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on Emerging Biotechnology

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Co-chair Wessel, Co-chair Helberg, and members of the U.S.-China Economic and Security Review Commission, thank you for inviting me to testify before the Commission about U.S.-China competitiveness in biotechnology, biomanufacturing, and related technologies. The National Security Commission on Emerging Biotechnology (NSCEB) is exploring the opportunities and challenges facing the United States at the intersection of national security and emerging biotechnology. Our interim report, released earlier this month, discusses our findings thus far and the research plan that will inform our comprehensive policy recommendations to be issued in 2024.[1]

Like the introduction of computers, biotechnology is a tool with the potential to revolutionize multiple economic sectors. Biotechnology—the application of living organisms in science or engineering—already solves problems today, like improved cancer treatment, agricultural sustainability, and novel types of materials. The United States can do more to integrate biotechnology across the domestic economy so that Americans are reaping the economic and security benefits that biotechnology can offer. Failing to meet this moment will have far-reaching consequences, especially because we have a strategic competitor that seeks to control critical supply chains and dominate key elements of the biotechnology industry.

Based on what we are seeing, China recognizes that advancements in biotechnology—such as DNA synthesis, gene editing, and precision fermentation—are essential to meeting the needs of their population and to competing globally. These same technologies could be used for nefarious purposes: China has expressly invested in biotechnologies that create military advantages. While any country can target technology areas for investment, we have seen a more nefarious side of China’s use of biotechnology. They have used biotechnology related advancements to support military purposes, acquire personal data, and surveil and control their own populations.[2]

China’s last three Five-Year Plans have prioritized biotechnology, and China has invested billions of dollars in the sector. Some estimate that China’s central, provincial, and local governments have collectively invested over $100 billion into the life science sector.[3] Most recently, China’s ‘14th Five-Year Plan for Bioeconomy Development’

describes China's intentions to use biotechnology and other life sciences to strengthen its economy, especially biomanufacturing.[4] The plan describes the importance that China sees in merging artificial intelligence (AI) and biotechnology, as well as the need for both political and financial support, stating "[w]e will promote the integration and innovation of biotechnology and information technology, accelerate the development of biomedicine, bioengineered breeding, biomaterials, bioenergy, and other industries and increase the size and strength of the bio-economy." In this plan, China sets a goal of increasing the scale and usage of biotechnology in multiple sectors by 2025. China aims for its bioeconomy to "be at the forefront globally" by 2035.[5]

China's Methods to Pursue Dominance

The United States is a global leader in biotechnology, but that status is increasingly threatened by China's strategic actions. China is positioning itself as a leader in biotechnology in order to increase their self-sufficiency and take advantage of associated economic and military benefits. China views biotechnology as the next industrial revolution and key to future economic development and comprehensive national power. This state support goes far beyond the traditional industrial policies implemented in Europe and other parts of Asia. China's strategy is comprehensive and represents an alternative blueprint for the development of emerging technologies and industries. China's all-embracing approach plays a key role in fostering technology areas that rely on longer timelines, multidisciplinary coalitions, or big science facilities—such as advanced computing, high-end gene sequencing, and colonies of non-human primates.

Over the last two decades, China has put in place policies to support the Chinese biotechnology industry, including: relatively high research and development (R&D) spending, talent recruitment programs, expansion of state-owned and state-supported enterprise, licit and illicit acquisition of intellectual property (IP), central government strategy and coordination, preferential tax treatment, subsidies, and government procurement initiatives. China is on the path to becoming a biotechnology superpower thanks to its long-term commitment to building an innovation base that includes industrial clusters and interdisciplinary research labs which collect and analyze extraordinary amounts of genomic and other "omic" data, and leverage its collaborations with foreign entities—much like its strategy to develop 5G.

Research Funding

The Chinese government heavily supports later stage R&D and translational research, often using basic research conducted in the United States as its starting point. In contrast, the U.S. Government funds basic research, and has historically taken a relatively hands-off approach to translational research. A system that funds translational research is better poised to realize applications in certain biotechnology sectors, including agriculture, industrial, and defense. In a way, China is taking advantage of American basic R&D by heavily funding translational research, while the United States relies on the market (mature pharma/biotechnology companies and VC-backed startups) to conduct translational work.

According to the Center for Strategic and International Studies, China's R&D spending on basic and applied research lags behind other major powers.[6] China's basic and applied research investment was $77 billion in 2018, compared to $200 billion in the United States. Chinese basic research averaged 5% of total R&D expenditure in 2000 to 2018, while the share of applied research dropped from 17% to 11%. Over the same time frame, U.S. R&D funding included 17% for basic research and 20% for applied research. China consistently spends most of its R&D resources on experimental development, using existing knowledge to improve products and processes. China's experimental development averaged 80% of R&D from 2000 to 2019, compared to 62% for the United States.

Talent Recruitment Programs

To achieve its goal of becoming a world leader in science and technology by 2050, China has orchestrated a coordinated campaign of hundreds of party- and state-sponsored talent programs. These talent programs are meant to bring back Western trained experts to drive China's research and cultivate China's domestic talent pool in support of civilian and military goals outlined in central government strategic plans. A recent study highlights how China's technology-transfer professionals, the so-called science and technology diplomats, broker technology-transfer deals and coordinate with overseas experts to fulfill technology wish lists for Chinese entities. More than half of the 642 projects examined in the study were biotechnology or AI projects.[7]

The most prominent program is the Thousand Talents Plan, which incentivizes individuals engaged in science and technology to work overseas to bring their expertise to China in exchange for Western level salaries, research funding, lab space, and more. According to a 2019 staff report from the Senate Committee on Homeland Security and Governmental Affairs' Permanent Subcommittee on Investigations, members of the Thousand Talents Plan misappropriated U.S. Government funding, provided research ideas to their Chinese employers, stole intellectual capital from U.S research before it was published and engaged in IP theft.[8] The Thousand Talents Plan is an example of one of China's premier talent programs; other programs operate at provincial, local, and academic levels.

China's talent programs take advantage of the United States' openness and target U.S. pre-competitive basic research, critically impacting the U.S. economy and competitiveness. Talent programs have been enormously successful as one of the primary means of misappropriating IP. China's IP theft machine steals an estimated $600 billion in IP every year, including from U.S. companies active in the national security field. Participants in talent programs are obligated to recruit new members. Normal, seemingly innocuous activities, such as contacting a researcher to provide a lecture in exchange for an honorarium can lead unsuspecting researchers to innocently participate in activities that benefit China and are designed to recruit them for talent programs. At present, there are no existing U.S. laws that makes it illegal for researchers to participate in a talent program. Tackling this scale of IP theft requires a whole-of-government effort and cooperation with universities and industry.

State-Owned and State-Supported Enterprise

Chinese state-owned enterprises have broad freedom to operate in the United States and can own land, sell products (e.g., seeds and software) directly to U.S. consumers and farmers, and access tax incentives, grants, and loans. At the same time, China prohibits foreign investment in biotechnology, mergers and acquisitions by foreign companies, foreign seed sales, technology licensing, and land ownership.[9] State-owned enterprises regularly interact with U.S. officials and influence policy matters without restriction as members and leaders of international trade associations.

The U.S. Department of Defense has identified multiple major Chinese biotechnology companies as Chinese military companies, including BGI Group (BGI), ChemChina, and SinoChem, which we discuss below. In addition, the Department of Commerce added BGI to the Export Administration Regulation's Entity List, noting that "their collection and analysis of genetic data poses a significant risk of contributing to monitoring and surveillance by the government of China, which has been utilized in the repression of ethnic minorities in China. Information also indicates that the actions of these entities concerning the collection and analysis of genetic data present a significant risk of diversion to China's military programs."[10] Both Syngenta and BGI subsidiary, MGI, have taken steps to conceal their connections to the Chinese government.[11,12]

Acquisition of Intellectual Property and Data

While China has made great strides in its domestic biotechnology capabilities and development strategies, they invariably incorporate technology transfer as a key component of dominating the field. China is working to access critical IP and data through a variety of legal and illegal means. Acquiring trade secrets through espionage has contributed to China's biotechnology advancement, and in some cases, Chinese scientists have stolen IP rather than conduct the research themselves. In other cases, Chinese companies have simply purchased U.S. companies with the goal of acquiring IP or data.[13,14]

Key Biotechnology Domains for China

Below, we describe China's methods to pursue dominance and key domains that are particularly important for biotechnology, including: sequencing technology, AI, agricultural biotechnology, and military applications.

Sequencing Technology

DNA sequencing technology is critical for the future of biotechnology. DNA sequencing is the process of determining the order of individual bases in a sample of DNA. Determining this genetic sequence can help identify an organism or understand some of its properties. This technology is indispensable for applied fields such as biotechnology, virology, and medical diagnosis, and is used in routine biotechnology research to help understand what genes do. As such, DNA sequencing technologies and services are foundational for emerging biotechnologies and could be considered a chokepoint or bottleneck. Especially important is that the future of DNA sequencing is evolving, for

example, new technologies that are proficient at reading longer stretches of DNA (e.g. nanopore-based sequencing) are changing the landscape.

DNA sequencing costs have fallen dramatically, to less than $600, to sequence a human genome. The increased accessibility has led to a proliferation of genomic data and biotechnology innovation. The global DNA sequencing market was estimated to be about $8.91 billion in 2022 and is expected to grow by 20% through 2030.[15] Academic research accounted for over half of revenue, and North America accounted for about half of the market.

There are two major aspects of the sequencing market – selling the instruments for genome sequencing (U.S.-dominated) and then selling genomic sequencing services (major U.S. companies do not provide this type of service, but some Chinese companies do). A critical differentiation in the sequencing market is that companies that provide sequencing services potentially have access to the genetic information provided by the customer, while users of sequencing instruments can potentially keep the genetic information that is produced in-house. Major players in the space include U.S.-based Illumina, Thermo Fisher Scientific, and Agilent Technologies, along with China-based BGI and its global network of over one hundred subsidiaries, including MGI (referred to collectively in this document as BGI). Illumina represents 80% of the DNA sequencing market globally, and primarily sells instruments for genome sequencing.

Similar to Illumina, BGI manufactures instruments for genome sequencing. In addition, they provide sequencing as a service, with sequencing facilities in China, Hong Kong, and Europe. By providing sequencing services in facilities in China, BGI has access to customer genomic data that could be directed towards the interests of the Chinese Communist Party (CCP).[16] The growth and success of BGI demonstrates not only the holistic nature of China's science and technology industry, combining the private and public sectors and the military, but also how sustained support can affect a key emerging industry.[2] These collaborations give BGI—and China—access to genomic data worldwide.

State-Owned and State-Supported Enterprise

China has been taking steps to boost Chinese companies and to acquire biotechnology companies both in the United States and elsewhere. In the sequencing space, BGI has publicly stated that "none of BGI Group is state-owned or state controlled, and all of BGI Group's services and research are provided for civilian and scientific purposes."[11] However, BGI has published at least twelve joint studies with the People's Liberation Army since 2010.[2] BGI has always been well connected and favored by the CCP, starting as state-backed lab at the Chinese Academy of Sciences before it was spun off to participate in the Human Genome Project in 1999. BGI leverages its ties to the government to develop products for the global market. For example, the Non-Invasive Fetal Trisomy Test (NIFTY) for prenatal testing of Down syndrome was developed by scientists from BGI, with hospitals and universities contributing to the project.[17] BGI has also been involved in more controversial activities for the Chinese government, such as the collection of genomic data from China's ethnic minorities in Xinjiang and Tibet.[18]

Several Chinese laws have favored BGI. For example, the Chinese government is required to only purchase from domestic corporations, which has been beneficial to BGI. BGI has received considerable Chinese state funds and support, including the Chinese government entrusting BGI to build and operate the China National GeneBank, the Chinese government's national genetic database. This partnership leverages the sequencing capability of BGI to form a biorepository hosting tens of millions of samples from humans, plants, animals, and microorganisms; banking DNA to "support science and technology development".[19] A $1.5 billion 10-year loan from the China Development Bank in 2010 allowed BGI to gain the world's largest sequencing capacity through purchase of 128 high-end Illumina-brand sequencers.[20] With Chinese state support, BGI expanded its operations through the acquisition of U.S.-based Complete Genomics in 2013, after review by the Committee on Foreign Investment in the United States (CFIUS). This provided BGI with the equipment and capabilities to compete with Illumina internationally.[21] In 2021, BGI received over $30 million in subsidies from Chinese state funds.[22] Government loans have been critical for BGI's growth.

Acquisition of Data

China views genetic data as a national resource and uses variety of means to ensure access. Through extensive partnerships with U.S. healthcare providers and researchers, BGI has provided large-scale genetic sequencing services for medical research efforts. U.S. researchers often look for low-cost providers of these services, which BGI can provide, thanks in large part to state subsidies; in February 2020, BGI said it could sequence a human genome for just $100.[23] These partnerships provide BGI with more genetic data on more diverse sets of people that they can use for more products and services, further intrenching their market position. Further, while it is unclear if clinical data is obscured, genetic information can be used to identify an individual.

While these partnerships give BGI access to genetic information, more nefarious means are also employed to gain access to data. In 2015, 78.8 million personal records were stolen from Anthem, a U.S. health insurer. The U.S. Department of Justice indicted two individuals in China, and an intelligence assessment showed that the Chinese government has directed actions to acquire genetic data from around the world.[24]

Internationally, Chinese institutions used the COVID-19 pandemic as an opportunity to create partnerships and donated or sold BGI equipment to eighty countries.[25] These capabilities may boost countries' diagnostics and research, but they also provide a means to collect genomic data that China otherwise would not have access to. BGI has also partnered with the Bill and Melinda Gates Foundation through a memorandum of understanding to work on genetics studies for human health and agriculture.[26]

Acquisition of Intellectual Property

While BGI is the largest Chinese sequencing company, multiple Chinese startups are using technology that can be traced back to the United States and other countries such as Canada and the United Kingdom, with little restriction. For example, Fapon Biotech acquired U.S.-based SequLite, and GeneMind has licensed IP from U.S.-based Helicos.

WuXi PharmaTech acquired the US firm NextCODE Health in 2015, which allowed integration of NextCODE's genome sequence analysis platform with WuXi's next-generation sequencing capabilities, and increased WuXi access to U.S. doctors and patients.[27]

As mentioned above, in 2013, BGI acquired U.S. sequencing company Complete Genomics, gaining proprietary sequencing technology and a U.S. base of operations. Illumina had made a competing bid for Complete Genomics, but the Federal Trade Commission (FTC) had antitrust concerns as Illumina was becoming a dominant presence in the market. Though some national security concerns were raised, CFIUS cleared the acquisition.[28]

Biotechnology-Artificial Intelligence Nexus

The use of AI and machine learning (AI/ML) to enhance research and encourage breakthrough discoveries through the combination of AI and biotechnology (AIxBio) has advanced over the last several decades.[29] Nearly every area of biology has advanced through the use of AI/ML tools, and will continue to do so as the data and models improve. AI has the potential to revolutionize biotechnology across all sectors. These tools help researchers and developers understand and interpret the genetic code, analyze images for farming and medical diagnostics, and run autonomous experimentation to increase the speed of cutting-edge research. These tools are important because they will increasingly impact every area of biotechnology research—from driving discovery, to automating experimentation, to streamlining scale-up manufacturing. Often it is the investments we make today, as well as the data that we acquire, that will have the biggest impacts in the future.

It is difficult to fully assess where we are vis-à-vis China in AI or biotechnology but there are elements that suggest that this is a close race. There are numerous AIxBio companies that are looking to leverage AI for biotech applications and products and there are leading-edge Chinese players in the field. For example, Insilico Medicine, with dual headquarters in Hong Kong and New York City, has become one of the biggest global players in AIxBio. The company claims that its use of AI in pharmaceutical development reduced a multiyear, hundreds of millions of dollars discovery process to 18 months at a fraction of the cost of traditional drug development[30]. Additionally, BioMap, co-founded by the owner of Baidu, has developed the first life science AI Foundation Model to hit 100+ billion parameters, which they call they "largest of its kind". As described by BioMap, "model training is enabled by our world-leading super-computing center and enhanced by our AI-centric, 100,000 sq ft, high-throughput wet labs."[31]

It appears that the Chinese system is better oriented towards convergent AIxBio research. The Chinese government has been prioritizing this intersection at a national level for years, while the U.S. Government has yet to do so at the same scale. China's actions in the AIxBio sector demonstrate how China leverages its own research funding, talent programs, and market access to both acquire technology in the short term and develop its domestic capabilities, which could provide a longterm strategic and geopolitical advantage.

Talent Recruitment Programs

AI models depend on good quality and large-scale data sets. China's National Genomics Data Center, founded in 2019, benefits from returned talent that have direct experience in leading U.S. universities and the U.S. National Institutes of Health (NIH). The center acts as a clearinghouse for China's genetic data, with a genome sequencing archive and branches with portfolios in precision medicine and agriculture. Many of its leading scientists have trained abroad and are members of China's various talent programs, often while still employed by their Western university. One of its leading scientists was selected for the Chinese Academy of Sciences 100 Talents Program while still working at the NIH.

Acquisition of Intellectual Property

Chinese investors are supporting AIxBio firms, many with ties to talent programs that could enable IP transfer. For example, ZhenFund is an early-stage investor, whose leadership partners with Chinese state-sponsored talent programs and start-up contests. ZhenFund has invested in numerous AI companies, some of which are in the biotechnology space. These include SYNYI-AI, a smart hospital solutions provider; Deep Intelligent Pharma, a firm pursuing pharmaceutical discovery and development through AI; and CareAI, a bioinformatics technology and high-performance computing company. AI-biotechnology firm XtalPi Technology, based in China with a Boston branch, also received investments from Zhenfund after winning a cash prize at the Harvard College China Forum Pitch Competition.[32] XtalPi provides drug R&D services for pharmaceutical firms using computational physics, quantum chemistry, AI, and cloud computing; all three of its co-founders were MIT postdoctoral researchers, recruited through China's talent programs.[33]

Agricultural Biotechnology

Agricultural biotechnology is another key area of interest, as it can be used to increase yields and improve sustainability; increase food quality and nutrition; protect against pests and diseases; and cultivate alternative food sources. China has been a net importer of agricultural products since 2004, and today imports more agricultural products—including soybeans, corn, wheat, rice, and dairy—than any other country. Accordingly, China considers food security an integral part of national security.[34] China aims to increase self-sufficiency by increasing domestic production through use of biotechnology and other methods, reducing dependance on imports, and increasing influence on agricultural production in other countries. Increased corn and soybean production within China would reduce China's dependency on U.S. products, potentially resulting in more challenging market conditions for U.S. farmers.

In recent years, China has become the largest funder of agricultural R&D in the world, surpassing the United States and the European Union.[35] In 2019, China applied for 22% of all international patents, surpassing the United States as the global leader. In particular, China applied for agricultural patents that use the genome editing tool, CRISPR.[36] While the number of patents does not necessarily indicate tangible advancements, it does indicate China's increasing interest in agricultural biotechnology.

To date, low yields, poor soil, water scarcity, low adoption of modern farming practices, and other problems are holding China back from meeting its goals.[37]

The potential weaponization of animal and plant disease to harm agriculture is a longtime concern. With advances in biotechnology, combined with access to U.S. agricultural data and IP, an adversary could develop a disease that selectively targets U.S. crops or livestock. The U.S. Government has established interagency approaches to prepare for, respond to, and recover from biological incidents, including those that target U.S. agriculture.[38]

State-Owned and State-Supported Enterprise

China is strategically positioning its companies to control more and more market share in the agriculture sector. During 2015 to 2020, consolidation in the agriculture sector reduced the number of major global companies from six to four and major U.S.-based companies from three to one. Today, just four companies control agricultural biotechnology and other agricultural inputs: U.S.-based Corteva, German-based Bayer and BASF, and China-owned Syngenta.

In 2017, state-owned ChemChina purchased then Swiss-based seed-producing giant Syngenta. CFIUS cleared the acquisition in 2016. At the time, agricultural stakeholders outlined many concerns with the merger, including that Chinese state-ownership of Syngenta would create a unique conflict of interest in which the Chinese government would be both approving and marketing genetically engineered (GE) crops and agrochemicals. Others warned that a Chinese state-owned Syngenta could withhold ongoing biofuel advancements from the U.S. military, and that many Syngenta facilities are near U.S. military facilities. Bipartisan members of the Senate Committee on Agriculture, Nutrition, and Forestry noted: “It is not unreasonable to suggest that shifts in company governance; operational strategy; or financial health…could have consequences for food security, food safety, biosecurity, and the highly competitive U.S. farm sector as a whole.”[39]

In 2020, China began combining agricultural assets of ChemChina and another state-owned company, Sinochem, under the Syngenta name. The resulting state-owned Syngenta will be the world’s largest seed and agrochemicals conglomerate, with $27 billion of annual sales and unprecedented global influence.[40] Syngenta is also planning a $10 billion initial public offering (IPO) to facilitate Chinese government-directed acquisition of global agricultural technology companies.[41]

Uneven Biotechnology Regulation

China’s ownership of Syngenta allows the Chinese government to both develop and approve seeds and agrochemicals, while disadvantaging and delaying approvals of U.S. and other foreign-developed products. China has taken steps to facilitate approvals of GE crops for domestic cultivation, and published their first regulations on gene-edited crops, providing a clear path to domestic cultivation and marketing. Simultaneously, China is working to improve Chinese public opinion of agricultural biotechnology, in

advance of more wide-scale plantings of Chinese-developed GE crops. China is also advancing regulations for biotechnology in animal agriculture.

While expanding its own ability to develop, produce, and potentially export GE crops, China delays or declines import approval for foreign-developed GE crops. Biotechnology developers will not market a GE crop in the United States prior to approval by major U.S. export markets, due to concerns about rejection of grain at the ports. This means that China effectively controls what technologies U.S. farmers can use in their fields. In January 2023, the Chinese government approved imports of eight GE crops after a decade-long wait, allowing U.S.-based Corteva to market a now-outdated GE canola variety to U.S. farmers.[42]

China's power over U.S. farmer access to GE crops is largely due to litigation that found then-Swiss-based Syngenta responsible for marketing to U.S. farmers GE seed that was approved in the U.S. but not yet approved by Chinese regulators. From 2013 to 2014, China's rejections of U.S. GE corn shipments contributed to a steep drop in grain prices. Syngenta ultimately settled with farmers and grain companies for $1.51 billion in 2017.[43]

Acquisition of Data and Intellectual Property

U.S. farmers' use of Chinese-made drones and apps allows the Chinese government access to farmers' data, including agricultural productivity data and high-resolution images of U.S. critical infrastructure. China leverages its scientists and businesspeople to acquire technology and technological knowledge. For example, Chinese operatives have stolen IP and sensitive agricultural trade secrets from U.S. firms, including by gaining access through education and employment in the United States and by physically digging up research seeds from U.S. fields.[44] China also requires large physical samples of viable GE seed when a company seeks import approval, far more than would be needed for routine testing. Using U.S. data and seeds, China can develop its own versions of American seed varieties in a fraction of the time.

Military Biotechnology

Advancing biotechnology is a stated goal of the U.S. Department of Defense as it provides opportunities for new methods of producing products in the military supply chain, as well as for creating new or improved products with enhanced capabilities. Biological systems can be used for biomanufacturing of products in the defense supply chain, for example in the critical chemicals that the Department of Defense uses to make lubricants, fuels, or energetics, on which it now relies on foreign or sole sources. Biological systems can also produce novel products, such as materials that trap and prevent toxic chemicals from affecting soldiers. Biomanufacturing on-demand could enable logistics in contested environments, for example through engineered microbes that can transform waste streams like plastics into critical supply chain components like fuels. Biotechnology can be used to generate novel materials, for example fabric resembling spider silk could make lighter, stronger, and more flexible body armor, allowing warfighters to operate under reduced physical strain. Biological sensors could

recognize a chemical or biological agent in real time and engineered human enzymes could deactivate nerve agents in the body.

However, biotechnology can also be applied for military usage in ways that run counter to the policies and goals of the United States, for example to produce a biological weapon. Additional potential future military capabilities enabled by biotechnology include augmented solider performance, brain-computer interfaces, as well as advanced biological weapons.

As the U.S.-China Economic and Security Review Commission has previously noted, China is prioritizing advancement in critical and emerging technologies because these technologies could lead to substantial scientific breakthroughs, economic disruption, enduring economic benefits, and rapid changes in military capabilities and tactics. Under the national policy of “military-civil fusion,” Chinese officials state that information and technology that are obtained in civilian sectors will be used to benefit the military and military applications. China’s pursuit of biotechnology could enable a range of military capabilities.

Specific Recommendations

The National Security Commission for Emerging Biotechnology is identifying policy options to address some of these concerns. The Commission will provide a full range of recommendations in our comprehensive report, to be provided to Congress in December 2024 and continuing through the duration of the Commission, which ends in June 2026. Our January 2024 report described our scope of research, which spans a wide range of topics related to biotechnology. We are considering how to better prepare the U.S. government for the age of biology, including by: leveraging international partners and allies, growing bioliteracy of the U.S. Government workforce, improving U.S. Federal interagency coordination, and harmonizing the U.S. system for biotechnology product oversight. We are looking at policy options to accelerate innovation and embrace biotechnology, including by: scanning the horizon for new and emerging technologies, leveraging biological data for future innovation, building an ecosystem conducive to innovation, increasing American bioliteracy, and bolstering the U.S. biotechnology workforce. Finally, we are identifying ways to protect against misuse of biotechnology, including by: promoting reasonable and responsible governance and preventing, detecting, and responding to misuse.

We also provided a policy proposal to strengthen ties between national security agencies and the U.S. Department of Agriculture. Amid rising concerns about China’s investment in U.S. agricultural companies and land, and both licit and illicit acquisition of intellectual property, particularly in agricultural biotechnology, U.S. agricultural groups have argued that food security should be considered part of national security. While the United States has some means in which to prevent or mitigate acquisitions by Chinese companies, these acquisitions continue to occur for biotechnology companies, including for sequencing technology. The United States cannot only rely on broad export controls to protect technologies due to the complexity of Chinese subsidiaries and the speed in which they can shift their business to avoid consequences from sanctions.

In the course of our research to date, the Commission identified that the United States lacks understanding of China's capabilities in biotechnology as a whole. We have some understanding of China's capabilities in the pharmaceutical sector, such as their recent move from "fast follower" to leader in CAR-T immuno-oncology therapies. CAR-T therapies now represent 10% of new drugs developed by Chinese companies, compared to 2% of drugs developed by U.S. companies.[45] We know less about China's work in industrial, agricultural, and other areas of biotechnology. Overall, it appears that the United States is not tracking China's advances in biotechnology the same way that it is tracking other technologies, such as AI and hypersonics. Additional intelligence in this sector will improve our ability to implement policies that respond to threats. For example, information that determines how much the U.S. Federal Government relies on Chinese-owned products and services is important to craft policies that could limit critical dependencies.

In addition to potential economic and food security risks, there is an ongoing contest to determine who will shape global norms and values around research, development, and deployment of biotechnology. Ultimately, there is a risk that adversaries may develop and weaponize biotechnology against the United States. Military applications could pose threats to American forces in the not-too-distant future. As with other technologies that have the potential for weaponization, preventing misinterpretation of each other's actions and intent is essential for the safe development of biotechnologies. For example, with the increased reliance on digital systems, nations have created normative and legal structures for optimizing the opportunities of the digital era while deterring cyberattacks. Though biotechnology is significantly different from cybertechnology, there are commonalities with cybersecurity in that both technologies can be used for civilian and defense purposes, and agreement upon and understanding of state actors' use of biotechnologies for civilian purposes can help prevent misinterpretation that could lead to escalation.

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