# A SPECIAL FORUM:

# COVID-19 AND THE ROLE OF TECHNOLOGY

DECEMBER 2021


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## NOTICES

In an era of expanding biological threats, caused by mother-nature and man-made, it is critical to understand the role of technology as a driver of historical evolution. What are the preliminary lessons of the Covid-19 experience and the anticipated road ahead for future generations?

This timely forum focuses on selected successful and disruptive technologies including bio-detection, respiratory epidemiology, vaccinations, AI, cyber defense, as well as other health and security related concerns nationally and globally. Inter-disciplinary experts shared their academic and professional insights on these topics and offer recommendations on "best practices and strategies" for disaster risk reduction.

Video of the full conference may be found here: https://www.youtube.com/watch?v=byUdTxs1gUg

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**"COVID-19 AND THE ROLE OF TECHNOLOGY"**



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## COVID-19 AND THE ROLE OF TECHNOLOGY

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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 challenges have come 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. In this era of expanding multi security challenges at home and abroad, it is critical to understand the role of technology as a major driver in world evolutionary events.

In this context, the current report focuses specifically on "COVID-19 and the Role of Technology" (December 2021) and its experienced lessons anticipating future health and security related challenges nationally and globally. This timely Forum reviews selected successful and new technologies, such as bio-detection, respiratory epidemiology, vaccinations, artificial intelligence, cyber defense, as well as other relevant topics. Contributions and insights were provided by an invited interdisciplinary panel of academics and practitioners who participated at a special virtual Forum held on June 29, 2021 and administered at the Potomac Institute for Policy Studies.

The program of this event began with opening remarks by Dr. Jennifer Buss (CEO, Potomac Institute for Policy Studies). The virtual Forum was moderated by Professor Yonah Alexander (Director of the International Center for Terrorism Studies and Senior Fellow at the Potomac Institute for Policy Studies). Presentations and discussion were offered by Distinguished Professor Rita Colwell (University of Maryland, College Park; Johns Hopkins University, Bloomberg School of Public Health); Dr. Daniel Gerstein (Former Acting Undersecretary and Deputy Undersecretary for the Department of Homeland Security); Dr. Donald Milton (Professor of Environmental Health at the University of Maryland School of Public Health, with a secondary appointment in the Department of Medicine, School of Medicine); Dr. Costis Toregas (Director, Cyber Security and Privacy Research Institute at The George Washington University); Dr. Neil Wasserman (Department of Computer Science The George Washington University); Dr. Eric L. Moore (Director, U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC)); Dr. Natividad Carpintero-Santamaria (Professor at the Polytechnic University of Madrid (UPM) and General Secretary of the Instito de Fusion Nuclear "Guillermo Velarde"); and Amb. (Ret.) Charles Ray (Former US Ambassador to Cambodia and Zimbabwe). Closing remarks were delivered by Professor Yonah Alexander.

The preface of this report includes an overview of Mother-Nature's and man-made threats as well as an academic context for our study.

### 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 include Anthrax.

Biological threats are difficult to control as they require a delivery system, or "vector," that can make distribution difficult and dangerous to their perpetrators, It seems likely that if terrorists were to use a biological weapon, they would probably choose a bacteriological rather than a viral 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, which 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. In addition, 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]

More recently, Avril Haines, Director of National Intelligence, stated inter alia in her opening remarks of the "Annual Threat Assessment" released on April 14, 2021 that: "The effects of the current pandemic will obviously continue to strain governments and societies over the coming year, fueling humanitarian and economic crises, political unrest, and geopolitical competition as countries, such as China and Russia, seek advantage through "vaccine diplomacy" to build influence and in some cases demand accessions from other governments. Countries with high debts or that depend on oil exports, tourism, or remittances face particularly challenging recoveries, while others will turn inward or be distracted by other challenges. The critical impact of the pandemic has also served to highlight the importance of public health to national security."[2]

## AN ACADEMIC CONTEXT

The national, regional, and global spectrum of biological challenges is limitless. As we have noted, the first critical threat is caused by Mother Nature's infectious diseases. The second concern is man-made violence deployed by individuals, groups, and nation states.

More specifically, COVID-19 alarmed the world in 2019 and 2020 because of similarities with the SARS (the respiratory syndrome) some 18 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 December 09, 2021, the United States registered 49,547,748 COVID-19 cases resulting in a total of 793,302 deaths. During the same period, the pandemic confirmed 268,089,819 cases with a total death toll of 5,283,708 worldwide.[3]

Many questions have arisen during the pandemic ranging from the exact origin 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 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 Forums are accessible on the following websites: www.ili.org and https://www.potomacinstitute.org/ .

Additionally, four printed publications drawn from the 2020 Events have already been released: Monograph on "Global COVID-19 and Sports: Exposure Claims and Liability Mitigation Considerations" (September 2020)[4]; "Global COVID-19 and Sports: Threats and Responses" (October 2020)[5]; "Combating Global COVID-19: From Isolation to International Cooperation" (November 2020)[6]; and "A Lab of One's Own: Fighting Bioterrorism, Cholera, and COVID-19" (December 2020).[7]

Nine Zoom conferences were held thus far in 2021: "Combating Terrorism Amid COVID-19: Review Of 2020 And Outlook For 2021 And Beyond" (February 25, 2021)[8]; "Combating Biological Threats: A Legal Agenda For Future National And Global Strategies" (March 31, 2021)[9]; "COVID-19 and the Role of Communication" (April 29, 2021)[10]; "COVID-19 and the Role of Human Rights" (May 26, 2021)[11]; "COVID-19 and the Role of Technology" (June 29, 2021)[12]; "War or Peace in the Middle East: Quo Vadis?" (July 22, 2021)[13]; "COVID-19 and the Role of the Military" (August 23, 2021)[14]; "Post 9/11: Twenty Years of Multilateral Counter-Terrorism Cooperation" (September 09, 2021)[15]; and "Combating Domestic and International Terrorism: The Role of Intelligence" (November 18, 2021).[16]

Four reports have been released in 2021: "Combating Terrorism Amid COVID-19: Review of 2020 and Future Outlook" (June 2021)[17]; "Combating Biological Threats: A Legal Agenda For Future National And Global Strategies" (August 2021)[18]; "Post 9/11: Twenty Years of Multilateral Counter-Terrorism Cooperation" (October 2021)[19]; and "COVID-19 and the Role of the Military" (November 2021).[20]


## ACKNOWLEDGEMENTS:

Professor Alexander wishes to express his deep appreciation for the decades-long academic and professional partnerships with the Potomac Institute for Policy Studies (PIPS) and the International Law Institute (ILI). He is most grateful to PIPS's Dr. Jennifer Buss (CEO), General Al Gray (USMC (Ret.), Chairman of the Board), and Gail Clifford (VP for Financial Management & CFO) for their inspiration and support. Likewise, he values the guidance and assistance of the ILI's Professor Don Wallace, Jr. (Chairman), and Robert Sargin (Executive Director). Additionally, special thanks are due to both Professor John Norton Moore and Professor Robert Turner, (Center for National Security Law, University of Virginia) for their continued contributions to our multiple educational programs over the years.

Finally, the internship program of the International University Center for Terrorism Studies (IUCTS), that is coordinated by Kevin Harrington, has provided research and administrative support for this publication. The IUCTS interns include: Victoria Airapetian (University of Maryland, College Park graduate), Sydney Betancourt (Stetson University, graduate), Sarah Butcher (Texas Tech University undergraduate), Matthew Dahan (the American University), Daan de Zwart (the University of Amsterdam graduate), Caleb Dixon (University of California, Berkeley), Emma Goldsby (University of Kentucky), Kaley Henyon (Mercyhurst University undergraduate), Stephen Mathews (Pennsylvania State University undergraduate), Matthew Phenenger (Ohio Wesleyan University graduate), Avgustina Peycheva (Moscow State Institute of International Relations, PhD), Rebecca Roth (Princeton University undergraduate), Maxim Ryabinin (Syracuse University), and Virag Turcsan (Erasmus Mundus Joint International Master's degree).


**END NOTES:**

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 Avril Haines, "2021 Annual Threat Assessment of the U.S. Intelligence Community" Office of the Director of National Intelligence. April 13,2021.

3 The statistical data is drawn from John Hopkin's University global COVID-19 data, December 09, 2021.

4 https://www.ili.org/images/stories/documents/ICTS-SPORTSCOVID-MONOGRAPH%202020.pdf

5 http://ili.org/about/news/1243-iutcs-and-ili-host- ambassador-s-forum-global-COVID- 19-threats-and-responses.html

6 https://potomacinstitute.org/images/ICTS/ICUTS_COVID%20Isolation%20and%20Cooperation%20Report.pdf

7 https://potomacinstitute.org/images/ICTS/IUCTS_LabofOnesOwn_RitaColwell_2020_F.pdf

8 https://www.ili.org/about/news/1269-ili-hosts-combating-terrorism-amid-COVID-19.html

9 https://ili.org/about/news/1275-combating-biological-threats.html

10 https://www.youtube.com/watch?v=JDXgaPGM0Ls&t=4191s

11 https://www.dropbox.com/s/q9smt725d4fcial/cv19hr-05-26-2021.mp4?dl=0

12 https://www.dropbox.com/s/v2fpbz13ndlhr8j/COVID19andtechnology7_14%20-%20SD%20480p.mp4?dl=0

13 https://www.dropbox.com/s/lr8ptivii3l1hkv/IUCTS-July-22-2021.mp4?dl=0

14 https://www.youtube.com/watch?v=VEXYIo0GwAk

15 https://ili.org/about/news/1358-iucts-hosts-post-9-11-twenty-years-of-multilateral-counter-terrorism-cooperation.html

16 https://www.dropbox.com/s/gbqh16baf1q8vvo/Nov-18-2021-the-role-of-intelligence.mp4?dl=0

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20 https://www.ili.org/about/news/1359-iucts-hosts-COVID-19-role-of-the-military.html

## II. SELECTED HIGHLIGHTS [DRAWN FROM THE FORUM'S PARTICIPANTS]

1. Cyber security and cyber infrastructure attacks have had a major impact on the country that we are currently seeing now even more than before.
2. The impact of businesses sending their employees home took a toll on our medical community and the patients' care system as a whole.
3. COVID-19 is not a domestic problem, it is an international one, occurring in different countries and handled in different ways.
4. Technologic innovation supported things such as contact tracing, but also, internationally, different vaccines, ventilators and, generally, medical capabilities.
5. Technologic innovations were drastic and in some cases we saw how lacking behind we were, while COVID-19 affects us in the United States, as well as worldwide.
6. Technology has provided both solace and solutions during the COVID-19 pandemic.
7. Much of the technology which has helped us during the pandemic has been researched for 20 or more years and most of the research has been funded by the federal government.
8. Technology keeps us informed, perhaps more than we want to be informed, but nevertheless it's critical for this kind of communication and analysis that occurs with pandemics such as COVID-19.
9. The COVID-19 vaccines are a culmination of decades of research combined with massive investment and the ability to produce huge amounts of the vaccines.
10. Using technology to combat the pandemic is a widespread practice. For example, robots were used in hospitals in Rwanda since PPE equipment was lacking and, therefore, it was not safe for medical personnel to be near COVID-positive patients.
11. Technologies that were either early stage, or perhaps just being considered, have been put to use during the pandemic.
12. Fundamental research precedes the technology and in order to be able to address future pandemics, future disasters, we really must invest significantly in fundamental research.
13. The handling of pandemics can be broken down into four relevant processes and technologies - 1. bio-surveillance and intelligence 2. preparedness and prevention 3. clinical operations and detection 4. response and recovery.
14. The pre-genomic age (early era of immunology studies) provided the building blocks for the development of our COVID-19 vaccines today.
15. The rapid development of the COVID-19 vaccines was the sum of decades of research and discovery, and resulted from the implantation of careful, established scientific processes.
16. Messenger RNA (mRNA) vaccines allow the host's immune system to develop a defensive response and recognize hostile pathogens.
17. Recent genome editing research initiatives undertaken by groups like the Defense Advanced Research Projects Agency (DARPA) lead to advances in mRNA vaccines.
18. Four targeted genome sequences were rapidly identified to produce an mRNA vaccine.
19. Operation Warp Speed (OWS) was responsible for successful large-scale manufacturing and distribution of vaccines.
20. The US still faces challenges in engaging in effective inoculation efforts.
21. Vaccine development faces several issues in reaching the US's target of 3 billion vaccines by 2021 - 1. cross-contamination 2. intellectual property rights 3. vaccine nationalism.
22. Development timelines have already been compressed, but must be shortened further.
23. Is the US allocating enough of its GDP (2.6%) to research and development?
24. The US may need to overhaul some of its antiquated laws and methods concerning research and development to keep pace with 21st-century practices.
25. Current US tactics of assessing and mitigating risk are ineffective and have affected the country's overall response.
26. "Policy without science is fantasy, but science without policy is problematic as well."
27. Public and private sector collaboration is critical in facilitating the development of research, ideas, and solutions.
28. There will always be some lag between the identification of a pathogen and pharmaceutical solutions. The goal must be to shorten this lag using technology and not depending upon societal behavior changes.

29. It was known early on that COVID-19 was airborne, yet there was a lack of public health understanding of airborne diseases.
30. Only tuberculosis specialists have complete training in airborne diseases, as most other viral infections are spread through other means.
31. To stop airborne viruses from spreading, technology should be implemented in our infrastructure such as ventilation, air sanitation, and UV systems.
32. UV sanitation seems to be highly effective, but is under researched.
33. Further studies must be conducted into advanced technologies for bio-aerosol detections, advanced detection of the infectiousness of bio-aerosols and controlled studies of air sanitation.
34. Implementing anti-viral infrastructure will help defend against future pandemics and will prevent people from having to rely on behaviors such as wearing masks.
35. The science-policy interface is hugely important and misunderstood.
36. The mission of the Cyber-security and Privacy Research Institute (CSPRI) is to provide faculty and students at the George Washington University with a platform for interdisciplinary dialogue in cyber-security and privacy, and incorporates three objectives: research, education, and service.
37. It is important to get scientists and decision-makers to agree to work together and to collaborate.
38. Good scientific work by itself will not suffice. Efforts have to be done proactively and carefully, and by people who know how to build communities of practice.
39. Let's make sure that we fund the connectors, the bridge-makers, the people who understand each other's language, because without that communication pattern our disasters will continue to grow and our ability to fight them will continue to diminish.
40. Blockchain is a type of data structure with a consensus validity determination mechanism that records transactions and distributes them over thousands of servers.
41. The various Blockchain applications of asset registration and identity, and data access and permissioning to facilitate interoperability integration of data sources provide the information needed to manage the condition in terms of Disaster Risk Reduction (DRR) management.
42. Blockchain applications can be applied to predictive modeling, carbon accounting, certification of infrastructures, allocation of resources, and managing supply chains, allowing a new way of thinking about disaster risk reduction with a broader time scale.
43. In relation to DDR, Blockchain can connect behavior with incentives, because behavior is at the core of disaster management as COVID-19 has demonstrated.
44. Blockchain can achieve two goals: act as an entropy reducer to toxic entropy exposure, the onslaught of the noise of information in order to manage any complex environment, and synchronize risk-limiting behaviors across different populations.
45. There are a lot of challenges in achieving these goals, among them are: cognitive obstacles to recognizing threats, means for global coordination, and different frames of reference for technologists and policymakers.
46. It is optimistic that we can deal with some of these issues in an effective way, because there is a growing public awareness of climate on the West Coast, acceleration of technology solutions, increasing prospect of international collaboration, and increasing acceptance of time-advanced action for disaster mitigation.
47. An Army four-star command was established for the first time since 1974 and named the DEVCOM Chemical Biological Center of Command Change – it specifically looks at the modernization of our forces.
48. The main mission is to provide innovative chemical, biological, radiological, nuclear, and explosive (CBRNE) defense capabilities. The capability area spans everything from Science and Technology (S&T) research and development to protection, detection, and decontamination capabilities.
49. During the COVID-19 pandemic, supportive partnerships were established to ensure CBRNE threats were addressed and health care/civil workers and soldiers were protected.
50. 3D printing is being used to study personal protection and filtration media solutions.
51. Support was provided to the Air Force using the MPC Conex and Conex-Lite to safely transport patients with infectious illnesses like COVID-19.
52. The study of olfactory sciences using canines can lead to improved surface decontamination methods and the detection of pre-symptomatic exposure biomarkers.

53. Due to the pandemic effects on small businesses, special attention must be paid to ensure the integrity of small business supply chains working in vital industrial bases.
54. There is an inherent power in collaboration across government agencies, industry, and international partners.
55. Frequent and factual communication is critical, and experts as well as the public must be empowered to work and be aware of the challenge at hand.
56. Special attention must be paid to defeating misinformation surrounding technical work.
57. There is a positive renewed interest in viral spread mitigation efforts including hygienic practices and general public health.
58. Artificial Intelligence is becoming one of the most powerful tools endowed with high intellectual processes through complex neural networks.
59. AI related issues we need to focus on are VUI, cloud, cyber-security, IoT, 5G, VR/AR, and Blockchain.
60. Emerging technologies were used in COVID-19 crimes, such as dissemination of false information, fraud attempts and production of counterfeit medicine.
61. Emerging technologies, such as Blockchain, drones, and 3D printing are dual-use technologies that can both be used to spread the reach of terrorism as well as combat it.
62. Nuclear power plants are just now undergoing digital transformation as the focus has shifted to their vulnerabilities within the cyberspace.
63. Attention must be paid to the problem of insider threats and the human factor as the weakest link of any security system.
64. Technological gaps must be closed if our response to the next pandemic is to be more effective.
65. There is a tech gap between wealthy and poor countries in the ability to access epidemic mitigation technologies.
66. Human comprehension and implementation do not adapt at the same rate as technological innovation.
67. The refusal of people to wear masks, social distance, or be vaccinated are examples of the gap between human comprehension and technological innovation.
68. Politicians and media organizations contribute to the hesitancy of the general public to technological or health related innovation.
69. Policy makers should be aware of the temptation to write people off as ignorant.
70. In the case of a global pandemic, public ignorance is deadly.
71. There are cases of individuals in emergency response organizations that deliberately attempt to undermine faith in the system for political advantage.
72. Public policy guidance was problematic in facilitating effective action.
73. The US needs to reevaluate its methods of engaging in strategic communication.
74. We need the CDC to be right, but even more so we need it to be strong, and to be able to listen to it. Many in the science community feel torn between sharing information they possess and undermining faith in the CDC.
75. The level of distrust among the general public affects the whole situation. To maintain its integrity, the CDC has to be upfront with information. People need to have a sense that it is sharing what it knows.
76. There are several lessons learned: the need to lower the risk of being uncertain, that the CDC is a premier organization and how to make it better and insulate it from political risk.
77. Putting the data forward should be something that's encouraged and applauded and not incur political risks.
78. There is a lot to learn from the COVID-19 experience that can be adopted into social behaviors and maybe answer questions such as how do we set up a regime in which strategic decisions are based on the best information and how do we make important threats visible and actionable?
79. We need to more heavily consider the adverse effects of social media disinformation that creates disbelief in our systems and health care professionals - there are more lessons to be learned from the 2016 election.
80. We have learned from history that we have not learned from history.

## III. OPENING REMARKS

**DR. JENNIFER BUSS,**

CEO, Potomac Institute for Policy Studies

Good afternoon everyone, and welcome to our ICTS seminar this afternoon. Today's topic is "COVID-19 and the Role of Technology." The Potomac Institute has been studying terrorism for over 25 years at the intersection of science and technology. We are a think tank in the Washington D.C. area for those of you that don't know. We're very happy to host Professor Alexander today and all of the distinguished panelists that he's invited to join us. So, thank you all for your time and your contributions.

I have a couple of quick remarks about the impacts of technology over the last 15 months. The first impact to society was when everybody went to work from home. Like most companies, we sent everybody home. We would not have survived as a country without the Internet. The role of internet technology was foundational in the continuation of so many businesses and government functions. So too, cyber security increased. The terrorist attacks to our cyber infrastructure, some using Blockchain and ransomware, have had a major impact on the country that we're seeing even more today than we did a year ago.

The impact of sending everybody home did spark some mental health and other health issues, which in turn, put a toll on our medical community and how they could care for their patients. Hospitals closed down, and in some cases, there wasn't enough money to continue to provide for the basic level of care that communities needed. Then, very quickly, the medical community switched to telemedicine and virtual visits, where we saw a lot of gaps in health care here in the United States. We understand this is not just a domestic problem, this has happened internationally in different countries and handled in many different ways.

Additionally, technology plays a big part in things like contact tracing for example. What happened here in the United States versus other places was very different when it comes to how technology was implemented to combat COVID-19. Different countries presented different solutions to how they were handling their societies movement – some more restrictive and others less private. Advances in medical capabilities in testing, ventilators and vaccine development increased at a pace we have never seen before.

So, these are just a couple of examples where technology changed the way of life during the pandemic, but there are plenty of others I haven't touched on today that I'm sure our panelists will talk about. I hope I gave a quick introduction to point out some of the technology innovations and how lacking they were in some cases, and how that affected us here in the country as well as worldwide. So, with that, I will hand it over to Professor Alexander to continue the discussion today.

Thank you.

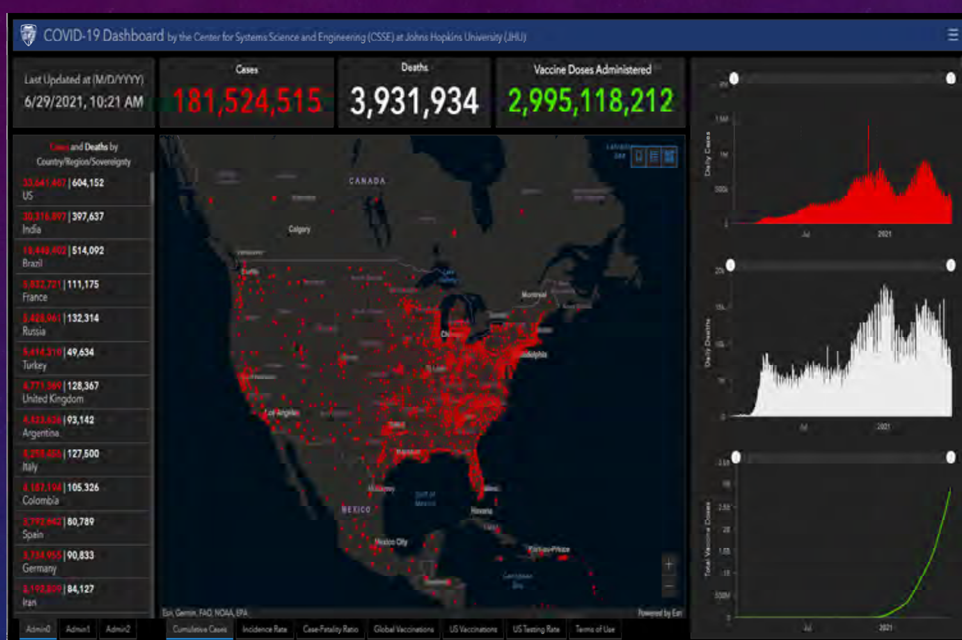
## IV. CONTRIBUTORS' PRESENTATIONS

This section of the Report consists of presentations made by the contributors at the Special Forum: "Covid-19 and the Role of Technology" that was held on June 29th, 2021 via Zoom conferencing. Some updates and revisions were made by the invited participants.

### DISTINGUISHED UNIVERSITY PROFESSOR RITA COLWELL,

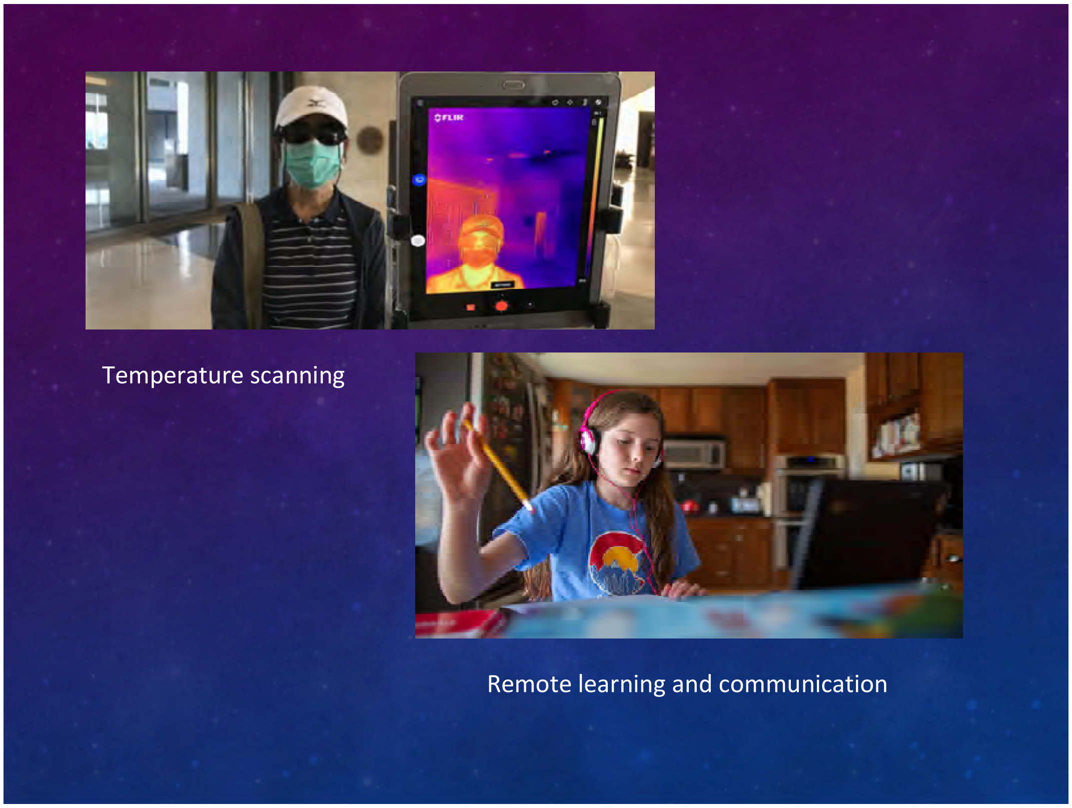
University of Maryland, College Park; Johns Hopkins University, Bloomberg School of Public Health; and Senior Fellow at the Potomac Institute for Policy Studies

Thank you, Yonah, it's always a pleasure to join you and your distinguished team on the forum panels. COVID-19 has upended all our lives and, interestingly, technology has provided both solace and solutions. The many contributions of technology in meeting the COVID-19 pandemic derive from foundational technology that traces back to many years of basic research. And, most if not all of those technologies derive from research funded by agencies of the Federal Government: NSF, NIH, DOE, DOD, USDA, Department of Energy, and others.

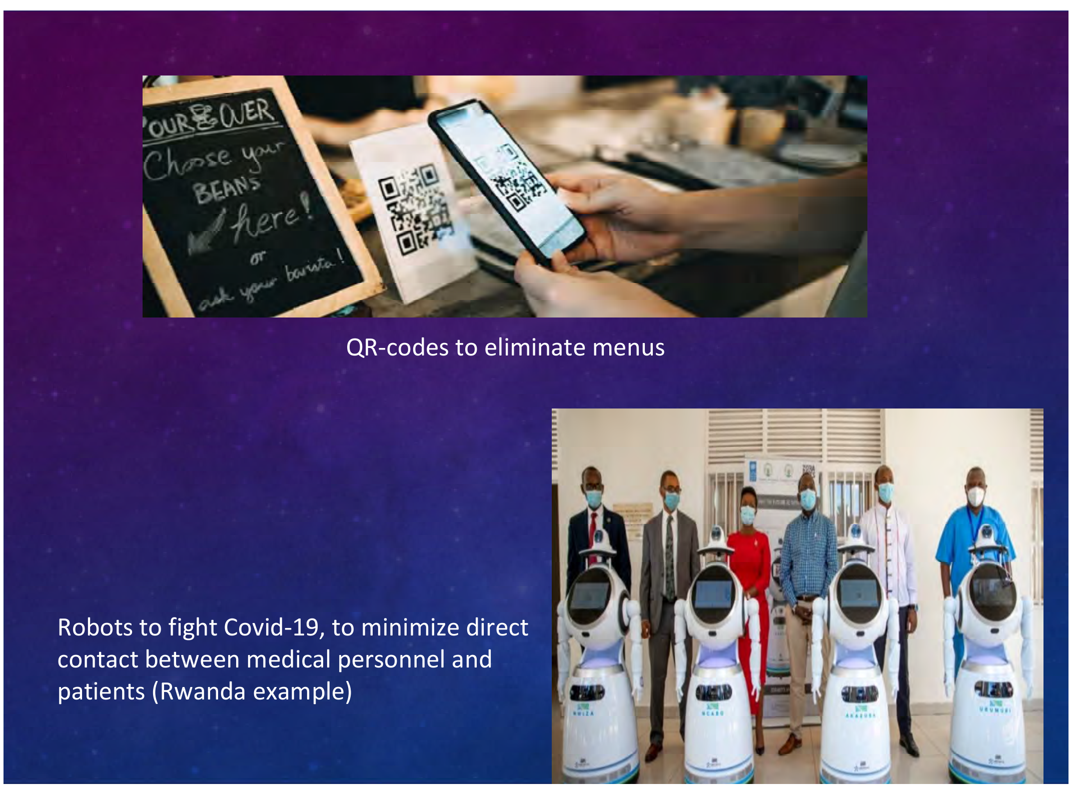



Dashboard of COVID-19 information continuously updated
https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6

The most up to date dashboard at the time of this panel is shown in (Figure 1.) Big data analytical presentations made it possible to monitor minute by minute the number of vaccinations and cases. Tragically, as of this date 604,152 lives were lost to COVID-19 in the US. Other countries similarly suffered enormous numbers of cases and many more deaths. The constant tracking, which we could not do 100 years ago for the 1918 pandemic, shows that technology can keep us informed, providing critical communication and analysis for COVID-19.

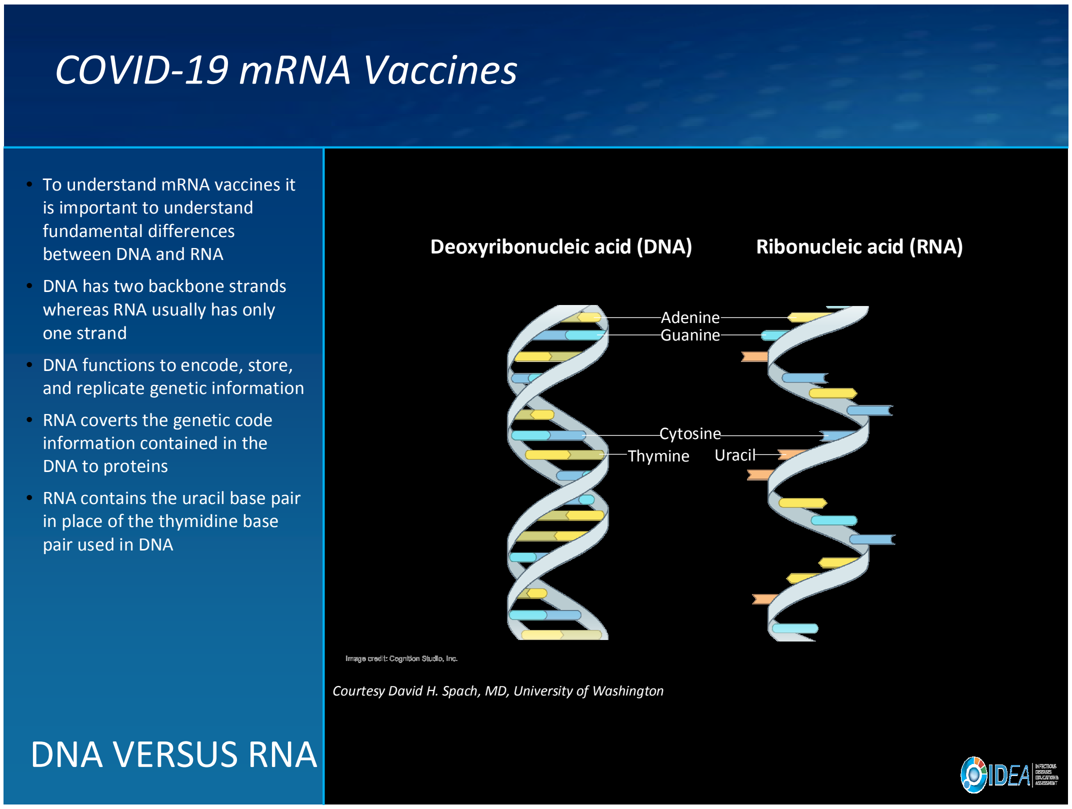



(Figure 2.) Temperature scanning required before entry to public places, such as supermarkets or offices. Temperature scanning technology has generated devices that provide instant determination of the presence of fever. Computer technology has made remote learning and communication possible. For some children this has been a blessing, namely those who thrived on remote learning has been an advantage. However, for others remote learning has been a serious disadvantage. Nevertheless, by being able to connect, we can provide mechanisms to ensure children will continue to be educated, despite the isolation that has been necessary to curb COVID-19.

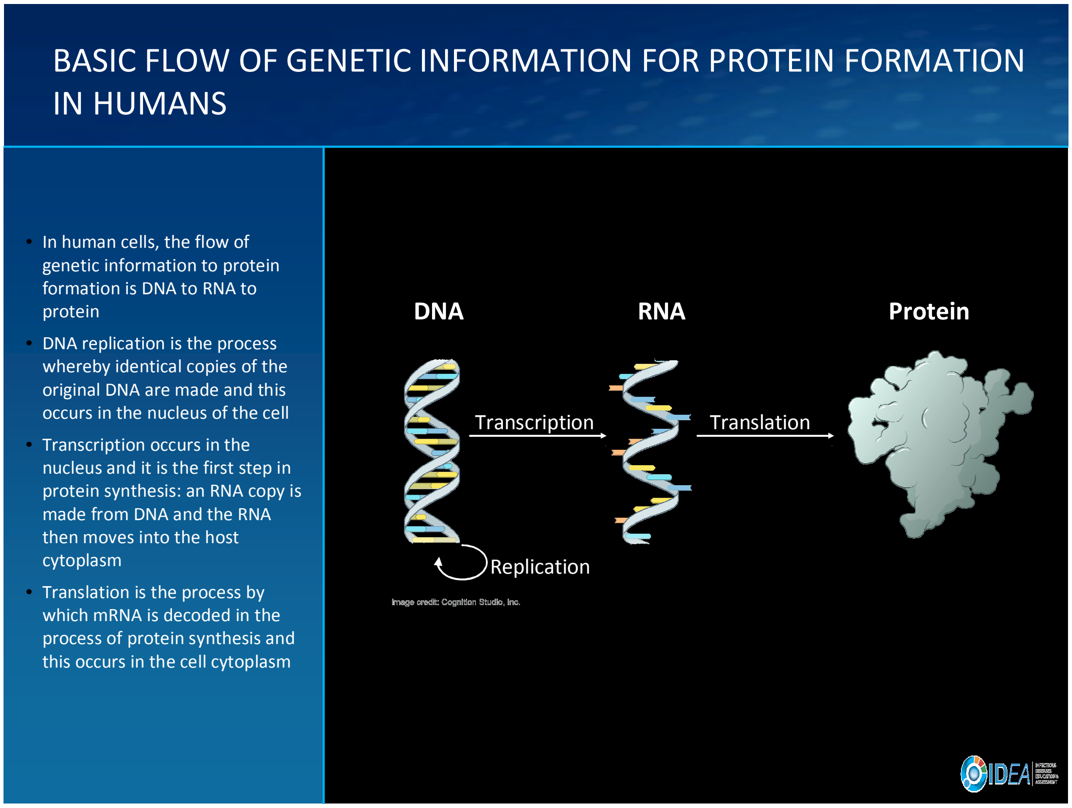


(Figure 3.) For some restaurants, QR codes eliminated menus. One restaurant I visited had imprinted its menu directly on the table and with a cell phone scan of the menu on the table surface one could read the menu and place an order without interaction by the server.

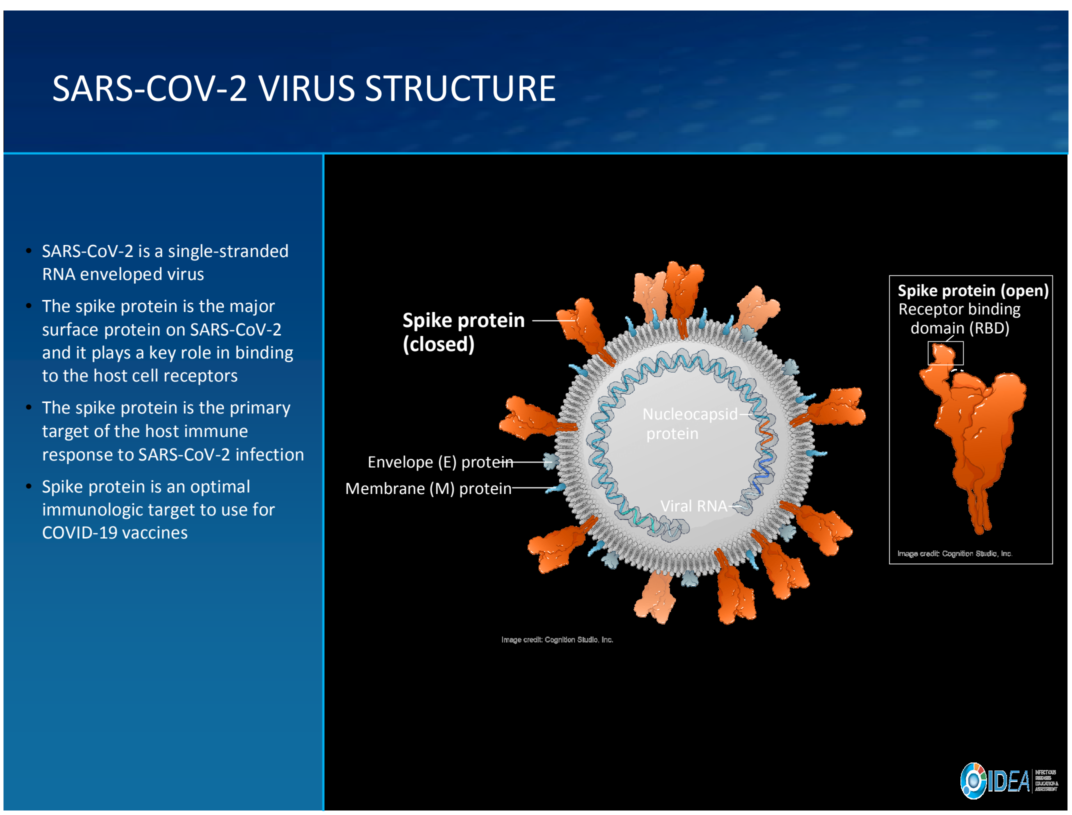
In some industries, robotics have proven critical in overcoming shortage of personal protective equipment. Robots provide interaction between medical personnel and patients. Interestingly the slide shows robots in a health care system in Rwanda, Africa, illustrating technology application globally.



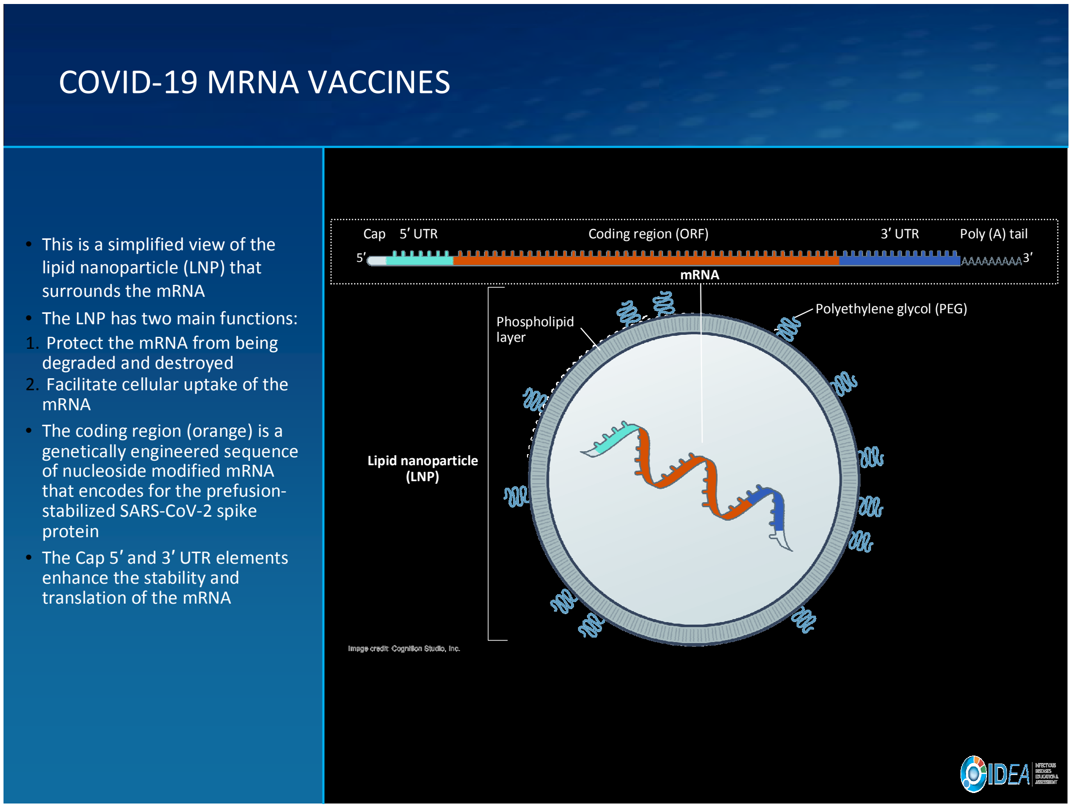

(Figure 4.) The most important technological development in the battle against COVID-19 was being able to benefit from more than 20 years of intensive research on ribonucleic acid to produce a vaccine directed against the COVID-19 SARS-Cov-2 virus. This breakthrough, coupled with massive investment in production of billion dose quantities of vaccines has made it possible to achieving 70% (herd level) immunity. The messenger RNA vaccine differs from DNA vaccines. DNA is a double stranded molecule, whereas RNA is a single stranded molecule and its action is to convert genetic information coded in DNA for production of immunoprotective proteins.

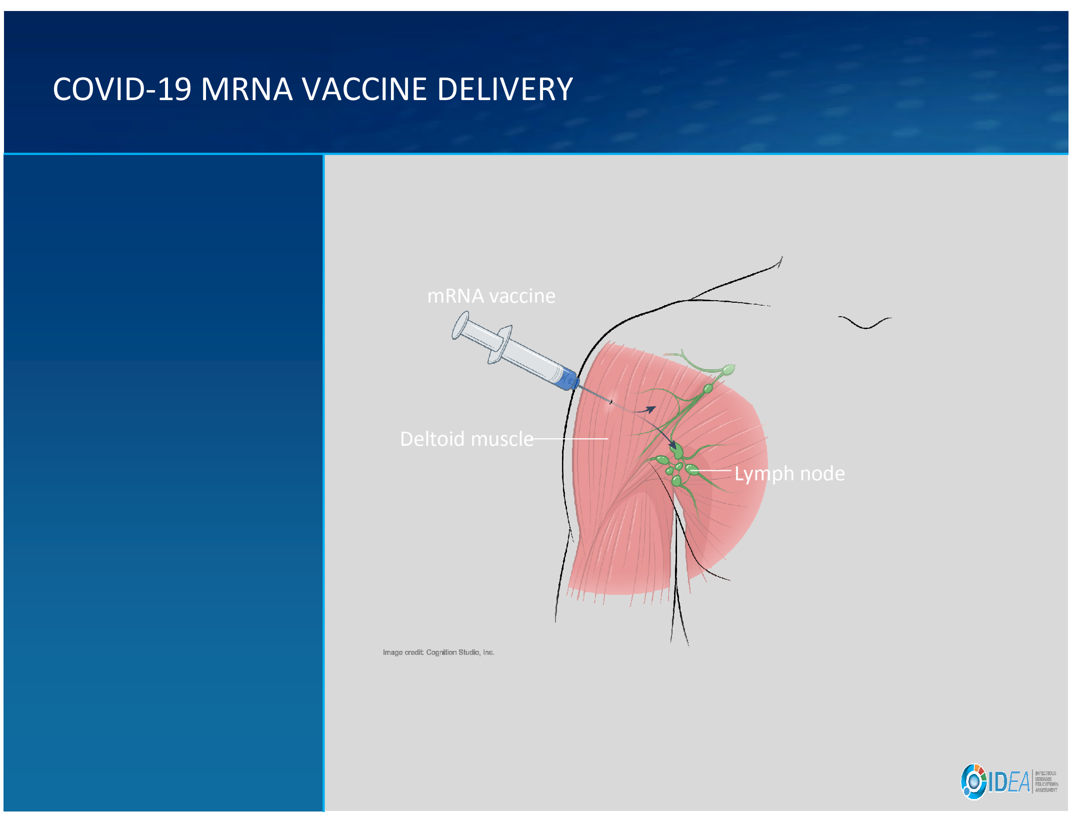


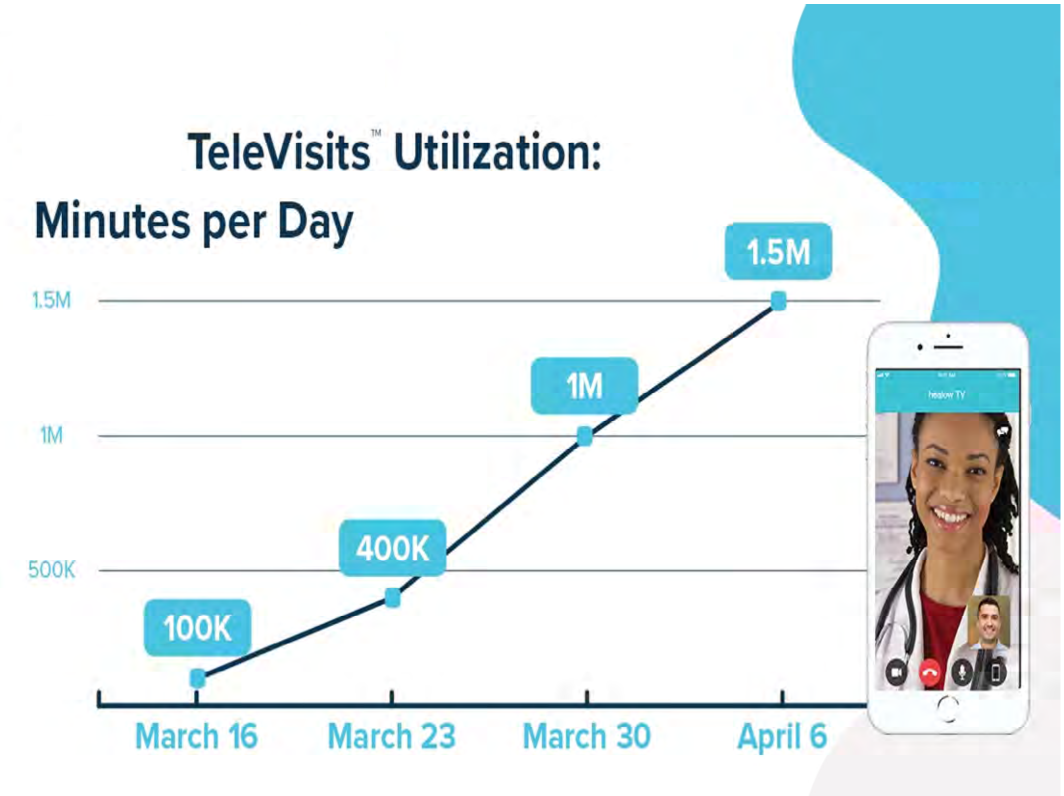

(Figure 5.) The flow of genetic information to protein formation is production of antibody. DNA replication is the process whereby identical copies of DNA are made. Transcription, the translation of information in DNA, is converted to machinery of the cell via single stranded RNA for production of protein, namely antibody.



(Figure 6.) The COVID-19 virus comprises single stranded RNA surrounded by a lipoprotein envelope that has spikes, i.e., extrusions of protein. The spike protein is an effective target and able to produce a genetic response, namely production of antibody which can envelop the virus and inactivate it.






(Figures 7, 8, and 9.) This is a simplified view of a complicated, but successful technological vaccine. The orange-coated region is the genetically engineered sequence for modified messenger RNA specifically coding for profusions of stabilized spike protein. That is, it codes for production of spike protein, which induces significant amounts of antibody, protecting the individual.

Vaccine delivery is not novel and the same method has been used for nearly 100 years, proving highly effective. Fortunately, production engines of industry were able to generate large numbers of vaccine doses, ultimately delivering several billion doses.

A simple, but effective technology is the surgical mask and when it is matched with distancing, washing hands, and avoiding personal contact has proven effective in preventing exposure to COVID-19. Telemedicine has taken off during the pandemic mainly because diagnosis and medical treatment by teleconference has proven effective. What has been successful with COVID-19 is technologies applications that were in the early stage were able to be used relatively quickly.
The important message is that fundamental research precedes technology. In order to address future pandemics and/or disasters, we must invest significantly in fundamental research. A research investment bill is being considered by Congress and that investment in fundamental research is both significant and desperately needed to maintain leadership of the United States. Fundamental research is necessary for technological development in the future. With this very brief overview, I hope it is clear that technology builds on basic knowledge and technology provides applications to address future exigencies.

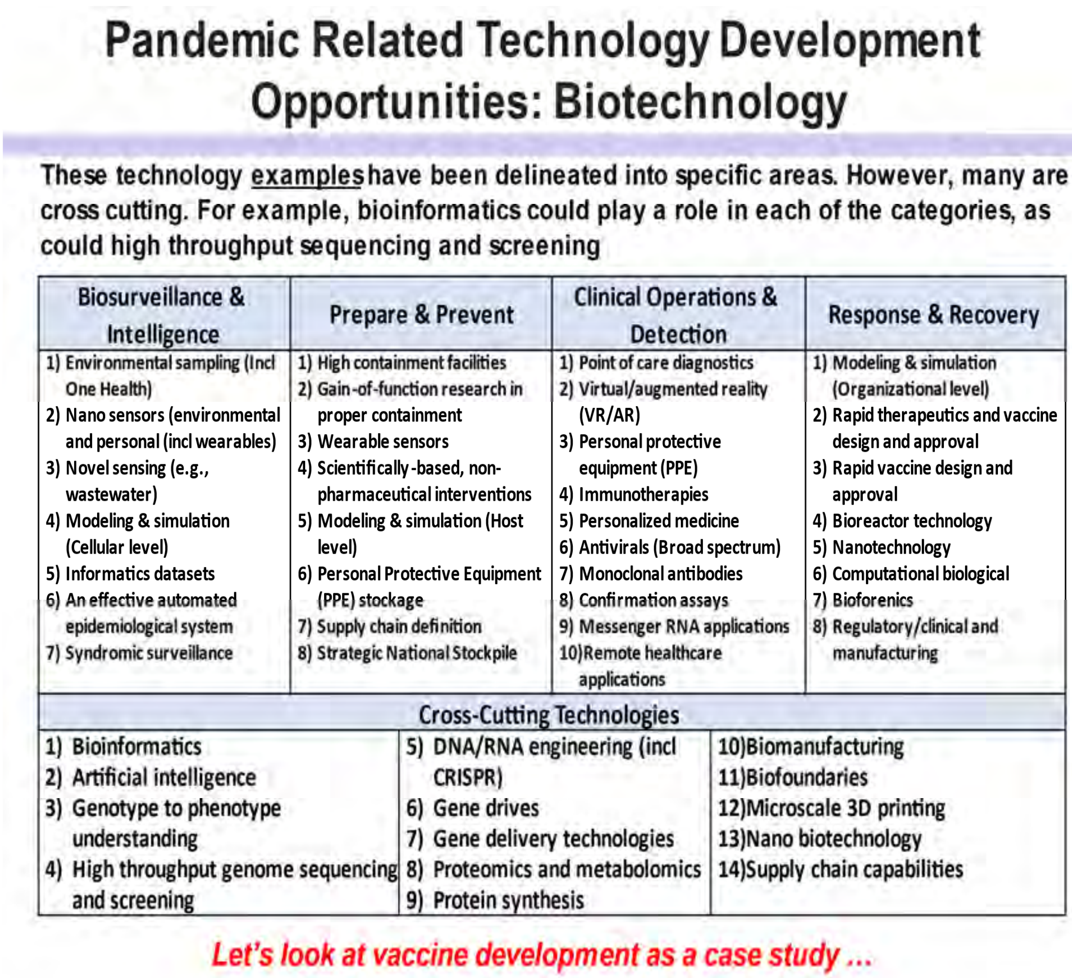
**DR. DANIEL GERSTEIN**

Former Acting Undersecretary and Deputy Undersecretary for the Department of Homeland Security

Well, thanks very much Yonah and It's great to be with this very distinguished group. I do have to say it's interesting to follow Rita because I can almost say, “thank you very much for your attention that concludes my briefing.”

My top-line message is very similar to Rita's and you'll see it on the slide but that the basic research of today is really the technology of tomorrow, and if we don't take care of that and watch it very closely, then we could be in trouble. So I have a couple of thoughts that I'd like to share with you today. The first is that we've learned many technology lessons over the last eighteen months, and I would say that some were good, some were not so good. It seems like just about everyone out there now is an amateur epidemiologist and virologist and I'm just kind of wondering which of the lessons are actually going to stick. I think there are some really important ones that we can take away.

I'm going to focus all of my attention today on bio-technology, I know that others are going to be talking about other technologies, so I want to really talk about biotech. I apologize in advance for the number and complexity of the slides. However, please do not be intimidated because what I really want to do is talk concepts and I don't want to talk about any of the real details. We will focus on the development of the mRNA vaccine, but I want to do it from a different perspective than Rita did. So next chart, please.



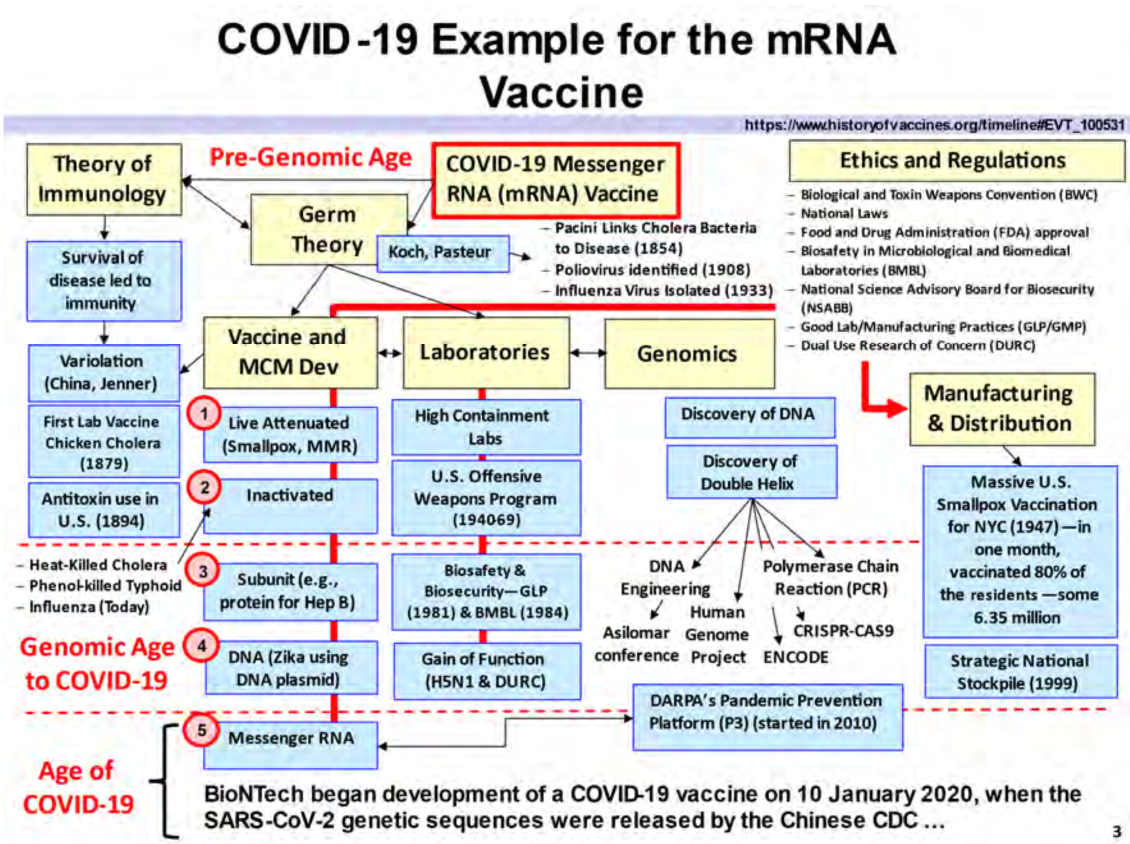
Here is an eye chart but it's very easy to get through, lots of words but mostly concepts. What I was trying to do was to look across the differences of the preparedness and response for the pandemic. The discussion begins of course with the bio-surveillance and intelligence, then prevention with the clinical operations and the detection, and then the response and recovery. At the bottom of the chart, I have some cross-cutting technologies. Now you might look at this and disagree with where some of these have been placed. For example, I placed immunotherapies under clinical operations, and you might believe it should go under recovery. That would be fine. The importance is to identify the key technologies and how they can assist in the preparedness and response. As you'll see this convergence of technologies that we are seeing means that there is a tremendous amount of interconnectedness and overlaps in the use cases of the technologies.

Let me just give you a couple of other examples of things that are really interesting lessons. So, the first one under bio-surveillance and intelligence are environmental sampling and we've been talking about One Health now for well over a decade. We would do very well to continue to think about One Health, to put more skin in the game *if you will.* Many are now talking about nano sensors which is the number two under bio-surveillance and intelligence, including the idea of biosensors and nanotechnologies that are wearable, which could serve as an early warning system for us. Look at the third one down on the novel sensing and wastewater.

Recently, gain-of-function research has gotten a lot of press recently, but I do have to say, having run several laboratories that were involved in what could be considered gain-of-function research, it's a very misunderstood set of technologies and it's something we need to think about before just cutting off any sort of further research. Years ago, I talked to the head of BARDA about this and he told me that gain-of-function research done as part of the dual-use research of concern issue back in 2012 actually changed the way they develop the seasonal influenza, and it paid dividends there. Look down at the bottom of the prepare and prevent under Strategic National Stockpile--that's an issue that has been problematic. We have learned a number of lessons during the COVID-19 pandemic. We need to figure out what needs to go in the stockpile and how to augment and support the stockpile with supply chains that are more effective.

In the clinical operations and detection, obviously, diagnostics has to be first and foremost. But we have also learned a great deal about the potential for personalized medicine. We've learned a lot just through Covid about how different people are reacting to different therapies and protocols.

And then of course on the response and recovery: The rapid vaccine design, the bio forensics, and across all of these is really modeling and simulation at the cellular level, at the host level, at the organizational level, and we don't have those capacities today. So, I think I'll stop on this chart, and I'll go to the next chart if I could.



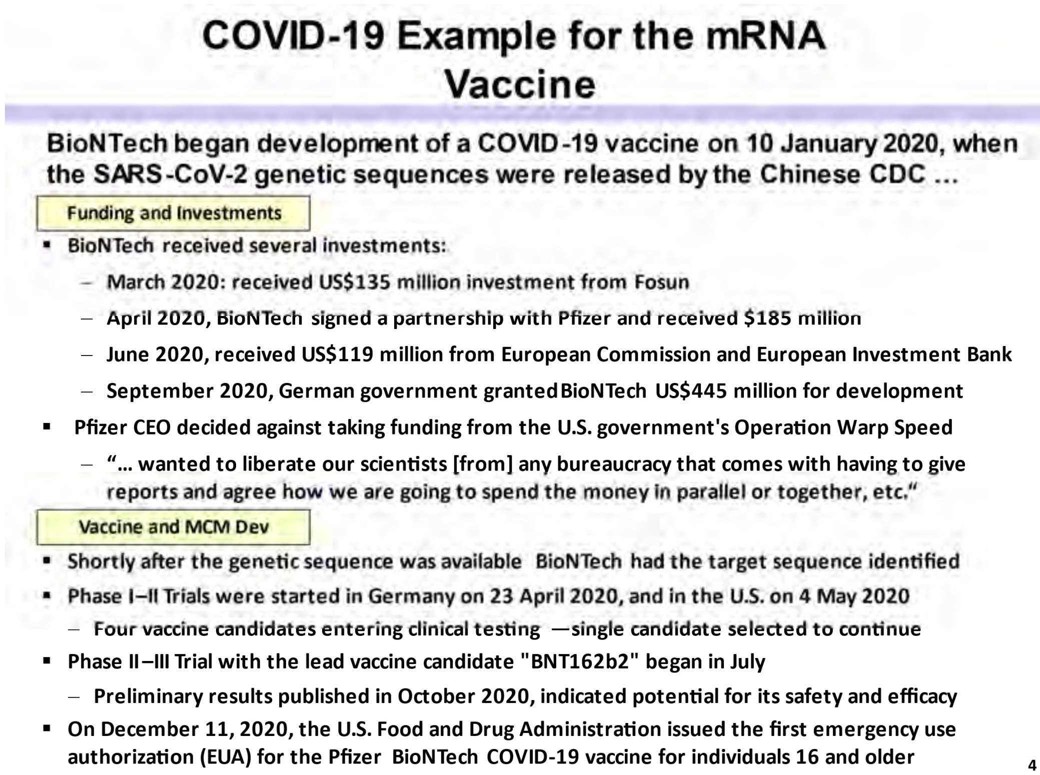
So, you look at the blocks in yellow, and what I'm trying to get across is: In the pre-genomic age, those areas and the types of technologies within the categories were the ones that were in very early stages. We talked about questions of the theory of immunology and germ theory, and people like Koch and Pasteur thought deeply about those issues. And there were theories of vaccine development and laboratories even if there were remarkably rudimentary by our standards. And of course, thinking about genomics manufacturing and distribution. Now what you see is underneath of those; the blue blocks and, in particular, if you think about - let's move over on the theory of immunology and we think about disease and what we learned and how we apply those concepts, those are the same building blocks that we use today. They're all derivative. And as we walk down into the vaccine area, you see then a list of vaccine types numbered one through five. At the bottom is messenger RNA. They all function with the same basic concept and that is to develop an immune response so that the host's immune response will be able to recognize and defend against a pathogen.
We have also learned much about containment methods and laboratories. Much of what we learned about high containment comes from our work with very deadly pathogen's during the height of the US offensive program prior to the dissolution of the program in 1969 and many of those same concepts have been translated down and are a working to be able to solve today's problems.

Think about genomics, all that we've learned starting with the discovery of DNA back in the 1800s and the discovery of the double helix structure in the 1950s. None of what we're seeing today with the mRNA vaccine would be at all possible without that basic research and the concepts that came from those earlier discoveries. And the human genome project, CRISPR/cas9 and DARPA's mRNA program that began in 2010 which was instrumental in developing the mRNA vaccines. The work on nanotechnology would prove to be essential technology for lipid development.

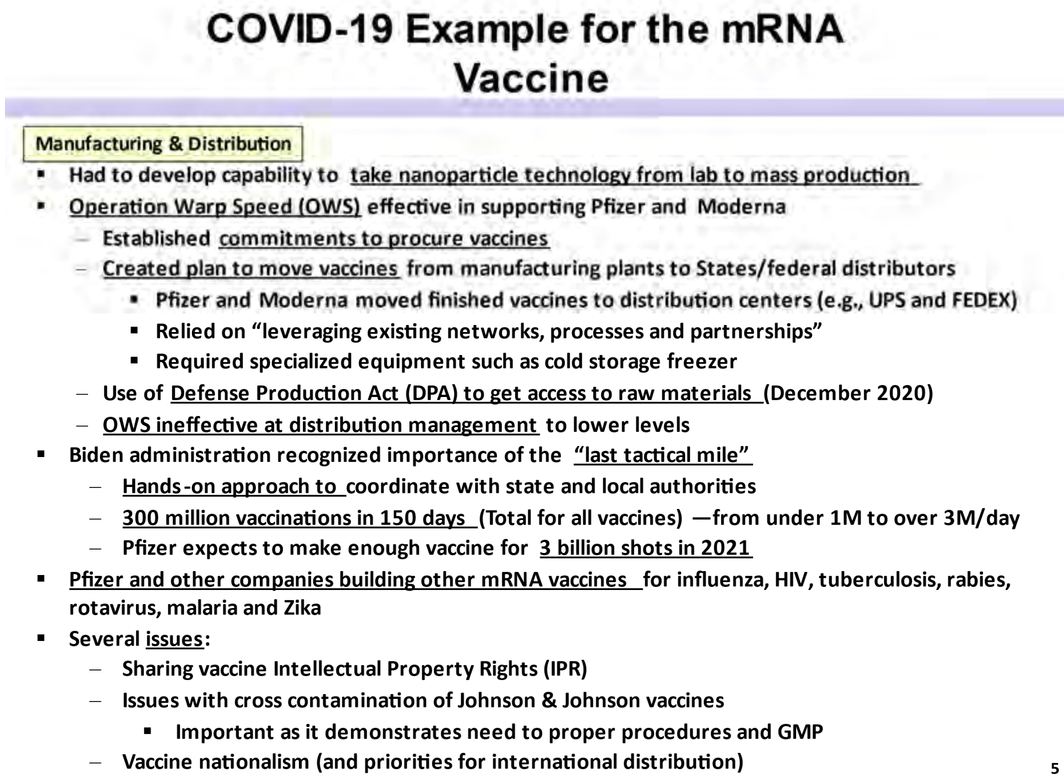
And then look at manufacturing and distribution. You know, we always kind of forget that we have experience with large-scale vaccination campaigns and distribution medical countermeasures. One only need look at the smallpox outbreak in New York City in 1947 to understand that we were able to inoculate over 6.35 million people in a little over a month or so and that was very important to stopping that outbreak. If you go to the next chart, please.

So how did we do this? While we're not going to go over all of the text, do look at the yellow blocks. We started with funding and investments, with taking the science that we had funded as part of the mRNA efforts. BioNTech, allied with Pfizer, was able to use this technology. And it's interesting how Pfizer's CEO thought about US government funding in this and how he didn't want to be tied to that.

Now go down to the vaccine and medical countermeasure development and think about the sequence, the target sequence - actually four target sequences - were identified within a handful of days. They thought they had some workable capabilities that they could build into a messenger RNA vaccine. And then the series of trials to demonstrate safety and efficacy. During this development, a process that had actually taken over a decade to develop was put through a very compressed timeframe. Really speaks to the importance of the foundations developed more than a century ago and the more recent efforts to develop these capabilities.



And then let's think about manufacturing and distribution. Operation Warp Speed (OWS) was important to monitoring the development of the vaccines, but it also had elements that were not so successful.




OWS was successful in helping to stimulate this process, but not so successful in distribution to the last tactical mile and getting vaccines into arms. This is an area where the Biden administration approach became focused. Three hundred million vaccines and one hundred and fifty days and the hopeful development of over three billion vaccines in 2021. Next chart. The only thing I'll say about this is regulations and ethics and the question is, the top one about the process normally taking a decade or more and now compressed into nine months, that's a little bit misleading because I just showed you our previous chart it was literally decades worth of work went into developing an mRNA vaccine. Basic and applied research and development. The question is what we can actually be learned about streamlining the process and shortening our timelines.

## COVID-19 Example for the mRNA Vaccine

**Regulations and Ethics**

- Took a process that normally takes a decade or more and compressed into 9 months
- Pfizer granted Emergency Use Authorization
  - 2 December 2020: UK's Medicines and Healthcare products Regulatory Agency (MHRA) gave the vaccine "rapid temporary regulatory approval to address significant public health issue"
  - United States
    - Emergency use authorization (EUA) is the FDA "mechanism to facilitate the availability and use of medical countermeasures, including vaccines, during public health emergencies"
      - 20 November 2020: Pfizer applied for EUA
      - 11 December 2020: FDA approved the application three weeks later
  - WHO and numerous other countries approve vaccine on emergency basis
- Ethical considerations and caveats regarding mandatory COVID -19 vaccination (WHO)
  - Only if necessary for, and proportionate to achieving an important public health goal identified by a legitimate public health authority
  - Must demonstrate the vaccine being mandated has been found to be safe in the populations for whom the vaccine is to be made mandatory
  - Data on efficacy and effectiveness should be available that show the vaccine is efficacious
  - Duty to carefully consider the effect that mandating vaccination could have on public confidence and public trust, and particularly on confidence in the scientific community and vaccination
  - Transparency and stepwise decision -making by legitimate public health authorities should be fundamental elements of ethical analysis and decision -making about mandatory vaccination

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So, you know, this gets right to Rita's point. The technology of today was the basic research of yesterday and if you think about the United States today, we're only spending about 2.6% of GDP on research and development. I ask the question *is that enough*? *Is two times that enough? Should it be 6%? Should it be 8%?* What should it be? And we really have to ask where we would be if we had not done the research and development we had done, but also what if we had even gone faster on some of it.

## Some Concluding Thoughts

| Conclusions | Examples |
|---|---|
| The technology of today was the basic research of yesterday | • Human Genome Project<br>• Messenger RNA<br>• Coronavirus mRNA vaccine |
| We are trying to develop 21st century technology with 20th century processes and 18th century laws | • Emergency management doctrine<br>• FDA processes and timelines for medical countermeasure (MCM) approval<br>• Modeling & simulation (cellular, host, community) |
| We remain challenged to identify, assess and mitigate risks | • Understanding supply chain risks<br>• Hinders decisionmaking process<br>• Communicating risk |
| Policy without science is fantasy, but science without policy can be problematic too | • Hydrochloroquine and bleach (Trump administration)<br>• CDC and mask guidance (Biden administration)<br>• Mixed guidance on non-pharmaceutical and pharmaceutical interventions |
| Innovation during all phases of the pandemic remains imperative | • Accelerated move to virtual society<br>• Operation Warp Speed for vaccine development<br>• Last tactical mile for vaccine distribution in Biden Administration |

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The other thing that we have to deal with is that second conclusion and trying to develop the 21st-century technology but we're using some pretty antiquated processes and laws and concepts and here. I like to point out that our emergency management doctrine is actually emanating from the first legislative act of federal disaster relief following a devastating fire in Portsmouth, New Hampshire in December 1802. So, it's well-worn and the question is does it suit us for this day and age? And think about the FDA processes for the medical countermeasures approval. Having said that we just had the Alzheimer's drug that is now getting criticized for not using proper procedure, so there is this tenuous balance.

On the third conclusion, I really think we're challenged to identify and assessing mitigating risks, we have shown ourselves here in this country, more generally, that is to say, we have not done well to understand and really mitigate the risks. And a lot of it comes down to strategic communications and how we communicate risk but that is something that we really need to understand because it cuts to the bone of our overall response.

My fourth conclusion is that policy without science is fantasy, but science without policy is problematic as well, and I go back on this to say look things like hydroxychloroquine and bleach really took the eye off the ball. We also had a problem in the Biden Administration's early stages about the CDC's communication of risk and masks, specifically regarding who can un-mask and when. And so, somehow, there has to be a melding between policy and science where it's a science-informed political approach to developing and providing guidance. And my final conclusion on this slide is the innovation and we need to figure out what we saw in terms of innovation and what now can survive.

Let me leave you with three high-level conclusions. So, three things, the first is, again Rita brought it up wonderfully, but it's about the public-private collaboration. It's figuring out funding for research and development and how do we cross the valley of death with all these great ideas that are out there. We have a tremendously innovative country, but we don't always necessarily bring things full circle and move them forward into development. When we look at all the opportunities for innovation, we should be questioning our methods and understanding and I would hope that organizations such as the Food and Drug in Administration would be looking to say what were we doing in the ten-year vaccination approval process that could be moved and lean six sigma to pull out the wasteful and make it streamlined so we can get vaccines, therapeutics, those kinds of things out more quickly. And then, you know, finally, I think this one is more encompassing, but it says really at the bottom of the last sentence, re-thinking of our national research and development enterprise.

The enterprise of today is essentially the same as it was, or conceived of, at the start of the Cold War in the late 1950s and we have been living off of that it has served us well it has some great components, but I ask the question: *Is it up to the challenges and opportunities of today?* And I thank you for your attention I look forward to a good dialogue.

## PROFESSOR DONALD MILTON

Professor of Environmental Health at the University of Maryland School of Public Health, with a secondary appointment in the Department of Medicine, School of Medicine

Thank you for inviting me today and, especially to Dr. Colwell, for extending the invitation. It's a pleasure to meet you virtually and get a chance to share some of my thinking about how technology and new research can contribute to the control of future respiratory virus pandemics. I am very much concerned about the causes of our early failures to control the COVID-19 pandemic. We are now seeing some late big successes with biotechnology. It looks like in the future, we will be able to respond more quickly with that technology and get the time lag between when a pathogen is first identified, and the availability of pharmaceutical interventions reduced dramatically. But there will always be some lag, and the question raised is how well can we control a virus during that lag? What if it turns out to be a more difficult virus to control? We're fortunate that SARS CO-V2 evolves relatively slowly compared to HIV and is not as variable in terms of its surface antigens so that we can make vaccines against it. We could get lucky, we could have something that's basically like measles, which is highly constrained and can't evolve. Once you're immunized against measles, you're done. But pathogens that evolve and evade immunity are going to present problems. If we get one that evolves more rapidly, it's going to be a really big problem. So how do we control pandemics in that early phase, which hopefully is not prolonged?

In this pandemic we had a perfect storm. We have an airborne transmissible agent and it was known early that this was probably airborne. Trump claimed Xi warned him of this, as Woodward has told us. China sent medical personnel in the Wu Han in full PPE including respirators and claimed none were infected. WHO retracted early statements and called airborne warnings false even posting a "False" label on top of some Twitter posts. Why do we have this lack of clinical and public health understanding and ability to respond? This lack of understanding resulted in delayed recognition by WHO and CDC for 15 months. It meant that airborne infection controls were not implemented in most countries. I think that that is one of the major reasons that we've seen it spread and it's become a global public health and economic disaster. There were people concerned and I claim to have been one of them, slide 3 shows some of my early tweets on the subject from January 2020 and points to a paper we published a couple of years before showing that influenza is infectious in exhaled breath with up to millions of RNA copies present in the breath. Lindsay Maher was another scientist raising early questions because she also had been working in this area of understanding aerosols and infectious aerosols in particular. But outside of a small community of people doing this research there wasn't much known about it. Within medicine pulmonologists who deal with tuberculosis (TB) transmission know about airborne transmission, but they think of TB as the only truly airborne transmittable infection. The TB medical community tends to see everything else as not "truly airborne" and therefore not important, and the infectious disease community generally downplays the role of aerosols in respiratory virus transmission. Why? Because they don't get any training in it. They deal with sexually transmitted diseases, waterborne diseases, vector borne diseases; they don't deal with airborne transmission and so they don't get trained in it. They don't know anything about aerosols really, and that became a huge vulnerability globally. We must to be able to control transmission early when vaccines and anti-virals are not available. We need to stop airborne viral spread before an agent causes a global pandemic. And, we really need to be able to do that without shutting down the economy. We need to make our economy robust and resistant to airborne transmission of respiratory pathogens. It is important to have that resistance to airborne transmission be continuously present in a passive way through the technology we implement in our buildings. So that we don't need to be thinking about the threat and depending on behavioral changes to protect us.

Talking about modes of transmission of respiratory viruses, you may have heard of the clinical paradigm of contact, droplet and airborne. Many of us, including many prominent members of the infection control community, such as Michael Klompas, the infectious control expert at Harvard, are pushing to move away from that paradigm now. We are beginning to think about the transfer process for agents from one person to another; what is the transfer process? There are three: spray with ballistic droplets, inhalation of small particles floating in the air, and touch of a contaminated surface followed by touch of your own mucosa such as rubbing your eye. These are the three main mechanisms by which respiratory viruses transmit between people. We know this but we tend to downplay inhalation partly because of the medical community mistaking respirable aerosols as the only droplet sizes that are aerosols. This mistake happened because respirable aerosols, which are less than five microns and can deposit deep in the lung are the only aerosols that are important for TB transmission because TB cannot infect the cells in your nose. But when you talk about measles or influenza virus or SARS Co-V2, those viruses can infect the upper airway. So, for these and many other respiratory viruses a lot of different particle sizes matter, and that has not been generally recognized by the medical profession until very recently.

Many of you have seen the illustrations on slides 6-9; examples of the abundant evidence of airborne transmission from multiple outbreaks. These outbreaks were characteristically in environments where there was very little transmission at the time. As a result, it was possible to recognize what was happening. Once infection becomes highly prevalent, it's very hard to know where somebody got infected and whether it was by the airborne route because it could have been, as we've been seeing in Australia recently, even a fleeting interaction. Slide 6 shows an outbreak in a restaurant in China, where the index case had recently traveled from Wuhan, had dinner with her family and friends at a restaurant and infected people at other tables. The infamous choir practice in Skagit County, whose choir director and the entire choir should be commended for sharing their experience, because many other choirs were also singing at that time but the Skagit County choir really deserve our thanks for being willing to have their case publicized. Then a few months ago, and this is before the delta variant got to Australia, a singer in a choir loft at the piano facing this direction who infected all these people down below, more than 10 feet down on the floor of the auditorium. Finally, a restaurant outbreak in South Korea, where the index case and his partner came in the back door and infected people who came in the front door and never got closer than where they were seated in the restaurant. These outbreaks plus the study (slide 10) that cultured the virus from the air in the hospital room of a COVID case in a Florida hospital, have told us that aerosols are important to this infection. Furthermore, when we look at what's been effective in schools, a paper from Hopkins shows that teacher masking was important in reducing transmission in the households of children going to school. Symptom screening was important, not having extra-curricular activities was important. Having outdoor instruction may have been helpful too, but there was one thing that was clearly bad: and that was plexiglass partitions on desks. Those of us in the aerosol community looked at this and were not surprised. When you have children in a classroom their exhaled air plumes will dissipate quickly when you have good ventilation, but when you put in partitions, you block the ventilation. Consequently, you get buildup of concentrated aerosols and anyone walking past that partition is going to get a nose full of virus.

So, what are the technological things we can do so that we are continuously protected even before we have a vaccine? One of them is ventilation and you've heard a lot about increasing ventilation, but there are things much better than ventilation; they have to do with air sanitation. Years ago, funded by a bio defense grant in early 2000s, we used vaccinia virus that we obtained from Acambis and sprayed it into the air of a simulated hospital room. We showed that by using upper room UV air sanitation, even in highly humid conditions, we could increase the effective ventilation from 2 air changes an hour with an additional nearly 30 air changes per hour with a single UV fixture. In a typical hospital room, you may have six air changes an hour and isolation rooms may have up to 12. Under optimal conditions with four fixtures, we added an extra 1000 air changes per hour of effective air sanitation. You can't do that outside of a hurricane. Upper-room UV fixtures can be used in classrooms as we did in Groton, Connecticut 20 years ago. This technology's been around for long time, it's not new, but there hasn't been much application. One of the reasons we don't apply this technology is a persistent gap in the research base. The clinical community is asking for gold standard randomized control trials. WHO infection control experts say they must have RCT evidence before they will believe that a respiratory virus is airborne. There has only been one randomized control trial of the mode of transmission of influenza virus; that study was published in 2020 by an international research consortium of which I was honored to be a co-lead. There were a couple of RCTs done with rhinovirus in the 1980s, but in those they didn't measure ventilation. Ours was the first viral transmission RCT to measure and control ventilation. We carefully prepared the ventilation systems of the exposure rooms with simulated occupants and monitored the ventilation throughout the study. What we learned was that by having a moderate amount of ventilation, it was nearly impossible to transmit influenza virus from experimentally infected donors. We need more such studies. Future studies need to go into greater depth, include advanced technologies for bio-aerosol detection, advanced detection of the infectiousness of bio-aerosols. Then, highly controlled studies should be performed to test air sanitation interventions. The National Institute of Allergy and Infectious Diseases (NIAID) recognized this need for studies of transmission even before the pandemic, with the release of a Request for Proposals (RFA) in June of 2019. They committed $6 million a year to fund three awards over five years, and the University of Maryland proposal received an outstanding priority and may be [was] the only one funded. The reviewers of our proposal wanted a bigger and longer study to give greater statistical power. We need proper facilities to do these studies appropriately and such facilities do not exist. We need facilities where we can simulate low ventilation and high aerosol exposures, where we can test new controls, such as 222 nanometer UV, which holds tremendous promise for the future. Now, we are beginning to recognize that the airborne spread of SARS-CoV-2 is really important, and that failures to control spread of the virus arise because of lack of clinical knowledge and few experts trained in the field of airborne infection. We really need research on what to do during the critical pandemic period before vaccines arrive. The picture on the final slide is from a restaurant that has 222 nanometer UV installed. It is hard to tell the lamps are there. They are using excimer lamps. It is safe to flood the entire space because it doesn't penetrate the skin or the eyes…. yet you're sanitizing all of the air all the time, even in the near zone between people. We need infrastructure, we need to incorporate new knowledge and new technologies into the infrastructure that we build and replace. We need it to be resistant and robust to transmission of airborne infections. And we need to prevent transmission passively before hazards are known. We need this because we don’t want to rely on requiring people to use conscious behaviors that they may not want to do like wear masks, much less shut down schools and businesses. Thank you.

**PROFESSOR COSTIS TOREGAS**

Director, Cyber Security and Privacy Research Institute at The George Washington University

Thanks very much Professor Alexander, and we're delighted to join this very important learning group and add our own experience in the topic of technology. I have to admit that the presentations that have preceded us have been breathtaking. Ms. Colwell, your reputation at the National Science Foundation and elsewhere, shows why you've earned such respect. You're right, basic research is vital, but it's more important perhaps to make sure that the communications link of what the basic research can do is made to the decision makers, and with a strong focus on diversity. Dr. Daniel Gerstein, you mentioned the science policy interface--that is hugely important and I think misunderstood, or perhaps not understood enough. How we communicate the benefits of science, and more specifically the benefits of technology to decision makers, whoever they may be, whether they're budget makers in Congress or whether they're private sector leaders, or whether an individual citizen like you and me.

So what I'd like to do is to take a step back and tell you a little bit about what we're trying to do at the George Washington University to create scientific discourse, some communication or some connections between two disparate branches, both of which don't really know each other exists almost. Perhaps from such connection we can draw some conclusions and discussions.

The mission of my own institute, the Cybersecurity and Privacy Research Institute (CSPRI), is to provide faculty and students at the George Washington University with a platform for interdisciplinary dialogue in cybersecurity and privacy. This effort is within the major academic objectives described by three words that most people that have gone through university will know quite well : research, education and service. So what we're going to discuss now falls into this latter category of service to the broader community.

I've had a long experience with international groups, starting with the United Nations Disaster Risk Reduction Program (UN DRR) for example, in Geneva. I've been an expert on their group that looks at global risk assessment frameworks. There's so many people so wonderfully engaged and involved in disaster risk reduction, DRR, who didn't really know much about technology. They use IT technology every day on their phone but don't necessarily understand its impact and how to introduce it into operations. So, you will hear from my friend Neil about a computer science topic that will bring these two disciplines together, technology and disaster risk reduction. We felt that it was important to get scientists and decision makers in those two fields to agree to work together and to collaborate and to do perhaps the simplest thing of all which is to write a paper together. We joined with Neil and a colleague in France, to develop a call for authors, which is open until January 2022 actually, for papers in the intersect of blockchain, which is a cryptographic technique and you'll hear more about it from Neil, and disaster risk reduction.

The next thing that we thought we'd do is to begin to develop a community of interest; the slides you see are intended just as visual mnemonics to remember, but we started doing webinars every month. Every month we did a webinar and the number of people began to grow, and the geography of the people who show up began to grow. We called it “Disaster Risk Reduction and Blockchain Webinar”. And pretty soon we had people like the Ambassador of Israel to Colombia, we have the head of the United Nations Development Program in central and western Asia, show up, we had people from Ernst and Young and other consulting firms show up. We had a tremendous number of people, including faculty and students from GW and other universities. So, this creation of a place to meet, a place to hear each other's vocabulary and concerns is so important, because nobody owns a scientific problem singlehandedly anymore. It's all done through working through connections through a network of smart people, scientists but not only scientists, policymakers, budget managers and communicators. So how to get these people together is a challenge, and there's work to be done, as well as the scientific work itself. Good scientific work by itself will not suffice in my mind.

So we are beginning to engage in a community of practice; CoP is serving the world in some respects, communities of practice. We're looking for students, faculty, entrepreneurs, industry, government, NGO community, and global partners. It takes time to develop this community of practice. This is what Professor Alexander, what you're doing, you're building a community of practice. Our own vision is immediate practices to be broadly based and has to include those problem solvers with whom we are working so hard. The actual people on the street and non-governmental organizations that work on the problems that we work on the problems on their behalf. So therefore, building relationships between disciplines of science, and disciplines of application in our society. It will not be done on its own, it has to be done proactively and carefully, and it has to be done by people who know how to build communities of practice. So, in addition to the importance of basic research funding, I will put a plug for an expanded definition of research here: let's make sure that we fund the connectors, the bridge makers, the people who understand each other's language, because without that communication pattern, our disasters will continue to grow, and our ability to fight them will continue to diminish. So with that cheerful note, I will give it over to my friend Neil.

**PROFESSOR NEIL WASSERMAN**

Department of Computer Science at The George Washington University

Good afternoon, everyone. Let me just say that I've learned a great deal from the previous speakers. The thought occurred to me that if those who advocate bleach might be mandated to take their own medicine; the world might be a better place for it. On a more serious note, Donald Milton's presentation raised the possibility of connecting him with my colleague at GW who does experimental research on dispersion of aerosols given a complex air flow environment, so I'm going to link the two of you and maybe something productive will happen out of that. But on that theme the connection between the policymakers and the technologists, that's kind of thing Costis and I have been trying to make happen. And we feel an urgency to this project, namely because the onset of disasters within the disaster risk reduction (DRR) framework seems to be accelerating due to climate change, due to the onset of pandemics. It's a very happy coincidence that the technologies that have emerged around CRISPR and mRNA have converged at the time of this pandemic. And we need to learn to derive benefit not just from that lucky coincidence, but from what we know about the need to manage behaviors that mitigate disasters, and also create the kind of networks that will manage these impending events, which we know will happen. We just don't know what event will happen, where and when.

So one of the opportunities that we've identified is to connect blockchain to DRR. I'm not sure how many people know what blockchain is, but let me just describe it in one brief sentence: it's a type of data structure that records transactions, sometimes cryptocurrency related. The data is distributed over thousands of servers. The data structure has a consensus mechanism that is made to agree on things that determine the validity of blocks that can be added to the chain. That's basically the core of the concept. And what we're looking at are opportunities to apply this technology to the disaster risk reduction universe. There are various blockchain applications of asset registration and identity, and data access and permissioning to facilitate interoperability. In the disaster management universe, we often need to connect disparate data sources, just as COVID response involves accesses to data from many, many sources. The integration of those data sources tells us something about what we need to know to manage the condition in terms of Disaster Risk Reduction management. This can be applied to predictive modeling, carbon accounting, certification of infrastructures, allocation of resources, managing supply chains - many applications. In the new way of thinking about disaster risk reduction we take a broader larger time scale view of things.

So this is what blockchain can do for DRR: connect behavior with incentives. We know behavior is at the core of disaster management as COVID has demonstrated. I like to use the term, toxic entropy exposure, that is the onslaught of the information needed to manage any complex environment. We need to control this information and blockchain is kind of an entropy reducer because it makes decisions around data, and data sources. The other goal is to create what I like to refer to a synchronization of behaviors. That is, across populations we need people to behave in a way that is conducive to limiting risk.

So there are a lot of challenges in achieving these goals. Among them, I think the most significant are the cognitive obstacles to recognize threats, and I think that's a very interesting question. You know, what are the factors that enable human beings to recognize the threat? So, terrorism, for example, is a threat because we can kind of know the target, but pandemics are probably a much more important threat, at least in terms of numbers of deaths associated, and it took us much longer to identify the pandemic as the threat because of that. We'll just leave that question on the table--why is that? We need a means for global coordination. You know, who is the first mover on these issues? And we're facing a compressed timeline for action on climate change in the next decade or two is critical--are we going to face that challenge with the urgency that's required? And then, as Costis mentioned, there are different frames of reference for policymakers and technologists. We can't exist in our own universe, we have to find mechanisms to communicate and collaborate, and that's what Costis and I have tried to do within our limited domain.

So, I don't want to leave here with just challenges because I'm actually optimistic that we can deal with some of these issues in an effective way, one of the reasons being the growing public awareness of climate on the West Coast. I'm sure people are very much aware of climate change facing 115 degrees in Portland and other places. There's been an acceleration of technology solutions: bioengineering, blockchain and artificial intelligence, maturing of these technologies. There's an increasing prospect of international collaboration which we know is necessary. We can't fight or control the pandemic without a global perspective. I applaud Biden's contribution of 500 million vaccine doses, but that's kind of a drop in the bucket in terms of what the global requirement is. So we need to amplify that target. And there's an increasing acceptance of time-advanced action for disaster mitigation, that is, we have to prepare now for disasters that would occur in the future. And so with that, I'll just leave these questions of how do we recognize threats, how do we respond to threats, how do we collaborate among disparate or distinct cognitive communities of interest, how do we connect these vocabularies, and I'm sure everyone will have some very interesting things to say on these and other subjects.

### DR. ERIC L. MOORE

Director, U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC)

Thank you. I really want to take the opportunity to say I'm elated to be amongst this distinguished panel, this distinguished group today. One of the things that I think the COVID pandemic taught us is that in some areas we used to be better poised to protect the nation and, in those areas, we see atrophy. We came together in some very interesting ways in which I think are good overall, but we had some important lessons learned that I want to highlight. I also want to highlight how we integrate not only within the Department of the Army and the Department of Defense (DoD), but also with some of our academic, industry, interagency and some of our international partners.

We're now called the DEVCOM Chemical Biological Center. This is a command change, the Army has a new four-star command for the first time since 1974, which likely will not happen again in most of our lifetimes that a four-star command will be established specifically looking at the modernization of our forces and achievement over match. We are located in Edgewood, MD and used to be called the Edgewood Chemical Biological Center. We also have facilities in Pine Bluff, AR; Rock Island, IL; and Dugway Proving Ground, UT. When Dr. Milton was talking about several bioaerosol capabilities, I resonated with that both from my previous job when I was at the Defense Threat Reduction Agency where I funded a lot of bio-aerosol research efforts to now where I have two major laboratories working with bioaerosols at Edgewood and in Dugway Proving Ground, UT.

They're also involved in a lot of the testing and evaluation work that goes on. The mission, as highlighted, is to provide chemical and biological research. We really work throughout the CBRNE spectrum although we initially started over 100 years ago in 1917 as a chemical munition filling station to ship chemical munitions across the Chesapeake Bay and the Atlantic Ocean over to the European theater during World War I. In that regard, we look at some of our defensive capabilities that allow the Joint war fighters' dominance on the battlefield, but we also do probably about 50% of our work supporting the interagency defense of the homeland. Those two factors are very linked together and a lot of that work goes on to support what we do for the Department of Homeland Security (DHS), the National Guard Bureau and other civil support teams. This capability area spans everything from Science and Technology (S&T) research and development, design, test and evaluation support, and providing some of the nation's premier experts across several technical domains' protection-detection capabilities and decontamination operations and also obscuration.

The workforce that we have is a very skilled group of scientists, technicians, and engineers who work together to combat some of the world's most dangerous CBRNE threats and during the COVID pandemic, we worked with several partners to support pandemic responses and relief efforts throughout the nation and government.

Initially when the pandemic occurred, several small businesses contacted us. Everyone had face mask capabilities and respirator capabilities – some even had capabilities for looking at new biocide solutions. However, oftentimes when folks handle new approaches it is not actually beyond basic research. This leads us to harvest the best capabilities that the nation has and find out what things we can use versus what needs to go further back into the development cycle. As we collected and tested personal protective equipment for health care workers and Soldiers to answer some of these technical questions, a lot of our staff were brought in specifically to look at some of the work to support the nation's health care workers, keep our Soldiers safe and safeguard civil support teams and first responders. We established supportive partnerships that are critical to addressing some of these challenges.

A lot of what we looked at was respiratory protection – everything from N-95 respirators, varying face coverings, to filtration media. We often had new filtration media that had some novel capabilities that we were looking at. There were also some things that were more in the developmental basic research fronts, but some of that we were able to advance much faster. Lastly, we looked at a lot of novel personal protection solutions using 3D printing. We have a huge additive manufacturing center, and it came to bear for COVID working with the United States Army Medical Research Institute of Infectious Diseases. We did a lot of work to support our Army at large. And, when you think about Operation Warp Speed, prior to moving into Army Futures Command we were a part of the Army Materiel Command, so General Perna led those efforts to do a lot of the capabilities that we possessed for additive manufacturing because some of the novel testing solutions use the 3D printing capabilities that we had.

We also did a lot in terms of looking at detection capabilities, diagnostics, and decontamination. For example, one of the things that we really highlighted and brought to bear quickly was our work with DHS as well as In-Q-Tel and others to provide mobile medical laboratories to go to the Javits Convention Center and provide laboratory capabilities. In some cases, we had to use 3D printing capabilities to re-engineer some of the bio-fire film arrays together and some of the vehicles that went up to support National Guardsmen. In an approach to supporting the Air Force, we had a Negatively Pressurized Conex (NPC) in which there are two versions. The NPC is a 40-foot metal shipping container outfitted for medical care and transport of up to 30 infectious patients aboard a C-17 transport jet. The Conex-Lite uses a C-130 allowing the transport of about 20 patients, and we actually used this capability back in June for CENTCOM to evacuate 12 COVID patients using these capabilities. Ultimately, this has expanded into something that is a capability for the future.

Along these lines, we looked at surface decontamination methods. We actually use canines for detection. We have a program that looks at olfactory sciences and we are using what nature has developed in terms of the dogs to look for biomarkers and pre-symptomatic exposure biomarkers. As we were doing some of this research, we found out that canines are outstanding for pre-symptomatic identification of folks that are positive for COVID that did you won't necessarily see in early COVID tests.

This includes applying expertise to areas such as supply chain management for those small businesses that closed in the surge of the pandemic. As for chemical biological defense, a lot of the carbon filtration companies are local to this area and are small companies. Without maintaining the industrial base, there would be irreparable damage to our ability to provide carbon filtration media. This meant we had to do some work to ensure that these folks were able to still operate to maintain that industrial base.

We utilized several mechanisms for interaction that were both formal and informal. When you look at the formal process this includes start agreements like Memorandums of Understanding, Memorandums of Agreement, Material Transfer Agreements, Cooperative Research and Development Agreements, as well as Technical Service Agreements. Beyond that, we had several informal approaches to actually getting work done. When I was having conversations with In-Q-Tel and others, I was actually having conversations with Governors of States until late into the night so we could come together and establish those networks and communities of practice that allowed us to be responsive in a timely fashion.

When I think about the lessons learned at a chemical biological organization such as ours, we have a lot of expertise that is very relevant to biological incidents such as COVID but also bridging the gap between emerging biological pandemics and emerging threats from a medical perspective. What we do in our core mission is look at biological threat agents where there are a lot of synergies that we could leverage and utilize. One unforeseen event, in general, was that there are a number of partners involved. Historically, Health and Human Services (HHS) have the legal authority and responsibility to lead the nation, but we're all at the table together. We have the expertise and facilities to contribute to developing technologies. One area that I found is that oftentimes folks that don't necessarily have the expertise or the facilities, but they own the mission, the money and the funding, that oftentimes puts us in weird situations where we don't always bring the right team of experts – I believe we have gotten better at dealing with this. For instance, there were a number of meetings historically with the Public Health Emergency Medical Countermeasures Enterprise that once existed, they still exist, but I think some of the membership has turned over especially as COVID has transpired. We have a number of folks who have just lost the touch-points of working together.

I do think that technology has facilitated many things, take how we are meeting right now for instance. One of the challenges I notice is that we're all on different systems so oftentimes it's hard for us to communicate across the board. The Department of Defense is mostly using Microsoft Teams, some defense agencies are using Zoom, and others are using some more commercial entities, and so on.

I think one of the most important things we must remember is in order to understand the problem we have to understand the fundamental principles involved, the science. I always say to our team "lead with science." Identify where we have gaps in addressing the problem. Identifying the right partners in interagency and across other disciplines. I think that the multidisciplinary approach when we started forming the teams over time really brought a lot of fruit to bear for us and helped us fill in the gaps whether it was for facilities, talent expertise or expanding our networks. Communicating and the communication of factual information is what we noted needed to happen between partners and teams and their external community frequently. So, we saw that rapid response is crucial and there is a need to quickly identify gaps in establishing partnerships with relevant entities. In addition to these relevant entities, we quickly learned the power of collaboration across government agencies and industry international partners. While it is unique, it satisfies experiences on all calls whether it is from the Office of the Secretary of Defense, National Institutes of Health or National Guard Bureau working together for a common purpose.

We have done a lot of work by matrixing folks to help support the HHS as partners for Operation Warp Speed and we ultimately became the DoD contracting arm for the vaccination effort. This was a large collaboration and was indicative of the power of coming together. Our personnel supported the Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense where we had matrix personnel who went to support the vaccination efforts. The important part here is maintaining critical plans and infrastructure because it is not just science fiction anymore. The threats are real and we need to stay ahead of them by committing funding, not waiting for the worst to happen. I think we have got to look and expand. An example of this is years ago I was briefing the Defense Science Board and they looked at some of the research that we were doing and they felt like we were being perceived as not having an offensive program. They said, "Look, you all are putting the nation at risk because you're being so conservative with what you're defining as an offensive program." Historically, in our space for offensive biological programs, you would have to look at disseminating bio-threats, weaponization and other sorts of things. Not necessarily going into the laboratory and doing some work for abetted compounds or looking at new chemical moieties where you had a functional group to change in the chemical world process. The same correlates for biology. Not necessarily going and synthesizing new threats but looking at not being so conservative that you put the nation at risk.

Factual, frequent communication is critical, and we need to empower the general public and experts actively working on technologies to have situational awareness and enhanced understanding of the challenge. When we looked at our COVID-19 response it demonstrates the power of misinformation. Many of our experts were battling answering questions that were the result of misinformation while others were trying to complete technical work in an environment that had sparse equipment and resources available. When this first started, I had a number of folks over in Australia who were there doing some of the demilitarization work from old stores of munitions that had been there, left by the U.S. from World War II. As our folks were doing this work, oftentimes they would be in quarantine stuck over there without all the infrastructure they would need when coming back and forth, such as having a new team refresh them.

We were overwhelmed with misinformation and many so-called “experts” responding to various queries during supply chain challenges. I think we saw that inherit throughout, where you had a lot of folks who were not necessarily as much of the subject matter experts that they were purporting to be and so we had 40 percent of our time spent on answering questions that were rooted in misinformation. A lot of our subject matter experts had a lot of their time wasted just responding to high-level officials and corporate CEOs who were pushing technologies that were not often of value to us at that time.

A good piece of all this was that it spurred renewed interest in mitigation strategies. In one case, we had a number of folks come together and look at some novel approaches to what we were doing. We also learned about new strategies for looking at threats because it is always a question and a challenge for us to understand what we would say is “what is live and what is Memorex?” in terms of threats. There are simple things to consider like maintaining clean and hygienic practices, air handling, mitigating and restoring laboratory operations, bio-surveillance as a critical capability, renewed interest in population health assessments and just public health in general. For us, we’ve developed some novel approaches to interrogating biological and chemical clouds from a battlefield scenario. However, some of those technologies where you have sensors on drones and other sorts of technologies could have applications here. These hurdles to overcome are beyond our control in a crisis but partnered with the right people and innovating helps achieve resolutions. Cutting through some of the bureaucracy and the red tape as well as some of the supply chain limitations, we found some ways to circumvent some of these challenges.

Let me see if there's anything here that I wanted to highlight that I did not. We continue to partner, and I will end with this – that CARES Act funding helped us complete some of these projects. We have done innovative work to put organs on a chip, which [referencing the slide] is a lung on a chip model that binds Sars-Cov-2 showing how we can do studies that look at some of the mechanisms in lung tissue. There's a lot of this going on that is being leveraged and worked on throughout the community for things like pharmaceutical development, detection and just understanding the response to diseases. With that, that is all I have right now. Thank you.

## PROFESSOR NATIVIDAD CARPINTERO-SANTAMARIA

Professor at the Polytechnic University of Madrid (UPM) and General Secretary of the Instituto de Fusion Nuclear "Guillermo Velarde"

Thank you very much Professor Alexander.

Good evening from Madrid. I would like to especially greet General Gray. I had the pleasure of meeting you in your Institute in Washington D.C. in 2015, so I'm very happy to see you here. As Professor Alexander said, my presentation deals with emerging technologies being developed and how their use has increased exponentially with the COVID pandemic. As we heard in the introduction, COVID-19 has brought significant socio-economic changes in our lives and unexpected acceleration of digital tools. During the confinement, digital technologies have been very important for our lives, for communication, for business, for education.

### INTRODUCTION

Artificial Intelligence (AI) was born at the beginning of the 20th century when Spanish engineer Leonardo Torres Quevedo invented the Telekino (1902), the first remote control device to execute commands transmitted via Hertzian waves. Evolution of scientific and technological know-how have performed an AI that is now one of the most powerful tools endowed with intellectual processes through complex neural networks. AI automation is the core of technologies such as Voice Use Interface (VUI) which allows us to interact with systems through voice or speech commands; the "Cloud" which provides a network of remote servers hosted in internet to process data; Internet of Things (IoT), digital interconnection of computer sensors inserted in everyday life devices. Blockchain that stores data in blocks chained together in chronological order. It is increasingly used in worldwide transactions which can be controlled by any person or group and which entered data are irreversible; Virtual Reality (VR) allows a person to interact with a simulated computer-generated 3D image or scenario using an appropriate electronic equipment. The security of the above electronic neuron systems is crucial since they pose large space and diverse profile opportunities for criminal purposes. Therefore, cybersecurity is of upmost importance to prevent cybercrimes, as AI is advancing.

During the pandemic COVID-19 confinement period, a high number of individuals received thousands of fake news that worsened their psychological/mental health as well as advertisements of counterfeit medicines that supposedly cured from the virus. Many people trusted these counterfeit medicines and were subsequently victims of fraud, swindle, personal data thefts, access to their bank accounts and so on, not to mention derived crimes such an extortion. The high number of these incidents became an issue of law enforcement concern. According to INTERPOL misinformation and malware, together with crimes such as fraud, phishing and hacking attempts, counterfeit medical supplies and medicines increased exponentially during the pandemic.

### EMERGING TECHNOLOGIES AND THE WMD TERRORISM THREAT

Emerging and advancements in technology have brought new security challenges and concerns related to the risks and threats of Weapons of Mass Destruction (WMD) terrorism, namely Chemical, Biological, Radiological and Nuclear (CBRN) terrorism.

All of us are aware that along the history of mankind, technical advances have been used for good purposes and for malicious ends as well. Therefore, it is especially disturbing the fact that users of these technologies might be terrorists and their objective mass destruction. Among technologies analyzed as potential tools for perpetrating a terrorist attack using CBRN agents or materials the following are relevant: 1) Unmanned aircraft systems (UAV), or drones. 2) Big data analytics. 3) Blockchain. 4) Additive manufacturing and 3D printers. 5) Cyberattacks.

UAVs technology has advanced amazingly in the last few years and new capabilities include in-flight automation, visual object recognition and optical sensors able to transmit infrared and nigh vision. UAVs present a double facet: the use for civil, commercial, educational, industrial, medical, agricultural, research, search and rescue, broadcasting, intelligence collection, photography, etc. But also they could be a tool for potential terrorist attacks if used to release CBRN materials, for example, during major events, thus creating a magnified overall fear effect. Also, UAVs swarms could transport CBRN materials. However, UAVs can be positively used in counterterrorism operations, helping to prevent CBRN terrorism. With appropriate detectors they can be used also to recognize CBRN materials and to collect samples for further characterization in CBRN forensics.

Blockchain and data cryptocurrency have been comprehensively explained by our colleagues of George Washington University. Blockchain is growingly used in worldwide economic transactions and favors and stimulate anonymity. Therefore, the negative side of this cryptocurrency technology is that terrorist or non-state actors could use it to buy dual-use items in the black market to assembly any CBR device. One of the positive aspects to the use of blockchain technology is its application to nuclear safeguards information management. The data that has been entered cannot be deleted and therefore they provide at the same time data protection and confidentiality.

Additive manufacturing is a specific 3D printing process and can be used for illegal manufacturing of equipment or components necessary for the production of WMD or their means of delivery. Additive manufacturing was created about 30 years ago but it is presently advancing in several sectors enabling a wide range of design optimization and upgrades to innovations that can only be made additively. The use of 3D analytical manufacturing could be used to counterfeit goods and to steal intellectual property. 3D could produce also in a next future a new generation of high explosives by modifying existing materials. This becomes a significant threat factor to consider in the case of building a Radiological Dispersion Device (dirty bomb) by terrorists. The more powerful the chemical explosive the more spread of ionizing radiation.

Cybersecurity is a critical point in the CBRN area, especially to prevent diversion of material. With respect to nuclear security, facing emerging risks and threats posed by the misuse of new tangible and non-tangible technologies makes essential the updating physical protection sites with nuclear and radioactive materials; human resource development; accounting, control and registry of all materials, and a nuclear emergency preparedness as part of a holistic prevention policy.

Cyberattacks pose threats with varying degrees of severity in terms of its consequences. At Nuclear Power Plants (NPPs), Instrumentation and Control Security systems and Facility Networking Security are being upgraded from obsolescent analog devices to digital systems. Due to the fact that nuclear energy is considered one of the main contributors to carbon-free energy, it is necessary to deeply secure the transition to digital technologies and their interconnectivity. These new threat factors require to critically reinforce the prevention of cyberattacks and the mitigation of inadvertent digital failures in the defense-in-depth security. At current, there are several international centers working on cyber defense applied to for NPPs. For example, US Sandia National Laboratories (New Mexico) are developing the Integrated Cyber-Physical Impact Analysis. Research is also carried out at the Center for International and Security Studies in Maryland. One of the main applications to NPPs is to distinguish whether a cyberattack would have exclusively an internal failure consequence or that it would imply a health public concern.

## THE INSIDER THREAT

Along the history of mankind, insider threat has presented a key point in the commission of crimes that have harmed institutions with serious social consequences. According to the International Atomic Energy Commission (IAEA), insiders present a unique threat for the effective control of nuclear materials because an insider could have access to physical protection elements or other provisions such as the safety systems and operating procedures. The profile of these individuals may vary from a range of characteristics that might motivate their attitude: personal dissatisfaction, resentfulness, sentimental or ideological affinities, or for economic gains. Increasing media platforms, anonymity on-line, smart phones, etc. would easily drive to malicious dissemination of sensitive information.

Several institutions at both national and international levels have issued instruction manuals and best practices to deal with the issue of insider threats and mitigation, as well as how to apply protective measures. Among others, in 2008, the IAEA published the *Preventive and Protective Measures against Insider Threats*, especially focused on nuclear materials and facilities. The US National Threat Task Force published also the *Insider Threat Program: Maturity Framework* and *Protect Your Organization from the Inside Out: Government Best Practices.*

## CONCLUSIONS

Science and technology advancements are crucial for the welfare of mankind, but sometimes they can be used to cause harm and unexpected malicious consequences. One of them are the tertiary effects of technology. Indeed, effects of increasingly emerging technologies might go beyond our hands and escape our own control, being not able to predict their evolution. On the other hand, emerging technologies would alter the tactics of terrorists and non-state actors.

In any case, technology cannot replace complete or totally the human role which can be seen from both positive and non-positive points of views. We must take into account that the weakest link in the security chain is the human factor. In the prevention of WMD terrorism is necessary to pay attention to human behavior, especially in the case of potential insider threat. For this, it is necessary to establish visible security policies to check individual motivation, teamwork interaction and communication and to reinforce active and passive vigilance.

COVID-19 pandemic has been and is being a worldwide bitter experience. We have learnt several lessons for our lives with the use of digital technologies. But we should not forget that the human role will be always at a higher level.

Professor Alexander, thank you very much again for your very kind invitation to this outstanding Forum.

## AMBASSADOR (RET.) CHARLES RAY

Former U.S. Ambassador to Cambodia and Zimbabwe

Thank you Yonah, and thank you for including me. As always, I am in awe at being included on a panel of such distinguished experts in their fields. They have given us some very interesting and informative presentations today.

I would like to briefly mention one issue that has been lightly touched on today but that I think is very important, and that issue is closing the technology gaps that limit our ability to respond effectively to crises such as the COVID 19 pandemic, or climate change or any other mass disaster. And I use the plural gaps deliberately, because in my study I have seen two that I think are very important. One is the gap between the wealthy countries and the poor countries in access to technology that can be used to deal with epidemics, such as the COVID 19 pandemic. And while it has been mentioned that things are being done, I think it was also mentioned that it is just a drop in the bucket. There is much more that that needs to be done and that should be done if we have the political will to do it.

But the second gap is one that really troubles me, and that is the gap between the rapid, almost light speed advances of technology that we have seen in our lifetimes, and the snail's pace at which the human mind is able to understand, accept and effectively use that technology. Unfortunately, that gap is, in my observations over the last 18 months of this pandemic, almost more prevalent in the so-called developed world. We have all seen it in the refusal of people to wear masks or social distance because they thought COVID was a fake, a hoax, and a viral outbreak that really did not exist. Or the refusals to be vaccinated because of the rapid speed at which the vaccines were developed.

I have my own experience when I got my COVID shots at the National Institute of Military Medicine at Walter Reed. The young military medical corps person, the person who checked me in to get my shots, informed me quite bluntly that she was not taking it because she did not trust it. It was developed too fast. Until we address this kind of attitude, we cannot close this gap, this lag between the development of technology and the human mind’s acceptance of that technology. And we will forever be constrained on how to effectively deal with outbreaks like this.

It is clear that we do not learn from history very well. If you study the 1918 influenza pandemic and listen to some of the protests that existed back then, you would think you were listening to the grotesque stuff we have been listening to for the last 18 months. You did not have the anti-vaxxers in 1918 because you did not have a flu vaccine, but I suspect that had the flu vaccine been invented in 1917, there would have been people in 1918 who would have refused to take it.

The other thing that distresses me about this technology gap, this lag between development and acceptance, are the number of people who you would expect to know better, politicians and media organizations, who feed this ignorance, this lack of understanding of technology. It would be easy to say that such people are just ill informed and ignorant if it were not so frightening and if it was not really a matter of human survival that is at stake. There is a saying that ignorance is bliss, but in this case, when a viral disease can start in a remote area of the world and become global in a matter of days, ignorance is deadly.

## V. QUESTION AND ANSWER DISCUSSION

Selected comments by the contributors to this report during the discussion following the presentations. Some of the invited attendees from the United States and internationally participated during this segment.

### DR. DANIEL GERSTEIN

Well, I thought this was a very productive session. I enjoyed hearing both the more general presentations but also some of the specific ones. It's very interesting about aerobiology, and what we got right and what we got wrong. With respect to the public policy guidance that came out, and how that was really problematic in terms of some of the actions and I think that difficulty in giving proper guidance complicates when you then have to tell the public, "Well, what we said before was wrong" and so I think we've got a lot of work to do with strategic communications. I'd be interested to hear from anybody else sees that same issue.

### PROFESSOR DONALD MILTON

Certainly. We have a professor here at the University of Maryland School of Public Health who used to be at CDC and whose focus is on crisis communications. She would argue that CDC was not following the playbook that she helped write many years ago. One of the key things is that you need to be very upfront that 'this is new, we don't know much about it yet, and what we're telling you is the best we've got, we'll tell you more as we learn more.' That caveat must be upfront in the message all of the time. It is important that people have a sense that you are sharing what you know. Now, I guess there's some question when Trump's telling Bob Woodward that he knew that it was airborne and he wasn't telling anybody else, whether that really happened. But it's really crucial in the current environment; the level of distrust that Ambassador Ray was referring to, affects the whole situation. Then starting early in the pandemic there were groups of outside scientists saying hey guys, we know something and it's not being paid attention to. I felt very conflicted about trying to get the message out about what I knew was most likely going on. I could see it right away, looking at CT scans coming from Wuhan in January, and knowing what I know about pulmonary physiology and the physiology of infectious aerosol generation. It was clear to me in mid-January, that this was likely to be airborne. And yet, I didn't want to undermine faith in the CDC, we need the CDC to be right, but even more we need it to be strong, and for people to listen to it. So it's a terrible conflicted situation many of us have been in this year. And that's the point of my talk is how do we convince the medical profession to consider including the possibility of airborne transmission until proven otherwise in the context of highly infectious respiratory viruses.

### PROFESSOR NEIL WASSERMAN

I'm inspired by that comment, and I think one of the lessons learned is perhaps the need to lower the risk of being uncertain, that the CDC is a premier organization, and I think we'll learn how to make it better--how to insulate it from, from political risk. Putting the data forward should not be a political risk. It should be something that's encouraged and applauded. The other issue that I like to highlight is, you know, how do we set up a regime in which strategic decisions are made based upon the best information, that is, how do we make the threats that are actually important, visible and actionable. And I think we'll learn a lot from the COVID experience in that area, and about how we translate that, when necessary, into social behaviors that need to be adopted and practiced on a population-wide basis. I mean, it's a big challenge to learn how to do that better.

### DR. ERIC L. MOORE

I have several questions I wanted to move to the group and comments. But the bottom line is I would just say I agree wholeheartedly with what I am hearing here, and I don't want to be redundant in that regard. One of the areas that I would just kind of ask about is when we talk about strategic communications and getting the right kind of information out – this is for the other panel members – have we learned enough from the 2016 election? Has anyone tracked the social media implications? Were there social media misinformation campaigns that went on that also impacted our response to COVID? I think we learned a lot from the 2016 election, but when we look at our response as a nation, what if there was a concerted effort by some of our adversaries to discredit some of the momenta and to create disbelief in our systems and the communications coming from our health care profession? Just a thought, just a question.

### AMBASSADOR [RET.] CHARLES RAY

I would like to take a stab at that, not as an expert, but as someone who was in government for 50 years. It is true that we had a problem with our adversaries attempting to undermine faith in our political system and our system writ large. And that is bad, but we also had what our distinguished Spanish colleague described as the insider threat. We had people who were part of the system, who in many cases were deliberately attempting to undermine faith in that system for political advantage. I do not think that there is an instant solution to this problem. It is a matter of looking at how we educate people to think about and evaluate the information they get.

If we are going to remain a democracy with freedom of expression, we need to equip people to do their own evaluation and look at it carefully. Unfortunately, I do not see a short-term answer to that because we have directly and irrevocably lost the ability to do so in terms of the adult generations. In this country, they are divided into two herds, with one herd milling around in a circle and the other herd heading for a cliff.

### PROFESSOR COSTIS TOREGAS

I'd like to also build on that if I can. There are two things going on here:

One is the recognized gap between what science can do and what policy and law is understanding and can empower science to do. That's number one, and that's been the case for many, many decades that science and technology runs ahead, and then laws have to catch up, and the ways that governments react have to catch up.

The second thing is the function of communication in work that helps the United Nations system. We are emphasizing the role the communications function between science and policy. How do you engage the scientists, but also people other than the scientists. We have to become a little bit more generous and get in the voices of others, whether it is people who are in government, people who are at the neighborhood level, or individual household level.

We have to engage an expanded number of stakeholders in the debate because there is no longer an absolute truth to anything. We have to be able to listen to each other, and then shape communication messages that are, in fact, representative of a variety of views. It is not to say that science doesn't have the best view, but it is still a view. So I'd like to beg my colleagues on the science side, to understand that listening to those who are impacted by what we know is vital to our ability to convince them of our truth.

### PROFESSOR YONAH ALEXANDER

We have to end our Forum at this point. I invite our distinguished members of the audience to kindly consider sending us their questions and we can continue the dialogue that way. On behalf of our colleagues at the Potomac Institute for Policy Studies and the International Law Institute, I would like to thank our speakers again for their very rich contributions. Hopefully, we can, however modestly, advance our work in this very important area of public concern.

## VI. ABOUT THE EDITORS

**PROFESSOR YONAH ALEXANDER** is the Director of the International Center for Terrorism Studies (at the Potomac Institute for Policy Studies) and the Inter-University Center 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 the 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 a US 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

**DR. JENNIFER BUSS** earned her B.S. in Biochemistry with a minor in Mathematics from the University of Delaware, and a Ph.D. in Biochemistry from the University of Maryland. She has served as Assistant Vice President, Vice President, then in 2018, was promoted to President of the Potomac Institute. Since joining the Institute as Senior Fellow in 2012, Dr. Buss has written and won numerous proposals, created several new centers and is in charge of all day-to-day business and operating functions of the Institute.

**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 scientist 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. DANIEL GERSTEIN** s a Senior Policy Researcher at the Rand Corporation and Former Acting Undersecretary and Deputy Undersecretary in the Science and Technology Directorate, Department of Homeland Security (2011-2014). Dr. Gerstein has extensive experience in the security and defense sectors in a variety of positions while serving as a Senior Executive Service (SES) government civilian, in uniform, and in industry. Before joining DHS, he served as the Principal Director for Countering Weapons of Mass Destruction (WMD) within the Office of the Secretary of Defense (Policy). In uniform, he has served on four different continents participating in homeland security and counterterrorism, peacekeeping, humanitarian assistance, and combat in addition to serving for over a decade in the Pentagon in various high level staff assignments. Following retirement from active duty, Dr. Gerstein joined L-3 Communications as Vice President for Homeland Security Services, leading an organization providing WMD preparedness and response, critical infrastructure security, emergency response capacity, and exercise support to U.S. and international customers. Dr. Gerstein graduated from the United States Military Academy at West Point and has masters degrees from Georgia Institute of Technology in Operations Research, the National Defense University in National Security & Strategic Studies and the Command & General Staff in Military Arts & Sciences and a PhD from George Mason University in Biodefense. Dr. Gerstein's latest book is titled, The Story of Technology: How We Got Here and What the Future Holds (October, 2019).

**PROFESSOR DONALD K. MILTON, MD, DRPH** is a Professor of Environmental Health at the University of Maryland School of Public Health, with a secondary appointment in the University of Maryland School of Medicine's Department of Medicine. An internationally recognized expert on the aerobiology of respiratory viruses, Dr. Milton developed the concept of using indoor CO2 to directly measure rebreathed air and airborne infection risk. He is the Principal Investigator of the UMD StopCOVID study (investigating SARS-CoV-2 transmission) and of the newly NIH-funded Evaluating Modes of Transmission (EMIT-2) study, a 5-year $15 million UMD-UMB collaboration to perform randomized controlled trials that will define the modes and mechanisms of influenza transmission.

Dr. Milton graduated from University of Maryland, Baltimore County with a Bachelor of Arts in Chemistry in 1976 and obtained his Doctor of Medicine from Johns Hopkins University in 1980. He went on to obtain his Master of Occupational Health and Doctor of Public Health from the Harvard School of Public Health in 1985 and 1989, respectively.

**DR. COSTIS TOREGAS** teaches courses in Public Private Partnerships and IT as Empowerment for Public Administrators. He is the Director of the Cyber Security and Privacy Research Institute at The George Washington University, where he manages and conducts research projects in cybersecurity. His research interests include workforce development, the role of insurance in cyber risk management, and exploring a fuller utilization of Community Colleges in the cybersecurity work force strategies. He is a Senior Advisor & Director, Scholarship for Service (SFS) Four-Year to the National CyberWatch Center.

He has led the non-profit Public Technology Inc. organization for more than 35 years, advocating the creation and deployment of new innovative technologies for local governments in partnership with the private sector, and has lectured extensively in 6 continents about the impact of the digital age on government. Professor Toregas also serves as the IT Adviser to the County Council of Montgomery County, MD, overseeing the investment of $230m annually in Information Technology goods and services. He is a fellow of the National Academy of Public Administration, and the immediate past chair of its standing panel on Social Equity in Governance. He has a Ph.D, Environmental Systems Engineering from Cornell University, M.Sc, Environmental Systems Engineering from Cornell University, and B.Sc, Electrical Engineering from Cornell University.

**DR. NEIL WASSERMAN** is an Adjunct Professor in Computer Science at The George Washington University. As a consulting services manager and systems engineer, Wasserman has been involved with IT strategic planning, enterprise architecture, systems analysis, IT governance and software implementation for 25 years. Following his A.B. degree in physics at Cornell, he studied graduate physics at Cornell and MIT and received a doctorate in the History of Science at Harvard. Wasserman then worked as a Research Associate at Harvard Business School, authoring several teaching cases and research papers, and a book on technical innovation. His current work focuses on the connection between social behavior change and risks associated with chronic disease.

**DR. ERIC L. MOORE** is the Director of the CCDC Chemical Biological Center. Dr. Moore has energized technology transfer (T2) at the U.S. Army Combat Capabilities Development Command Chemical Biological Center (CCDC CBC) since his appointment as director in late 2017. He contributes in-depth understanding of T2 needs from his decades of federal service to counter potential chemical, biological, radiological, nuclear, and explosive (CBRNE) threats to national security and public safety. Prior to this role, Dr. Moore had already built an impressive career of both educational and professional achievements, with a long list of CBRNE-linked activities that undoubtedly inform his deft leadership of the Army laboratory and its technology transfer efforts.

With a Ph.D. in neurophysiology, Dr. Moore began his meritorious federal service in 1992 as a principal investigator on bio-weapon countermeasures at the U.S. Army Medical Research Institute of Chemical Defense. Additional positions as director of the Army's Forensic Toxicology Drug Testing Laboratory, senior officer with the Defense Intelligence Agency, and senior science and technology manager for chemical medical countermeasures in the Defense Threat Reduction Agency (DTRA) preceded his move in 2016 to director of CBC's Research & Technology Directorate. Collectively, these experiences reinforced Dr. Moore's commitment to the crucial technology transfer of Army innovations to best achieve field-ready products.

**PROFESSOR NATIVIDAD CARPINTERO-SANTAMARIA** is a Professor of Energy Security at the Universidad Politécnica de Madrid (UPM) (Polytechnic University of Madrid); Department of Energy Engineering at the Escuela Técnica Superior de Ingenieros Industriales (ETSII) (Industrial Engineering College) / Universidad Politécnica de Madrid (UPM) (Spain). 2)

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**U.S. AMBASSADOR [RET.] CHARLES RAY** served 30 years in the Foreign Service (from 1982 to 2012), after completing a 20-year career in the U.S. Army. His Foreign Service assignments were Guangzhou and Shenyang, China; Chiang Mai, Thailand; PM bureau/ DCM in Freetown, Sierra Leone; Consul General in Ho Chi Minh City, Vietnam; ambassador, Phnom Penh, Cambodia; Diplomat in residence, University of Houston; deputy assistant secretary of defense for POW/Missing Personnel; and ambassador, Zimbabwe. He has a B.S. from Benedictine College, Atchison, KS; an M.S. from the University of Southern California; and an M.S. the National War College. He's also a graduate of the U.S. Army Command and General Staff College, the Army War College's Land Forces Commander Course, and the Defense Intelligence School's Postgraduate Intelligence Course.