Global Forum on Scientific Advances Important to the BWC

JOHNS HOPKINS CENTER FOR HEALTH SECURITY

Global Forum on Scientific Advances Important to the Biological & Toxin Weapons Convention

Held in conjunction with the 2018 Meeting of States Parties to the Biological & Toxin Weapons Convention

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EXECUTIVE SUMMARY

On December 3, 2018, the Johns Hopkins Center for Health Security convened the first annual Global Forum on Scientific Advances Important to the Biological and Toxin Weapons Convention, coinciding with the 2018 Meeting of States Parties to the Biological and Toxin Weapons Convention (BWC MSP) in Geneva, Switzerland. The forum had 2 purposes: (1) to inform States Parties' delegations of cutting-edge biological capabilities, including the ability to engineer pathogens or more complex organisms, and (2) to build awareness of and support for international bioweapons nonproliferation norms among the scientific community. Advanced biology, engineered pathogens and other organisms, and accidental biological threats as sources of risk are of great concern to international biological nonproliferation regimes such as the BWC.

The Global Forum aimed to facilitate engagement between scientists and international policymakers to identify mutual challenges and potential solutions to deter and prevent the deliberate and accidental misuse of biology. There is often little direct interaction between policymakers and the scientific community on these issues, which has resulted in insufficient awareness among scientists about the BWC and its associated norms and insufficient awareness among policymakers regarding emerging biological risks, particularly in the context of advanced biological capabilities and industrial or commercial applications of biotechnology and dual-use science. Substantive engagement and discussion on the potential benefits and risks of emerging and advanced biology and the impacts of associated policies will ideally foster a more comprehensive understanding of these complex issues on both sides.

One of the guiding principles of the inaugural Global Forum was to ensure participation from a highly international, intergenerational, and multidisciplinary group of attendees, representing both the cutting edge of biological research and the international diplomatic and policy community. As an independent entity from the BWC, the Johns Hopkins Center for Health Security is able to identify leaders from across the scientific and policy communities and bring them together with BWC delegations in an open and collegial setting to facilitate engagement on critical and complex issues that might not occur otherwise. The Global Forum consisted of a series of expert panels and speakers that discussed recent, current, and future biological capabilities that are of concern to the BWC, either because they could potentially be misused or because they could provide benefit to the BWC and strengthen bioweapons nonproliferation norms.

The Global Forum was hosted immediately prior to the 2018 MSP with the hope that it would encourage the participation of States Parties' delegations already in Geneva for the MSP and facilitate engagement by scientists at the MSP events that followed. Global Forum attendees

represented States Parties from around the world, including all 3 Regional Groups, as well as a broad scope of international, intergovernmental, and nongovernmental organizations. In addition to the formal panels and presentations, the Global Forum scheduled ample time for informal discussions between sessions and after the meeting to encourage further conversation between the participants and delegates on issues of importance to the BWC.

The Global Forum will be an annual event in which BWC delegations and scientists can plan on participating for years to come. Ultimately, the Global Forum serves as a mechanism to illuminate technical and policy challenges posed by rapidly advancing biological capabilities and facilitate engagement between scientists and policymakers in order to identify potential solutions to deter and prevent the deliberate and accidental misuse of biology.

His Excellency, Ambassador Ljupčo Jivan Gjorgjinski, Chair of the 2018 BWC Meeting of States Parties, delivers the opening remarks at the 2018 Global Forum on Scientific Advances Important to the BWC.

BACKGROUND

The need to facilitate engagement between the science and policymaking communities on challenges facing biological weapons nonproliferation became starkly evident in light of a series of recent organizational and funding struggles faced by the Biological and Toxin Weapons Convention (BWC). Since the 6th Review Conference, the intersessional process (ISP) has consisted of Meetings of Experts (MXs) and Meetings of States Parties (MSPs) held each year to facilitate engagement on priority technical and policy issues, respectively, for the purpose of reinforcing and advancing the norms against biological weapons between the Review Conferences that are held every 5 years. The 8th Review Conference, however, failed to reach an agreement on the format or substance of the 2017-20 ISP, jeopardizing ongoing engagement on complex issues such as emerging capabilities stemming from advances in biology and biotechnology. The issue of the ISP was tabled until the 2017 MSP, in hopes that an agreement could be reached to salvage a program of work for the remaining years leading up to the 9th Review Conference in 2021.

Fortunately, there was a positive outcome at the 2017 MSP and an agreement on a program of work for 2018-20, including multiple MXs and a MSP for each year. The MXs typically focus on scientific and technical issues more so than the MSPs; however, the experts engaging in the MX proceedings either represent or are invited by States Parties' delegations. Additionally, many States Parties do not dedicate sufficient resources to the BWC to enable them to bring experts to the MXs, leading to limited opportunities for the broader scientific community to engage in BWC proceedings and, therefore, limited discussion and understanding of the state of biological capabilities and their implications for the BWC. The Global Forum was scheduled to immediately precede the 2018 MSP in order to increase the potential for direct engagement between the invited scientists and delegations attending the MSP.

The concept of the Global Forum grew out of the necessity to simultaneously inform policymakers of emerging and future biology and biotechnology capabilities in order to facilitate progress on policies to mitigate the associated risks and raise awareness of the BWC within the scientific community in order to build support for bioweapons nonproliferation norms at the operational level. Ultimately, this engagement is designed to provide technical input into policy discussions with the goal of developing international policies that promote the responsible use of biology.

MEETING OVERVIEW

The format for the Global Forum included a series of panels, each addressing a critical aspect of the potential benefits and risks associated with advances in biology and biotechnology. Each panel was followed by a period of questions and discussion to further facilitate engagement between the BWC delegations, scientists, and other experts and policymakers. The BWC MSP Chair, His Excellency Ambassador Ljupčo Jivan Gjorgjinski from the Former Yugoslav Republic of Macedonia, opened the meeting, emphasizing the importance of the issues covered in the meeting and engagement (remarks in Appendix A). A keynote address was delivered by Dr. Jason Matheny, former director of the US Intelligence Advanced Research Projects Activity (IARPA), who implored participants and the scientific and policy communities more broadly to become "gigaheroes" for biological weapons nonproliferation, referring to saving lives on the order of billions of people (remarks in Appendix B).

The first panel of the day focused on the cutting edge of biology, discussing the current state of capabilities as well as their potential positive and negative effects on the BWC. Zhang Weiwen, Dean of Tianjin University's Center for Biosafety Research and Strategy in China, discussed the current landscape and challenges associated with synthetic biology, including the potential to increase existing economic and biological disparities, priority targets for research, and the absence of effective oversight and regulation globally. Lucas Cespedes, from SENAI Innovation Institute of Innovation Management in Brazil, provided insight into the current role of synthetic biology in research and industry in Brazil as well as ongoing efforts to establish domestic gene synthesis capacity and to reduce existing barriers to expanding these capabilities nationwide. Patrick Boyle, the Head of Design for Gingko Bioworks, described emerging parallels between computer science and biology, specifically noting the role of automation in the rapidly growing scale-up efficiency in biology and the need to proactively implement biological analogues to cybersecurity as capabilities advance.

The second panel built on that foundation, providing context on historical efforts to incorporate science and technology into the BWC and its role in establishing international bioweapons norms. Jo Husbands, from the US National Academies of Sciences, Engineering, and Medicine, discussed the importance of directly engaging with scientists on science policy, including an overview of recent efforts by the InterAcademy Partnership (IAP) and regional BWC engagement through support from the European Union. Lela Bakanidze, Chair of the International Federation of Biosafety Associations Board of Directors, provided insight into Georgia's efforts to raise awareness of biosafety and biosecurity challenges in the context of dangerous pathogens across multiple stakeholder groups, ranging from children to university students to senior scientists. Piers Millett, from the Oxford University Future of Humanity

Institute (FHI) and International Genetically Engineered Machines (iGEM) competition, addressed horizon scanning efforts to identify future capabilities and threats through international fora such as the International Committee for the Red Cross/Red Crescent and the BWC as well as nongovernmental and academic efforts, such as those at academic institutions like FHI and private organizations like Biosecu.re and iGEM.

The third panel looked to the future to examine forthcoming biological capabilities and envision potential risks and opportunities for the biological sciences to aid in BWC implementation. Vitor Bernardes Pinheiro, from the Rega Institute for Medical Research at Katholieke Universiteit Leuven in Belgium, addressed the incredible power of synthetic biology, xeno-nucleic acids (XNA) and the possibility of orthogonal biology, and potential technical mechanisms for regulation of advanced biology. James Diggans, Director of Bioinformatics and Biosecurity at Twist Bioscience, discussed the future of gene synthesis and the synthetic biology supply chain more broadly, touching on efforts to scale up production capacity, the challenges of screening for potentially dangerous requests, and innovative uses for DNA. Poh Chueh Loo, from the National University of Singapore, addressed a range of emerging and future capabilities in synthetic biology, such as biosensors and light-sensitive gene expression, noting the potential benefits as well as potential risks, including novel production pathways for toxins.

In the fourth and final panel, experts discussed outstanding challenges for the BWC and ways to leverage current and future advances in biology and biotechnology to support the BWC and international bioweapons nonproliferation efforts. Oshiorenoya Agabi, the founder and CEO of Koniku Inc., highlighted their platform for synthetic olfactory sensors and their potential role in detecting airborne biological contaminants. Filippa Lentzos, Senior Research Fellow at Kings College London, addressed the need to develop products and capabilities that make bioweapons less appealing, the effects of advanced biology on other scientific fields, and the importance of evaluating biological capabilities in the context of broader social, economic, and political environments. Finally, Vlada Pashynska, from the Science and Technology Centre Ukraine, provided an overview of efforts to integrate scientists with WMD expertise into legitimate biological research and to raise awareness of bioweapons norms as a means of mitigating the risk of nefarious use of biology as well as ongoing national and regional biosafety, biosecurity, and bioethics training programs.

This inaugural Global Forum on Scientific Advances Important to the BWC illustrated the tremendous interest by both States Parties and scientists to initiate and sustain dialogue on future biology and biotechnology capabilities, associated risks, and their potential role in supporting international bioweapons nonproliferation norms.

APPENDIX A: WELCOME REMARKS FROM AMBASSADOR LJUPČO JIVAN GJORGJINSKI, MSP CHAIR

Thank you for the invitation to attend this first annual Global Forum on Scientific Advances Important to the Biological & Toxins Weapons Convention. I applaud the Johns Hopkins Center for Health Security for organizing this meeting. The Center is a world leader in examining how scientific and technological innovations can strengthen health security. The Center operates an amazing range of activities, from meetings such as this, to the Emerging Leaders in Biosecurity Initiative—and several ELBI Fellows are here this week—to exercises such as the recent Clade X tabletop exercise and dialogues with countries from different regions around the world.

Today you will consider issues that are vital, not just for the BWC itself, but also for international peace and security, and perhaps even for our future survival.

A recent conference—which was also co-organized by the Center for Health Security—concluded that "high-impact bio-threats have the potential for global catastrophic, population-wide consequences, and urgent actions on a global scale are needed to mitigate the consequences posed by them." This threat is taken seriously by those of us here in Geneva who work on the Biological Weapons Convention, as is the urgent need for global action to mitigate the consequences. I was pleased that the report of the conference referred to the pressing need to strengthen the BWC.

It is therefore highly appropriate that you are meeting here in Geneva on the eve of the 2018 Meeting of States Parties to the BWC. As most of you know, the BWC was the world's first multilateral treaty to ban an entire category of weapons of mass destruction. While subsequent treaties covering other WMD have incorporated robust verification systems, the BWC remains a bulwark against the hostile use of biology. No country today even publicly admits to possessing biological weapons, let alone having them as part of its military strategy.

However, we cannot take this situation for granted. Norms that we thought were strong can be undermined before our eyes. Without an autonomous international organization to address this issue, it is incumbent upon the BWC's States Parties to work together to uphold the BWC.

Turning to the subject of this global forum, we also need to maintain our vigilance with respect to advances in science and technology that are relevant to the BWC. During this meeting, you will hear from a world-class and regionally diverse group of experts about the cutting edge of biology and current and historical approaches to addressing scientific advances.

We had similar discussions here in August in the context of the BWC's Meeting of Experts on science and technology, ably chaired by Pedro Dalcero of Brazil. This Meeting of Experts, which

meets for 2 days every year, is currently the main mechanism within the BWC for maintaining vigilance over scientific advances. However, we have to be honest: 2 days of meetings per year is not sufficient in the face of the dramatic and accelerating pace of advances in the life sciences.

It is therefore essential that experts also come together informally in meetings like this and the recent one I referred to earlier. It is also vital that such meetings take place at a regional level, as has been the case over the past 12 months with regional workshops on science and technology funded by the European Union.

I am also pleased to see that this global forum will also discuss the "positive role" of advanced biology. Scientific advance is not something that we should fear; instead, we should celebrate it. Without scientific advances our world would be a very different place. We should not see science and technology as an existential threat. Instead, scientific advances are to be harnessed and used for the good of humanity. We will not be able to achieve the Sustainable Development Goals without the contribution of science and technology.

At the same time, we should not remain blind to the possibility that science and technology may indeed enhance existing divides and empower further the already powerful. Power is always relational, which means that the less powerful may consequently become even less powerful.

Advances in the life sciences can help combat infectious diseases, enhance food security, and alleviate poverty around the world. But they may also lead to less diverse natural biosystems that will not be as resilient as a system that is diverse.

We cannot un-invent these advances, nor should we. We cannot simply ban new technologies or keep them limited to a small number of countries. We need to all work together and think together—across our traditional boundaries and silos—to come to consensus agreements on how to manage such advances, while taking account of ethical, environmental, legal, economic, societal, and, of course—as in the framework of today's event—security implications. For these security implications, trust and balance are key. The BWC provides a framework for maintaining trust and keeping an informed balance. We must remain mindful of this and of how new advances in science and technology might influence both.

Only in this holistic way, based on awareness and education, can we hope to use the huge potential presented by scientific advances for the benefit of humanity, and at the same time uphold the norm enshrined in the BWC.

I would like to once again thank the Johns Hopkins Center for Health Security for organizing this meeting, and I wish you all stimulating discussions today and look forward to reading the outcomes of your deliberations.

APPENDIX B: JASON G. MATHENY KEYNOTE ADDRESS

It's a privilege to be here and for me to make a small installment in my lifelong debt to the Center for Health Security, whose work and staff I so admire. I'm going to talk for 30 minutes about my experience in the US intelligence community worrying about biological weapons and share some thoughts about safely navigating the next couple decades of biological risks. Then I hope to leave 30 minutes for discussion.

I started my career in global health, working on malaria, HIV, and tuberculosis in South Asia. Then in 2002, the first virus was synthesized from scratch, and with that milestone, I became convinced that the misuse of emerging biotechnologies would pose one of the most serious risks to global security during the 21st century. So I moved from traditional public health to biosecurity. I was fortunate enough to have cold-called the Center for Health Security, which took pity on me and gave me a job to learn about biorisks and how to address them through sound policy. A few years later, I was lucky enough to spend time at the Future of Humanity Institute at Oxford University, also represented here by their talented researchers, who consider long-term challenges facing the world. And then, in what seems in retrospect like a highly improbable career move, I went to work for the US intelligence services. I entered with the hope of improving our intelligence on biological threats, and during my last post, I ran the Intelligence Advanced Research Projects Activity, or IARPA, which develops new technologies for the intelligence agencies—sort of like Q Branch from the James Bond movies but not as dapper. IARPA occupies an unusual place in the intelligence services, as it spends part of its time assessing technologies that could pose threats to national and global security and the rest of its time addressing those threats by developing other technologies. This leads to a conflicted attitude toward technology as both the cause and cure for risk. And having recently left IARPA, I feel like I should have taken a sabbatical on an Amish farm. After spending 10 years at IARPA worrying about various ways in which the world could break, I want to share some of my worries related to biological weapons.

Even without the application of human creativity, biology can be highly threatening. A century ago, a single influenza virus caused more than 50 million deaths during a 12-month period, ranking as the most severe loss of life in human history, including all wars and disasters. As deadly as natural pathogens can be, prior biological weapons programs in the Soviet Union and in the United States demonstrated that human ingenuity can produce pathogens that are more deadly than their natural counterparts. A challenge for the future is that improvements in biotechnologies will make traditional and enhanced biological weapons broadly accessible—they will no longer require national-level efforts.

As described this morning, the cost of DNA synthesis has decreased by a factor of 1,000 over the last 15 years, while the cost of sequencing has decreased by a factor of 100,000. And the costs

continue to decrease. Coupled with the introduction of efficient gene editing methods, these tools can be used to build microbiological factories for making small things in large numbers. One can instruct the factories to produce beneficial things, like medicines, fuels, food, textiles, and catalysts. Or one can instruct the factories to produce destructive things, like viruses and toxins.

Unfortunately, the economics of biotechnology seems to favor offense over defense. As one example, the 2016 synthesis of horsepox virus cost $100,000 using commercially available equipment and materials. Synthesizing the smallpox virus is not believed to require substantially more money. Meanwhile, a new defensive vaccine costs more than $1 billion to develop. Offense has a 10,000-fold cost advantage over defense, and the advantage has been increasing over time as synthesis costs decrease while medical countermeasure development costs increase. There are more ways to kill people than there are to keep people alive. Of the possible arrangements of atoms, a small fraction of the arrangements are conducive to human life, so making stuff that kills is generally cheaper than making stuff that saves.

Even with effective distribution of medical countermeasures, a smallpox outbreak in the world today would kill millions of people. So a weapon with the destructive potential of multiple hydrogen bombs may now be accessible to a single biologist prepared to spend a few years of his savings. This is unique in the history of global security. Previously, weapons of mass destruction had been monopolized by nation-states that could mobilize billions of dollars and thousands of scientists and engineers. Today, a single person can kill millions. I'm generally optimistic about humanity, but in a world with 7 billion people, there are at least a few who want to derail civilization due to their psychiatric disorders, apocalyptic beliefs, or secular goals, such as reducing human population sizes to limit environmental pressures. I went to college with a few such people, and maybe some of you did, too. Biotechnologies will allow the misguided and the foolish to cause global catastrophes on a scale that is unprecedented.

As worrying as the prospect of a lone wolf is, I remain just as concerned about state biological weapons programs. We frequently underestimate the extent of biological weapons programs because these programs no longer make strategic sense to us. The conventional view is that biological weapons pose the risk of collateral damage to a country's own citizens, so they are less valuable than other weapons that can be precisely targeted. This view doesn't assign enough weight to the political, institutional, and technical incentives for bioweapons programs. To give one example, the US bioweapons program defied modern strategic sense, but it was well funded and staffed until its end in 1969. It was driven by political concerns about falling behind the Soviet program, institutional concerns about having unemployed bioweapons engineers, and technical concerns about what foreign labs might discover through their own research that we believed could be assessed only by being just as creative. We see all these motivations in today's bioweapons programs, and if you put hundreds of bright biologists onto the challenge of inventing new ways of killing large numbers of people, they generally succeed. This is not to

malign biologists—the US bioweapons program was led by scientists who believed they were serving critical national missions. No doubt the same is true of biologists working in bioweapons programs today, which makes biosecurity in large part a social science problem.

I joined the intelligence community 10 years ago with the hope of improving intelligence on bioweapons programs. This is difficult. Biotechnologies typically lack signatures that distinguish malicious from benign research. Relevant knowledge and materials are widely accessible, and tracking either is difficult. Most key intelligence questions come down to assessing intent, which is hard when clear statements are rarely made in intercepted communications, even when they're part of national weapons programs.

Then there are biorisks that have nothing to do with intent, such as unsafe lab practices. In the US intelligence services, we are increasingly worried about accident risks. In 1979 at the Soviet Sverdlosk bioweapons lab, a filter was incorrectly installed, leading to an accidental release of anthrax. The world is lucky that the release didn't involve one of the modified smallpox viruses developed by the Soviet program. An important question for biosecurity in the 21st century is: How do we ensure that klutzes correctly install air filters?

I don't know that we'll solve the problem of klutzes, but at IARPA, we have been working to improve intelligence on some of these problems. Most of what IARPA funds is unclassified research in university labs and small companies around the world, because that's where most of the new ideas come from. I'll describe a few IARPA programs where scientists and technologists, some in this room, have contributed to biosecurity:

- One IARPA program, called FunGCAT, has developed tools to screen sequences intended for DNA synthesis to assess whether a novel sequence is one we should worry about.

- The FELIX program is developing new methods for bioforensics to detect engineered organisms and tell us something about how those organisms were developed.

- The OSI program detects outbreaks weeks faster than traditional epidemiological surveillance by looking at indicators of illness in social media, web search queries, overhead imagery of health facilities, mobile phones staying home instead of going to work, or even people cancelling their dinner reservations.

- The SILMARILS program has developed an infrared laser that can identify chemical residues on surfaces hundreds of meters away.

- The MAEGLIN program is developing a very low-powered mass spectrometer that can be left behind to phone home if it detects something bad, such as effluent from a bioweapons facility.

- The BRITE project is funding a series of experiments at biolabs to identify methods for increasing whistleblowing by laboratory personnel. The first people who know about mischief or unsafe behavior in labs are usually not the intelligence community or any government agency but, rather, coworkers. How can we increase the likelihood that a coworker will say something if they see something?

That's some of what IARPA is pursuing, but we know it's not nearly enough. Among the technologies we will need for the future are revolutionary improvements to diagnostics that can provide continuous monitoring for disease states in humans and animals; sensors that can monitor for disruptions to key agricultural and environmental organisms; improvements to drug and vaccine development—such as systems that can produce new countermeasures in days or hours as opposed to months or years; and approaches that make safety and security intrinsic to engineered systems, making misuse substantially more costly and accidents substantially less likely. We need many more smart people to solve these problems. So, I'm deeply grateful to the scientists and engineers here today and to the policymakers who help to fund them.

I want to close with a few suggestions:

1. For the scientists here, please take a more active role in advising your government about trends in the life sciences and potential new vulnerabilities. Please also consider applying for funding from IARPA and DARPA so that you can help us build the technologies we need to improve biosecurity. Most of our programs have no limitations on citizenship.

2. For the policy professionals in the room, please make biosecurity a greater priority. Seek out and build connections to the technical community, and advocate for national policies that build more support for the world's biological nonproliferation regime.

3. If you work for a national funding agency, put more money into biosecurity research. We need a broad range of investments, including in diagnostics, sensors, medical countermeasures, bioforensics, and attribution. The Center for Health Security has recently published a great report titled Technologies to Address Global Catastrophic Risks. If you're looking for technologies to support, I recommend reading their report.

4. Fourth, I suggest that everyone spend more time thinking about the worst possible outcomes. Humanity is resilient, and we've made it through many tragic events. But here's a list of events that killed at least 50 million people, in total, and/or killed at least 5 million per year:

- Antonine Plague (smallpox) killed 5 million people per year (year 175).
- The Plague of Justinian (bubonic plague) killed 10 million people per year (year 500).
- The Black Death killed 65 million people over 2 decades (1350).
- The American epidemics (smallpox, measles, Mapucho virus) killed 5 million people per year (1545).
- World War I killed 20 million people over 4 years (1914).
- The 1918 influenza pandemic killed more than 50 million people in just 1 year, which as I mentioned earlier makes it the single most intense mortality event in human history.
- World War II and the Holocaust killed 50 million people over 7 years (1939).
- The Great Leap Forward killed 30 million people over 4 years (1958).

These are the highest mortality events in human history. As a species, we've managed to recover from events that killed as much as 15% of the human population. What sorts of events would we not recover from? I suggest spending at least 5% of your time thinking about such events, even if they are low-probability. The expected value of reducing the probability of 1 billion deaths by one-one-thousandth is 1 million lives saved. We might neglect these risks because it's repugnant to think about events that involve the deaths of billions of people. But because such catastrophic biorisks have received little attention, there might be important risks that we've ignored, and there might be opportunities to cost-effectively address them.

5. My fifth suggestion is to be a "gigahero." The 20th century had some "megaheroes"—people who were responsible for saving at least a million lives. People like Norman Borlaug and D. A. Henderson were megaheroes. But in the 21st century, we'll need gigaheroes—people who are responsible for saving a billion lives. I predict that some of you in this room will prevent a global biological catastrophe and achieve the rank of gigahero.

6. My last suggestion to all of you potential gigaheroes is to take advantage of our time together. Find out what people here are working on, and identify projects on which we can collaborate to improve humanity's odds. If we can safely navigate the next few decades of progress in biotechnology and harness its benefits while avoiding its risks, it will be owed in large part to the work that you do.

Clockwise from Top Left: Plenary session at the 2018 BWC Meeting of States Parties; Oshiorenoya Agabi delivers his presentation during Session #4 on leveraging science and technology to benefit the BWC; Global Forum presenters Patrick Boyle and Piers Millett engage with event attendee Kenneth Oye (Massachusetts Institute of Technology) between sessions; Jo Husbands delivers her presentation during Session #2 on historical approaches to addressing science and technology in the BWC; audience question and answer period during Session #1 on the cutting edge biology capabilities; and Patrick Boyle delivers his presentation during Session #1.

APPENDIX C: 2018 GLOBAL FORUM AGENDA

0930 Welcome Remarks

His Excellency Ambassador Ljupčo Jivan GJORGJINSKI, Chargé d'Affaires of the Former Yugoslav Republic of Macedonia and Chairman of the 2018 Meeting of the States Parties to the Biological and Toxin Weapons Convention

0945 Session #1: *The Cutting Edge of Biology: What is the current state of capabilities, and what are the impacts on the BWC?*

Moderator: **Gigi GRONVALL**, Senior Scholar, Johns Hopkins Center for Health Security

Panelists: **ZHANG Weiwen**, Dean, Center for Biosafety Research and Strategy, Tianjin University, China

Lucas CESPEDES, Consultant, SENAI Innovation Institute of Innovation Management, Brazil

Patrick BOYLE, Head of Design, Ginkgo Bioworks, United States of America

1100 Coffee/Tea Break

1130 Session #2: *What are the current and historical approaches to addressing advancements in science and technology and their impact on the BWC?*

Moderator: **Anita CICERO**, Deputy Director, Johns Hopkins Center for Health Security

Panelists: **Jo HUSBANDS**, Senior Project Director, Board of Life Sciences, US National Academy of Sciences, Engineering and Medicine

Lela BAKANIDZE, Chair, Board of Directors, International Federation of Biosafety Associations, Georgia

Piers MILLETT, Director of Safety and Security, International Genetically Engineered Machines Competition (iGEM), and Senior Research Fellow, Future of Humanity Institute, University of Oxford, United Kingdom

1230 Lunch

1330 Keynote Address

Jason MATHENY, Former Director, Intelligence Advanced Research Projects Activity (IARPA), Office of the Director of National Intelligence, United States of America

1440 Session #3: *Looking to the Future: What capabilities can we expect of advanced biology that could play a positive or negative role in the BWC and bioweapons nonproliferation norms?*

Moderator: **Nancy CONNELL**, Senior Scholar, Johns Hopkins Center for Health Security

Panelists: **Vitor BERNARDES PINHEIRO**, Associate Professor, Rega Institute for Medical Research, Katholieke Universiteit Leuven, Belgium

James DIGGANS, Director, Bioinformatics and Biosecurity, Twist Bioscience, United States of America

POH Chueh Loo, Associate Professor, National University of Singapore

1540 Coffee/Tea Break

1610 Session #4: *How can we leverage science and technology to strengthen the BWC?*

Moderator: **Zalini YUNUS**, Science and Technology Research Institute for Defence, Ministry of Defence, Malaysia

Panelists: **Oshiorenoya AGABI**, Founder and CEO, Koniku Inc., Nigeria

Filippa LENTZOS, Senior Research Fellow, Kings College London, United Kingdom

Vlada PASHYNSKA, Senior Specialist and Project Coordinator, Science and Technology Centre Ukraine

1725 Closing Remarks: The Importance of Continued Dialogue

Gigi GRONVALL, Senior Scholar, Johns Hopkins Center for Health Security

1730 Closing Reception

APPENDIX D: SPEAKER BIOGRAPHIES

Oshiorenoya E. AGABI, PhD

Oshiorenoya Agabi is the founder and CEO of Koniku, Inc. Dr. Agabi has over 15 years of experience in neuroelectronic interfacing in industry and academia. He led cross-disciplinary an industry/academia team in developing an in vitro reflex arc for modeling implantable neural chips.

As a visiting scholar at MRC (London Institute of Medical Sciences, Hammersmith) and during his PhD studies at the Imperial College in London, he built and customized 2 photon microscopes for studying synaptic transmission in the mouse visual cortex and Alzheimer's disease models. He also worked on developing micro addressable spots for stimulating optogenetic neurons, a random access laser pixel for programming neurons in the mouse brain.

Koniku is a start-up based in Berkeley, California. Their premise is as simple as it is radical: "the merger of synthetic neurobiology, neuroscience, and silicon technology into a sturdy and elegant device which solves urgent real-world problems anywhere—in the lab, industry, home, and a street corner." Our maxim is: "Bio is Tech™." Koniku believes that "any sufficiently advanced technology is indistinguishable from nature."

Their current device is able to detect volatile organic compounds (VOCs) associated with explosives, gauge health status (food metabolism and more), disease diagnostics, and even design the taste of food by activating specific receptor profiles on our chip.

Lela BAKANIDZE, PhD, RBP

For more than 30 years, Lela Bakanidze worked at the National Center for Disease Control and Public Health (NCDC) of Georgia. During this period, she was the head of the Department of Biosafety and Threat Reduction, Deputy Head of the Department of Especially Dangerous Infections (EDI).

Her PhD thesis dealt with morphology and morphogenesis of toga- and retroviruses in mixed infections. After attending bioterrorism summer school at Johns Hopkins University, Dr. Bakanidze, together with her department, has worked out a bioterrorism national concept and bioterrorism preparedness plan. For 10 years, Dr. Bakanidze was the head of the NCDC Bioethics Committee. While working at NCDC, she delivered lectures at the International Black Sea University and Caucasian School of Business. She later moved to Georgian Agrarian University, where she was the Nonproliferation Programs Manager. Dr. Bakanidze is a registered biosafety professional (RBP) with the American Biosafety Association (ABSA), and she is an International Federation of Biosafety Associations (IFBA) Certified Professional in Biorisk Management and Biomedical Waste Management.

At present Dr. Bakanidze works in Tashkent, Uzbekistan, where she is the key expert for on-site technical assistance to the Chemical, Biological, Radiological and Nuclear Centres of Excellence Regional Secretariat for Central Asia. She is also chair of the IFBA Board of Directors. Dr. Bakanidze is the author of 2 monographs and more than 80 scientific papers.

Patrick BOYLE, PhD

Patrick Boyle is the head of Codebase at Ginkgo Bioworks, a Boston-based synthetic biology company that makes and sells engineered organisms. He is responsible for Ginkgo's Codebase, the company's complete portfolio of biological assets. Codebase includes novel strains, enzymes, genetic parts, and diverse genetic repositories, including millions of engineered DNA sequences. Codebase is being developed, maintained, and leveraged by Ginkgo's Organism Engineers via dozens of strain engineering projects. Prior to leading Codebase, Dr. Boyle founded the design group at Ginkgo, which now produces hundreds of millions of base pairs of DNA designs each year to support Ginkgo's projects. At present, more than 30% of the world's DNA synthesis is performed for work at Ginkgo.

Dr. Boyle also participates in a number of efforts related to the broader development of synthetic biology and biosecurity. This includes a fellowship in the Johns Hopkins Center for Health Security Emerging Leaders in Biosecurity Initiative, serving as a technical advisor to the Synthetic Biology for Military Environments program for the Department of Defense, and co-authoring the 2018 "Biodefense in the Age of Synthetic Biology" report by the National Academies of Sciences, Engineering, and Medicine. Prior to Ginkgo, Dr. Boyle received his PhD from Harvard Medical School in 2012, developing synthetic biology applications in bacteria, yeast, and plants in the lab of Dr. Pamela Silver. He received an SB in biology from the Massachusetts Institute of Technology in 2006.

Lucas CESPEDES, MS

Lucas Cespedes is a consultant, SENAI Institute of Innovation Management, Brazil. He is an experienced specialist with a demonstrated history of working in biotechnology and clinical industries. Mr. Cespedes is skilled in molecular biology, microbiology, and fermentation technology in order to achieve concrete results on developing new products and technologies. He has a master's degree focused in biotechnology from Universidade de São Paulo.

Anita CICERO, JD

Ms. Cicero is the Deputy Director at the Johns Hopkins Center for Health Security and a visiting faculty member at the Johns Hopkins Bloomberg School of Public Health. She is a lawyer with over 27 years of experience. Ms. Cicero works closely with the Center Director to lead strategic

and budget planning and program development. She is also an Associate Editor of the journal *Health Security*, the leading peer-reviewed journal in this field.

Ms. Cicero has greatly expanded the Center's efforts in epidemic preparedness policy, global catastrophic biological risk issues, and international programs to engage other countries and regions in collaborative efforts to address biosecurity threats. In working to engage the Center in valuable new exchanges, Ms. Cicero has also launched a number of initiatives to improve mutual understanding and collaboration with countries including the People's Republic of China, Kuwait, the Kingdom of Saudi Arabia, India, Singapore, Malaysia, Thailand, Philippines, and Indonesia.

Ms. Cicero has authored or co-authored a number of widely cited articles and reports on biosecurity policy, pandemic preparedness, nuclear consequence management, biosurveillance, international disease surveillance, and public health law.

Before joining the Center, Ms. Cicero spent nearly two decades as a practicing attorney in both the US federal government and the private sector. She was Managing Partner in charge of the Washington, DC, office of Drinker, Biddle & Reath, LLP, where she was responsible for more than 300 lawyers and staff. In her legal work, she created and managed a number of pharmaceutical consortia, with a particular focus on clinical research and regulatory compliance. Ms. Cicero's work required constructive engagement with members of Congress; the World Health Organization; the European Commission; the US Food and Drug Administration; the US Departments of State, Defense, and Health and Human Services; and the Environmental Protection Agency.

Before entering private practice, Ms. Cicero focused on environmental litigation and counseling. She began her career as a trial attorney in the Honors Program at the US Department of Justice, Environmental Enforcement Section. Ms. Cicero is a graduate of the Yale Law School and Oberlin College.

Nancy D. CONNELL, PhD

Nancy D. Connell is a senior scholar at the Johns Hopkins Center for Health Security and a visiting professor in the Department of Environmental Health and Engineering at the Johns Hopkins Bloomberg School of Public Health. She is a microbial geneticist by training.

Dr. Connell's work at the Center is focused on advances in life sciences and technology and their application to a number of developments in the areas of biosecurity, biosafety, and biodefense. Her research projects analyze novel biotechnologies that might have an impact on the development of global catastrophic biological risks (GCBRs) in ecosystems, and the

development of surge capacity for medical countermeasure manufacturing and other response mechanisms in the event of global pandemics or global catastrophic events. She is an associate editor of the journal *Health Security*.

Dr. Connell is a member of the Board on Life Sciences and is a National Associate of the National Academies of Sciences; she completed a 6-month sabbatical as Visiting Scholar at the Board on Life Sciences. She has served on more than 15 committees at the US National Academies, including Advances in Technology and the Prevention of Their Application to Next Generation Biowarfare Agents (2004), Trends in Science and Technology Relevant to the Biological and Toxin Weapons Convention (2010), and Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 *Bacillus anthracis* Mailings (2011). She is currently chairing the NAS components of a series of international science and technology workshops, supported by the EU and the UN, designed to explore regional advances and activities related to implementation of the Biological Weapons Convention (BWC).

Dr. Connell is a member of the of the National Science Advisory Board for Biosecurity as well as the US CDC's Biological Agent Containment Working Group in the Office of Public Health Preparedness and Response. She has had a longstanding interest in the development of regulatory policies associated with biocontainment work and dual-use research of concern. In addition to biomedical research policy, Dr. Connell has considerable experience and interest in pedagogy, with a focus on ethics education and the responsible conduct of research: She chaired the NRC Standing Committee for Faculty Development for Education about Research with Dual Use Issues in the Context of Responsible Science and Research Integrity, which has conducted a series of workshops throughout the Middle East and North Africa over the past 5 years. These workshops seek to apply contemporary teaching and learning methodologies ("active learning") to the challenge of increasing awareness among young scientists of the societal implications of their research. She has presented at workshops and meetings around the world on the interrelated issues of biocontainment, infectious disease research, research ethics, and dual-use research of concern.

Before joining the Center, Dr. Connell was professor and director of research in the Division of Infectious Disease in the Department of Medicine at Rutgers New Jersey Medical School and the Rutgers Biomedical Health Sciences. Her major research focus was antibacterial drug discovery in respiratory pathogens such as M. tuberculosis and *B. anthracis*. Dr. Connell chaired the Institutional Biosafety Committee of Rutgers University and directed NJMS's biosafety level 3 (BSL-3) containment laboratory beginning in 1997. Her recent work has focused on the use of predatory bacteria as novel therapeutics for treatment of Gram-negative bacterial infections, including MDR strains and select agents. Dr. Connell was continuously funded by the NIH, the Department of Defense and DARPA, industry, and other sources from 1992 to 2018. She received a PhD in microbial genetics from Harvard University.

James DIGGANS, PhD

James Diggans is director of bioinformatics and biosecurity for Twist Bioscience, a DNA synthesis company based in San Francisco. He holds a PhD from George Mason University in computational biology and bioinformatics and has worked in target discovery, molecular diagnostic development, and biodefense, including 5 years leading the computational biology group at the MITRE Corporation. His research has included methods for adaptive detection of biological weapons release, machine learning-based cancer diagnosis, and novel algorithmic approaches to discerning intent in oligonucleotide-length DNA synthesis requests. At Twist, his group builds cloud-based bioinformatics systems for manufacturing design, biosecurity screening, and analysis of next-generation sequencing data to power silicon-based DNA synthesis at record scale.

Ambassador Ljupčo Jivan GJORGJINSKI

His Excellency, Ambassador Ljupčo Jivan Gjorgjinski is Chargé d'Affaires of the Former Yugoslav Republic of Macedonia and chairman of the 2018 Meeting of the States Parties to the Biological and Toxin Weapons.

Gigi GRONVALL, PhD

Gigi Gronvall is a senior scholar at the Johns Hopkins Center for Health Security and an associate professor in the Department of Environmental Health and Engineering at the Johns Hopkins Bloomberg School of Public Health. She is an immunologist by training.

Dr. Gronvall's work at the Center addresses the role of scientists in health security—how they can contribute to an effective technical response against a biological weapon or a natural epidemic. She is particularly interested in developing policies that will boost the safety and security of biological science activities while allowing beneficial research to flourish.

Dr. Gronvall is the author of the book *Synthetic Biology: Safety, Security, and Promise*, published in fall 2016 (Health Security Press). While the synthetic biology discipline is poised to revolutionize important sectors for national security, there are technical and social risks. Dr. Gronvall describes what can be done to minimize risks and maximize the benefits of synthetic biology, focusing on biosecurity, biosafety, ethics, and US national competitiveness. Dr. Gronvall is also the author of the book *Preparing for Bioterrorism: The Alfred P. Sloan Foundation's Leadership in Biosecurity*. By describing the major grants that represented Sloan's investments in civilian preparedness, public health law, law enforcement, air filtering in buildings, influenza preparedness, and business preparedness, Dr. Gronvall constructed, for a nontechnical audience, a chronicle of early gains in US efforts to confront the threat of bioterrorism.

Dr. Gronvall is a member of the Threat Reduction Advisory Committee (TRAC), which provides the Secretary of Defense with independent advice and recommendations on reducing the risk to the United States, its military forces, and its allies and partners posed by nuclear, biological, chemical, and conventional threats. In 2014-15, she led a preparatory group that examined the US government response to the Ebola outbreak in West Africa as a case study for DoD's strategic role in health security and that made recommendations for future DoD actions in response to disease outbreaks.

She served as the Science Advisor for the Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism from April 2009 until the Commission ended in February 2010. She has testified before Congress about the safety and security of high-containment biological laboratories in the United States and served on several task forces related to laboratory and pathogen security, most recently the National Institutes of Health Blue Ribbon Panel to Review the 2014 Variola Virus Incident on the NIH Campus (2016) and the Committee for Comprehensive Review of DoD Laboratory Procedures, Processes, and Protocols Associated with Inactivating *Bacillus anthracis* Spores, formed in response to the Dugway anthrax shipments (2015). Dr. Gronvall has investigated and presented policy recommendations on the governance of science to the Biological Weapons Convention (BWC) in Geneva, Switzerland.

Dr. Gronvall is an alumna of the European Union Visitors Program, a competitive program designed to increase mutual understanding between professionals and future leaders from non-EU countries and their EU counterparts, and the Council on Foreign Relations Term Member Program.

Dr. Gronvall is an associate editor of the journal *Health Security* (formerly *Biosecurity and Bioterrorism*). She is a founding member of the Center, and, prior to joining the faculty, she worked at the Johns Hopkins University Center for Civilian Biodefense Strategies. She was a National Research Council Postdoctoral Associate at the US Army Medical Research Institute of Infectious Diseases (USAMRIID) in Fort Detrick, Maryland.

Dr. Gronvall received a BS in biology from Indiana University, Bloomington. She subsequently worked as a protein chemist at the Memorial Sloan-Kettering Cancer Center and received a PhD from Johns Hopkins University for work on T-cell receptor/MHC I interactions.

Jo L. HUSBANDS, PhD

Jo L. Husbands is a scholar with the Board on Life Sciences of the US National Academies of Sciences, Engineering, and Medicine, where her work focuses on issues related to science, technology, and security. She also represents the Academies on the Biosecurity Working Group of the InterAcademy Partnership (IAP), a network of more than 130 national and regional

academies of sciences and health. From 1991 to 2005 she was director of the Academies' Committee on International Security and Arms Control and its Working Group on Biological Weapons Control. From 2001 to 2012, Dr. Husbands was an adjunct professor in the Security Studies Program at Georgetown University. She is a fellow of the International Union of Pure and Applied Chemistry, an inaugural member of the Advisory Board on Education and Outreach of the Organization for the Prohibition of Chemical Weapons, and a member of the editorial board of Politics and the Life Sciences. She holds a PhD in political science from the University of Minnesota and a master's in international public policy (international economics) from the Johns Hopkins University School of Advanced International Studies.

Filippa LENTZOS, PhD

Filippa Lentzos is a senior research fellow at King's College London, with appointments in both the Department of War Studies and the Department of Global Health & Social Medicine. Her research focuses on biological threats and on the security and governance of emerging technologies in the life sciences.

A biologist and social scientist by training, Dr. Lentzos has researched and been actively involved in biological arms control for over 15 years. She has worked with several ministries of foreign affairs on projects related to compliance-monitoring, transparency, and confidence-building, and she regularly contributes her expertise to support and shape multilateral discussions on biological disarmament.

Dr. Lentzos has a history of working with scientists and was involved as the social science lead on the first synthetic biology center established in the UK. In 2016, she was showcased in the Evening Standard feature on career paths for women in science, technology, engineering, and mathematics (STEM), and, later in 2016, she was voted "STEM career hero of the month" in the Telegraph.

Dr. Lentzos's book, *Biological Threats in the 21st Century*, was published by Imperial College Press in 2016. She is currently completing a second book titled *Synthetic Biology & Bioweapons*, to be published by World Scientific.

Jason MATHENY, PhD

Jason Matheny was assistant director of National Intelligence, and director of IARPA, responsible for the development of breakthrough technologies for the US intelligence community. Before IARPA, he worked at Oxford University, the World Bank, the Applied Physics Laboratory, the Center for Biosecurity, and Princeton University, and he was the co-founder of 2 biotechnology companies. He holds a PhD in applied economics from Johns

Hopkins University, an MPH from Johns Hopkins University, an MBA from Duke University, and a BA from the University of Chicago.

Dr. Matheny is a member of the National Academies' Intelligence Community Studies Board; he is a recipient of the Intelligence Community's Award for Individual Achievement in Science and Technology, the National Intelligence Superior Service Medal, and the Presidential Early Career Award for Scientists and Engineers; and he was named one of Foreign Policy's "Top 50 Global Thinkers." He has served on various White House committees related to high-performance computing, biosecurity, artificial intelligence, and quantum information science.

Piers MILLETT, PhD

Piers Millett is director of safety and security at iGEM and co-chairs iGEM's Safety Committee, which is tasked with ensuring that cutting-edge biotechnology is used safely and securely. Dr. Millett is a certified biorisk management professional, with a specialization in biosecurity.

Until June 2014, Dr. Millett was deputy head of the Implementation Support Unit for the Biological Weapons Convention (BWC), a treaty for which he worked for over a decade. Trained originally as a microbiologist, he is a chartered biologist and works closely with the citizen science movement, synthetic biologists, and the biotechnology industry as well as governments. His efforts have seen him collaborate with a range of intergovernmental organizations spanning health (human and animal), humanitarian law, disarmament, security, border control, law enforcement, and weapons of mass destruction—both inside and out of the United Nations system.

Dr. Millett holds a wide range of other appointments relevant to his work at iGEM, including as co-founder of Biosecure Ltd, a company dedicated to safeguarding the bioeconomy. He also holds fellowships with the Future of Humanity Institute at the University of Oxford and the Woodrow Wilson Center for International Scholars in Washington, DC, where he researches pandemic and deliberate disease and the implications of biotechnology. He also consults for the World Health Organization, supporting their R&D efforts.

Vlada PASHYNSKA, PhD, MBA

Vlada Pashynska is senior specialist at the intergovernmental organization Science and Technology Center in Ukraine (STCU, www.stcu.int); she is responsible for management and coordination of the STCU international research & development, training, and other projects in areas of CBRN risks mitigation, biosafety & biosecurity, biosciences, and medicine.

Dr. Pashynska graduated from Karazin National University, Kharkiv, Ukraine, in 1993 (master of sciences in biophysics) and started her scientific career as a postgraduate student at the Institute for Low Temperature Physics and Engineering of the National Academy of Science of Ukraine (ILTPE NASU). In 2000 she obtained PhD degree in molecular biophysics and in 2001-2003 worked as an invited postdoctoral researcher at the University of Antwerp, Belgium. In 2003-2004 Dr. Pashynska was employed as a senior researcher at the Molecular Biophysics Department of the ILTPE NASU. Her main scientific fields of expertise are molecular biophysics, pharmaceutical and environmental biophysical applications, andmass spectrometry. Dr. Pashynska is a co-author of around 100 scientific publications, including 44 papers in international and national scientific journals.

In 2008-2011 Dr. Pashynska studied distantly in the Open University (OU) of the UK and in the International Institute of Management LINK. She has been graduated with a professional diploma in management with distinction of the OU and master of business administration degree of the International Institute of Management LINK.

From 2004 until now, Dr. Pashynska has worked as a senior specialist in the Kharkiv Field Office of the STCU. Based on her scientific background and experience, she coordinates the STCU projects in bioscience areas.

Vitor PINHEIRO, PhD

Vitor Pinheiro is an associate professor, Rega Institute for Medical Research, Katholieke Universiteit Leuven, Belgium. Prior to this Dr. Pinheiro was senior lecturer in synthetic biology at University College London. Dr. Pinheiro has a PhD in microbiology from the University of Cambridge.

Chueh Loo POH, PhD

Chueh Loo Poh is an associate professor with the Department of Biomedical Engineering at National University of Singapore (NUS), Singapore. He is also a principal investigator at NUS Synthetic Biology for Clinical and Technological Innovation (SynCTI) and leading the NUS Biofoundry. He obtained his PhD in bioengineering from Imperial College London, UK, and a B.Eng. in electrical and electronic engineering from Nanyang Technological University, (NTU) Singapore. His current research interests in synthetic biology include microbial biosensors, synthetic gene circuits design and automation, modeling of biological systems for design, and computer aided design (CAD) tools for SynBio. His group has been reprogramming microbes for biomedical and industrial applications, including engineering microbes to fight infection-causing pathogens, to tackle metabolic diseases, and to control biofilm formation for bioproduction. He has also been actively involved in international synthetic biology competition (iGEM) since

2006. He has received a number of awards including Tan Chin Tuan Fellowship in 2012 and NTU Excellence in Teaching award in 2010. He is currently the co-editor-in-chief of the IET Engineering Biology journal.

Zalini YUNUS, PhD

Zalini Yunus began work with the Science and Technology Research Institute for Defence (STRIDE) in 1988 as a microbiologist. Currently, she is the senior director, Biological Weapon and Toxin Convention Nucleus.

She has been involved, both nationally and internationally, in strengthening the Biological and Toxin Weapons Convention (BWC). She actively promotes the implementation of biosafety and biosecurity measures in Malaysia in fulfilling national obligations to the convention. In addition, she is the chairman of the BWC Technical Committee for Malaysia. She is also currently the national contact person/coordinator for the country's collaboration in the Biosecurity and Biorisk Management Program.

Over the years, Dr. Yunus has presented a number of papers in national and international conferences. She has been actively involved in organizing the national and international conferences related to biosafety and biosecurity and multisectoral coordination in response to biological incidents.

She graduated with a degree in microbiology from the University Kebangsaan Malaysia, obtained her MSc degree in immunology and allergy from the University of Nottingham, United Kingdom, and received her PhD in chemical engineering from the University of Manchester, Institute of Science and Technology (UMIST), UK.

Weiwen ZHANG, PhD

Weiwen Zhang is distinguished professor of microbiology & biochemical engineering; director of Laboratory of Synthetic Microbiology, School of Chemical Engineering & Technology; and director of Center for Biosafety Research and Strategy at Tianjin University of China. Dr. Zhang graduated from Chinese Academy of Sciences in 1996 with a doctoral degree in molecular microbiology. Prior to joining Tianjin University, Prof. Zhang was a faculty with Biodesign Institute of Arizona State University, and a senior principal investigator with the Pacific Northwest National Laboratory of the US Department of Energy (DOE). Dr. Zhang has broad research experience in microbial genetics, physiology, and ecology; he has authored more than 180 peer-reviewed papers and has 16 international and China patents. His recent research focuses on biosafety research and strategy, microbial systems biology, and synthetic biology.

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