the brains are needed. We have to overcome inhibitions to bringing women and the underrepresented into the bio-economy… and the economy in general. It is critical that we do that.

IV. INTERVIEW: DR. VINTON G. CERF AND PROFESSOR RITA COLWELL

CERF: Yes I'd be happy to and I thank you very much for the opportunity to do so. Rita, as always it is a pleasure to have anytime with you, no matter what the circumstances. I had a lovely time reading your book, but I have to admit that first of all I had not understood that there was an angry Colwell hiding behind the facade that I got to know. Wow, talk about powerful energy. But more importantly, I think the compelling stories that you told about your experiences as a woman and others who have experienced this is terrible, I mean it's worse than bias, it's just totally unfair treatment and wrong treatment, is very compelling, and I'm glad that you felt comfortable sharing some of those painful stories with the rest of us to simply reinforce the importance of correcting them.

I did have a couple of questions though, particularly with regard to the cabal that you set up in the Friday afternoons. First of all I absolutely agree with the tactic that doing something informal was actually important. There's a parallel example of this in my world, there's something called the [?] worm. It's essentially a piece of malware and it popped up quite some time ago and a very informal group got together to figure out what it is and what it can do and maybe even where it came from, and the group was deliberately set up to involve government people and private sector and so on with absolute no formality whatsoever because we all assumed that as soon as you introduce requirements for participation and everything bureaucracy would suddenly set in so informality turned out to be incredibly important to draw hackers into the story and people from outside the US and so on. So I think your intuition was exactly right there. Do I remember correctly that Josh Lederberg might have been part of that discussion, because I remember that he was very worried about the abuse of biotechnology in a variety of different ways?

COLWELL: Josh Lederberg was not a member of the group but several of his colleagues who had worked with him were on the team. This was a government agency group, hence representatives from government agencies. What we did was that we pooled our funds. At the first few meetings I used a chart on which I wrote "Anthrax", and asked, "which agency can fund sequencing it?' Those whose agencies had funds to do that then volunteered. For example, Dr. Maria Giovanni indicated that NIH would assist.

Each agency represented at the meeting, including Department of Homeland Security and the NSF provided funding. That is how we pooled our funding. The agency representatives were those who had funds and budgetary control.

CERF: Now this is not unlike the small consortium of NSF, Department of Energy, NASA, and DARPA, who pooled their resources in order to enhance the growth of the internet, which of course NSF had a great deal to do with.

COLWELL: Exactly so.

CERF: So the reason I mentioned Josh though is that I remember having a conversation with him about a genetic model that he speculated which was to somehow infect people in such a way that their body would generate narcotics and leave them in a state of utter euphoria, and of course if you can do that through the military you might easily overcome any kind of opposition because the opposition would be too busy off in lala land. And I remember thinking how terrifying it was to imagine that might even be feasible. Is it, in fact, possible to do that?

COLWELL: I think it will eventually be possible and that actually was part of the question Norman Khan asked: is it possible to behaviorally modify? And the microbiome represents one mechanism by which it could be done. That there are compounds produced by bacteria in the gut that pass the blood-brain barrier is already known. And some can influence the sense of wellbeing by acting on cells in the brain. We need to be aware of this potential and understand that, for example, breakfast yogurt may contain a certain Lactobacillus species that may have been engineered to induce production of endorphins.

CERF: Wow, so I could just imagine cereals containing endorphins and peyote or something which we've already discovered do these interesting things and we know now or presumably centuries or thousands of years. Wow, well this is all very scary. Well let me come back actually not to the national security topic but one that you spent a substantial amount of time on in the book. Are you seeing significant shifting now in this gender bias space or are we still, the statistics still do not look very attractive, although in the bio space it looks like there are more women being involved and successful than in computer science and engineering.

COLWELL: Computer science and engineering have improved a bit as has physics. Engineering has about 17% of the population represented by women which is insufficient. We're losing a lot of talent. It has changed since I was an undergraduate and on my way to medical school but met a handsome graduate student spring semester of my senior year. Jack and I were married two months later. We decided it would be better for him not to lose a year of graduate study so we decided to do M.S. degrees at Purdue together and then move on to do PhD and/or MD. I went to my department chairman and asked for a graduate fellowship. His response was "we don't waste fellowships on women." Very upset at this response, I went to my undergraduate advisor who knew I was a good student and his reaction was "well, their loss is our gain." He had a research assistantship available whose duties were to maintain the fruit fly genetic stocks. That's how I earned an M.S. degree in genetics.

I don't think any department chair would be as blatant today. They might say "we don't have a fellowship available", but they wouldn't be so crude. I classify the setbacks and the disparagements as ranging from the criminal to the clueless. The criminal you can recognize, e.g. a physical attack, resolution of which belongs in the courts and/or with police. Clueless are the actions that wear individuals down. It is when one is ignored after offering a path of action or suggestion at a meeting. Too often, it is received with momentary silence and then a male makes the very same suggestion. The response is "what a wonderful idea." These clueless insults can be depressing. That kind of activity hasn't gone away. What I recommend to women is "Get yourself a posse, a group of friends, and meet regularly… talk about these experiences. Experiences you thought were your own are shared by almost all women." A good example is that of Dr. Nancy Hopkins at MIT thirty years ago in a now famous study where she walked around her

building and measured laboratories. Male faculty were assigned almost twice as much space for research as the women faculty.

CERF: Didn't Charlie Vest respond fairly well to that? Am I remembering that correctly?

COLWELL: Chuck Vest was super. He said that he felt, I'm paraphrasing, that there was substance to the complaints but he didn't realize how much and how significant. Nancy Hopkins and the fifteen other women faculty at MIT met with Chuck Vest. Dr. Vest responded by making significant changes.

CERF: So get your data together and form a posse.

COLWELL: That's one way to win the battle.

V. PANEL DISCUSSION AND AUDIENCE QUESTIONS: PROFESSOR RITA COLWELL, DR. NORMAN KAHN, AND DR. VINTON G. CERF

Q. Were there any anomalous behaviors of the suspect observed in the anthrax case?

A. COLWELL: There were many anomalous behaviors, but they didn't reach the point of recognition. Things have changed. I was asked by the federal government to testify when the widow of Robert Stevens filed a suit. I read the psychiatry report and Bruce Ivins did some things that were not normal. He had a strange obsession with the Kappa Kappa Gamma sorority. His behavior is described in books about the anthrax attack. Before committing suicide, he had been required to see a psychiatrist to whom he stated a threat to "take out his enemies". It is fortunate there was no shooting incident and it is tragic that he committed suicide. There had been a few odd behaviors, but were ascribed to a scientist spending all his time on his work. Today such behavior as Norm and I referred to as "abnormal" merit reporting to authorities. We are more proactive today than twenty years ago.

Q. Any thoughts about the ongoing question on the origins of COVID-19? Natural or Lab – Grown? To follow up what are the dangers of similar viruses being used as bio-weapons by terrorists or state actors?

What agencies in the U.S. government are tasked with tracking and assessing that threat?

A. COLWELL: We have learned a great deal about SARS-CoV-2, the causative agent of COVID-19 in a relatively short time, literally within months. The first virus sequence was provided by the Chinese government in January, 2020 and today hundreds of corona-virus sequences and their variants are available. There is no evidence of genetic engineering of the virus. Interestingly, the greatest genetic engineer of all, Mother Nature, has produced variants and mutations, including mutants of the protein spikes. One such variant is more transmissible. The likelihood of the virus having been engineered and released, either inadvertently or intentionally, is slim. Norm and I agree that for a rogue or a loner to engineer and release this virus is highly unlikely. The highly trained insider demonstrating anomalous behavior is the greatest concern. There is a need for vigilance by those who work with highly pathogenic microorganisms in monitoring behavioral problems, such as excessive debt or abnormal or threatening behavior.

The evidence is strong that bats carry a variety of corona-viruses. It is most likely that the most effective engineer, Mother Nature, will have another surprise for us, perhaps COVID-20 or COVID-21. We are moving into previously unexplored geographical areas of the planet where humans have not lived before, exposing ourselves to new pathogens. We are destroying biodiversity that comprises the chain of

connections that keeps us healthy as humans. Loss of biodiversity is a threat to our communal health. All life on the planet is a highly interconnected system. We should worry when we lose a species because there is connection between it and other levels in the web of life. We must pay serious attention to climate change and what it is happening to biodiversity. Warming of the oceans leads to loss of protective species as well as declining food stocks. I assume the national intelligence agencies continue to monitor these threats. In conclusion, we do need to pay attention to potential release of bio-threat agents and must maintain vigilance.

Q. You mentioned COVID-20 or COVID-21 and what's next, could the prediction model that you tried to chart in regard to the cholera work somehow be applied to the next COVID threat?

A. COLWELL: We have successfully adapted the model developed for predicting cholera. It is used in a collaboration with the British Aid Agency and UNICEF to provide a four-week prediction of risk of cholera in Yemen. We show where risk of cholera is highest. This allows location of medical supplies, physicians, and safe water in areas where most needed. Cholera outbreaks were reduced significantly in that ravaged country under strife with civil war. Satellite sensors are used to provide data for the model. With modification of the cholera risk model, we can now provide prediction for counties in the U.S. of the risk of COVID-19. It would be interesting to predict what threat agent with the pattern of occurrence as COVID-19 might emerge in a year or two in the future. That would be an interesting exercise.

Q. You mentioned you also worked with UNICEF, could you elaborate on that?

A. COLWELL: My first predictive model for cholera was developed twenty years ago. I had determined the host relationship of the cholera bacterium to zooplankton, namely copepods, and the zooplankton-phytoplankton interactions with respect to vibrios. Launch of the LandSat satellite provided data on chlorophyll, sea-surface temperature, and sea-surface height. That was twenty years ago and allowed us to correlate cases of cholera in Bangladesh with those parameters measured by satellite in the water just off the coast, in the Bay of Bengal. We perfected the model to the point where we were able to do retrospective analysis of the cholera outbreaks in Haiti, notably the most recent when Hurricane Matthew passed by Haiti. The model worked so well that we extended the analyses to include retrospective analysis of the 2017 cholera epidemic in Yemen. The results were published in late 2017in a scientific journal, of which Scientific American published a brief summary of the Yemen work. A colleague in England read the Scientific American article and phoned us in January, 2018, to ask if we could collaborate by providing a risk map for Yemen. We now provide a monthly predictive map of cholera risk to the British aid agency and UNICEF. The work is funded by DFID (UK) and NASA (US). Working collaboratively, we are able to provide cholera risk alerts that allow the aid agencies to position medical personnel and supplies in high risk areas. This collaboration continues. The latest risk map is prepared each month by the collaborative team headed by Dr. Antar Jutla, Associate Professor in the School of Engineering, University of Florida.

Q. Do you see more collaboration and cooperation in science and technology around the world?

A. COLWELL: Public health issues and challenges are global and public health, by its nature, is international and interdisciplinary. One extension of the cholera prediction by satellite sensing is that we now can monitor COVID-19 risk using a modification of the cholera risk model and, simultaneously, use molecular genetics and bioinformatics to monitor wastewater and sewage for SARS-CoV-2 virus. This dual approach provides a very powerful public health tool.

Q. What would the panel identify as the top three bio-terrorist threats today and in the near future?

A. COLWELL: There is always a bio-threat with a pathogen as the weapon. Science has become much more sophisticated and behavior modification is a serious potential threat. It is a genuine threat to national security, social stability, and the nation's economic strength. A second major threat is the disparity in the world economy between the haves and have-nots. That is a very serious threat to national security for the United States.

A. KAHN: I echo your thoughts Rita. It is very difficult to have a top three or a top ten. I will get back to something I mentioned earlier; in terms of the impact such an event would have you look at the balance between intent and capability. And so, if someone has very high capability, they could do very bad things. If someone does not have that capability, if they don't have the training or understanding of tacit knowledge, they may have terrible intent but won't be able to pull it off. I think there's this huge range of possibilities and I can't think of how I would begin to rank them other than just by intent and capability. And again, echoing your comment Rita, the idea of behavior modification which gets away from the traditional pathogen-based threat. I think it's very important to understand that biothreats are not necessarily directly pathogen-based.

A. CERF: I'm just thinking a little bit about the problem of detection. I'll stick on the pathogen side for just a moment even though Norm's point about modification is pretty scary. But one thing is we might have been able to detect the presence of this particular COVID-19 disease if we had been analyzing water samples, for example, in sewage processing systems. So it does suggest to me introducing analytical capability, especially in our metropolitan area, might actually be the useful and cost effective thing to do.

A. COLWELL: I agree with that point very strongly.

Q. This has to do with global warming and side-effects of the thawing of permafrost and the release of methane, but also possibly of ancient pathogens that we have not been exposed to for a long time: How serious is that problem?

A. COLWELL: Global warming is a very serious threat to our national security and exposure to pandemic agents of historical times is very possible. The 1918 influenza virus has been recovered from bodies exposed by melting of the ice in Polar Regions. The virus was reconstituted by sequencing and identified. A very serious concern is a pathogen like smallpox. Only those of us in our seventies and eighties have residual immunity. However, the entire global population would be at risk to smallpox. That's a nightmare in public health terms.

A. CERF: You know, I wonder whether a consequence of that logic suggests eliminating toxins or pathogens like that is actually potentially hazardous as opposed to having a more general built up resistance to it.

A. COLWELL: It is a hazard and there should be a stockpile of the vaccine.

A. KAHN: I concur. If you eliminate something you do need to keep the capability of dealing with it, should it resurface.

A. CERF: What would that imply in terms of stockpile because the most recent reports of the vaccine for COVID-19 is that they need to be kept in -80 degrees and that's a fairly intensive and expensive proposition. I wonder if there's anything to be done to find vaccines that are storable at room temperature.

A. COLWELL: It is possible for smallpox, because the vaccine is prepared by traditional methods, essentially a killed or weakened virus and easily started.

A. KAHN: The Moderna vaccine is less constrained in terms of temperature than the Pfizer vaccine. But also, I think what we're seeing now, these are just first-generation vaccines. To your point Rita, I would expect follow-on vaccines to be more amenable to less rigorous constraints in terms of storage.

A. COLWELL: The second vaccine has been reported to be approximately 95% effective and does not have a severe cold storage requirement.

A. CERF: That's good to know. Some people are suggesting small molecule treatment in order to interfere with the reproduction or ACE2 connectivity, but I wonder what is the implication of trying to use that kind of a small molecule treatment. It doesn't reproduce itself unlike the antibody effects of normal vaccines. So, does that just imply lots and lots of shots over a period of time in order to maintain a level of small molecule defense against the virus?

A. COLWELL: I suspect that it will prove to be similar to the influenza virus, requiring a booster vaccination. There is an effort underway to produce a multivalent influenza vaccine. The new first-generation type vaccines involve mRNA molecules, will it have surprises? We don't yet know all the potential side effects. We need to proceed carefully with the newest technology.

A. KAHN: The one thing we know about biology is whenever you think you've got something figured out there's always something else that pops up and you realize you didn't quite get it the way you though you did.

A. CERF: Norm, this is Theorem #206 which reads "Everything is more complicated!".

Q. What is the intersection between the internet and bioterrorism? Thinking about behavior modification or bad actors sharing information on how to produce and distribute pathogens and toxins?

A. COLWELL: Colwell: Behavior modification is a fascinating topic. For example, inducing production of endorphins, not by injection but by transmitting microorganisms via food or drink to produce compounds that effect certain behavior, behavior modification without injection.

A. CERF: Since the internet is being mentioned here, I feel compelled to at least say something. I will tell you that a lot of people will say, "Look what I found on the internet this is horrible!" and then I will have to say, "By the way have you been to your public library recently?". It's very hard to hide knowledge once it's been discovered. I don't mean to make fun of the point, which is that there are hazards associated with learning how to do x, y, and z, but I'm not sure that trying to suppress information is the successful advance. I think we just have to do a better job of indications, warnings, intelligence gathering, and good old-fashioned law enforcement.

A. COLWELL: When the anthrax bacterium was first sequenced, my initial reaction was that we should hold the information, at least for a while. Interestingly, John Phillips and Norm Kahn responded that the information must be released immediately because the bad guys will get it anyway and we must make sure the good guys have immediate access to the information. That was a powerful and convincing argument for me.

VI. ABOUT THE EDITORS

PROFESSOR YONAH ALEXANDER is the Director of the Inter-University Center for Terrorism Studies (at the Potomac Institute for Policy Studies) and the Inter-University for Legal Studies (at the International Law Institute). He is a former Professor and Director of Terrorism Studies at the State University of New York and George Washington University. Professor Alexander also held academic appointments elsewhere such as American, Catholic, Chicago, Columbia, and Georgetown's Center for Strategic and International Studies (CSIS). He has published over 100 books and founded five international journals. His personal collections are housed at the Hoover Institution Library and Archives at Stanford University.

PROFESSOR DON WALLACE, JR., Yale University, BA, Harvard University LLB, is a Professor of Law at Georgetown University as well as Chairman of the International Law Institute. He is the U.S. delegate to UNCITRAL, vice-president of the UNIDROIT Foundation, a member of the American Law Institute, and the former Chairman of the International Law Section at the American bar Association. He is also the author and co-author of several books and articles.

VII. ABOUT THE CONTRIBUTORS

DISTINGUISHED UNIVERSITY PROFESSOR RITA COLWELL is a pioneering microbiologist and the first woman to lead the National Science Foundation. She is a Distinguished University Professor at both the University of Maryland and Johns Hopkins University's Bloomberg School of Public Health and has received awards from the Emperor of Japan, the King of Sweden, the Prime Minister of Singapore, and the President of the United States. Her interests are focused on global infectious diseases, water, issues, including safe drinking water for both the developed and developing world. She is a nationally recognized scientists and educator, and has authored or co-authored 16 books and more than 700 scientific publications. She produced the award-winning film, Invisible Seas, and has served on editorial boards of numerous scientific journals. She is the author of the highly acclaimed book A Lab of One's Own (Simon & Schuster).

DR. VINTON G. CERF is Vice-President and Chief Internet Evangelist for Google. He has held positions at MCI, the Corporation for National Research Initiatives, Stanford University, UCLA and IBM. Dr. Cerf served as chairman of the board of the Internet Corporation for Assigned Names and Numbers (ICANN) and was founding president of the Internet Society. He served on the US National Science Board from 2013-2018. Widely known as one of the "Fathers of the Internet," he received the U.S. National Medal of Technology in 1997, the Marconi Fellowship in 1998 and the ACM Alan M. Turing award in 2004. In November 2005, he was awarded the Presidential Medal of Freedom, in April 2008 the Japan Prize and in March 2013, the Queen Elizabeth II Prize for Engineering. Dr. Cerf is a Fellow of the IEEE, ACM, and AAAS, the American Academy of Arts and Sciences, the American Philosophical Society, the Computer History Museum and the National Academies of Engineering and Science. He holds a BS in Mathematics from Stanford University and MS and Ph.D. degrees in Computer Science from UCLA and holds 29 honorary degrees from universities around the world.

DR. NORMAN KAHN is the Principal and President of Counter-Bio LLC, providing consulting services on national security issues with particular emphasis on weapons of mass destruction and biological weapons. His career at the Central Intelligence Agency spanned over 31 years, including multiple assignments in the Directorate of Intelligence (currently, the Directorate of Analysis) and Directorate of Science and Technology. In his last assignment he created and directed the Intelligence Community's Counter-Biological Weapons Program. In that capacity, he changed the focus of the Intelligence Community's (IC) resource allocation directed against the biological weapons threat and greatly expanded the scope of bio-weapons collection and analysis across both the IC and the broader U. S. government. Dr. Kahn holds a bachelor's degree in Biology from the City College of New York and a Ph.D. in Oceanography from the University of Rhode Island.