INSTITUTE FOR DEFENSE ANALYSES

Beyond Biological Defense: Biotech in U.S. National Security and Great Power Competition

Robert Carlson
Chad Sbragia
Katherine Sixt

August 2021
Approved for public release; distribution is unlimited.
IDA Paper NS P-22700
Log: H 21-000213

INSTITUTE FOR DEFENSE ANALYSES
4850 Mark Center Drive
Alexandria, Virginia 22311-1882

The Institute for Defense Analyses is a nonprofit corporation that operates three Federally Funded Research and Development Centers. Its mission is to answer the most challenging U.S. security and science policy questions with objective analysis, leveraging extraordinary scientific, technical, and analytic expertise.

About This Publication
The work was conducted by the Institute for Defense Analyses (IDA) under CRP C6599.

For More Information:
Dr. Katherine M. Sixt, Project Leader
ksixt@ida.org, 703-575-6695
ADM John C. Harvey, Jr., USN (ret) Director, SFRD
jharvey@ida.org, 703-575-4530

Beyond Biological Defense: Biotech in U.S. National Security and Great Power Competition

Robert Carlson, Chad Sbragia, and Katherine Sixt

The U.S. government has historically viewed biotechnology as a civilian and economic pursuit. The Department of Defense (DOD) discusses biology infrequently, except in areas such as military medicine and biological weapons. However, while U.S. attentions were focused elsewhere, a significant dependence on biotechnology has crept into DOD. To be sure, biotechnology supplies critical medicines, and, as more than 90% of the corn and soy grown in the United States is genetically modified, biotechnology also helps feed members of our armed forces as they defend the nation.[1] It may come as a surprise to learn that industrial biotechnology is now responsible for upwards of 20% of chemicals produced in the United States,[2] suggesting a similar proportion of chemicals used in the military are also biologically derived. Biotechnology is a foundational technology of the United States, and, while widespread, it remains a poorly understood contributor to U.S. military readiness and to national security.

In contrast, China is sensitive to biotechnology's central role in its military and security. For decades,[3] China has sought to harness the power of biotechnology to elevate its economic standing, national security, and military reach.[4] Furthermore, China's concept of "biosecurity" is broader than that of the United States. China's definition of security encompasses not only pathogens, but also the larger biotechnological industry.[5] In addition to China's aspirations to dominate worldwide in the field, biotechnology is a key part of China's military-civil fusion system, which has as one goal to amalgamate the People's Republic of China (PRC) defense industrial base with its civilian technology and industrial base.[6]

While DOD's primary biotechnology focus is on biowarfare defense and the broader U.S. government has been more concerned about bioterrorism, emerging pathogens, and aspects of healthcare, China has been gradually increasing investment, integrating biotechnology into its strategic development as a great power, and elevating biotechnology to be a key component of its national security.[7] Biotechnology is a core priority for the People's Liberation Army (PLA) through the PRC military-civil fusion development strategy.[8]

---

[1] Robert Carlson, "Estimating the Biotech Sector's Contribution to the US Economy," *Nature Biotechnology* 34, no. 3 (March 2016): 247–255, https://www.nature.com/articles/nbt.3491.pdf. For updates, see the "Bioeconomy Dashboard: Economic Metrics," Bioeconomy Capital, 2018, http://www.bioeconomycapital.com/bioeconomy-dashboard.

[2] Robert Carlson, "Engineering Our Way to a Sustainable Bioeconomy," Written Testimony for a hearing of the Subcommittee on Research and Development of the House Committee on Space, Science, and Technology, U.S. House of Representatives, 12 March, 2019, http://www.bioeconomycapital.com/s/Carlson-Robert-12-March-2019-Testimonyv6.pdf.

[3] For example, see 12th, others to FN.

[4] Robert Carlson, *Causes and Consequences of Bioeconomic Proliferation: Implications for U.S. Physical and Economic Security*. BNA 2012-03 (Falls Church, VA: Homeland Security Studies and Analysis Institute, 2011), http://www.biodesic.com/s/Carlson_Bioeconomic_Proliferation_Final_edited_for_public_release.pdf.

[5] Standing Committee of the National People's Congress, "Biosecurity Law of the PRC," 2020-10-17.

[6] Standing Committee of the National People's Congress, "Biosecurity Law of the PRC," 2020-10-17.

[7] Xi, Jinping. "习近平：全面提高依法防控依法治理能力 **健全国家公共**卫生应急管理体系." **新**华网. (Xi Jinping: Comprehensively Improve the Ability to Prevent, Control and Govern According to Law and Improve the National Public Health Emergency Management System) **求是** (Seeking Truth), February 19, 2020, http://www.xinhuanet.com/politics/leaders/2020-02/29/c_1125643629.htm.

[8] 韩昊辰. "**中共中央 国**务院 **中央**军委印发《关于经济建设和国防建设融合发展的意见》."(The Central Military Commission of the Communist Party of China and the State Council issued the "Opinions on the Integrated Development of Economic Construction and National

Biotechnology security *is* national security— for the United States and for China. It is a key component of both nations' economic security and supports fulfillment of DOD and PLA missions. DOD should recognize biotechnology's already established position as a foundational technology and that it could further advance DOD missions and make biotechnology development and security a DOD priority.

Just how big is biotech?

Biotechnology in the United States dwarfs a number of better-known industries, including the worldwide semiconductor industry. By 2017, U.S. biotechnology revenues exceeded $400 billion, or 2 percent of gross domestic product (GDP),[9,10] surpassing those of better-measured sectors.[11,12] Notably, **worldwide** semiconductor revenues for 2017 were about $400 billion, approximately equal to U.S. biotechnology revenues alone.[13] More recently, the U.S. National Academy of Sciences concluded that the biotechnology industry contributes a substantial 5%–7% of U.S. GDP.[14]

The biotechnological economy—the bioeconomy—is therefore already a significant contributor to the broader economy, growing at an average rate of 10% annually for at least two decades.[15] While DOD is certainly aware that biological commodities such as medical supplies use bio-based production, how could DOD not know that a fifth of chemicals used by defense industry are sourced from biology? The answer lies in how the United States measures (or does not measure) biotechnology.

Biotechnology is underappreciated as a contributor to the U.S. economy primarily because the relevant data are not collected by the government.[16] Whereas the Department of Commerce tracked economic contribution of semiconductors at least as early as 1958, when semiconductors were nascent and made up less than 0.1 percent of GDP, as of 2021, biotechnology is still not officially tracked by the government.[17] This illiteracy about the size of the bioeconomy is a national security issue because the U.S. government has no means to evaluate the degree of our dependence upon or exposure to risks in this emerging technology sector. More importantly, as biotechnology continues to mature, its contribution to physical and economic security will become even more significant. DOD would be wise not to ignore it.

The extant economic impact of biotechnology has been delivered using *first-generation* biotechnology, now commonplace tools that enable the modification and movement of genes from one organism to another. The impact of these rudimentary tools is being dwarfed by

---

Defense Construction")_中国政府网. Central government portal www.gov.cn / Xinhua News Agency, July 21, 2016, http://www.gov.cn/zhengce/2016-07/21/content_5093488.htm.

[9] Carlson, "Estimating the Biotech Sector's Contribution." For updates, see the "Bioeconomy Dashboard," Bioeconomy Capital, (http://www.bioeconomycapital.com/bioeconomy-dashboard).

[10] The scale of China's biotechnology industry underwent a fourfold increase from 2010 to 2019 and exceeded 1.5 trillion yuan in 2020. ("2019年中国生物技术行业发展回顾" ("Review of the Development of China's Biotechnology Industry in 2019"), Industry Information Network, https://www.chyxx.com/industry/202006/873345.html).

[11] Carlson, "Estimating the Biotech Sector's Contribution."

[12] "GDP-by-Industry," Bureau of Economic Analysis (BEA), last modified on March 29, 2021, https://www.bea.gov/data/gdp/gdp-industry.

[13] Semiconductor Industry Association (SIA), "Building America's Innovation Economy" (San Jose, CA: SIA, March 2020), https://www.semiconductors.org/wp-content/uploads/2020/03/2020_SIA_Industry-Facts_4-16-2020.pdf.

[14] National Academy of Sciences, *Safeguarding the Bioeconomy* (Washington, DC: National Academies Press, 2020).

[15] Bioeconomy Dashboard. http://www.bioeconomycapital.com/bioeconomy-dashboard

[16] Carlson, "Estimating the Biotech Sector's Contribution."

[17] Ibid.

ongoing technological improvements. *Second-generation* tools are now being deployed that enable the engineering of biological systems to manufacture materials that will not only displace petrochemicals, but will also surpass them in production scale and performance.[18]

Biotechnology in the PRC's Innovation-Driven Development Strategy (IDDS) and Military-Civil Fusion System

In China, biotechnology is a national development and a security matter. The blueprint to build composite national power and meet transformational goals is the PRC IDDS, which aligns under its broader national strategy and serves as the principal guiding framework for an array of substrategies and initiatives. The publicly available outline of the IDDS underscores its essential role of advancing mass innovation and whole-of-nation entrepreneurship, further affirming China's aim to become an "innovation country" by 2020 and a global "innovation leader" by 2030.[19] The IDDS orchestrates the substrategies and initiatives for the planned and the market economic systems. Biotechnology is among the critical technologies of IDDS that enables the developmental transformation of China. The IDDS also serves as a crucial conductor for China's national security and defense, principally through the Military-Civil Fusion Development Strategy that bridges developmental and security goals.[20] While DOD continues in its narrow view of biotechnology, the PLA esteems it as the "most rapidly developing science and technology in the world today, and the field of biotechnology has become one of the fastest growing and most cutting-edge new military fields."[21]

PRC biotechnology revenues are reported to be of a similar size to those in the United States, although subject to even lesser clarity in reporting.[22,23] One way to approach a quantitative comparison of the two bioeconomies is via the hypothesis that product revenues are a useful proxy measure of technical capability, and thus the comparison of these revenues could support the conclusion that the two countries are roughly equally matched today. However, the existing technical capabilities and revenues should not be viewed as necessarily representative of the future.

Although China will continue its well-documented licit and illicit acquisition efforts focused on burgeoning U.S. intellectual property in the biotech sector,[24] it is shifting its attention in all

---

[18] Oliver Morton, "The Engineering of Living Organisms Could Soon Start Changing Everything," *The Economist*, April 4, 2019, https://www.economist.com/technology-quarterly/2019/04/04/the-engineering-of-living-organisms-could-soon-start-changing-everything.

[19] The Communist Party of China (CPC) identifies "economic development" as the "central task" to achieve its mid-century strategic aspirations and concludes its approach has "made major achievements" and "remained committed to the new development philosophy, adopted the right approach to development, and endeavored to transform" its growth model. ("Full Text of Xi Jinping's Report at 19th CPC National Congress," *China Daily*, 4 Nov. 2017, www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-11/04/content_34115212.htm.) ("National Innovation Driven Development Strategy Outline," The People's Republic of China Ministry of Science and Technology, 17 January 2017).

[20] cite mil-civ fusion strategy

[21] The PLA clearly views biotechnology as the "most rapidly developing science and technology in the world today, and the field of biotechnology has become one of the fastest growing and most cutting-edge new military fields." (战略学 (Science of Strategy), 战略学 / 肖天亮主编.—北京:国防大学出版社 (Strategic Studies/Editor-in-Chief Xiao Tianliang—Beijing: National Defense University Press), 2020年修订 (2020 edition), 167.)

[22] Carlson, *Causes and Consequences of Bioeconomic Proliferation*.

[23] Rob Carlson and Rik Wehbring, *Two Worlds, Two Bioeconomies: The Impacts of Decoupling US–China Trade and Technology Transfe*r, National Security Report (Laurel, MD: Johns Hopkins Applied Physics Laboratory, November 1, 2020), https://www.jhuapl.edu/Content/documents/Carlson_Wehbring-Biotech.pdf.

[24] Sean O'Connor, "How Chinese Companies Facilitate Technology Transfer from the United States" (Washington, DC: U.S.-China Economic and Security Review Commission, May 6, 2019), https://www.uscc.gov/research/how-chinese-companies-facilitate-technology-transfer-united-states.

foundational technology areas, including biotech, to domestic innovation.[25] While it is unclear whether this spurred domestic innovation will be successful in the absence of illegitimate acquisition of foreign technologies, China continues its pivot toward "technology self-reliance and self-improvement," which will take on new meaning for biotech with the PRC's economic agenda.[26] China holds biotech as a key sector for self-reliance, paying "great attention to the impact of disruptive new materials on traditional materials" and calling out "bio-based materials" in particular. [27] In addition to acquiring U.S. biotech assets, China is also positioning itself to drive innovation in this area, providing new PLA capabilities in the future and further weakening DOD's supply chain with PRC-created products.

What does the future hold for biotechnology in DOD and PLA and the countries' entwined bioeconomies?

"What's clear is that the nation that leads the world in biotechnology will accrue enduring economic, societal, and defense gains." – Stephanie Rogers, Acting Principal Director for Biotechnology, DOD.[28]

If approximately 20% of U.S. chemicals revenues are indeed now derived from biotechnology, then one could estimate that approximately 20% of DOD chemicals rely on biotechnology rather than on petrochemistry. Yet, because there is currently no plausible means to identify and quantify these materials, there is no plausible means to for DOD to meet its current legal requirements to secure the respective contributions to the supply chain.

China has been cornering the supply chain in numerous sectors, from semiconductors to pharmaceutical ingredients,[29] and early days of the COVID-19 pandemic revealed supply chain weaknesses.[30] Numerous chemical precursors and the laboratory supplies to make those chemicals are sourced primarily from China.[31] In addition to tainted supplies of heparin[32] that could infiltrate U.S. military medical supply, unbeknownst to DOD, many of its chemicals and materials are also vulnerable to the same supply chain weaknesses.

Improvements in engineering capabilities will drive innovation in biology just as they have in semiconductors. Moreover, the *rate* of improvement in engineering capabilities determines the rate at which those innovations are deployed via manufacturing into the economy and the rate at which innovation impacts such factors as employment, productivity, and security. While the

---

[25] Dual circulation policy?

[26] David Bandurski, "Slogans for Self-Reliance," China Media Project, May 31, 2021, https://chinamediaproject.org/2021/05/31/chinas-turns-up-the-volume-on-self-reliance/.

[27] Made in China 2025.

[28] Stephanie Rogers (@DeptofDefense), "Biomade," Twitter, April 28, 2021, 3:55 p.m., https://twitter.com/TheBioMADE/status/1387495674556555265.

[29] Rosemary Gibson and Janardan Prasad Singh, "The Vitamin C and Penicillin Cartels," chap. 5 in *China Rx: Exposing America's Dependence on China for Medicine* (Guilford, CT: Prometheus Books, 2021).

[30] *The Wuhan Coronavirus: Impact on Supply Chain Operations Amid the Lunar New Year*, Resilience360 Special Report, (Troisdorf, Germany: DHL Innovation Center, January 29, 2020), https://www.mcci.org/media/230938/20200129_the-wuhan-coronavirus-impact-on-supply-chain-operations.pdf.

[31] Carlson and Wehbring, "Two Worlds, Two Bioeconomies."

[32] *FDA's Foreign Drug Inspection Program: Weaknesses Place Americans at Risk: Hearing Before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives*, Serial No. 110-107, 110th Cong. (April, 22, 2008), https://www.govinfo.gov/content/pkg/CHRG-110hhrg52415/html/CHRG-110hhrg52415.htm.

United States is arguably still in a leading position in biotechnology, it risks losing this lead by allowing U.S. rate of improvement to be surpassed by a China that is investing with the specific intent of becoming economically preeminent through technological superiority.[33] Moreover, the PRC organizational approach leverages the fusion of industrial policy and security policy into a coherent strategy for balancing risk and opportunity in the service of technology development.

The assessment that biotechnology will further transform the global economy is based on an assessment that biotechnology is undergoing a transformation. First-generation biotechnology is now being superseded by the emergent capability to read and write deoxyribonucleic acid (DNA), coupled to in silico design and testing of novel protein functions and metabolic networks. These second-generation tools enable interconversion of biological and digital representations of DNA and metabolism and thereby facilitate the application of mature digital design methods to engineering biology. Digital transformation of biological engineering delivers quantifiably higher rates of progress. In one case about which we know, using these new tools cut product development and commercialization times in half at two established, global biotechnology companies that were already seen as leaders in innovation.[34]

Participation in the future of the global bioeconomy will be determined by the nations that develop and have access to these emergent tools. Biological production could supply up to 60 percent of physical inputs across the global economy, and biotechnology could have a "direct economic impact of up to $4 trillion a year" for decades to come.[35] Those new biology-based physical inputs to the economy will not only innovate bio-based military applications, but also supplant the DOD and PLA supply chains with bio-based materials and chemicals.

Recommendations to the DOD

"Our strength are our values because the competition with China is … a competition of systems."[36] – Colin Kahl, Undersecretary of Defense for Policy

U.S. forces, and indeed the nation, have access to the safest, most technologically advanced, most effective vaccines ever created. It is a remarkable feat that DOD's mission can continue in the midst of a global pandemic—made possible because the democratic government and biotechnology industry of the United States prevailed.

U.S. and PRC bioeconomies are indeed in a competition of systems, and U.S. strength is in its values. However, to secure the role of biotechnology in DOD, the rate of growth of the U.S.

---

[33] Carlson and Wehbring, "Two Worlds, Two Bioeconomies."

[34] Riffyn, "Novozymes Delivers Four Break-Through Biofuels Products to Market in Half the Normal Development Time with Transformative Digital Infrastructure," Case Study (Oakland, CA: Riffyn, 2020), https://riffyn.com/assets/uploads/case-studies/Novozymes-Case-Study.pdf; Tim Gardner (Riffyn CEO), personal communication with authors, May 13, 2021.

[35] Michael Chui, Matthias Evers, James Manyika, Alice Zheng, and Travers Nisbet, *The Bio Revolution: Innovations Transforming Economies, Societies, and Our Lives* (New York, NY: McKinsey Global Institute, May 2020), https://www.mckinsey.com/~/media/mckinsey/industries/pharmaceuticals%20and%20medical%20products/our%20insights/the%20bio%20revolution%20innovations%20transforming%20economies%20societies%20and%20our%20lives/may_2020_mgi_bio_revolution_report.pdf.

[36] Jim Garamone, "Official Talks DOD Policy Role in Chinese Pacing Threat, Integrated Deterrence," *Defense News*, June 2, 2021, https://www.defense.gov/Explore/News/Article/Article/2641068/official-talks-dod-policy-role-in-chinese-pacing-threat-integrated-deterrence/.

bioeconomy must increase more quickly than that of China, and the United States will need to protect its investments. We recommend the following plan of action.

1. Improve the situational awareness of the U.S. government—and in particular of DOD—around the role of biotechnology in the economy, supply chains, and domestic and foreign manufacturing.

The responsibility to understand, prepare for, and respond to threats to biotechnology is balkanized, spread across at least nine Departments and Agencies within the Executive Branch, demonstrating the broad scope of the problem.[37] Specific vulnerabilities in the bioeconomy affect biotechnology security, and these vulnerabilities will affect DOD in readiness, health, and the ability to fulfill missions. Addressing those vulnerabilities must begin with a sustained, comprehensive effort to understand the role of biotechnology in industry today, how that industry contributes to DOD supply chains, and how DOD acquisitions influence economic development and employment around the United States. To that end, DOD should work with the Department of Commerce to create domestic reporting codes for biotechnology revenues and employment for the quarterly and annual economic census and then push to include those codes in the North American Industrial Classification System (NAICS) as soon as possible.[38] Institutionalizing the gathering of these data via the NAICS, which is how the rest of the economy is quantified, is the first step towards sustainable policymaking and rational spending.

The Department of Commerce should consider adding import/export controls on biotechnology, while avoiding overly broad restrictions that suffocate innovation. Solidifying the place of biotechnology as a foundational technology protected by the Foreign Investment Risk Review Modernization Act (FIRRMA) and Export Control Reform Act (ECRA) will be critical for securing biotechnology.[39] However, biotechnology competition is not exclusive to commercial activities. It is a crucial feature in sustaining an advantage in U.S. defense. DOD should audit critical defense innovation base vulnerabilities by dependencies to assist the other agencies in bringing China's foreign biotech access in line with standards in other major markets.

The drumbeat is accelerating, calling DOD to document and secure supply chains critical to defense applications and to the overall U.S. economy.[40,41] Securing DOD supply chains, which includes a recognition of their inputs from biotechnology and the origins of the materials feeding those supply chains, will buttress the strength of the U.S. military in its mission sets and keep readiness levels high. Current DOD efforts to expand domestic biological manufacturing capabilities are a needed start[42], but these focused programs also serve to emphasize the larger

[37] Carlson, "Engineering Our Way to a Sustainable Bioeconomy."

[38] Carlson, "Estimating the Biotech Sector's Contribution"; Carlson, "Engineering Our Way to a Sustainable Bioeconomy."

[39] Emma Rafaelof, "Unfinished Business: Export Control and Foreign Investment Reforms," Issue Brief (Washington, DC: U.S.-China Economic and Security Review Commission, June 1, 2021), https://www.uscc.gov/sites/default/files/2021-06/Unfinished_Business-Export_Control_and_Foreign_Investment_Reforms.pdf.

[40] " The US Is Worried about Its Critical Minerals Supply Chains – Essential for Electric Vehicles, Wind Power and the Nation's Defense", *The Conversation*, April 6, 2021, https://theconversation.com/the-us-is-worried-about-its-critical-minerals-supply-chains-essential-for-electric-vehicles-wind-power-and-the-nations-defense-157465.

[41] Andrew Edgecliffe-Johnson, "Manufacturers Warn US Must Do More to Maintain Fragile PPE Production," *Financial Times*, April 13, 2021, https://www.ft.com/content/c04571c0-69d9-49a6-b1a0-40a6cfa892fe.

[42] "Welcome to Biomade," BioMade, https://biomade.org; Brian Feeney, "Army Seeks to Establish Self Sufficiency Through Biomanufacturing," *Military Spot*, May 12, 2021, http://www.militaryspot.com/news/army-seeks-establish-self-sufficiency-biomanufacturing.

strategic need to understand and invest in the broader bioeconomy. Enhance the relationship between DOD and the National Economic Council to promote DOD's economic and commercial interests and security considerations, which might be accomplished via *an empowered deputy national security adviser*.

2. Develop a better understanding of the accomplishments and intent of China in developing biotechnology as a strategic technology, especially within the PLA.

Mirror the National Security Council's effort to stand up an emerging tech portfolio in Office of the Under Secretary of Defense (OUSD) for Policy. While other technology-focused DOD offices focus internally, an entity in OUSD Policy that concentrates externally on foundational technology competition is required. Assessments of PRC biotechnology revenues and capabilities are plagued by uncertainties similar to those in the United States. For example, while it is difficult today for Western observers to ascertain exactly how many PRC companies are operating in biotechnology, China may have the same problem.[43,44]

Capture critical U.S. biotech dependencies on China, despite the opacity of the industry. This initiative demands an interagency examination to identify cross-cutting resources, develop mitigation strategies to diminish or eliminate dependencies, formulate U.S. government and best practices that bolster innovation while removing vulnerabilities, and expand outreach to allies and partners to reduce systemic gaps that China can exploit. Partnership with industry and U.S. allies will allow us to assess long-term risks from China's planned economic system and interventions in market systems and formulate appropriate policies that respond to related challenges. DOD must actively collaborate to counter China's malicious efforts to distort commercial activity in Beijing's favor.

3. Identify opportunities for a dialog between the PLA and DOD about biotechnology-related security issues of critical importance to both countries.

Add biotechnology as a topic for the dialogue mechanisms that compose bilateral U.S. defense relations with the PLA. The policy dialogues should prioritize the ethics of biotechnology in the context of future warfighting concepts, risks of escalation due to the impact of biotechnology on the spectrum of conflict, and cooperation where the interests of the two nations intersect.

Unlike the U.S. government, Chinese leadership has a carefully considered position on the importance of biosafety and "biological problems" in national security.[45] While these problems are understood to encompass traditional weapons concerns, they also extend to the health of the entire natural world in the context of ever-expanding applications of biotechnology. This position might provide an opportunity for constructive engagement at a time when tensions are rising.

The expansion of biotechnology into the rest of economy demonstrates that DOD needs to open its aperture on biotechnology beyond biodefense. If China maintains biological warfare aspirations, by all means capture those, but also consider them in China's broader approach to

[43] "The Next Biotech Superpower," *Nature Biotechnology* 37 (2019):1243, https://www.nature.com/articles/s41587-019-0316-7.

[44] Carlson and Wehbring, "Two Worlds, Two Bioeconomies."

[45] Liu Yuejin "The Status of Biosafety in the National Safety System", *China Daily*, February 17, 2020.

biotech in the landscape of its development and security systems, integrated through civil-military fusion.

As DOD embarks on integrated deterrence, which includes the gray zone short of conflict that we are arguably experiencing now, maintaining and increasing the U.S. lead in biotech is critical to the military, the economy, and the nation's resilience. Investing in biotechnology enhances our national security. Securing biotechnology enables national security. Collaboration on biotechnology policies within the Nation, among allies and partners, and, where possible, even with competitors will ensure the future security of the United States.

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From – To)
XX-08-2021	Final	

4. TITLE AND SUBTITLE	5a. CONTRACT NO.
Beyond Biological Defense: *Biotech in U.S. National Security and Great Power Competition*	5b. GRANT NO.
	5c. PROGRAM ELEMENT NO(S).

6. AUTHOR(S)	5d. PROJECT NO.
Robert Carlson Chad Sbragia Katherine Sixt	C6599
	5e. TASK NO.
	5f. WORK UNIT NO.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NO.
Institute for Defense Analyses Strategy, Forces and Resources Division 4850 Mark Center Drive Alexandria, VA 22311-1882	IDA Paper NS P-22700 Log: H 21-000213

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR'S / MONITOR'S ACRONYM(S)
Institute for Defense Analyses Strategy, Forces and Resources Division 4850 Mark Center Drive Alexandria, VA 22311-1882	11. SPONSOR'S / MONITOR'S REPORT NO(S).

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The United States (U.S.) government has historically viewed biotechnology as a civilian and economic pursuit. In contrast, China is sensitive to biotechnology's central role in its military and security. While DOD's primary biotechnology focus is on biowarfare defense, and the broader U.S. government has been more concerned about bioterrorism, emerging pathogens, and aspects of healthcare, China has been gradually increasing investment, integrating biotechnology into its strategic development as a great power, and elevating biotechnology to be a key component of its national security[1]. Biotechnology is a core priority for the People's Liberation Army (PLA) through the People's Republic of China (PRC) military-civil fusion development strategy. Biotechnology security is national security, both for the United States and China. We describe the current state, the trajectory of biotech in both the United States and China, and provide recommendations to the U.S. government to secure their biotechnology industry and maintain dominance in this foundational technology.

15. SUBJECT TERMS

Biotechnology, People's Liberation Army, China, foundational technology, military-civil fusion, bioeconomy, bio-based materials

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NO. OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Katherine M. Sixt
U	U	U	UU	14	19b. TELEPHONE NUMBER (Include Area Code) 703-575-6695

This page is intentionally blank.