INTRODUCTION
Humans began attempting to influence genetics long before the first Punnett square—and recent advances in technology have vastly expanded the realm of the possible, from risks to remediation. As demonstrated by the last years, technological advances in travel have facilitated pathogens’ spread—but they have also accelerated the development of preventative and treatment options, from vaccines to personal protective equipment (PPE). The collective term for this capacity is the bioeconomy, which describes the “economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences.” ¹ Today’s bioeconomy is vibrant, rapidly evolving, and vast, with the U.S.-based bioeconomy alone valued at $1 trillion per year.² This presents a promise and a challenge for governments interacting with their national bioeconomies. On the one hand, bioeconomies present great promise for addressing today’s challenges. On the other, the bioeconomy is a quickly evolving and loosely bounded space that represents a staggering number of technologies. As a way to address the vast topic within the confines of a brief, this paper explores three case studies.

THE ISSUE
This brief concludes the CSIS Defense-Industrial Initiative Group’s series on enhancing future biosecurity, examining three cross-national case studies and aspects of the U.S. response, to provide lessons learned from the overall project. The case studies include aspects of three government responses to the Covid-19 pandemic: South Korea’s strategy for testing and diagnostics, New Zealand’s strategy for data management, and China’s strategy for laboratory research. The brief then examines aspects of current U.S. government biosecurity preparations and responses, including the flagship Apollo Project. Lessons learned highlight the importance of accessible, effective data management for both biosurveillance and dispatching supplies to outbreak hotspots. The bioeconomy has the potential to act as surge capacity and innovation reservoir—if mechanisms for coordination and production are established ahead of crisis periods to take advantage of this resource. Likewise, biosecurity research and development (R&D) is a peacetime priority to ensure that resources are ready when they are needed: biosecurity-related defense R&D spending remained relatively flat through the first year of the Covid-19 pandemic even as procurement spiked, demonstrating that many of the technologies that turned the tide of a pandemic were developed over the years and decades before.
development (R&D) for biosecurity across illustrative segments of the federal government and several current policy initiatives. Where that brief examined the macro picture of the field, this one will look at the micro: it will drill down on three case studies that experts in the field identified as particularly key during the initial workshop of this series. These case studies are drawn from country responses to the Covid-19 pandemic from across the Asia Pacific. This brief will cover them in depth, drawing out what worked particularly well abroad before examining the current U.S. response—including proposed policy changes in this year’s Apollo Program and the specific tasks associated with ensuring that the U.S. homeland is safe and secure. From there, the brief will conclude with specific lessons learned from the case studies.

As a note on definitions, the first brief in this series argued that “U.S. government definitions of biosecurity are too limited,” as they focus primarily on the safe handling of pathogens. Instead, it posited that for the purposes of this project, “biosecurity should be understood in the context of a broad definition: biosecurity is an integrated approach to assessing and managing risks posed by biological agents and biotechnology to human, animal, and plant life and health.”

To disambiguate terms, this brief will continue to use the broader definition of biosecurity and will use the term “biosafety” when referring to the safe handling of pathogens.

**CASE STUDIES**

Throughout this series, three areas emerged as particularly crucial touchpoints for enhancing biosecurity in the face of another pandemic like Covid-19: testing and diagnostics to find and follow disease, data management to understand and track it, and laboratory research to respond to it. The first brief in this series described “four core biosecurity capabilities: (1) detecting, characterizing, and attributing biological threats; (2) manufacturing PPE and vaccines; (3) developing treatments, countermeasures, and biosecurity infrastructure; and (4) building data technologies and situational awareness for tracking the progression of bio threats and enabling biotechnologies.”

These three case studies map to the core capabilities: testing and diagnostics speak to the first, laboratory research to the middle two, and data management to the last.

The case studies are as follows:

- **Testing and Diagnostics**: South Korea’s early and rigorous testing program relied in part on comparatively greater data surveillance and fewer regulatory restrictions than in the United States.

- **Laboratory Research**: U.S. government (USG) labs play an important role in early-stage research, but the focus of later-stage research shifts aggressively to public-private partnership—which provides a contrast to countries including China where research is state-driven throughout.

- **Data Management**: Many island countries, including New Zealand, responded to Covid-19 using data management tools originally developed for agricultural biosurveillance programs.

Each case study speaks to a different core capability, and each will show how a different government addressed its associated in-country challenges in the Asia Pacific. The lessons learned from these case studies will then be synthesized with an eye to what worked well in the United States. Each case study presents distinct but not unique challenges: diagnostic testing was plagued by supply chain and manufacturing problems, unified data management faces a highly federated health system with limited information sharing, and laboratory research must bridge the so-called valley of death between early- and late-stage research as it brings new innovations to market.

**TESTING AND DIAGNOSTICS: SOUTH KOREA CASE STUDY**

Early in the Covid-19 pandemic, South Korea’s diagnostics strategy attracted global praise: Seoul swiftly developed and deployed testing kits, a key advantage in curbing the spread of the infectious disease by enabling a test, trace, and isolation approach to containing the spread of the virus. This case study will examine the policies and actions the South Korean government took that enabled that response—and the lessons it learned from the 2015 MERS outbreak that may have given South Korea a head start.

As noted in this series’ second expert workshop, much of the testing infrastructure for a pandemic outbreak needs to be preexisting—and South Korea had such a robust infrastructure that it could track the second wave of its outbreak down to a single individual. The roots of this rapid response can be largely traced back to 2015, when South Korea saw 38 deaths from MERS, the largest outbreak outside the Middle East. Following the outbreak, Seoul aimed to bolster its biosecurity posture, launching policies that ultimately shaped its Covid-19 strategy as state agencies developed rapid response processes for emerging infectious diseases. These policies included the Emergency Authorization Program, which enables the brisk authorization of products for emergency use. This measure
was codified through an amendment to the Medical Device Act in 2016.9

Seoul also embarked on a series of R&D investments in emerging diagnostic capabilities. One standout investment was $25 million into the diagnostics industry from 2017 to 2020. This included $14 million allotted to the Ministry of Science and ICT (MIST), as well as $5.7 million and $2.8 million to the Ministry of Health and Welfare and the Ministry of Trade, Industry and Energy, respectively.10 The MIST launched the Research Council for Infectious Diseases and Medical Devices, which is composed of various government-funded research institutes that span the infectious disease and medical device portfolios. The council assists diagnostic manufacturers by providing access to technology, equipment, and research networks. The remit of the council includes: (1) promoting collaborative research among industry, academia, hospitals, and businesses; (2) offering consultations regarding technologies and clinical studies; and (3) providing equipment and facilities for companies to aid them with carrying out their R&D activities.11

This preparation allowed South Korea to distribute its first testing kits a mere three weeks after the Covid-19 genetic sequence data was released, a similar timeline to the United States.12 Of the six companies that obtained emergency use approvals under the Emergency Authorization Program, three had previously received investments from the Ministry of Science and ICT to conduct R&D pertaining to infectious diseases.13 While the test kit approval period in South Korea roughly mirrored the FDA’s approval period in the United States, the former’s sustained public-private sector ties perhaps enabled it to avoid some of the manufacturing issues that dogged the early U.S. response.

Some of these government-industry ties were in place well before the pandemic, but the South Korean government forged more in the early days of Covid-19 as Seoul took steps to reduce the financial risk of commercial diagnostic developers.14 Policies like its Purchasing Conditioned-New Product Development Program were widely used to offset the risks of developing new technologies by guaranteeing minimum government purchase orders and supporting development of smaller private-sector entities.15 While engaging industry in January 2020, the Korea Disease Control and Prevention Agency (KCDA) guaranteed the purchase of a minimum quantity of tests, thus covering overhead costs incurred by private-sector firms. In February 2020, the Ministry of Health and Welfare also offered reimbursements to diagnostic manufacturers. These incentives significantly accelerated the production of testing kits.16

South Korea’s testing efforts also benefited from the country’s National Stockpile Plan, which was established following the H1N1 influenza outbreak in 2009 to oversee the management and distribution of medical countermeasures for infectious diseases, and which provided cotton swabs and other supplies in the early months of Covid-19.17 After the first year of the Covid-19 crisis, South Korea proposed establishing a multinational stockpile at May 2021’s Northeast Asia Conference on Health Security. If established, this would include “medical [and] quarantine supplies for future health crises.”18 Diplomats from the United States, China, Japan, Russia, and Mongolia heard the proposal, and $300,000 worth of diagnostic test kits were sent to Mongolia as a pilot effort.19

In January 2016, the KCDA launched the Emergency Operations Center within the Center for Public Health Emergency Preparedness and Response. The center collects and analyzes infectious disease information in real time and boasts an emergency response team for biological threats.20 The information fidelity provided by diagnostics enabled the South Korean government to prioritize sending resources to Daegu, a southeastern city approximately two hours outside of Seoul—and the site of over 70 percent of South Korea’s Covid-19 cases.21 This strategy successfully contained the initial outbreak in South Korea.

South Korea’s rapid response relied on years of planning after the 2015 MERS outbreak—and, once the most immediate crisis had been addressed, the country began planning for the future fight. South Korea established a rapid emergency authorization process with timelines similar to the United States and it developed mechanisms to facilitate rapid, comparatively riskless relationships with key industry partners. This allowed it to quickly manufacture the diagnostics it approved in quantities that supported widespread testing. Robust diagnostic capacity enabled robust contract tracing, which in turn enabled a surveillance testing system that allowed the South Korean government to map and curtail the spread of Covid-19. A more robust test supply allowed South Korea to track the outbreak almost in real time, and it provided enough granularity to its testing data that tracking was able to connect new cases to specific prior cases, as with the infamous patient 31.22 A robust diagnostic framework, including both technology and policy, provided for a rapid South Korean response to the outbreak of Covid-19.

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DATA MANAGEMENT: NEW ZEALAND CASE STUDY

In 1854, physician John Snow managed to trace a deadly cholera outbreak to a single water pump on London’s Broad Street by plotting the disease’s cases on a map—the birth of modern epidemiology. Data management has only shown more promise for enhancing national biosecurity since then. As important as collecting diagnostic data is managing that data: applying it to disease prevention and outbreak response. Advances in data management and collection create the potential to track the spread of disease in real time, enabling a pandemic response that will direct resources and surge capacity to disease hotspots in real time. Biosurveillance capable of tracking outbreaks and the initial spread of diseases offers the possibility to curb pandemics before they start. The outbreak of Covid-19 brought disease tracking to the forefront of the public consciousness: after the first year of the pandemic, the United States dedicated $100 million over four years to “building a pan-African disease surveillance and laboratory network based on pathogen genomic sequencing,” with the partial goal of identifying and surveilling disease outbreaks abroad before they reach U.S. shores. Yet data management for pandemic prevention is a relatively new focus; in the pandemic “peacetime” before winter 2019, few governments focused on it. Island governments had previously led some of the most ambitious data mapping efforts for biosecurity purposes, often for defense against invasive species and agricultural pests. This case study focuses on the government of New Zealand’s biosecurity preparation efforts before the outbreak of the pandemic, tracking how those plans have correlated with its pandemic response.

In March 2018, New Zealand released a 2025 biosecurity management plan to make its national biosecurity “more resilient and future-focused” over the following 10 years. The plan drew on the conclusions of five working groups, the third of which was dedicated to data management. The conclusions of the third working group focused on three key priorities: making data accessible, where what data is needed is known and that data is collected and regarded as a system-wide asset; effective use of the data, leveraging it for “information and intelligence for risk assessment,” situational awareness, and resource dispersal; and preparing for the future through “affordable, scalable and adaptable” information systems that take advantage of current opportunities and anticipate future needs.

Originally developed for other uses, many geospatial mapping technologies were repurposed for tracking Covid-19; New Zealand’s response to the Covid-19 outbreak maps to the working group’s priorities. This working group, as well as other regional planning, left New Zealand on solid footing for the outbreak of Covid-19 less than two years later.

Accessibility was the first goal. This was achieved for the Covid-19 response, as expressed in Covid-19 mapping projects. Data collection was standardized enough to be shared and edited as “heat maps” that showed where cases were highest—and therefore where resources should be sent. In New Zealand, the Ministry of Health formed an aggressive contact tracing network from the outset to contain any outbreaks. It did so through mandated contact tracing and record keeping, including through its COVID Tracer application.

An integral part of New Zealand’s Covid response was the NZ COVID Tracer app, which undergirded the country’s contact tracing efforts—and data accessibility. The app received significant national support: in a country with a current population of 4.8 million, the app has over 3.2 million current registered users. This would indicate an approximate 67 percent adoption rate, assuming that all users are unique and remain residents of New Zealand. The app’s features support both contact tracing and testing: it allows the user to register their own contact details for contact tracing, and it uses a mix of scanned QR codes and Bluetooth tracing to record the locations and people that each user encounters. This allows for more rapid notification if a user has encountered infected persons. The COVID Tracer app will also locate nearby testing centers, as well as other useful information, and saves each user’s National Health Index (NHI) number to expedite the testing process. The adoption at scale of the NZ COVID Tracer app shows that data management achieved its first goal: accessibility. The app was developed with ethics and personal identifiable information (PII) in mind, and its use provided for the large-scale standardized data collection called for in the Biosecurity 2025 plans.

The next wicket, then, is effective use. Rather than gauging whether information was collected and accessibly mapped, this depends on whether it was well used to trace cases or to allocate resources. If it was not, effective use asks how we might collect data differently in the future. The New Zealand government leveraged the data collected by its tracking app to implement contact tracing and a zero-tolerance policy, locking down the city of Auckland after a single case was detected. New Zealand’s policies were some of the strictest—rating an 85.19 out of 100 on
the Oxford Stringency Index—but they kept the country’s death rate an at astonishingly low 0.48 per 100,000. The U.S. death rate, by contrast, was 191.5 per 100,000 for the same timeframe.\textsuperscript{33} Aggressive contact tracking by the Ministry of Health helped understand and contain outbreaks within its communities. After the initial level 4 national lockdown, subsequent level 3 lockdowns were successful at the community level, rather than bringing the entire nation back into a level 4 situation. Cluster cases were actively managed in New Zealand.

That is not to say that the government’s app was the only factor in New Zealand’s success; a private-sector app, Rippl, was also widely used, and the government may have benefited from previous whole-of-society disaster planning efforts with other Pacific nations.\textsuperscript{34} These repeated exercises may have given the New Zealand government a certain muscle memory as it responded to the Covid-19 crisis.

In sum, the New Zealand government met many of the benchmarks laid out in its Biosecurity 2025 workshop goals. The data it collected on Covid-19 cases was accessible: its data needs were known and clearly articulated, collected in a centralized fashion, and designed with ethics and PII in mind. Once collected, the data was effectively used to initiate lockdowns when necessary. An app-based approach represents an “affordable, scalable and adaptable” strategy for the future—and one that may draw on whole-of-society disaster planning workshops of the past.\textsuperscript{36}

**LABORATORY DEVELOPMENT: CHINA CASE STUDY**

Laboratory research is an integral part of the bioeconomy. Government labs often propel the earliest—and riskiest—stages of research, while the private sector acts as a crucial partner for late-stage research and production. The specific model that partnership follows can differ significantly by country, but China’s laboratory research is of particular interest. China’s state key labs (SKLs) are modeled after the U.S. labs template and bridge the same functional areas, and both China and the United States leverage labs for early-stage research.\textsuperscript{37} Echoing the United States, Chinese SKLs are a key source of basic research, and both countries leverage the private sector for late-stage research and production. China also plans to expand government-industry linkages. While the other case studies were chosen as examples of success, this case study was chosen as a matter of strategic importance. It should also be noted that China’s labs are slated to undergo restructuring in the next 10 years.\textsuperscript{38}

### Three Goals of Biosecurity

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<tr>
<th>Strategic Direction</th>
<th>New Zealand Ministry of Health Contact Tracing</th>
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| 1. **Accessibility** | - System-wide priorities were clearly articulated and defined at the national level  
- The COVID Tracer app supported diverse and distributed implementation practices at the individual level  
- Ethics and PII were considered in methodology—not routinely available, but accessible when positive cases emerged in the network  
- Business requirements to ensure accountability within their stores reinforced compliance |
| 2. **Effective Use** | - Smartphones scanning QR codes created a network of sensors that gave high fidelity to emerging Covid cases  
- Tracing supported rapid responses to potential and actual cluster outbreaks  
- Cluster cases were actively managed by public health officials until closure |
| 3. **Preparing for the Future** | - Methodology relied on support of the COVID Tracer app; a majority of the population appeared to use it  
- App use indicated a level of social affluence as it requires use of a smart device  
- Whole-of-society disaster-planning efforts may have underscored successful response |

Source: Authors’ research and analysis.
In March 2021, China's Five-Year Plan included a dedicated technology chapter—its first ever. In October 2017, President Xi was quoted as saying, "We will strengthen basic research in applied sciences, launch major national science and technology projects, and prioritize innovation in key generic technologies, cutting-edge frontier technologies, modern engineering technologies, and disruptive technologies." The country aims to be a science and technology leader by the People's Republic of China's centenary in 2049, and it is currently devoting substantial attention to developing—and redeveloping—its national research architecture. This section will lay out the overall structure of China's federal research funding, focusing particularly on state key labs (SKLs), before moving to some of the unique ways that the Chinese government works with its national bioeconomy. In this way, this section will be devoted to China's federal bioeconomy research approach.

The UK government-funded Newton Fund Evaluation’s 2016 Baseline Report aimed to map the research and innovation capacity of its 15 partner countries. Its map showed China’s R&D funding flowing from the State Council’s National Steering Group for Science, Technology, and Education through different ministries before arriving at universities, research institutes, and enterprises. Broadly, Chinese scientific research is conducted between five institutional sectors. The first, the Chinese Academy of Sciences (CAS) “oversees some 120 institutes – including China’s ‘big science’ facilities – and three institutions of higher education.” Second are universities, including both those who focus on basic and on applied research; industrial enterprises are third, with R&D expenditures there comprising approximately 80 percent of the total in China. Government civilian ministries and research supporting the military comprise the final two sectors. Federal laboratory research in China is highly centralized: propelled by high-level individuals who see technology dominance as key to future geopolitical wealth and influence, the resulting science policy has a strong “top-down design process” and focus on national needs. Research funding is increasingly centralized through the Ministry of Science and Technology, (MOST), which administers funds through national programs, or “platforms.” There have been some efforts to diversify funding streams to attract international talent and improve the quality of Chinese scientific research; for instance, in 2013, the Center for High Pressure Science and Technology Advanced Research (HPSTAR) was created and directly funded by China’s Ministry of Finance, without routing the funding through MOST. Similarly, the National Natural Science Foundation of China (NSFC) was originally independently funded and “seen as a pioneer in promoting a culture of basic science through the support of original investigator-driven, peer-reviewed research,” but its March 2018 reorganization to sit under MOST has stoked fears that it might lose its independence.

China’s SKLs are one major line of effort for the government. Established in 1984, each SKL receives state funding for basic applied research toward a topic area designated by the host institution, which may be a research institute or university rather than a wholly government-owned facility. SKLs will host standout domestic and international researchers, from postgraduates through senior research supervisors. These SKLs are patterned after the U.S. government labs, spanning different institutional sectors, and in some cases have very strong similarities to their U.S. counterparts.

For example, China patterned its $150 million Materials Genome Engineering (MGE) initiative to develop new materials after the United States’ $250 million Materials Genome Initiative.

China’s research facilities are largely located on its East Coast, and its ambitious target had called for developing 700 state key labs by the conclusion of 2020. This goal included 270 labs “at Chinese enterprises,” echoing an alliance between the Chinese government and its labs which will be explored later in this section. The country fell short of this ambitious target, however, with just 515 key labs in place at the end of 2019, and 501 in 2018, suggesting that the current trajectory will remain well short of its target. Perhaps as a result, Chinese SKLs will be restructured over the next decade.

Narrowing the focus to biosecurity, 3 of the top 10 of these SKLs seem dedicated to it:

- **CanSino Biologics** produces vaccines. Created in 2009 by a group of Chinese-Canadians, this lab is located near Tianjin in the north.
- **Wuhan Institute of Virology** was China’s first lab to be cleared for high-risk work—and while well known, it is a relatively recent addition. It began trial runs in 2015 and was only approved to handle high-risk pathogens in 2017.
- **BGI Genomics**, founded in 1999, focuses more on genomic sequencing than on epidemiology.

As in the United States, China heavily leverages its
federally funded laboratories for basic research. “State key labs are the ‘main vehicles that the Chinese authorities are employing to direct resources towards advancing basic research capacity and capabilities’,” according to Naubahar Sharif, associate professor of public policy at the Hong Kong University of Science and Technology.57 The United States has raised significant concerns about the ethics of some Chinese bioeconomy practices even beyond its laboratory system.58

China’s SKLs fuel its basic research; to translate that basic research into production, China employs a number of strategies, including creating an expectation that fundamental research will translate into production and incentivizing scientists to develop spin-off companies from their research.59 Where the government could not produce sufficient quantities of PPE, for instance, it called on the private sector for supplements. These efforts may find parallels in U.S. policy, but others are strikingly different: the pandemic introduced “a new concept of ‘sharing,’” for instance, whereby private industry alleviated financial burdens that would otherwise fall to the government.60 Under one implementation of “sharing,” 45 percent of all companies in China stepped up and hired temporarily unemployed staff during this lockdown economic crisis. This hiring reportedly represented 92 percent of all recruiting during that period, moving people off unemployment rolls and “controll[ing] the country’s unemployment rate.”61

Moreover, public companies, including Alibaba and Walmart, have provided funds to the government.62 Thus, China and the United States have several similarities in developing new laboratory technologies: both leverage labs for early-stage development, and Chinese labs have been modeled on U.S. labs as they bridge functional areas. China’s state key labs are a key source of basic research, just as U.S. labs are, and China leveraged government-bioeconomy interaction to address the pandemic. But the ways China leverages its private sector contrast with the U.S. approach, with a much more forceful push from the state.

**ANALYSIS AND U.S. POLICY**

Each case study presented here describes how a particular country managed a different aspect of responding to Covid-19. Each government, of course, must tackle all elements of biosecurity preparedness, and the United States launched an overarching plan to do so in early 2021: the Apollo Program. This section will describe

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*Figure 1: Biosecurity-Relevant Investment Budget*

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Source: CSIS analysis based on procurement and research, design, testing, and evaluation (RDT&E) budget documents and justification books (President’s Budget 2010–22), which can be found at https://comptroller.defense.gov/Budget-Materials/.
current U.S. policy and budgetary support for biosecurity initiatives, before describing proposed projects like the Apollo Program and other current initiatives. For each, it will draw comparisons with the earlier case studies.

**USG POLICY: CURRENT FUNDING**

The first brief in this series laid out overall government spending patterns by sector, detailing biosecurity spending by function (e.g., agricultural sciences, biological and biomedical sciences, health sciences) and agency. This showed that the majority of biosecurity spending within government is located in the Department of Health and Human Services, the Department of Defense (DoD), and the Department of Energy.

The DoD, while not the lead agency for many aspects of biosecurity, presents a more detailed budget than most. Much of its traditional work focuses on a larger chemical, biological, radiological, and nuclear (CBRN) mission. R&D by both the Defense Health Agency (DHA) and Chemical-Biological Defense Program have biosecurity aspects and are shown in their entirety in the figure above, with the latter also including clearly labeled procurement funding lines (the former spending is entirely dedicated to R&D). The Defense Advanced Research Projects Agency (DARPA) and the U.S. Army also fund key biosecurity research lines.

The relatively flat spend on R&D even in the midst of the Covid-19 crisis indicates that R&D spending fuels long-term solutions, while the increase in DHA spending reflects the Covid-19 crisis. This strongly suggests that capacities used in crisis—say, DARPA-funded advances in mRNA editing—must be developed over the years and decades of comparative “biosecurity peacetime,” so that they can be rapidly leveraged in a crisis. Notably, these budgets did not include the billions in vaccine funding that took place through Army Other Transaction Authority (OTA) agreements employing an agreement created to support the Medical CBRN Defense Consortium.

**THE APOLLO PROGRAM FOR BIODEFENSE**

The Apollo Program was named to reflect the moon landing: a $65.3 billion dollar plan to prepare for the next pandemic. The project aims to equal the “seriousness in purpose, ‘commitment’ and ‘accountability’” of the program that took the United States to the moon over the next 7 to 10 years. The Apollo Program for Biodefense was the compilation of 125 experts’ input, and it put forth four priorities: (1) implementing the 2015 National Blueprint for Biodefense, (2) producing a national biodefense science and technology strategy, and (3) producing a cross-cutting budget with (4) appropriate multi-year funding. The specific recommendations of the report include incentivizing the medical countermeasures enterprise; incentivizing the development of rapid point-of-care diagnostics; and developing a modern environmental detection system, similar to surveillance testing, which speak to the case studies of this brief. The final two recommendations relate to budget, specifically creating a unified plan where current funding is divided between agencies.

In a September 2021 press release issued by President Biden, this list was expanded to five priorities: Transforming our Medical Defenses, Ensuring Situational Awareness, Strengthening Public Health Systems, Building Core Capabilities, and Managing the Mission. These objectives map onto the case studies outlined above, with “ensuring situational awareness” speaking to diagnostics and data management, while “transforming our medical defenses” and “building core capabilities” speak to laboratory research. The final two priorities include cross-cutting aspects and extend beyond the scope of this brief, but speak to shoring up the public health system, protecting the vulnerable, showing commitment to the purpose, and establishing a mission control in charge of the pandemic prevention mission.

Under these broad goals, the September plan “American Pandemic Preparedness: Transforming Our Capabilities” extended these overarching goals into subgoals, many of which map to the case studies. Table 2 shows a selection of these goals.

**ADDITIONAL ONGOING AND PROPOSED EFFORTS**

All this is not to imply that the Apollo Program, as exciting as the pandemic equivalent of a moon landing may be, is the only current USG effort to achieving biosecurity. The first brief in this series presented a detailed list of agencies involved in biosecurity, as this project defines it: the Department of Health and Human Services acts as the center; the Departments of Defense, Agriculture, and Homeland Security contribute secondary roles; and the Federal Emergency Management Agency and the Centers for Disease Control and Prevention (CDC) contribute in times of crisis.

**SPECIFIC CHALLENGES FOR THE NATIONAL SECURITY SPACE**

The national security space brings additional challenges for implementing effective biosecurity—and there is
more ground to cover. The DoD and the Department of Homeland Security (DHS) are charged with protecting the United States against biohazards, bioweapons, and bioterrorism—what this brief calls biosafety, and is elsewhere described as biosecurity. This space presents its own challenges, including a necessarily higher barrier to entry for the bioeconomy. One central concern here is attribution: as with cybersecurity, attributing biosecurity threats is both key to national security efforts and difficult. The current administration has effected several changes that prioritize biosecurity. The previously mentioned Apollo Program is one such effort. The administration reestablished biosecurity as a priority of the National Security Council (NSC) in its first month in office: Elizabeth Sherwood-Randall called for a national biosecurity initiative even before joining the NSC, which later added Beth Cameron as the senior director for global health security and biodefense.67

CONCLUSION

Biosecurity is a crucial function of national safety, and a challenging one. Recent years have brought attention to a field where success is often silent: true biosecurity includes counting the pandemics averted and the pathogens contained as much as the outbreaks that are managed. That makes this moment critical for codifying smart policies and mechanisms for biosecurity, to use momentum now to prepare for the next biosecurity event. The first brief in this series outlined that governments have a unique role to play in enacting biosecurity, but theirs is not the only one: partnership with their national

Table 2

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<tr>
<th>Testing and Diagnostics</th>
<th>Data Management</th>
<th>Lab Research</th>
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<tr>
<td>Develop technologies to meet sustained demand for highly accurate testing at low cost for any virus within a matter of weeks</td>
<td>Create early-warning networks to aggregate and analyze global data</td>
<td>Establish the capability to rapidly make effective vaccines against any virus family and have them reviewed within 100 days of a threat appearing; ensure that enough doses are manufactured for the U.S. population within 130 days</td>
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<tr>
<td>Conduct genome sequencing of patients with unexplained fevers around the world</td>
<td>Improve tracking by combining diagnostic, epidemiological, sequencing, and environmental data</td>
<td>Develop therapeutics for any virus family and enable the rapid production of antibodies</td>
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<td>Enact wastewater sampling</td>
<td>Improve analysis and forecasting (this goal is broken down into improving the data analysis infrastructure and improving the quality of the data being fed into the models)</td>
<td>Accelerate biosafety and biosecurity innovation</td>
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<td>Develop more cost-effective and accurate testing technologies</td>
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LESSONS LEARNED FOR FUTURE BIOSECURITY

- ** Coordination may streamline cooperation.** The current biosecurity government space is highly segmented, with each silo arriving to the discussion with its own mission—and often its own definition of biosecurity, as the first brief discussed. The first brief in this series recommended creating a unified command in the NSC. Such a move would create a common definition of biosecurity, and it might raise the seniority level of leadership devoted to it. It could also lower the transaction cost of doing business with government by streamlining the process for exploring government investment.

  Recommendation: This brief redoubles the first brief’s call for the creation of a central biosecurity hub under the NSC. It recommends that said hub take responsibility for the biosurveillance activities described below, and it suggests that it might be best modeled on the DoD’s Warfighter Senior Integration Group (SIG).

- **The bioeconomy can act as surge capacity and an innovation reservoir.** In crisis, the bioeconomy may provide more intellectual and production capital to the government. The mechanisms by which the private sector cooperates with the government could include a biosecurity corps similar to military reserve forces, as well as OTAs.
and other tools that the government commonly uses to work with small and mid-size businesses—where much of the bioeconomy's innovation currently resides.

Recommendation: The Civil Reserve Air Fleet (CRAF) allows civilian aircraft to be mobilized at moments of national need, and it includes unique contracting mechanisms. To prepare for biosecurity emergencies, an equivalent mechanism should be built for the bioeconomy.

- **R&D is a peacetime activity.** Spending was largely flat for federal R&D throughout the early months of the pandemic, suggesting that this spending is not a method of rapid crisis response but instead a slow, steady build over time. New mRNA technology meant that vaccines could be developed in a year—but it built on decades of research when no crisis was on the horizon. Investment in biosecurity research, this suggests, is just as important in a steady-state environment.

  Recommendation: Sustain a high level of biosecurity R&D funding during steady-state environments.

- **Decisionmaking rests on data and diagnostics.** Early and robust data management, combined with diagnostics, is crucial to the successful management of pandemics. This capacity can be used to target hotspots, as it was in New Zealand, but also to project needs for PPE, field hospitals, and other additional supplies.

  Recommendation: Develop a data-based decisionmaking framework that incorporates best practices on storage guidelines and timelines for PII.

- **Biosurveillance is a three-level effort.** True biosurveillance includes three levels of assessment: technology to assess the genome of potential biothreats, a domestic reporting system to monitor cases within the United States, and an international monitoring system designed to detect cases where information may present through nonstandard channels. (As one example, an early indicator of the Covid-19 pandemic in China was the rapid building of hospitals.) This last function may benefit from a mechanism that promotes international cooperation.

  Recommendation: Establish an international biosecurity monitoring capability under the DoD or DHS to complement the CDC’s domestic monitoring function.

- **Preparation for production matters.** South Korea was widely praised for its rapid diagnostic response, while the United States was not—but federal approval timelines for diagnostics were roughly equal across both countries. Where the former pulled ahead was in manufacturing: South Korea successfully mitigated the risk so that their bioeconomy was ready to move research rapidly into production.

  Recommendation: One function of a biosecurity hub should be to act as outreach to, and an ingress for, the private-sector bioeconomy into government.

This brief has extended the first installment in this series. The first defined biosecurity and the government’s engagement with the bioeconomy, detailing the scope and funding of its mission. This second brief examined several key case studies, drawing on specific examples of government actions to build biosecurity across the Asia Pacific to draw out which policy positions worked well. From there, the brief cross-referenced its case studies to U.S. policies, especially the colossal Apollo Program.

By fusing the analysis of the first brief with the case studies of the second and the combined discussion of the three workshops in this series, this brief presents the following lessons learned and recommendations.

One of the enduring challenges of the biosecurity space is that success is silent: it is more difficult to count the pandemics avoided and the lives saved because of efficient prevention. This moment, then, is central: the Covid-19 pandemic has generated the will and momentum to drive biosecurity policy forward, even as it has shown a mirror on the many advances made by the bioeconomy. The challenge now is to catch the momentum of the bioeconomy revolution: to codify the lessons learned on diagnostics, data management, and development into policy, and to establish contracting mechanisms that will let policy spring into contracting actions when the next pandemic arrives.
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