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2023–24 WILSON CHINA FELLOWSHIP

US-China Rivalry in the Age of Weaponizable Biotechnology

Yelena Biberman is an Associate Professor at Skidmore College and a 2023–2024 Wilson China Fellow

Abstract

The US-China competition over biotechnology is a relatively quiet one, with the economic dimension attracting most of the attention. However, biotechnology is dual-use. It has both civilian and military applications. The latter may range from precision targeting to mass destruction. Rapid innovations in genetic engineering, synthetic biology, data-driven machine learning ("artificial intelligence"), nanotechnology, and neurotechnology are enabling the leading powers—the United States and China—to acquire genetic capabilities that could be used for peaceful, defensive, or offensive purposes. How do Chinese policymakers and strategists view the power of biotechnology in the context of the intensifying great-power rivalry? What are China's capabilities and intentions vis-à-vis dual-use, or weaponizable, biotechnologies? This report addresses these questions by probing the plausibility of three hypotheses with evidence that draws on primary and secondary sources, including government reports and expert interviews. The investigation reveals the central role of biotechnology in China's pursuit of both economic development and national security. It is among the means by which China seeks not just to catch up to, but surpass, the United States and achieve its full civilizational potential. Although there is inadequate publicly available data to draw conclusions about the full scope of Beijing's intentions for biotechnology, the existing and anticipated dual-use capabilities, grand ambitions, and hurried nature of technological development do create a serious risk of unintended consequences of mass destructive potential. These range from an accident triggering a new, deadly pandemic to a genetic arms race.

Policy Implications and Key Takeaways

- China is acquiring, intentionally or not, dual-use capabilities in biotechnology that could be used for peaceful, defensive, or offensive purposes.

- Dual-use emerging biotechnologies satisfy and bridge China's economic aspirations and security aims. They support the main goals of transitioning the country to a more sustainable form of economic development and self-sufficiency while rebuilding the foundations of communist rule and expanding regional and global spheres of influence.

- The US-China economic decoupling is taking place at a time when the two states are in most need of communication and mutual understanding—that is, deep and sustained diplomatic engagement. China is too technologically advanced to be isolated or ignored.

Introduction

The race for the high ground in emerging technologies is a key feature of the intensifying US-China rivalry. The rapidly evolving advancements in data-driven machine learning ("artificial intelligence," AI) dominate the headlines. As does the contest over the earliest and strongest AI capabilities, as derived from access to resources such as semiconductors and large datasets. However, AI is a means to a variety of ends. Surprisingly little attention has been paid to perhaps the most consequential of these ends. It is the power to read, edit, and write from scratch the programming language of all life on Earth. This report directs attention to biotechnology, with a focus on the US-China rivalry over the power to genetically manipulate microorganisms for dual-use, or weaponization, purposes.[1]

The global leaders in biotechnology, the United States and China, recognize the security implications of the emerging genomic capabilities. In 2016, the US intelligence community's worldwide threat assessment listed gene editing as a technology that could generate new weapons of mass destruction.[2] The 2020 edition of *Science of Military Strategy*, an authoritative textbook published by China's National Defense University, considers how biotechnology could serve as "a brand-new territory for the expansion of national security."[3]

How do Chinese policymakers and strategists view the power of biotechnology in the context of the intensifying great-power rivalry? What are China's intentions vis-à-vis dual-use, or weaponizable, biotechnologies? The aim of this report is to present the existing knowledge, preliminary conclusions, and recommendations on a difficult but urgent problem facing US-China relations and global security.

Research Strategy

Intentions are notoriously difficult to discern. They are part of a complex inner world prone to change and contradiction. The intentions of China's political elite are no exception. This report uses the following research strategy to investigate the intentions of China's political elite vis-à-vis weaponizable biotechnology. It begins by identifying a range of possibilities, or hypotheses to be probed for likelihood with the available evidence.

Hypotheses:

1. *China is pursuing biotechnological development for peaceful purposes only, such as boosting economic, health, and food-related capabilities. It is not weaponizing biotechnology for offensive or defensive use.*

2. *China is pursuing biotechnological development for peaceful and defensive purposes only.* The latter may be a reaction to what Beijing perceives as US aggression and intent to weaponize biotechnology.

3. *China is pursuing biotechnological development for offensive purposes, in addition to peaceful and/or defensive.* The underlying aim may be to establish and maintain dominance in the Indo-Pacific.

The first is the null hypothesis, or default answer in the absence of evidence suggesting otherwise. The second possibility carries graver implications than the first for US-China relations and global security. The third carries the gravest implications and, because of this, demands the highest degree of skepticism and scrutiny.

Next, the likelihood of each of the three possibilities is evaluated in light of the available evidence. The material for the evidence is drawn from primary and secondary sources, including government reports and expert interviews. Underlying the analysis is a set of questions designed to interrogate each of the possibilities. The questions approach the problem from three measurable angles: 1) expressed ideas; 2) capabilities; and 3) a smoking gun. As with any attempt to study intentions, a limitation of the findings from this "triangulation" is that they are incomplete. They may underestimate or overestimate the intentions. The benefits are that they identify useful focal points and provide a baseline for judging new information, as it becomes available.

Questions:

1. What are the expressed ideas, if any, that suggest weaponization intentions?

2. What are the capabilities, if any, with weaponization potential?

3. Is there a smoking gun?

The sections that follow address each of these questions.

Expressed Ideas

China has come a long way since political theorist and practitioner Wang Huning lamented the widespread perception that innovation and tradition are inherently at odds. "The development of a society is inseparable from its spirit of innovation," Wang reflected in 1988 after a six-month visit to the United States. He observed that America's extraordinary capacity for innovation stems from its deeply-rooted tradition of combining two seemingly contradictory ideas: pragmatism and futurism. The former compels Americans to pursue the egoist incentives of the marketplace; the latter requires them to forgo immediate gratification for "something that has no direct effect at the moment, but will have an effect in the future."[4]

Chinese President Xi Jinping's "New Era" ushered in unprecedented devotion to future-focused innovation. National rejuvenation came to depend on China attaining "world power in science and technology."[5] Failing to do so would leave China economically behind and defenseless against exploitation and aggression, Xi argued.[6] In his 2014 "Total National Security Paradigm," Xi instructed the party cadres to adopt a total security approach. This meant attaching "equal importance to internal and external security" and integrating science and technology, among other things, into the national security system. This was the beginning of what observers called "the securitization of everything."[7] Cutting-edge technological innovation was not just a means of achieving "high-quality" development in an era of slower economic growth. It was imperative for achieving self-reliance and maintaining sovereignty in a world in which the waning superpower – the United States – deems China the main obstacle to global supremacy. Biotechnology became a key area of focus. In a 2020 article published in the party magazine *Qiushi*, Xi described biotechnological advancements as "important tools for the country and must be in one's own hands."[8]

The rapid advances in modern biotechnology preoccupied select Chinese intellectuals and officials since before Xi's tenure. Among the first to take note was Guo Jiwei, a chief physician at China's military hospital and medical university. Guo predicted that the future of war would be based on the command of military biotechnology in a 2005 article, which he then followed with multiple articles and books on the subject.[9] Guo envisioned the use of biotechnology to subdue adversaries in a "merciful" (nonlethal and reversable) way through "precision injury."[10]

Another prominent official to take note was He Fuchu, then-president of the Academy of Military Medical Sciences who would later become the vice president of the Academy of Military Sciences, the premier research institute of the People's Liberation Army (PLA). In 2015, He was struck by the establishment of a Biotechnology Office by the Pentagon's Defense Advanced Research Project Agency. Biotechnology was becoming "a new strategic commanding height in the future military revolution and the game between major powers," he observed. Among its potential uses, He imagined, was in developing new subversive weapons and unmanned combat platforms.[11]

In 2017, Zhang Shibo, a retired general who was then-president of China's National Defense University, identified biology as a new domain of warfare. He saw the advances in modern biotechnology as "showing strong signs characteristic of an offensive capability," which include the possibility of "specific ethnic genetic attacks."[12]

While the 2013 edition of the *Science of Military Strategy* prepared before Zhang's tenure makes no mention of biotechnology, the 2017 edition contains a section on "biology as a domain of military struggle."[13] The subsequent, 2020 edition, characterizes the biological field as "the strategic commanding heights of the game between big powers."[14] It offers striking examples of how biotechnology could be used "not only [to] bring biological damage to specific targets and people, but also bring large-scale effects and deterrent effects":

> [T]he use of new biological weapons, bioterrorism attacks, large-scale epidemic infections, specific ethnic genetic attacks, the purposeful genetic modification of the ecological environment, food and industrial products, and the use of environmental factors such as population migration, climate change, and natural disasters.[15]

Biological incidents can also be used as a psychological tool to influence public attitudes. During the COVID-19 pandemic, Chinese officials and state media sought to deflect public attention from ineffective or unpopular policies by claiming that the virus may have been leaked from a US Army lab.[16] As payback, the US military launched a clandestine program in the Philippines to discredit China's Sinovac inoculation at the height of the pandemic.[17]

China's national strategy of military-civil fusion, designed to create stronger linkages between the civilian economy and defense industrial base, highlights biology as a priority.[18] A special fund has been set up to support basic national defense research projects and help transform civil research into military applications—specifically, in the fields of biological crossover and disruptive technologies.[19] Synergies are expected among biotechnology, AI, and brain science.[20]

In 2021, China's new Biosecurity Law came into effect. It covers lab biosafety, or the hazards involved in working with microorganisms and toxins, and biosecurity—the deliberate theft, misuse, or diversion of biotechnology. Article 53 establishes the state's "sovereignty over our country's human genetic resources and biological resources" and directs the state to "strengthen the management and oversight of the collection, storage, use, and external provision of our nation's human genetic resources to ensure the security of human genetic resources and other biological resources."[21]

In 2022, the National Development and Reform Commission issued the *14th Five-Year Plan for Bioeconomic Development*. Among its main goals is to "prevent and control biosecurity risks" while also meeting the rising domestic demand for healthcare. By 2025, China's bioeconomy is to significantly increase in total scale. By 2035, it is to be at the "forefront of the world."[22] The next section describes China's growing scientific and technological capabilities as it pursues these goals.

Capabilities

This section takes a deep dive into China's capacity for innovation in the sphere of biotechnology with a focus on genetic sequencing, editing, and synthesis. It then examines two other elements needed to create products: manufacturing capabilities and a skilled workforce.

It is easy to understate China's indigenous innovation in contrast to that of the United States, a high-income country with a head start. When compared to other countries at a similar level of development (i.e., upper middle-income), China's capacity for innovation is extraordinary. In 2023, the World Intellectual Property Organization's Global Innovation Index ranked China as the 12th most innovative country (up from 43rd in 2010).[23] The Index comprises some 80 indicators, including measures of the political environment, education, infrastructure, and knowledge creation.

The Australian Strategic Policy Institute offers an alternative look at China's capacity for innovation. Its Critical Technology Tracker uses data from what are likely to be high-quality research publications (top 10 percent most-cited) from the past five years on 44 technologies that could "significantly enhance, or pose risk to, a country's national interests, including a nation's economic prosperity, social cohesion, and national security."[24] In 2023, the data indicated that China had built the foundations "to position itself as the world's leading science and technology superpower."[25] It led in 37 of the 44 critical technologies, including in synthetic biology and biological manufacturing.

China's capabilities are still considered weak when it comes to basic research. Basic research and early-stage development are required for proof of concept—invention. Invention precedes innovation. The latter involves turning the proof of concept into a product. Emphasis on innovation over basic research has, according to experts, led China to make up for its "invention deficit" through licensing technology, repatriations, and digital theft.[26]

However, a closer look at the research conducted in China over the past decade shows remarkable progress in transitioning to "discovered in China," consistent with President Xi's directive to "aim for the frontiers of science and technology, strengthen basic research, and make major breakthroughs in pioneering basic research and groundbreaking and original innovations."[27] In particular, this has been the case with the sequencing, editing, and synthesis techniques increasingly making it possible to engineer entire genomes. Some of the cutting-edge research coming out of China may be under the radar. But what is evident is that, having advanced to the frontier of genomic research, Chinese scientists are contributing significantly to global efforts to understand the power of genes and gain "a much greater degree of control" over organisms.[28]

By 2022, China had at least 600 biotech science parks to accelerate the development of novel science.[29] The World Intellectual Property Organization monitors what it calls "science and technology clusters"—geographical areas with the highest density of inventors and scientific authors—based on patent-filing activities and scientific article publications. In 2023, three of world's five biggest clusters were in China: Shenzhen-Hong Kong-Guangzhou, Beijing, and Shanghai-Suzhou. China also, for the first time, topped the list of countries with the highest number of clusters, having 24 in total. The United States followed with 21 clusters.[30] The patent data must be taken with a grain of salt, however, as applications tend to vary in quality. According to one Chinese expert, as many as 90 percent of the patent applications "may be garbage and can only be used as vases to collect money for projects."[31]

Reading DNA

China's rise as a global leader in genetic sequencing can be traced to the year 2010, when Shenzhen-based BGI (formerly Beijing Genomics Institute) became the largest next-generation genome sequencing company in the world. It had purchased 128 high-end genome sequencers from San Diego-based Illumina. Just three years earlier BGI was "on the brink of extinction."[32] A $1.5 billion ten-year loan from the China Development Bank, the Chinese government's so-called "superbank,"[33] made possible the purchase. The move coincided with a remarkable "boom of scientific productivity in China" centered around next-generation sequencing technology, with three "landmark papers" published by Chinese researchers in a span of just two months in 2009–2010.[34]

In 2012, BGI acquired San Jose-based DNA sequencing company Complete Genomics, raising fears of US losing competitiveness in a technology that was becoming "crucial for the development of drugs, diagnostics and improved crops."[35] Illumina expressed concern that BGI would become a competitor, liking the transaction to selling China the "formula for Coke."[36] China would no longer be dependent on US machinery.

BGI was founded during China's participation in the Human Genome Project, which the United States initiated at the beginning of the 1990s and was later joined by the United Kingdom, Japan, France, Germany, and China. What began as a small research institute trying to decode the DNA of pandas turned into "a sprawling conglomerate, active in animal cloning, health testing, and contract research."[37] In 2020, BGI announced that it plans to sequence full genomes for just $100.

The Chinese government has "long prioritized" the collection of human genomic data, domestically and abroad.[38] In 2003, China's Ministry of Public Security began building a forensic DNA database. Ten years later, Chinese authorities expanded DNA collection to entire ethnic minority communities and people with no history of serious criminal activity. In 2016, the Chinese government launched the country's first national-level storage facility for genetic information. The idea behind National GeneBank was to create the world's largest repository of genetic data that would "develop and utilize China's valuable genetic resources, safeguard national security in bioinformatics, and enhance China's capability to seize the strategic commanding heights" in the domain of biotechnology.[39] China Development Bank contributed $1.5 billion to the venture. BGI was picked to build and operate it.[40] By 2020, the Chinese government came to possess genomic data on up to 140 million people as it continued to grow to become the world's largest DNA database.[41]

US experts have warned that Chinese entities may have gained potential access to US healthcare data through investment in US firms, such as genetic testing company 23andMe, partnerships with US universities and hospitals, and sales of equipment and gene sequencing services.[42] Shanghai-based WuXi Biologics invested in consumer genetics company 23andMe in 2015. In 2020, it announced a production facility in Worcester, Massachusetts, and, in 2021, purchased a Pfizer manufacturing plant in China.

BGI boasts strong ties to the Chinese government. According to a 2021 *Reuters* report, it has worked with the Chinese military to improve "population quality" and on genetic research to combat hearing loss and altitude sickness in soldiers.[43] It has also played a key role in China's collection of DNA material from abroad. For example, BGI developed in collaboration with the Chinese military a neonatal genetic test that enabled it to gather data on millions of people around the world.[44] It has had contracts and partnerships with US health institutions, providing inexpensive genomic sequencing in return for access to data.[45] In 2019, BGI partnered with SpaceTime Ventures in Brazil on a large-scale R&D center for studying tropical plant genomics. It also entered into collaborations with institutions in Ethiopia and South Africa.[46] During the COVID-19 pandemic, BGI sold millions of test kits to the United States, Europe, and Australia.[47]

Much of BGI's success may be attributed to Chinese government support and a system that "blurs private and public, as well as civilian and military, to meet the goals of the state."[48] In March 2023, US Department of Commerce's Bureau of Industry and Security added three subsidiaries of BGI Group to the Entity List, a trade restriction list, partly due to concerns that the genetic data they were collecting and analyzing were at "a significant risk of diversion to China's military programs."[49]

A US intelligence assessment in 2021 linked BGI to China's global effort to obtain even more human DNA, including from the United States. In 2022, US Department of Defense officially listed BGI as one of several "Chinese military companies" operating in the United States.[50]

China has been not only amassing the world's largest DNA repository. It has also been acquiring the artificial intelligence capabilities to read it. AI is a major priority for the Chinese government. In 2017, it expressed the ambition to become the world's "major AI innovation center" by 2030.[51] China becoming a world leader in AI publications and patents in 2021 does not necessarily "translate into a robust advantage in AI innovation and global leadership moving ahead."[52] However, AI heavily depends on data, and China has one of the largest repositories of genetic information.[53] It does not need to be a global leader in AI to be a global leader in reading DNA.

Editing DNA

Genome editing involves the use of tools that modify an organism's DNA by inserting, replacing, or deleting a DNA sequence. The gene-editing tool CRISPR-Cas9 developed in 2012 is one of the biggest discoveries of the 21st century. Two of its pioneers, Jennifer Doudna and Emmanuelle Charpentier, were awarded the Nobel Prize in Chemistry in 2020. The other CRISPR pioneer, Chinese-American biochemist Feng Zhang, was not awarded the Nobel Prize, but his Broad Institute team was awarded key patent rights by the US patent office.[54]

Chinese scientists have in recent years demonstrated foundational work in developing and deploying CRISPR as a tool for gene editing in plants and animals, including humans. The same years as the US intelligence community's Worldwide Threat Assessment listed genome editing as a potential weapon of mass destruction, Chinese scientists became the first to use CRISPR on humans.[55] Two years later, Chinese biophysicist He Jiankui created the world's first genetically modified humans—the so-called "CRISPR babies."[56] A Chinese court sentenced him to three years in prison, though the scientist initially claimed in various documents that the experiment was supported by Chinese government funding.[57]

Many of China's CRISPR trials have taken place at the PLA General Hospital. PLA's medical institutions became major centers for research in gene editing, as well as other new frontiers of biotechnology. When the PLA's Academy of Military Medical Sciences was in 2019 placed directly under the purview of the Academy of Military Sciences, it signaled "a closer integration of medical science with military research."[58]

Naturally-occurring gene-editing systems are limited in what they can target and the sorts of changes they can make. Advances in generative artificial intelligence are "expanding the repertoire of editors."[59] In 2022, with the support of the National Natural Science Foundation of China Excellent Young Scientists Fund, a team of researchers used machine learning to optimize CRISPR.[60] In 2024, California-based researchers announced the development of a model that enables prediction and generation tasks from the molecular to genome scale. Trained on prokaryotic genomes, the model was used to design fresh CRISPR systems.[61]

Some have sought alternatives to CRISPR. In 2024, Belgian researchers developed a new toolbox of 16 different short DNA sequences that allow triggering controlled and specific recombination events in the genomes of both prokaryotes and eukaryotes.[62] In 2023, Beijing-based researchers announced their development of a new protein-based gene-editing tool called CyDENT that may be more effective than CRISPR.[63]

Writing DNA

Synthetic biology is widely viewed as a "strategic domain," with at least thirty-two countries investing "vast amounts of money into this field."[64] Over the past two decades, it became increasingly popular (and possible) to treat biological organisms as "a kind of high technology, as nature's own versatile engines of creation."[65] Redesigning organisms to produce substances or gain new abilities by stitching together long stretches of DNA and inserting them into an organism's genome is increasingly common. The idea behind synthetic biology is to treat biological organisms like computers—as "ready-made, prefabricated production system… governed by a program, its genome." By making changes to the "genetic software," one could theoretically produce "practically any imaginable artifact."[66] What began as "mostly an artisanal activity that was too immature and too expensive to be put to use in industrial R&D laboratories" is now "at the forefront of developing new drugs, new crops, and new chemical production pathways."[67]

In 2017, China made its international debut in synthetic biology with a significant contribution to an ambitious international collaboration. The immediate goal of the Synthetic Yeast Genome Project (Sc2.0) is to develop the first eukaryote genome from scratch by redesigning and reengineering yeast chromosomes. The underlying goal is to "pave the way for engineering more complex synthetic multi-cellular organisms."[68] In 2008, researchers at the Maryland-based J. Craig Venter Institute synthesized the first mega-size genome using chemically synthesized short DNA molecules. In 2010, Venter scientists installed a completely artificial genome inside a host cell.[69] In 2016, Boston-based scientists redesigned and engineered an *E. coli* genome.

Yeast would be the first synthesized eukaryote—an organism whose cells have a nucleus. Other eukaryotic organisms include plants and humans. What began as a Johns Hopkins undergraduate course entitled *Build a Genome* and "a mission impossible when it first started" turned into a "very ambitious project."[70] Yang Huanming, one of the project's participants and an academic with the Chinese Academy of Sciences, described the aspiration: "If genome sequencing is reading the code of life, then genome synthesizing is writing the code of life. From reading to writing, it is a breakthrough."[71]

Chinese scientists assembled four of the sixteen synthetic yeast chromosomes, making China the second country, after the United States, capable of designing and building eukaryotic genomes.[72] The Chinese researchers involved in the project came from BGI Research, Tianjin University, Tsinghua University, as well as the Agricultural Genomes Institute at Shenzhen, University of Chinese Academy of Sciences, and Peking Union Medical College.[73] China very soon expanded exploration to larger and more complex multicellular systems through projects like GP-write China. In December 2017, the Shenzhen Institutes of Advanced Technology set up a GP-write China center and held the first workshop in January 2018. It was later rebranded as the China Synthetic Genomics Centre and enjoyed "significant funding."[74]

SynMoss was another Chinese project to come out of the yeast collaboration. In 2024, Chinese researchers announced that they synthesized part of the genome of a type of moss. *Science* magazine described the achievement as potentially "smooth[ing] the way for creating artificial genomes for other multicellular organisms—and for turning the moss into a factory for medicines and other products."[75]

In 2022, the United States led the field of synthetic biology in terms of accumulative research output over the previous 18 years (at 34 percent), followed by the United Kingdom, at 14 percent. China came third (at 13 percent) but was the "fastest growing."[76] In 2023, the Australian Strategic Policy Institute flagged synthetic biology as a "high monopoly risk" because nine of the world's top ten synthetic biology institutions were located in China. China also boasts three times the share of publications in the top 10 percent relative to the United States, the next closest country.[77]

Manufacturing and Skilled Workforce

Economic production does not automatically correlate with weapons production capabilities. However, there is good reason to expect some correlation in China, where military-civil fusion involves "the elimination of barriers between China's civilian research and commercial sectors, and its military and defense industrial sectors" and exploitation of the inherent dual-use nature of key technologies, including biotechnologies.[78]

In 2015, the Chinese government launched the "Made in China 2025" initiative. The goal was to transform China into "a leading manufacturing power by the year 2049, which marks the 100th anniversary of the founding of the People's Republic of China."[79] By 2025, key industries were to be transformed so that China would not have to rely on global supply chains or imports of finished products in key sectors, which include biomedicine and high-end medical equipment. Meanwhile, Beijing would open its market and attract foreign investors to invest in key areas, including biomedicine. Foreign companies and institutions would be encouraged to set up R&D

centers in China. The initiative has borne fruit, including in the biotechnology sector. In 2000, there were no Chinese biotech/pharmaceutical companies on the Forbes Global 2000 list. By 2021, China beat Japan to the second place on the list, with 14 companies. The United States had 31 companies.[80]

The Information Technology and Innovation Foundation's Hamilton Index uses Organization for Economic Cooperation and Development data to compare countries' output in ten advanced-technology industries, including pharmaceuticals. The data showed that, in 2020, China was the leading producer in seven of the ten advanced-technology industries. It was third in pharmaceutical production, but "rapidly gaining."[81] The analysis concluded that the United States' lead in pharmaceuticals "might not last, as the Chinese government has targeted biopharmaceuticals and artificial intelligence as key industries for development."[82]

In 2023, China came to lead in biological manufacturing at a "medium monopoly risk," according to the Australian Strategic Policy Institute's Critical Technology Tracker. Six of the world's top ten biological manufacturing institutions were located in China. China also had 2.5 times the share of publications in the top 10 percent relative to the United States, the next closest country.

Skilled workforce is key part of China's goal to preserve its competitive advantage in the industrial chain system while climbing toward mid-to-high development.[83] China's approach includes talent recruitment and massive expenditure in leading universities.[84] One-fifth of high-impact papers coming out of China are being authored by researchers with postgraduate training in a Five-Eyes country.[85]

A Smoking Gun?

A smoking gun refers to strong circumstantial evidence. When direct observation is impossible, it is as close as one can get to supporting a claim. It is the most compelling item of evidence that most effectively supports a given claim about an actor's behavior—past, present, or future. In this case, it is China's near-future weaponization of biotechnology for offensive use.

A potential smoking gun appears in the testimony of Steven Quay, Chief Executive Officer at Atossa Therapeutics, Inc., before the US Senate

Committee on Homeland Security and Governmental Affairs' Subcommittee on Emerging Threats and Spending Oversight in August 2022. According to Quay's testimony, the Wuhan Institute of Virology was conducting synthetic biology research on the Nipah virus in December 2019. And it was doing at least some of it in laboratory facilities with low biosafety levels, lacking the necessary precautions. This was, as Quay put it, "the most dangerous research I have ever encountered."[86]

Nipah is a zoonotic virus—it spreads between animals and people. It can also spread from person to person, which means that it has the potential to cause a global pandemic. The name "Nipah" comes from a Malaysian village, where the virus was first discovered in 1998–1999. The subsequent outbreak of the virus in Malaysia and Singapore resulted in nearly 300 human cases and over 100 human deaths. Over one million pigs were killed to try to control the outbreak. Since then, outbreaks have occurred almost annually in some parts of Asia, primarily in Bangladesh and India. The symptoms of a Nipah infection range from mild to severe. In the documented outbreaks between 1998 and 2018, death occurred in 40–70 percent of those infected.[87] Multiple features of the Nipah virus disease, including its high mortality rates and multiple plausible forms of transmission, have "left the medical community perplexed."[88]

For Quay, it began when the Wuhan Institute of Virology received five bronchial lavage specimens taken from patients in Wuhan. The patients had pneumonia, and a sequencing machine from a US company identified SARS2. In February 2020, a paper written about these patients was published and subsequently received millions of views. The Wuhan Institute of Virology also published the raw data that came from the specimens. "These samples were massively expanded, using a PCR like process, and ultimately yielded tens of millions of reads of genetic material," Quay described.[89] He and his team then conducted a forensic analysis on the specimen reads and made three observations. They confirmed that they contained the SARS2 virus. They also identified 20 unexpected contaminants that they suspected were "the inadvertent amplification of other research going on in the laboratory… [t]hings not expected to be found in a human specimen like honey suckle genes or a horse virus."[90] Published research from the previous two years confirmed that the lab had indeed been working on 19 of the 20 unexpected contaminants.

The publications did not account for one contaminant. According to Quay, it was a portion of the Nipah virus genome in a laboratory vector commonly used for synthetic biology. Quay concludes: "Why were they [Wuhan Institute of Virology researchers] conducting synthetic biology research in December 2019 on the Nipah virus? I cannot speculate. But a laboratory-acquired infection with a modified Nipah virus would make the COVID19 pandemic look like a walk in the park."[91]

Nipah virus was incidentally one of the two Level-4 pathogens Canada's National Microbiology Lab shipped to the Wuhan Institute of Virology in March 2019.[92] The other was Ebola. The scientist responsible for the shipment was one of the two virologists (a couple born and married in China) who later lost their clearances and jobs at Canada's only Level-4 lab for unauthorized cooperation and information exchanges with Chinese institutions.[93]

In addition to Nipah, Quay also testified to observing one genomic region in the SARS-CoV-2 virus with "features of the two types of forbidden gain-of-function research that are associated with bioweapons development, asymptomatic transmission, and immune system evasion."[94] There were also, according to him, two regions with features of the types of academic gain-of-function research that was permitted.

Alleged research on the Nipah virus at biosafety facilities below Level-4 at the Wuhan Institute of Virology does not automatically mean that China is intent on weaponizing deadly pathogens. It does suggest a high level of carelessness or boldness, reminiscent of the He Jiankui gene-editing experiments. In 2018, He announced that he edited the genomes of three embryos that developed into living babies. He recruited couples in which the father was infected with HIV and the mother was not and then mutated three of their healthy embryos. In 2019, a Chinese court sentenced He to three years in prison for "illegal medical practices."

The first experiment that resulted in the birth of humans with edited genes is notable not just for crossing the existing ethical and legal boundaries. He's work was virus-centered. It involved altering a gene (CCR5) that allows a virus (HIV) to infect an important class of cells in the human immune system. He's stated goal was to give lifetime immunity from HIV infection. However, critics pointed out that the (potentially botched) attempt does not in effect protect from all strains of HIV in humans.[95]

In conclusion, the prospect of Chinese scientists conducting gain-of-function research on lethal pathogens such as Nipah, while also exploring germline editing as an immunization mechanism against a specific viral strain, raises a red flag. It does not automatically indicate intent to develop offensive military capability. But it does indicate a willingness to cross long-established ethical lines and take unprecedented public-health risks. Whether it is for the sake of science, national defense, or geostrategic ambitions remains an open question.

Conclusion and Policy Recommendations

A central challenge the United States faces is balancing the thrilling economic and medical benefits of biotechnology with the enormous risks to global and US national security. The United States and its allies cannot realistically go it alone. The problem of genetically-engineered bioweapons requires deep and sustained diplomatic engagement between the countries at the biotechnological frontier, the United States and China.

The risk of accidental biological harm grows in tandem with US-China competition. The drive to outcompete by speeding up the pace of innovation could lead to lapses in security and judgement. The result may be an accidental catastrophe. The risks involved are serious and must be tackled through communication and cooperation between US and Chinese officials, as well as the scientific establishments.

Biological agents do not behave in accordance with internationally-recognized borders, which means biosecurity threats are transnational by default. Confronting the new generation of biological security threats requires building, updating, and strengthening international regimes and organizations. The Biological Weapons Convention (BWC), which bans proliferation of bioagents and toxins that have no peaceful use, must be updated to include a formal verification regime system to monitor compliance. The dual-use nature of biotechnology also presents a challenge that requires serious consideration and diplomatic engagement, including back channels[96] and Track II dialogue.[97]

The United States should pay closer attention to the politics of expertise in emerging technologies in general and biotechnology in particular. Industry insiders on whom government institutions rely for expert opinion may have perverse incentives if their investment portfolios stand to benefit or suffer as a result of policy changes. The composition of advisory committees and expert panels should consider potential conflicts of interest.

Understanding the current and anticipated advances in biotechnology, and other emerging technologies, is imperative for the American public and the officials representing them. Scientific and technological literacy is crucial for informed citizenship and policymaking. Supplemental professional training for policymakers, an updated K-12 curriculum, and public awareness campaigns would improve understanding and reduce the political impact of conspiracies and misleading claims by actors with a vested interest.

Building domestic resilience against the new generation of biological threats will require not just state-of-the-art medical technologies but also a healthcare system that is accessible to the entire population. One concerning trend is in American life expectancy, which is one of the most commonly used measures of overall health of a population. American life expectancy began to decline in 2020. As of 2024, it is the lowest of all G7 countries, lower than in China, and continues to decline.

For the United States to stay competitive in innovation is not as simple as increasing the number of scientists, technologists, engineers, and mathematicians (i.e., STEM talent). There is a problem of employment. Wages for US workers in computer and math fields have been stagnating, and many have struggled to find STEM jobs.[98] Consequently, most STEM graduates do not end up working in STEM occupations. The Census Bureau found in 2021 that only 28 percent of them were working in STEM. The rest opted for higher-paying careers in business, finance, and management.[99]

The rules-based international order is collapsing while the world faces a "polycrisis"—multiple challenges affecting it simultaneously and interacting in such a way that their overall impact far exceeds the sum of all parts.[100] Genetically-engineered bioweapons are a daunting addition to the overflowing list of US national and global security concerns. But they are also an opportunity to appreciate the urgency of bringing back order in partnership with, rather than opposition to, the rising powers. As massive and difficult such a diplomatic undertaking would be, it pales in comparison to the challenge of surviving a genetically-engineered biological catastrophe.

The views expressed are the author's alone, and do not represent the views of the US Government, Carnegie Corporation of New York, or the Wilson Center.

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One Woodrow Wilson Plaza
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