

Issue Brief

China, Biotechnology, and BGI

How China's Hybrid Economy
Skews Competition

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Table of Contents

| | |
|--|----|
| Executive Summary | 2 |
| Introduction | 8 |
| Beijing’s Drive for Sequencing Capacity: The Race from Genotype to Phenotype..... | 11 |
| The BGI-China Success Story: China’s Hybrid Economy and the Power of National Champions..... | 15 |
| Piecing Together BGI’s Corporate Structure: China’s Hybrid Companies..... | 18 |
| Overlapping Leadership Blurs the Lines Between BGI and MGI and the State | 21 |
| State Provides BGI and MGI Funding | 22 |
| Government Guidance Funds Are Directly Invested in Both BGI and MGI | 26 |
| How Companies Grow: Characteristics of MGI and BGI’s Market Growth..... | 35 |
| China’s Hybrid Economy and Implications for the U.S. | 41 |
| Competitive Tools Available to the United States and Allies | 44 |
| Preparing to Compete in the Genomic Future | 46 |
| Conclusion | 49 |
| Authors..... | 50 |
| Acknowledgments | 50 |
| Appendix 1: Detailed Ownership Analysis..... | 51 |
| Appendix 2: Key Areas of Biotechnology | 92 |
| Bioinformatics | 92 |
| Synthetic biology..... | 92 |
| Gain of function research..... | 92 |
| Agricultural biotechnology..... | 93 |
| Data privacy, data security, and population surveillance..... | 93 |
| Appendix 3: China’s Policies That Support Genomics and Biotechnology | 94 |
| Endnotes | 97 |

Executive Summary

Biology has the potential to offer solutions to the biggest challenges facing society in the 21st century, from the global climate crisis to food insecurity to new materials that will transform industries and manufacturing at scale. How nations pursue the power to engineer with living systems will reshape our ways of life, including whether our strategies reflect and reinforce—or contradict—the values of democratic societies. The United States and its allies must be positioned to harness these developments, ensure that applications reflect our values, and protect against misuse. If an authoritarian nation dominates the genomics space—and the industry that supports it—that nation will control the development of next-generation medical technologies, research standards and norms, and future genomics applications. This will have economic, ethical, and security implications for the U.S. and other liberal democratic states.

However, in the changing nature of global competition, what will be even more important than any one technology or any one field is how open market economies ensure a level playing field for their companies and researchers. Using BGI Group* as a case study, we dive into the complex world of China’s hybrid economic system that blurs private and public, civilian and military to meet the goals of the State. This system creates market distortions and undermines the global norms of science by leveraging researchers as well as academic and commercial entities to further national priorities, rather than open, mutually beneficial collaborations or fair commercial competition that fosters innovation and is free from market-distorting subsidies and restrictions. Through its policies and programs, China uses the power of the State to not only advantage its own companies but to disadvantage others, with the goal of dominating these industries of the future.

BGI Group is the “pointy end of the spear” for Beijing’s industrial policy for biotechnology. China’s policies to develop its Strategic Emerging Industries—including biotechnology—were first issued in 2013 and re-issued in 2020; they provide a blueprint for its goals of dominating key sectors through interconnectedness and central planning. These plans focus on first securing the domestic China market, as a

* Throughout this piece we will refer to “BGI” to include the mix of subsidiaries, affiliates, branches and holding companies that make up BGI Group. We will identify individually listed companies when what we present references that particular entity, such as BGI Genomics and MGI Tech. We will explain this complex corporate structure later in the paper.

first step on the path to building global champions. Using a playbook that reaped success in the development of Huawei and 5G, China uses R&D subsidies, process reforms, export financing, diplomatic support, and procurement rules for a guaranteed market in China that pushes out foreign competition and creates an unfair playing field.

Observing the growth of BGI Genomics and MGI Tech is watching China's industrial policies unfold in real time. BGI Group has grown into an international competitor, taking on the same role in the biotech space as Huawei has in telecommunications. BGI Genomics and MGI Tech have financed their growth in ways that are not typical for growth-stage public or private companies of their scale, and point to direct involvement of the state in funding their growth. Moreover, their publicly disclosed capital markets activity seems at odds with the rapid expansion of market share, the scope of international activities, and the number of affiliates both companies maintain.

The Ministry of Finance and Ministry of Industry and Information Technology's 2021 "Buy China" policy, or Order 551: Guidance of Government Procurement of Imported Products, outlined new rules for procurement of "315 local products, including 178 medical items."¹ MGI Tech products such as sequencing, PCR, mass spectrometers, and sample preparation instruments and devices are all included in the list. MGI Tech has openly stated that it sees this "trend of domestic substitution" as an opportunity to increase its market share.² These policies directly impact the ability of foreign firms like Illumina and Thermo Fisher Scientific to maintain market share in China. Moreover, China's evolving regulatory environment—and resultant state support to companies like BGI Group—is expected to enhance the companies' ability to grow domestically.

To better understand these corporations, as well as their global reach, accumulation of genomic data worldwide, and support from the Chinese government, we assembled information from financial data, public disclosures, and databases. We assess that at a minimum, we have uncovered an unusual structure that is inconsistent with the norms of most global companies and demonstrates BGI Genomics, MGI Tech, and Complete Genomics' (a major subsidiary of MGI Tech based in the United States) ties to the Chinese government. We have uncovered a lack of transparency with nested LLC structures, among not only BGI Group but also its investor base, that obfuscate how the company is funded and conducts operations. Additionally, *we found that other Western sources such as PitchBook, Refinitiv, and Crunchbase did not have the same comprehensive coverage of Chinese companies as our primary data sources*—highlighting the lack of transparency in China's commercial ecosystem and the difficulty in conducting due diligence.

With China's recent moves to further restrict the flow of information in its economy and to tighten regulations and surveillance over foreign companies and investors in the People's Republic of China (PRC), we anticipate that it will become increasingly difficult to understand the real nature of China's companies like BGI Group.

As evidenced by numerous financial abnormalities we identified within BGI Genomics and MGI Tech, the BGI Group entities exemplify Chinese companies that are publicly listed on international stock exchanges but do not conform to global market norms. Key findings include:

A majority of the shareholders having direct or indirect ties to the Chinese Communist Party (CCP).

- BGI Group's shareholder base is majority-controlled by corporate insiders and state-affiliated entities. Approximately 59% of the company's shares float on the stock exchange, while the remaining 41% are privately held. Over half of the private shareholders are government-affiliated, and an additional several are insiders. Meanwhile, via the publicly traded shares, state-linked shareholders and shareholders affiliated with BGI Group together control 57% of the company. Effectively no power or influence can be wielded by those dozens of shareholders who together split the remaining 2% of the public shares.
- Approximately 77% of MGI Tech's shares float publicly—that is, are traded on the public markets—while 23% remain privately held. Looking at the publicly floated shares, the vast majority of those shares—69% of all MGI Tech shares—are held by either state-affiliated or BGI Group-affiliated entities. Looking at the privately held shares, 75% of those shareholders are government-affiliated.

Direct investment into both BGI and MGI by multiple Chinese government guidance funds.

- BGI Genomics and MGI Tech (and, as a result, their U.S. subsidiary Complete Genomics) are supported by China's practice of channeling capital to select companies through government guidance funds (政府引导基金). Guidance funds are public-private investment funds that aim to both produce financial returns and further the state's industrial policy goals, including China's pursuit of leadership in strategic and emerging technologies.³ BGI and MGI rely primarily on the state as the primary source to fund their operations and global expansion.

- Beyond the involvement of government guidance funds, both BGI Genomics and MGI Tech raise funding directly from other state-owned enterprises as a primary means to fund their operations and global expansion.

BGI Genomics has also undertaken a number of capital markets activities that are unusual in global markets outside of China.

- These activities include pledging shares, accepting guarantees from executive officers, and engaging in unusual related-party transactions that make it look unlike a regular public company. Beijing has historically used economic and financial tools like these to support its national champions.

Overlapping current and former leadership roles blur the lines between BGI and MGI and the State.

- Several key executives simultaneously hold leadership positions in multiple parts of the organization, as well as government-related positions in State Key Labs or Government Guidance Funds—this is similar to the leadership movements of State Owned Enterprises (SOE) where individuals move between the SOE, research enterprises such as State Key Labs, Universities and Chinese Academy of Sciences, as well as positions in Chinese ministries and government offices. For example, Wang Jian (汪建) is the chairman of MGI (深圳华大智造科技股份有限公司) and, through Zhizao Holdings (智造控股) and Huazhan Venture Capital (华瞻创投), owns 52% of its stocks. He is also the co-founder and chairman of the board of directors of BGI Group, and according to 2022 MGI prospectus is chairman of both Shenzhen Huada Gene Technology Co Ltd. (深圳华大基因科技有限公司) and BGI Genomics (深圳华大基因股份有限公司).⁴

Despite the importance of genomics and initial investments into the Human Genome Project, the U.S. still lacks a comprehensive national strategy for the bioeconomy. China will gain an advantage in technology competition if we don't acknowledge and address those areas where national security and market forces diverge. The early stages of development for these new knowledge-based industries—such as biotechnology—will be most critical for government support and policies. These “first-mover” advantages may prove to be so critical that those nations that fail to make similar investments and commitments may have difficulty catching up. This gives centrally funded programs targeting specific new technologies an advantage. An erosion in leadership could constrain Washington's policy options such as the United States' ability to set global

technology norms, regulations, and standards, as well as harness and control access to technologies for military purposes.⁵

Our analysis of BGI highlights the depth and breadth of China's use of a hybrid economic model that necessitates new kinds of actions if the U.S. and like-minded countries are going to compete in technology development, and will require new approaches to level the playing field. Steps the U.S. (as well as its allies) can take include:

- **Secure U.S. genomics data.** Protect U.S. citizens' genomic data so that it cannot be exploited by foreign entities, without overcompensating such that innovation is stifled. For example, developing sequencing capabilities that support both research and clinical settings; setting regulations on foreign-funded, supported, and controlled entities' access to U.S. genomic data; and creating platforms where U.S. researchers and clinicians can share data securely.
- **Foster U.S. companies** (and companies in allied countries) so they can compete with entities that are state-supported. The CCP's policies have created an ecosystem in which Chinese companies are not neutral actors* nor fair competitors.
- **Reconfigure anti-monopoly** and other laws to reflect the nature of global competition and incorporate the impact that state-supported companies have on U.S. companies' ability to compete.
- **Treat the research base as critical infrastructure.** *The U.S. should not be dependent on China for our current medicines, future medicine, or tools of discovery.* This will require rethinking the supply chain, investments in biomanufacturing, and talent development.
- **Support translating R&D into useful applications.** Harnessing the acquisition process, the U.S. government can support not just precision medicine but the multiple areas this technology will touch. Too often the U.S. funds basic research

* By neutral actors, we mean that they function in the same way companies, researchers, and universities function in open liberal democracies. This is not the case due to China's policies and laws.

but then does not provide an avenue for the discoveries to either be commercialized or used as a public good.

- **Think the unthinkable.**⁶ These technologies can be used in ways we would consider unethical. Understanding the depth and breadth of research globally and discussing ways to regulate—as well as develop countermeasures—with allies and like-minded countries will ensure we are better prepared for misuse.

Policy solutions will need to look beyond traditional trade remedies such as export controls and tariffs because, in the early stages of these new technologies, there are not-yet-produced tradeable goods. Traditional trade remedies such as tariffs and trade sanctions probably will be ineffective at correcting all of the imbalances in biotechnology, which relies on know-how and expertise, as well as the accumulation of genomic data. They will also have limited impact on China's major national initiatives because China views this as a key part of its future and U.S.–China competition. The ultimate lesson from past successes, 5G development, and Operation Warp Speed is that the U.S. government and like-minded allies have tools that can be used to foster the development of emerging technologies, and that they should not be afraid to take a proactive approach to foster the building blocks of future discovery and the national innovation base.

Introduction

Emerging technologies are increasingly at the center of global competition, providing the foundational research and development that underpins future industries and drives economic growth. Key among them will be developments in biotechnology* that will touch on almost every aspect of society including creating new capabilities for medicine, agriculture, energy, materials, and the environment. While these technologies present extraordinary opportunities, they also have the potential to introduce new threats, such as synthetic pathogens, catastrophic laboratory accidents, and ethical dilemmas surrounding human enhancement, the use of non-human primates, and the modification of human embryos.

China, recognizing the promise of this field, has made growing its *biotechnology capabilities* a national priority, stating that it wants to transform China from a biotech power (生物技术大国) to a biotech superpower (生物技术强国)⁷—allowing it to benefit across multiple sectors. Leading in different aspects of the bioeconomy—including the tools and technical infrastructure needed for discovery—would enable Beijing to dominate the many fields that will be enabled by advances in biotechnology, including understanding what genes do. This would allow China to both control the development of next-generation applications and create dependencies worldwide.

Similar to what happened with Huawei and 5G,[†] China has put in place a multi-decade effort to support this goal, which includes nationally guided efforts aimed at advancing basic and applied R&D; strengthening research institutes, laboratories, and test facilities; promoting civil-military integration of science and technology (S&T) research; improving manufacturing expertise and capabilities; and developing human capital. This supports both economic goals as well as traditional national security goals, including advanced surveillance and biological weapons (BW) development. In particular, China has supported sequencing capacity and collection of genomic data,[‡] as well as fostering

* We recognize biotechnology is a broad field, but for the purposes of this paper we use it to refer to the ability to use biology for medicine and agriculture, as well as future applications made possible by unlocking the secrets of the genome. We also include the technical infrastructure and tools that will enable these discoveries.

[†] By referencing China's "5G experience," we mean how China grew to dominate the 5G market through government support. Please see: <https://cset.georgetown.edu/publication/the-huawei-moment/>.

[‡] Appendix 2 provides an overview of these policies.

a constellation of companies that make up its national champions. This blueprint—which worked successfully with fostering Huawei and China’s development of 5G—enabled China to drive technical standards, become the supplier of choice worldwide due to support from the Chinese government, and dominate in this foundational technology. The tools China used include R&D subsidies, process reforms, export financing, diplomatic support, and procurement rules for a guaranteed market in China—pushing out foreign competition because of an unfair market access environment.

Box 1. What Do We Mean by Global Norms?

Open liberal democracies share well-established norms to protect research and commercial relationships. These include the following:

- Integrity and trust guide researchers’ and institutions’ behavior.
- Transparency (especially with regard to methods, data used, collaborators, and sources of funding) enables constructive review and scrutiny by peers and society.
- Research collaborations allow the rapid sharing of knowledge while protecting the rights of inventors and researchers.

These norms allow researchers to trust their colleagues; behave ethically; protect the subjects that are researched; know who they are collaborating or working with; and share the benefits of the research and data.

Evolving from a Chinese Academy of Sciences research institute to a global player in genomics and sequencing tools, BGI Group*—which includes a mix of holding companies, BGI Genomics, MGI Tech, and their associated subsidiaries, affiliates, associates, and branches—has become China’s biotech national champion, running its

* Throughout this piece we will refer to “BGI” to include the mix of subsidiaries, affiliates, branches, and holding companies. We will identify individually listed companies when what we present references that particular entity, such as BGI Genomics and MGI Tech.

national gene bank, orchestrating bio-prospecting* globally through China's Belt and Road Initiative and Huoyan labs,[†] and becoming the collaborator of choice for many due to its lower costs enabled by government support.

What follows is a close look at some of the drivers of the new technological race to understand what genes do, the race from “genotype to phenotype,” and why this is increasingly important to U.S. national security. However, in the changing nature of global competition, what will be even more important than any one technology or any one field is how open market economies ensure a level playing field for their companies and researchers. Using BGI as a case study, we dive into the complex world of China's hybrid economic system that blurs private and public, civilian and military to meet the goals of the state. This system creates market distortions and undermines the global norms of science by leveraging researchers and academic and commercial entities to further the goals of the state, rather than open collaborations that benefit both parties, or fair commercial competition free from market-distorting subsidies and restrictions. Through its policies and programs, China uses the power of the state to not only advantage its own companies, but to disadvantage others with the goal of dominating these industries of the future.

However, unlike what the U.S. faced with China's 5G champion Huawei, there are proactive steps the U.S. and other open liberal democracies can take to ensure that the research and tools of discovery reflect democratic values and are not controlled by a strategic competitor. It will require a holistic approach that recognizes those areas where national security and the market diverge. It will also require a clear vision and committed government funding support that prioritizes long-term national security and national economic security over short-term cost savings, cheap goods, and corporate profits for companies operating in the biotech and medical fields. It will require the U.S. government to take a more active role in supporting and protecting U.S. and allied countries' biotech companies, as it has done in other sectors such as aerospace and chips development. A strategy that fosters the best of biology innovation and provides support so that our companies can compete in what has become an unequal playing

* By bioprospecting, we mean collecting the genomic data of plants, animals, pathogens, and humans worldwide.

[†] Labs in BGI's affiliated virus detection laboratory built during the COVID-19 pandemic to support disease detection, prevention, and control.

field will have implications far wider than biology itself, and can provide our own blueprint for fair and balanced technology competition in the future.

Beijing's Drive for Sequencing Capacity: The Race from Genotype to Phenotype

Understanding what genes do—so that society can harness that knowledge to understand human and organism traits, discover the causes of diseases, and harness this knowledge for a wide range of applications—will drive competition in biotechnology. If an authoritarian nation dominates the genomics space—and the industry that supports it—that nation will control the development of next-generation medical technologies, research standards and norms, and future genomics applications. This will have economic, ethical, and security implications for the U.S. and other liberal democratic states.

DNA sequencing—or the general laboratory technique for determining the exact sequence of nucleotides, or bases, in a DNA molecule—allow scientists to begin to understand which gene or group of genes are responsible for which physical characteristics.⁸ Sequencing capacity and development of new sequencing and analysis tools are essential to understanding the genome and driving discovery and impact almost every aspect of biology. This ecosystem consists of companies that produce the instruments and equipment required for gene sequencing, as well as the supporting reagents and consumables for these processes; institutions providing sequencing services, such as services for basic research and for clinical and medical genetic testing; and various end users of gene sequencing technology and genetic testing, such as medical institutions, research institutes, pharmaceutical companies, and academic users, as well as government and military institutions.

Box 2. The Bioeconomy—Driver of Future Industry

Developments in the biosciences will touch almost every aspect of society, and impact economic development. While there is no one estimate of all the pieces of the bioeconomy,* examples of its impact include the Human Genome Project (HGP), which officially ran from 1990 until 2003; it was a multinational effort to sequence the human genome and facilitated the emergence of the modern genetic sequencing and genomics industry. From 1988 until 2010, the U.S. government invested approximately \$12.8 billion in the HGP and related genomics research, generating \$796 billion in economic activity. In 2010, the genomics industry—which was created in large part by the initial R&D investment by the U.S. government—directly supported more than 51,000 jobs, indirectly supported more than 310,000 jobs, and added \$67 billion to the U.S. economy.⁹ The recent executive order on biomanufacturing¹⁰ is focused on yet another key area of growth. The ability to harness biology for multiple applications will have a tremendous impact on GDP. According to a Congressional Research Service report,¹¹ the estimated direct economic impact of bio-based products, services, and processes to the economy will be \$4 trillion per year globally over the next 10 years.

China has made developing sequencing capacity a national priority¹² and has supported the development of companies and research institutions that are beginning to dominate each part of the ecosystem. The first part of the sequencing ecosystem is made up of the companies that make the tools of discovery: gene sequencing equipment. Technological advancement in sequencing equipment has driven the rapid growth in sequencing speed and the corresponding rapid reduction in the cost to sequence genomes, enabling the creation of new diagnostics, new research on different functions of the genome, and new therapeutics. The largest companies/players in this space include global market leaders Illumina and Thermo Fisher Scientific. In addition, MGI Tech Co.—and its U.S. subsidiary, Complete Genomics—are recent competitors with Illumina and Thermo Fisher in next-generation sequencing. This segment of the market is currently dominated by U.S. and U.K. companies—with the exception of MGI Tech

* Studies done of the bioeconomy include the 2020 National Academies of Sciences' "Safeguarding the Bioeconomy" report.

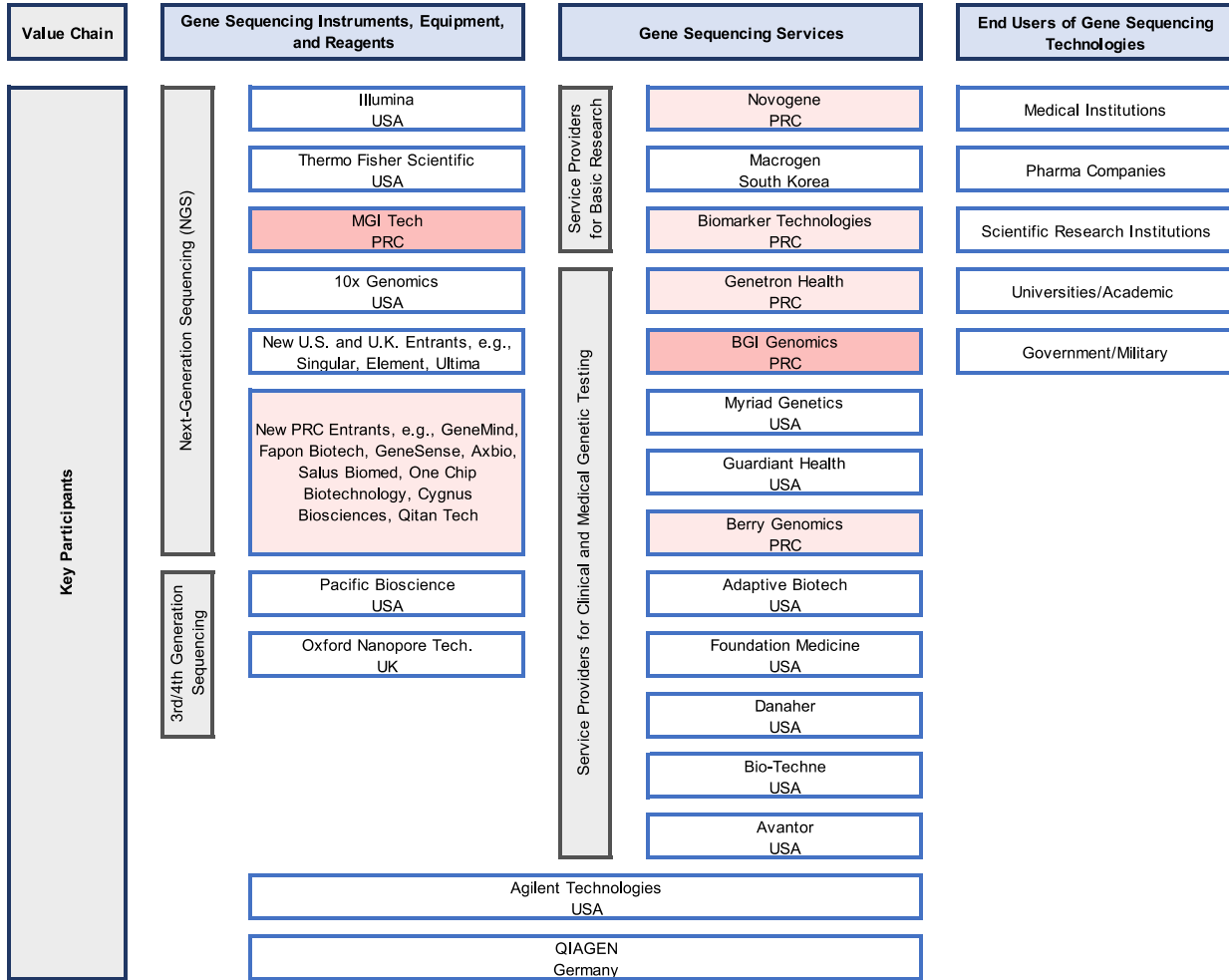
and its U.S. subsidiary, Complete Genomics, that will begin selling sequencing technology into the U.S. market.

Gene sequencing services make up the second part of the ecosystem. These are companies that purchase sequencing equipment and consumables and use them to perform sequencing and genetic testing for their own research or for clients such as medical institutions or research institutes. Because genomic data is massive in scale and sequencing is complex, industrial players are incentivized to purchase large-scale equipment with higher throughput. (Less costly, smaller equipment that is simpler and easier to operate, with flexible throughput, is used in clinical settings.) This part of the ecosystem is increasingly dominated by Chinese players, including BGI Genomics, Novogene, Biomarker Technologies (BMKGENE), Genetron Health, Berry Genomics, AmoyDx, New Horizon Health, and DaAn Gene—creating a dependency where global researchers rely on gene sequencing from Chinese entities.¹³ *When the rest of the world's research institutions rely on Chinese companies for sequencing, it gives Chinese entities—and the Chinese government—access to not only worldwide genomic data, but also the world's biotech research ideas, putting the foundation of global biotech research at risk of IP theft, exploitation, and manipulation.*¹⁴

Finally, end users of gene sequencing technology and genetic testing, such as medical institutions, research institutes, pharmaceutical companies, and academic users, as well as government and military institutions, make up the last part of the ecosystem. These applications include research on infectious disease, metagenomics, and reproductive genetics, as well as tumor diagnosis and the development of targeted therapeutics.¹⁵

Figure 1: Gene Sequencing Ecosystem

Illustrative Gene Sequencing Value Chain



Note: (1) 万众一芯生物科技有限公司 (2) 齐碳科技

Legend

- BGI Group Entities
- Other PRC-based Companies

Source: CSET analysis.¹⁶

The BGI-China Success Story: China's Hybrid Economy and the Power of National Champions¹⁷

Despite the importance of genomics and initial investments into the Human Genome Project, the U.S. still lacks a comprehensive national strategy for the bioeconomy. At the same time, China has made biotechnology—and genomics in particular—a national priority. A combination of long-term planning, government assistance, and subsidies that enable the BGI Group to provide services and equipment below market cost has allowed it to become the global leader it is today. Beijing's ability and willingness to use its domestic market, strategic planning, and global reach to foster BGI's growth provides it a large advantage over its competitors, who exist in the market and are subject to traditional market forces. In many ways, BGI is the “pointy end of the spear” for Beijing's industrial policy for biotechnology.

BGI—formerly the Beijing Genomics Institute—evolved from part of the Chinese Academy of Sciences to participate in the Human Genome Project in 1999, to become the hybrid company it is today. Funding from the China Development Bank in 2010 allowed BGI to purchase 128 Illumina DNA sequencers, setting BGI up as one of the largest DNA sequencing facilities in the world.¹⁸ Later, when it went public on the Shenzhen Stock Exchange, BGI received over \$30 million in subsidies from Chinese state funds—and this is only the amount disclosed publicly.¹⁹

BGI works closely with the Chinese Communist Party (CCP) and China's agencies and ministries, bringing Beijing's biotech ambitions to reality. It runs China's National GeneBank DataBase (CNGBdb), which was approved in 2011 by China's National Development and Reform Commission, Ministry of Finance, Ministry of Industry and Information Technology, and Ministry of Health and Family Planning, further blurring its connections to the CCP. This partnership leverages the sequencing capability of BGI to form a biorepository hosting tens of millions of samples for humans, plants, animals, and microorganisms, banking DNA to “support science and technology development.”²⁰

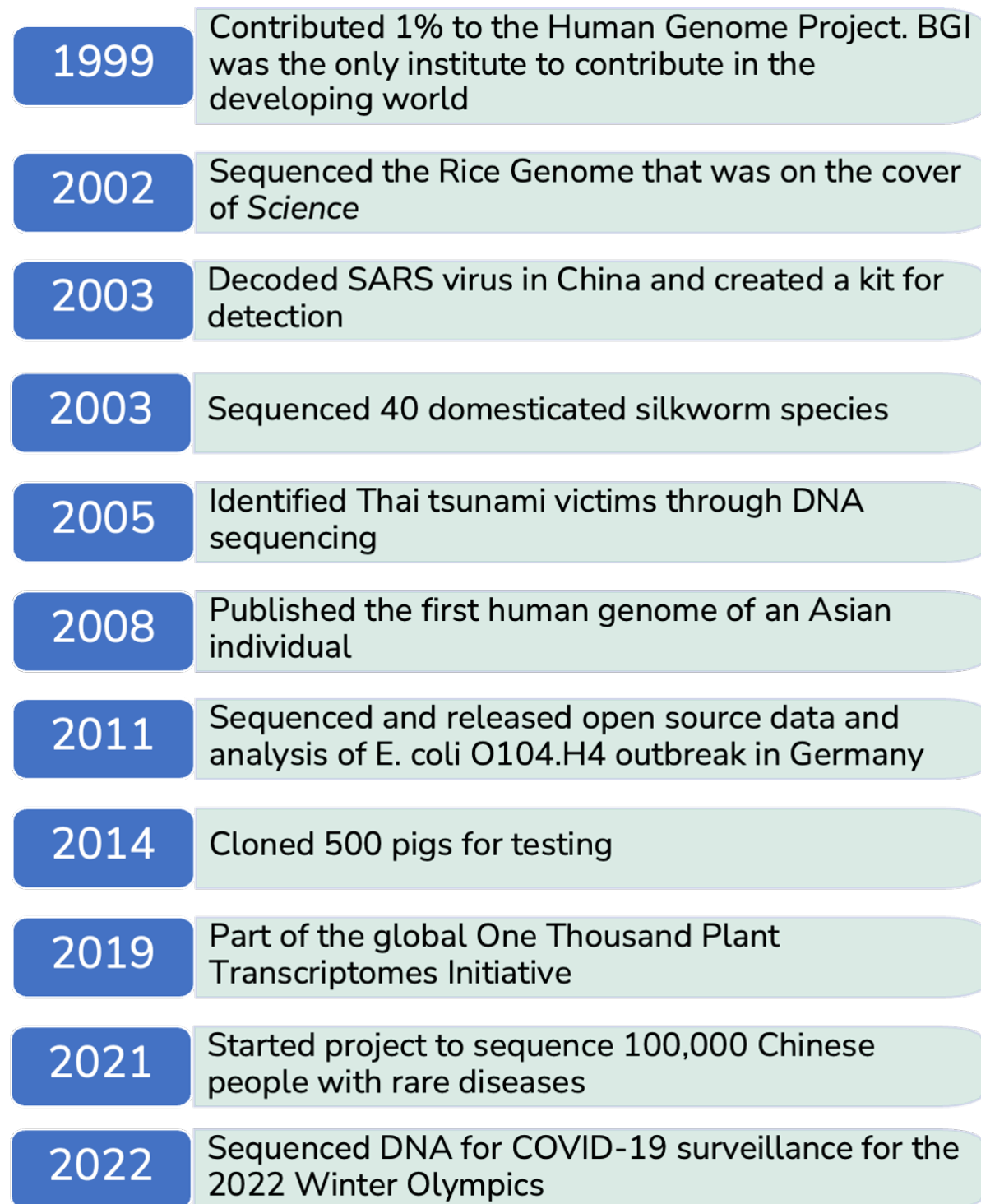
BGI leverages its ties to the government to develop products for the global market. For example, the development of the prenatal NIFTY* test was initially funded by the Key Laboratory Project in Shenzhen, with scientists from BGI, hospitals, and universities

* NIFTY is a noninvasive prenatal test designed to provide similar information to amniocentesis.

contributing to the project.²¹ In this study, participants were recruited from the local hospitals in Shenzhen. The funding support as well as a sourced participant pool allowed BGI to test and develop NIFTY. In addition to providing the service of prenatal screening, BGI also uses data from the NIFTY tests to publish in high-impact journals, both bolstering Chinese science and driving innovation through access to this unique data source that is not shared with other researchers.²²

BGI has been involved in more controversial activities for the Chinese government as well, such as the collection of genomic data from China's ethnic minorities in Xinjiang.²³ In Xinjiang, BGI has collected over 18 million people's genetic data on behalf of the state, under the auspices of anti-terrorism campaigns or promises of health care.²⁴ In question is the lack of consent as well as the state's use of this information for surveillance. Additionally, BGI researchers have subsequently used the collected information in studies focused on determining facial features of different groups based on their genomic data. Several of these published studies have been retracted by the journals due to ethical concerns surrounding the collection and use of the DNA.²⁵

Figure 2: BGI's Evolution



Source: CSET Analysis and press reports²⁶

Piecing Together BGI's Corporate Structure: China's Hybrid Companies

Given BGI Group's structure and global reach, its accumulation of genomic data worldwide, and its support from the Chinese government, we set out to better understand its corporate structure, as well as the depth and breadth of its activities. BGI Group is a massive international entity, and mapping the corporate family involved assembling information from several sources. BGI Genomics is publicly traded on the Shenzhen Stock Exchange (SHE: 300676), and therefore provides public disclosures. An analysis of BGI Genomics' annual and semi-annual reports (年半年度报告 and 年年度报告) from 2019 through 2022 provided an initial subsidiary, branch, associate, and affiliate list. We also analyzed the 2022 Prospectus of MGI Tech (深圳华大智造科技股份有限公司), a major affiliate of BGI Genomics, which went public on the Shanghai Stock Exchange on September 9, 2022 (SHA: 688114) for additional subsidiaries, associates, and affiliates. These five documents served as the starting point for our analysis. As a way to most accurately portray the complex and overlapping nature of BGI Group, BGI Genomics, MGI Tech, and their holding companies, we rely on the taxonomy and lexicon taken from these reports.

We obtained these documents from CNINFO, an investment firm in Shenzhen, China. We complemented our primary sources with corporate press releases, searching the Refinitiv (now LSEG) database of corporate entities, and Baidu searches (the primary Chinese search engine). Together, these sources provided us with information about BGI Genomics and MGI Tech, such as the nature of their corporate relationships, their subsidiaries, affiliates and associated companies, and their stockholders and holdings. Altogether, we extracted 445 corporations, research institutions, branches, and banks related to the BGI corporate family.* We also utilized data available via PitchBook and S&P Capital IQ databases to examine the public and private shareholder base of BGI Genomics and MGI Tech and the ultimate beneficial ownership of shareholders.

However, because we relied on disclosure documents for two publicly traded companies within a much larger, privately held corporate family, we have variable levels

* We want to note that we analyzed a total of five disclosure documents capturing corporate information from 2019–2022, with our most recent document being BGI Genomics' 2022 annual report (published in 2023), and therefore we may not have included information from entities that severed relationships with BGI or MGI prior to 2019, that were included in previous disclosures but dropped in later ones, or that engaged in activities with BGI or MGI during fiscal year 2023.

of information for the various entities identified in our analysis. For example, the main holding company for BGI Genomics is privately held, and therefore does not have widely available disclosed documents. As a result, other entities within the larger BGI corporate family are only identified if they directly relate to BGI Genomics (such as through joint ventures or holdings). Similar limitations exist for the MGI Tech branch of the corporate family. In addition, we did not verify the validity of the claims in the disclosure documents, nor did we ensure that the list of entities we found is exhaustive. However, given the complexity of these corporations, we assess that we have at a minimum uncovered an unusual structure that is inconsistent with the norms of most global companies and demonstrate BGI Genomics, MGI Tech, and Complete Genomics' (a major subsidiary of MGI Tech based in the United States) ties to the Chinese government.

We cross-checked other databases when possible, and an interesting point to note is that *we found that other sources such as Refinitiv and Crunchbase did not have the same comprehensive coverage of Chinese companies as our primary data sources.* Given China's recent moves to further restrict the flow of information in its economy and to tighten regulations and surveillance over foreign companies and investors in the PRC, we anticipate that it will become increasingly difficult to understand the real nature of companies like BGI. We have uncovered a lack of transparency even prior to these changes, with nested LLC structures among not only BGI affiliates but also its investor base, that obfuscate how the company is funded and conducts operations.

For this analysis we categorized the relationships among companies—taken from the documents discussed above—as follows:

Primary companies: One of the four main, “controlling” companies in this network:

- **Shenzhen BGI Technology Co., Ltd.** (深圳华大基因科技有限公司), the parent holding company of BGI Genomics, referred to in this report as “BGI Group”
- **BGI Genomics Co., Ltd.** (深圳华大基因股份有限公司), referred to in this report as “BGI Genomics”
- **Shenzhen Huada Intelligent Manufacturing Holdings Co., Ltd.** (深圳华大智造控股有限公司), the parent holding company of MGI Tech
- **MGI Tech Co., Ltd.** (深圳华大智造科技股份有限公司), referred to in this report as “MGI Tech” (note that MGI Tech changed its name from 深圳华大智造科技有限公司)

Subsidiary (of BGI or MGI): An entity with more than 50% equity owned (directly or indirectly) by one of BGI Genomics or MGI Tech. These include entities such as the following:

- Complete Genomics
- Wuhan Huada Zhizao Bioengineering Co., Ltd. (“Wuhan Biology”)
- BGI Genomics Canada Ltd.

Affiliate (of BGI and/or MGI): An entity owned in part by BGI Genomics and/or MGI Tech.

- Wuhan Guao Gene Technology Co., Ltd. (“Guao Gene”)
- Suzhou Synbio Biotechnology Co., Ltd. (“Suzhou Synbio”)
- Kunshan MGI Yunying Medical Technology Co., Ltd. (“Kunshan Yunying”)

Associate (of BGI and/or MGI): An entity controlled by one of BGI’s or MGI’s senior executives.

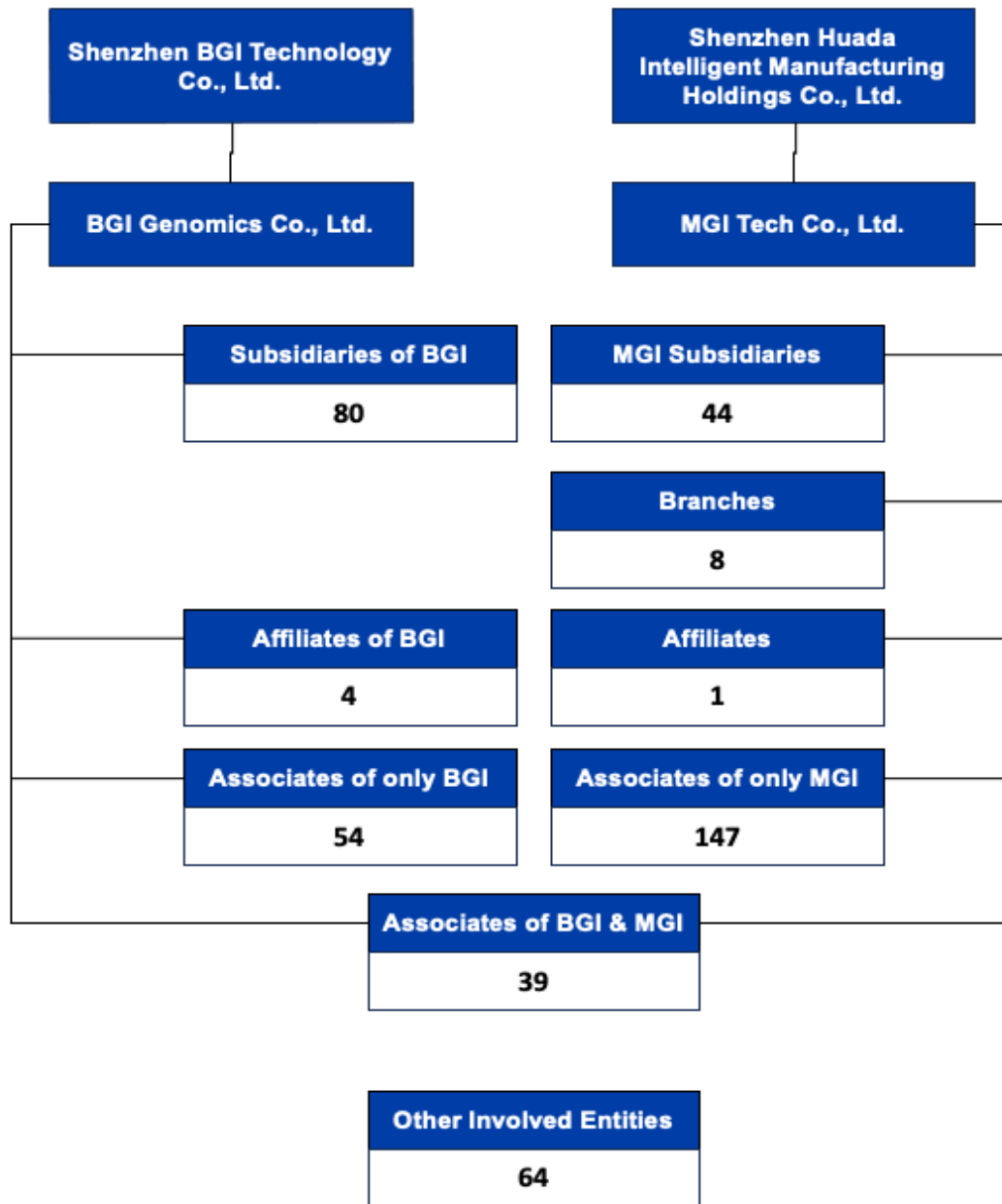
- Shenzhen BGI Technology Innovation Center Co., Ltd.
- BGI Luoyang Agricultural Innovation Center
- CITIC Industrial Investment Fund Management Co., Ltd.

Branch (of MGI): One of the eight regional branches of MGI.

Other: An entity with some other relationship to either MGI or BGI. This includes the following kinds of organizations:

- Exchanges in which BGI- or MGI-related companies are traded, including:
 - Shanghai Greenwoods Jingqi Investment Center (Limited Partnership)
- Banks and investment firms with major holdings in BGI or MGI, such as:
 - Bank of China Co., Ltd.—China Merchants State Certificate Biomedical Index Hualing Securities Investment Fund
- Companies identified in prospectuses but lacking a clear explanation of relationships. Below are some examples:
 - Beijing Rongzhi Lian Technology Co., Ltd.
 - Shaanxi Hua Darre Technology Co., Ltd.
 - Shenzhen Huada Clinical Examination Center

Figure 3: BGI's Structure



Source: CSET analysis.

Overlapping Leadership Blurs the Lines Between BGI and MGI and the State

Further complicating the corporate structure of BGI Group, BGI Genomics and MGI Tech, several key executives simultaneously hold leadership positions in multiple parts of the organization, in each organization, as well as government-related positions in

State Key Labs or Government Guidance Funds or actual government positions. This is similar to the leadership movements of State Owned Enterprises (SOE) where individuals move between the SOE, research enterprises such as State Key Labs, Universities and Chinese Academy of Sciences, as well as positions in Chinese ministries and government offices. For example, Wang Jian (汪建) is the chairman of MGI (深圳华大智造科技股份有限公司) and, through Zhizao Holdings (智造控股) and Huazhan Venture Capital (华瞻创投), owns 52% of its stocks. He is also the cofounder and chairman of the board of directors of BGI Group, and according to 2022 MGI prospectus, chairman of both Shenzhen Huada Gene (深圳华大基因科技有限公司) and BGI Genomics (深圳华大基因股份有限公司).²⁷ Other examples include:

- Xu Xun, executive director of BGI Group, chief scientist of BGI Group, director of BGI-Research, director of the International Planning & Development Center, director of the Key Provincial Laboratory of High Throughput Genome Sequencing and Gene Editing (a state organization), former CEO of BGI Americas and executive director of China National GeneBank DataBase, a government organization.
- Mei Yonghong, director and executive vice president of BGI Group, previously held multiple positions in the government including as deputy director of the Ministry of Science and Technology and mayor of Jining, Shandong Province before joining BGI in 2015.²⁸
- Mu Feng, CEO of MGI, previously served as the rotating CEO of the BGI Group in 2017.
- Lu Jun, currently serves as executive director, chief operating officer, and director of the China Regional Planning and Development Center of BGI Group. Before joining BGI, he served as secretary of the Suzhou Municipal Party Committee and party secretary of the Communist Youth League in Jiangsu Province.

State Provides BGI and MGI Funding

In addition to examining the corporate structure of BGI, we also examined its corporate funding. Using the same documents and sources described above, we examined funding sources, shareholder base, and market share trends to gain a better understanding of both BGI and MGI's rapid growth, how they compare to their competitors in the market, whether their revenue and global reach are aligned, and who

financially supports their developments. We examined the public shareholding of both companies, which are dominated by executives of both companies and affiliates on the one hand, and China's government-linked and state-owned entities on the other. As evidenced by numerous financial abnormalities, which will be highlighted later in this paper, the BGI Group—which includes BGI Genomics and MGI Tech—exemplified Chinese companies that are publicly listed on international stock exchanges but do not conform to global market norms. The evolving regulatory environment—and resultant state support—is expected to enhance the companies' ability to grow domestically.

What our examination found was a collection of patterns that indicated the degree of control and influence that the CCP and the Chinese state have over BGI Group, including BGI Genomics, MGI Tech and the associated subsidiaries, affiliates, and associates via various mechanisms; a collection of financial behaviors that are uncommon among for-profit companies operating under market pressures; and various forms of guarantees and financing that are also irregular and provide clear advantages to the BGI Group when competing with other companies, both domestic and international. These include:

- A majority of the shareholders having direct or indirect ties to the CCP.
- Direct investment into both BGI Genomics and MGI Tech by multiple Chinese government guidance funds.
- BGI and MGI relying primarily on the state as the primary source to fund their operations and global expansion.

While any one of these may occur in some form in any company anywhere in the world, the totality of these collectively is not normal in free market societies and indicates the high degree of coupling that exists between the CCP, the Chinese state, and the BGI/MGI constellation of companies. Below we explain each of these in turn.

Shareholder base: A majority of MGI and BGI's shareholders have direct or indirect ties to the CCP.

MGI Tech Shareholders

Approximately 77% of MGI Tech's shares float publicly—that is, are traded on the public markets—while 23% remain privately held. Of the 16 publicly identified current private shareholders, 75% are government-affiliated, including funds managed by

CITIC Group, a state-owned enterprise (SOE); Shanghai International Group Assets Management (a subsidiary of state-owned Shanghai International Group); and others (see Appendix 1). China State Development and Investment Corporation (SDIC), the largest state-owned investment holding company in China, holds shares in both MGI and BGI.

Among the MGI's public shareholders, of those shareholders owning 0.05% of the company or greater, 76% (22 entities) are directly state-backed or have state links.* Of the four non-state-affiliated shareholders (note there are an additional three shareholders whose ultimate affiliation could not be determined), one is chairman and cofounder Wang Jian, who holds 46.8% of the common stock outstanding and represents the largest shareholder in the company. The second largest single shareholder is CPE Investment, which is the private equity arm of CITIC Securities, an affiliate of state-owned investment company CITIC Group. In total, eight entities controlled by CITIC are invested in MGI, representing 6.6% of the public shareholding and an additional undisclosed portion of the private shareholding.

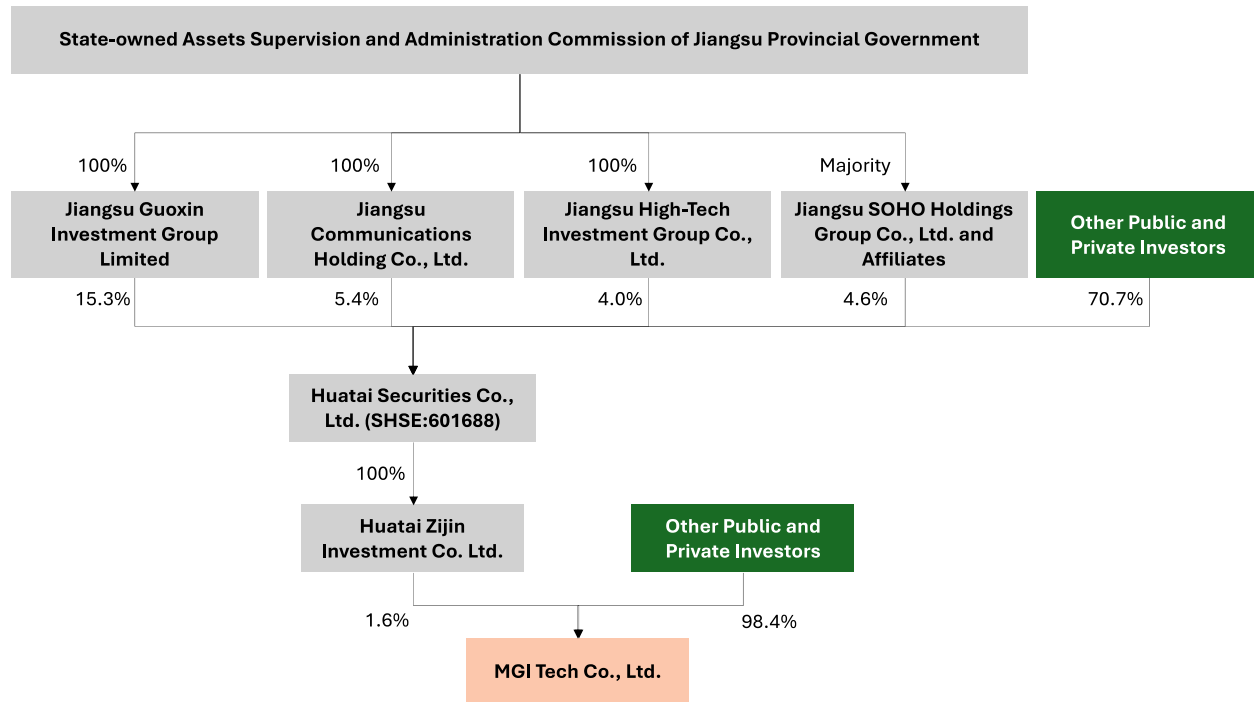
While ownership of shares in a company does not necessarily translate to control (which is typically determined primarily by the company's formal governance structure), a company's shareholder base is still an important barometer of its sources of capital and may additionally indicate sources of direct or indirect influence.

The lack of transparency associated with the Chinese state's true level of involvement in each investor complicates assessing state links among BGI and MGI shareholders. For instance, one of MGI's larger single shareholders, Hubei Science and Technology Investment Group Co. (2.4% stake), is a state-owned holding group engaged in industrial investment, development, and construction that is based in Wuhan and was founded in 2005 with the specific aim of promoting economic development in the province.²⁹ Here, the state link is unambiguous. In comparison, shareholder Huatai Zijin Investment Co. (1.6% stake) is an affiliate of Huatai Securities, one of the country's largest securities brokerages. Huatai Securities itself is now publicly traded. However, it remains at least partially controlled by the government of Jiangsu province, where the company was founded in 1991, via a collective 29.3% stake held by various entities controlled by the State-owned Assets Supervision and Administration Commission of

* For an additional three public shareholders, we were unable to determine the ultimate ownership of the entity (state-linked vs. private/other).

Jiangsu Provincial Government (see Figure 4 below). (Indeed, four of Huatai Securities’ top five shareholders are affiliated with the Jiangsu provincial government).³⁰ This example illustrates the difficulty in untangling the extent and manner in which the CCP is directly or indirectly influencing, funding, and directing the activities of MGI and BGI.

Figure 4: Illustrative Ownership Example, MGI Tech Co.



Source: CSET analysis; S&P Capital IQ database as of January 25, 2024.

BGI Genomics Shareholders

BGI’s shareholder base looks similar, and is majority controlled by corporate insiders and state-affiliated entities. Approximately 59% of the company’s shares float on the stock exchange, while the remaining 41% are privately held. Of the 41 private shareholders, 22 are government-affiliated (54%), while three are entities affiliated with or related to BGI Group (7%). Likewise, via the publicly traded shares, state-linked shareholders and shareholders affiliated with BGI Group together control another 57% of the company. Specifically, for the public shares, of the 27 investors holding more than 0.05% of the company, 11 are state-affiliated (10% of total shareholding), while an additional seven are affiliated entities or insiders (48%). Effectively no power or

influence can be wielded by those dozens of shareholders who together split the remaining 2% of the public shares.

Government Guidance Funds Are Directly Invested in Both BGI and MGI

BGI, MGI, and as a result, Complete Genomics, are supported by China's practice of channeling capital to select companies through the use of government guidance funds [政府引导基金]. Guidance funds are public-private investment funds that aim to both produce financial returns and further the state's industrial policy goals, including China's pursuit of leadership in strategic and emerging technologies.³¹ Unlike subsidies funded through grants or low-cost loans, guidance funds represent direct equity subsidies to industry. With their government backing and strategic mandate, guidance funds offer longer-term "patient capital," a critical resource for emerging technologies—like those in biotech—with lengthy R&D cycles.³² In this way, state investment remains a major driver of venture capital and other innovation-oriented investment in China, and the state determines "where innovation takes place."³³

Guidance funds have a government sponsor who serves as an "anchor investor," typically putting up 20 to 30 percent of the fund's capital; the remainder of capital will be raised from what China calls "social capital" investors such as SOEs, corporations, and financial institutions.³⁴ The government sponsor creates an entity or recruits an existing firm to serve as the fund manager. The fund managers may be traditional private equity or venture capital investors managing other non-guidance fund capital simultaneously, or they may be state-controlled entities. According to Zero2IPO Research, there were a total of 2,107 guidance funds established in China as of the end of 2022, with RMB6.51 trillion (\$920 billion) raised.³⁵ This is greater than the entire GDP of Turkey in 2022 (approx. \$905 billion).³⁶ This enormous scope reveals the vast resources the CCP is directing toward industrial policy in its ambition to surpass the United States in advanced technology.³⁷

Examples of guidance funds that are shareholders in BGI and MGI include:

MGI Tech

- China Grand Prosperity Investment (CGP) operates as a fund-of-funds manager, under which auspices it manages dozens of government guidance funds in Beijing, Shanghai, Jiangsu, Zhejiang, Hunan, and Chongqing across more than 400 funds.³⁸

- SDIC Unity Capital is a government guidance fund and parent fund management platform of China's State Development and Investment Corporation (SDIC), which is the largest state-owned investment holding company in the country and is under direct control of the central government.³⁹
- Hubei Science and Technology Investment Group (discussed above) sells large amounts of their corporate bonds to various guidance funds.⁴⁰ So while this entity is not a guidance fund (though it is a state-owned conglomerate and development agency), it channels guidance fund capital to investee companies. The group raises capital through the sale of bonds and dispenses that capital to companies, with the goal of promoting development in Hubei province.

Additionally, MGI as recently as mid-2023 had other government guidance funds in its private shareholder base, all of whom have recently exited their positions, perhaps ahead of anticipated increase in U.S. government scrutiny about MGI's ties to the Chinese government. These include the below:

- Shenzhen CoStone Asset Management Co. (sometimes translated as Cornerstone Asset Management) is a private shareholder of MGI. CoStone manages or co-manages multiple guidance funds on behalf of the government of Shenzhen, including the Xiangjiang Fund, a RMB 20 billion (\$2.8 billion) provincial government guidance fund, and the Shenzhen New Energy Automobile Industry Fund, a RMB 2 billion (\$280 million) fund they co-manage with Shenzhen Investment Holdings.^{41 42 43} One of CoStone's major LPs (investors) is Shenzhen Capital Group, a state-owned entity that administers the guidance funds for the government of Shenzhen. Relatedly, Shenzhen Capital Group is a direct shareholder in BGI.
- GTJA Innovation Investment Co., Ltd., otherwise known as Guotai Junan Innovation Investment, was established in 2009 and is a wholly-owned private equity investment management subsidiary of Guotai Junan Securities, a partially state-owned enterprise. Guotai Junan Innovation Investment focuses on emerging technology, biomedicine, green development, and similar industries.⁴⁴ It serves as a fund manager for multiple guidance funds and openly cooperates with guidance funds. It manages over RMB 70 billion (\$9.8 billion), and has over 100 direct investment projects.⁴⁵

- Green Pine Capital Partners, based in Shenzhen, is an investment firm that provides fund management services and private equity and venture capital investments. It has over \$2.2 billion in assets under management. Its LPs (investors) include multiple guidance funds and government economic development agencies, including Shenzhen Futian Guiding Fund, Longyou County Industrial Fund Management, and Nanjing Industrial Development Fund.⁴⁶ As well, state-owned enterprises China Merchants Group and Shenzhen Capital Group (discussed below) are Green Pine's largest LPs, having made 37 and 47 total capital commitments, respectively, to the firm over its lifetime.⁴⁷

BGI Genomics

- Shenzhen Capital Group Co., Ltd (SCGC; 深圳市创新投资集团有限公司) is a state-owned venture capital company based in Shenzhen, China.* It is affiliated with the Shenzhen Government and its investments cover industries supported by national policies. SCGC invests in high-tech SMEs and high-potential SMEs from emerging industries such as Information Technology, Internet, Biotech/Healthcare, New Energy/Clean Technology, New Materials, Advanced Manufacture, and Consumer Goods/Modern Services. SCGC also established Hotland Innovation Asset Management Co., Ltd., China's first mutual fund management company owned by a VC firm, which is also an investor in BGI.⁴⁸
- Great Wall Fund Management (Shenzhen) Co., Ltd. (前海长城基金管理(深圳)有限公司), also known as Qianhai Great Wall Fund or Qianhai Great Wall Fund Management (Shenzhen) Co., is an investment entity that manages guidance funds on behalf of the government of Shenzhen. Limited partners include Futian Guidance Fund, Shenzhen Capital Group Co., Ltd. (see above), Shenzhen Futian Guide Fund Investment Co., Ltd., and Shenzhen Government Investment Guidance Fund.⁴⁹

* Shenzhen Capital Group operates as a government policy fund, a type of government-backed fund that conducts direct investments to support a particular policy initiative. It also manages various guidance funds on behalf of the government of Shenzhen. While it is difficult to identify which pool of capital Shenzhen Capital Group utilized to invest in BGI, what is clear is that the investment funds are directly state-linked.

- Share Capital (分享投资) was founded in 2007 and is headquartered in Shenzhen; it is ultimately backed by China Life Insurance and the government of Jiangsu Province.* ⁵⁰ It has investments in over 200 enterprises and manages more than RMB 8 billion in assets (over \$1.1 billion).⁵¹ Investors in its individual funds include national and local governments, top universities, fund-of-funds (FOFs), listed companies, and established entrepreneurs. Share Capital manages guidance funds on behalf of the government of Shenzhen.⁵²
- SDIC Chuangyi Industry Fund Management manages multiple individual guidance funds on behalf of the State Development and Investment Corporation (SDIC). Assets managed total RMB 37.7 billion (\$5.3 billion).⁵³ † As of the end of 2021, the SDIC managed ten national industrial guidance funds totaling RMB 158.7 billion (\$22.4 billion).⁵⁴ Among others, these guidance funds include the Poverty-stricken Area Industrial Development Fund, which is managed by SDIC Chuangyi Industry Fund Management, which is a private shareholder in BGI.

Beyond the involvement of government guidance funds, both BGI Genomics and MGI Tech raise funding directly from other state-owned enterprises as the primary means to fund their operations and global expansion. BGI and MGI need to obtain cash to fund R&D, build out new offices, expand internationally, meet payroll, conduct marketing, and execute other business activities. Neither company has generated meaningful positive free cash flow in any of the last four years that they could use to fund their growth, and neither carries significant debt (see discussion below). As a result, BGI and MGI's only funding option is to raise equity (i.e., sell shares). MGI went public in 2022, raising RMB 3.6 billion (approx. \$520 million) capital via its IPO.⁵⁵ As discussed, our analysis demonstrates that 76% of the largest public shareholders (entities who have

* Share Capital's primary backer is Oriza FoFs Investment Management, which in turn is a subsidiary of Suzhou Oriza Holdings Co., Ltd., which is directly backed by China Life Insurance Company Limited (SEHK:2628) (an SOE) and Jiangsu Guoxin Investment Group Limited (backed by State-owned Assets Supervision and Administration Commission of Jiangsu Provincial Government).

† Guidance funds managed by SDIC Chuangyi Industry Fund Management include across Poverty-stricken Areas Industry Development Fund, Central SOEs Industrial Investment Fund for Poverty-stricken Area, Datong Industrial Energy Development Fund for Poverty-stricken Areas, Ankang Science and Technology Industry Development Fund for Poverty-stricken Areas, and Chuangyi Shengtun New Energy Industry Investment Fund.

provided cash to the company in return for equity) of MGI are state-owned or state-affiliated (see Appendix 1).*

BGI, which has been public since 2017, more recently accepted approximately \$310 million in capital from China Merchants Securities, Huatai Securities, SDIC Chuangyi Industry Fund Management, Tianjin Liren Investment Management, the Central Enterprise Poverty Area Industry Investment Fund—all state-owned entities—via a private investment in public equity (PIPE) in 2020.

Additional Indicators of Government Ties

BGI Genomics has undertaken a number of capital markets activities that are unusual in global markets outside of China, including pledging shares, accepting guarantees from executive officers, and engaging in unusual, related-party transactions that make it look unlike a regular public company. Beijing has used economic and financial tools like these to support its national champions for decades.⁵⁶

Share Pledging: BGI and MGI pledge shares to raise capital at a level similar to China's SOEs. Typically, companies borrow money against real things that they can use as collateral, such as buildings, equipment, or inventory. When a company partakes in “share pledging,” they use company shares as collateral to issue debt, which is very risky because, by definition, share value fluctuates. A lender can force the company to sell those shares—which could strongly signal to other investors that the company is in trouble.⁵⁷ As a result, Western companies rarely do this. In 2022, BGI pledged a total of 45.16 million shares, on top of any share pledges already outstanding, to China Construction Bank, China Merchants Bank, Industrial Bank Co., Bank of Shanghai, Export-Import Bank of China, and Huaxia Bank, all state-affiliated. At the end of fiscal year 2022, 79,187,600 shares of the company were pledged, representing 51% of the number of shares held by the controlling shareholder (BGI Group and parties acting in concert) and 19% of the total share capital of the company.⁵⁸

Though share pledging is usually viewed a last-resort mechanism to raise capital, it remains popular among controlling shareholders of publicly listed Chinese firms, with an average of 38% of shares pledged by controlling shareholders of publicly listed, non-state-owned firms (versus 8% on average among public SOEs).⁵⁹ Guo et. al. find

* Largest public shareholder defined as shareholders owning 0.05% or more of the company

that “share pledging by controlling shareholders is significantly higher for publicly listed non-SOEs than for publicly listed SOEs [in China]. This difference is smaller for publicly listed non-SOEs with at least one minority shareholder that is an SOE or government agency,” like BGI, “suggesting that such government connections allow controlling shareholders of publicly listed non-SOEs to gain better access to cheap financing channels and hence a lower demand for more costly share pledging.” The takeaway is that share pledging itself, while not unusual in the Chinese context, remains costly, and BGI’s pledges of less than 20% of its outstanding shares represents a level of share pledging somewhere between a typical private firm and an SOE—indicative of how one should conceptualize BGI overall.

Related party guarantees: BGI Genomics’ executives provide loans to the company.

According to the financial statements we analyzed, in December 2019, BGI Genomics accepted a guarantee of RMB 100 million (approx. \$13.8 million) from company Chairman Wang Jian; the guarantee expires in December 2024. A guarantee is a promise made by one party (in this case, Wang Jian) to another party (BGI) to cover its debt in case the borrower (BGI) defaults on an obligation such as a loan. A guarantee might have economic benefits to the borrower; for example, by increasing the amount they can borrow, or allowing them access to more favorable borrowing terms such as a better interest rate. Guarantees between related parties (for example, between a company and its subsidiary) are commonly used.⁶⁰ However, it is unusual that an individual would provide a guarantee for a large company. Typically, a public company would have other means of raising capital besides relying on guarantees from its executive officers. This type of guarantee is likely better explained by political signals or connections that drove the chairman’s guarantee—another feature of China’s interconnected economic system.

Related party accounts receivables: BGI, through its non-collection of receivables, is funding the activities of its subsidiaries. BGI’s 2019 Annual Report shows RMB 330.2 million (\$45.6 million) of related party receivables, indicating this money is owed to BGI by a subsidiary or affiliate. The company provides for approximately 5% of the total related party receivables as “bad debts,” meaning it views these receivables as no longer collectible because the customer is unable to fulfill their obligation to pay. The implication is that BGI is effectively indirectly funding or subsidizing at least a portion of its affiliates’ operations through related party transactions for which it never expects to be repaid. For a company that itself is still in growth mode, and not yet substantially profitable, these transactions raise questions around where the capital is coming from to fund subsidies to dozens of subsidiaries.

MGI has received equipment donations from a nonprofit founded by their shareholders. In 2019, BGI received a RMB 1.11 million (\$153,243) equipment donation from Shenzhen Mammoth Public Welfare Foundation, a nonprofit foundation founded by Vanke Group, the country's largest residential real estate developer, and Songhe Venture Capital, also known as Green Pine Venture Capital or Green Pine Capital.⁶¹ Green Pine Capital is a previous private shareholder in MGI, and also is backed by China Merchants Group, a state-owned entity; Shenzhen Capital Group, a venture firm controlled by the government of Shenzhen; as well as other state-backed economic development agencies and funds.⁶² While not a large transaction in absolute terms, this donation serves to illustrate the complicated interlinkages between BGI, MGI, and the various state entities that directly and indirectly support it financially and otherwise.

Challenge to U.S. Companies: Expansion of Market Share and Growth of BGI and MGI

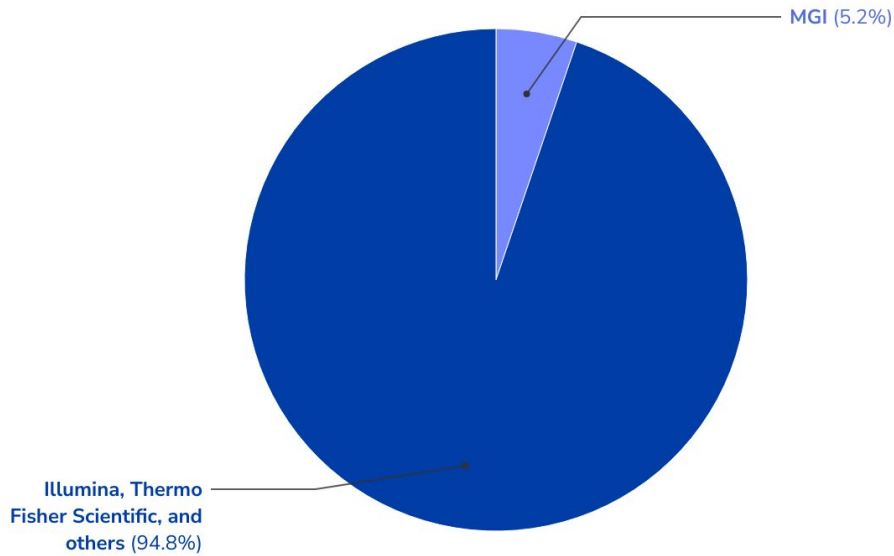
MGI and BGI have financed their growth in ways that are not typical for a growth-stage public or private company of this scale. Moreover, their capital markets activity that is publicly disclosed seems at odds with the rapid expansion of market share, the scope of international activities, and the number of affiliates both companies maintain.

Both MGI Tech and BGI Genomics have expanded their market share at rapid rates despite their smaller scale (as measured by revenues and market cap) versus global competitors, following a similar pattern to China's other national champions that are supported by China's central government policies. Expanding market share is typically driven by more spending (on advertising, marketing, sales personnel, etc.).⁶³ MGI's SG&A margin—or the percent of revenues spent on Sales and Administrative Functions—steadily rose from 21% in 2021 to 39% in the twelve months ending September 30, 2023.⁶⁴ This is one reason why tracing the sources of MGI and BGI's capital is important. The companies' funding, sourced in large part from the Chinese state, and the resultant spending of those funds is driving dramatic changes in market share—and thus influence—in China and globally.

The company with the dominant market share in any given market is the company likely to enjoy the highest profits in that market⁶⁵, and without anti-trust policies to hold it back, MGI is well on its way to becoming that player. In the five years from 2017 to 2022, MGI captured 5% global market share in the gene sequencing market (from 0%), according to Haitong Securities (see Figure 4). The company's revenue was 100% PRC-based in 2017, versus just 46% derived from China in 2021 (latest available; see Figure 5). Domestically, the company has also expanded its market share, growing from

a 13% share in 2020 to a 39% share of the PRC market in 2022, according to China Galaxy Securities, an investment bank and equity research provider (see Fig. 7).⁶⁶ This explosive growth in domestic market share is at least partially attributable to the recent surge of government support for domestic enterprises in critical industries, and the resulting challenges faced by foreign firms like Illumina and Thermo Fisher Scientific to maintain market share in China. The Ministry of Finance and Ministry of Industry and Information Technology's 2021 "Buy China" policy, or *Order 551: Guidance of Government Procurement of Imported Products*, outlined new rules for procurement of "315 local products, including 178 medical items."⁶⁷ MGI products such as sequencing, PCR, mass spectrometers, and sample preparation instruments and devices are all included in the list, and MGI has openly stated that it sees this "trend of domestic substitution" as an opportunity to increase its market share.⁶⁸

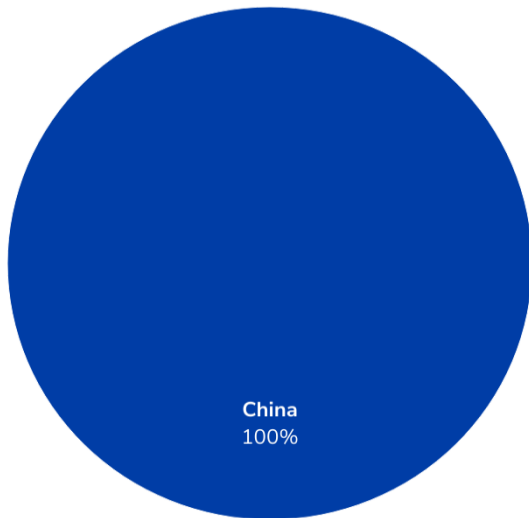
Figure 5: MGI's 2022 Global Market Share Was Approximately 5.2%



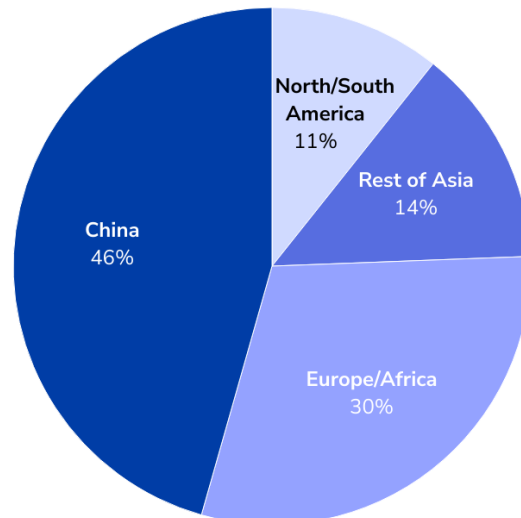
Source: Haitong Securities analysis, based on MGI 2022 Annual Report. Kehan Meng, “首次覆盖：NGS 行业寡头上游、生态圈长坡厚雪，” Haitong Securities International, June 20, 2023.

Figure 6: MGI Revenue Breakdown by Region, 2017 versus 2021

Revenue by Region, 2017

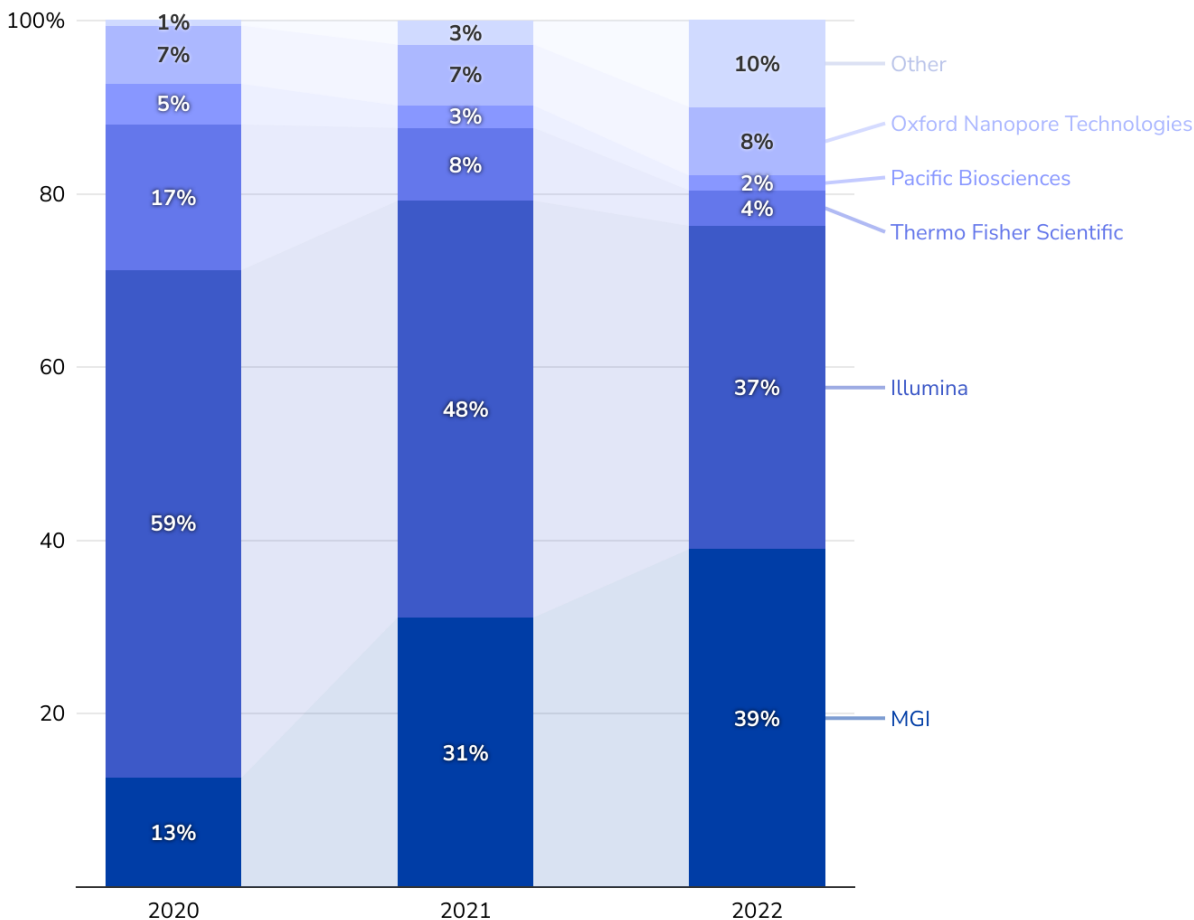


Revenue by Region, 2021



Source: Jialin Zhang and John Nie, “MGI Tech: A rising competitor in global genome sequencing market,” Global Markets Research, January 6, 2023.

Figure 7: MGI Revenue PRC Market Share, 2020–2022



Source: Haitong Securities analysis, based on MGI prospectus and annual reports, and company investor presentation at 2023 JP Morgan conference. Kehan Meng, “首次覆盖：NGS 行业寡头上游、生态圈长坡厚雪,” Haitong Securities International, June 20, 2023.

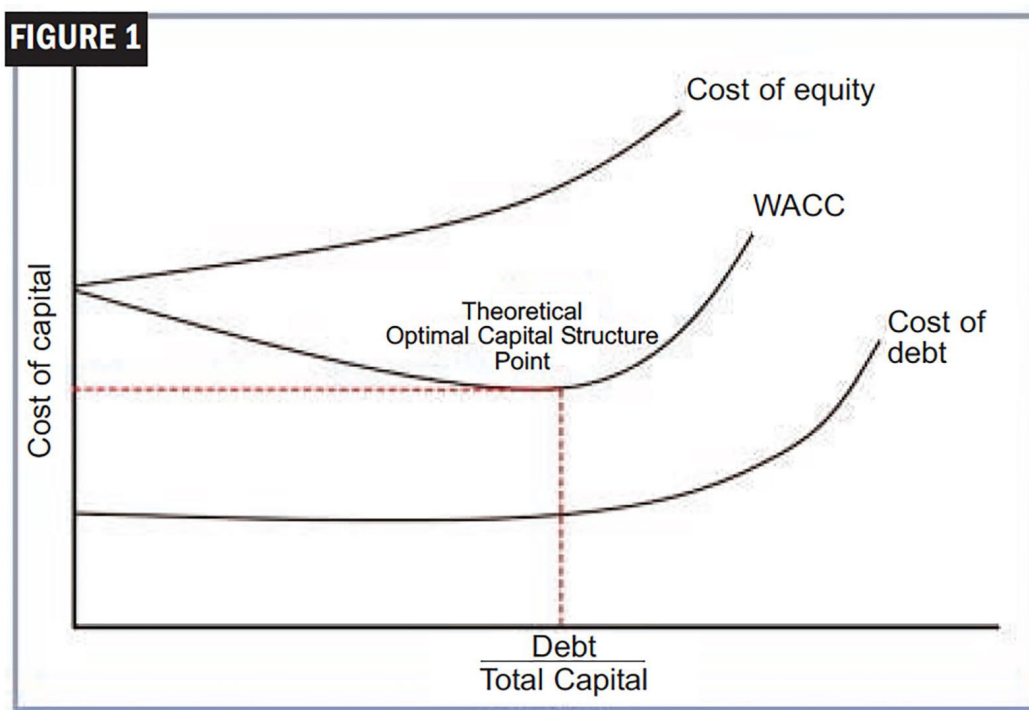
What follows is a more in-depth discussion of these points.

How Companies Grow: Characteristics of MGI and BGI's Market Growth

A company can generate cash to fund growth (e.g., invest in R&D, develop new products, hire additional personnel, run sales and marketing campaigns, buy new equipment, build new facilities, etc.) via one of three avenues: (i) debt financing (borrowing money with interest that must be repaid at a later date); (ii) equity financing (selling shares or a stake in the company); or (iii) using cash from operations (i.e., using

any excess cash the company has left over from sales, after covering all of their operating expenses, interest expenses, and taxes). A core principle of corporate finance holds that debt financing is cheaper than equity financing because lenders' expected returns are typically lower than those of equity shareholders. Therefore, the interest a company pays on a \$100 loan is typically lower than the cut of the company's profits owed to a shareholder who invested \$100. The more profitable a company is, or will be in the future, the more costly it is to give up equity (i.e., sell a stake in the company), because presumably that share of the company will be worth (much) more in the future. Therefore, it is more economical for a company to simply raise debt and pay interest.⁶⁹ The optimum capital structure for a firm is one that produces the lowest weighted average cost of capital (WACC), i.e., minimizes the firm's cost of financing (see Figure 8). This optimal point usually occurs between 20–50% debt in a firm's capital structure.⁷⁰ The only economic reason a company would not take on debt to raise capital is if they can't: it's too early (they are a start-up) or too late (they are in distress), though there might be other strategic reasons not to.

Figure 8: Illustrative Cost of Capital Curve



Source: BVA Group, "Optimizing Capital Structure and the Level of Debt Assumption," April 11, 2016 (<https://www.bvagroup.com/publications/2016/04/11/optimizing-capital-structure-and-the-level-of-debt-assumption>).

Company disclosures show both MGI and BGI carry effectively no debt, implying they fund day-to-day operations and any growth from elsewhere. Other sources of capital could include equity financing or cash from operations. As of this writing, MGI held \$57 million of debt while BGI held \$40 million, which are negligible quanta relative to the size of both companies and which imply very low leverage ratios for both.* On a net basis, neither company carries debt at all—as of Q3 2023, BGI holds \$776 million of cash on its balance sheet, and MGI \$722 million, meaning that the companies' net leverage is actually negative (i.e., they hold more cash than debt).⁷¹ This is quite unusual—typically a maturing company would carry reasonable leverage to fund operations and growth, as debt is a more economically attractive means of funding growth than equity. It is possible that both companies have lower levels of debt because they are not highly profitable and might struggle to service the debt; however, in contradiction to this argument, MGI itself as recently as 2019 held \$344 million of debt, while BGI held \$187 million of debt in 2020.[†]

The average market debt-to-equity ratio for publicly traded biotechnology firms globally, according to financial scholar Prof. Aswath Damodaran at New York University, is 16%, implying that if they were to conform to global averages, BGI would carry approximately \$226 million of net debt and MGI approximately \$206 million of net debt, based on book equity values of \$1.38 billion and \$1.26 billion, respectively.⁷²

Using a WACC analysis to calculate the optimal capital structure for each firm yields similar conclusions (see Figures 8 and 9). The analysis implies MGI would optimally have a debt ratio of 10–30% (\$140 million to \$541 million of net debt) while BGI would optimally operate between 20–30% (\$345 million to \$592 million of net debt).[‡]

*Debt figures include capital leases.

†Both of these figures represent the highest leverage levels on either company during the years in which public financials are available.

‡Debt ratio is defined as net debt divided by total enterprise value. Enterprise value is calculated as equity value plus debt minus cash.

Figure 9: MGI Tech Co. Illustrative Optimal Capital Structure (values in millions USD, unless otherwise stated)

| Debt Ratio | D/E | Beta* | Risk-Free Rate | Market Risk Premium | Cost of Equity ^{†73 74} | Interest Rate on Debt | Tax Rate | Cost of Debt (after tax) | WACC ⁷⁵ | Firm Value (G) | |
|------------|--------|-------|----------------|---------------------|----------------------------------|-----------------------|----------|--------------------------|--------------------|----------------|--|
| (106.2%) | (0.5x) | 0.58 | 2.685% | 8.000% | 5.79% | 2.99% | 25.0% | 2.2% | 9.6% | 612.1 | <i>Current capital structure</i> |
| 0.0% | 0.0x | 0.95 | 2.685% | 8.000% | 7.74% | 2.99% | 25.0% | 2.2% | 7.7% | 1,262.0 | |
| 10.0% | 0.1x | 1.03 | 2.685% | 8.000% | 8.16% | 2.99% | 25.0% | 2.2% | 7.6% | 1,402.0 | <i>Implied optimal capital structure</i> |
| 20.0% | 0.2x | 1.13 | 2.685% | 8.000% | 8.69% | 2.99% | 25.0% | 2.2% | 7.4% | 1,577.2 | |
| 30.0% | 0.4x | 1.26 | 2.685% | 8.000% | 9.37% | 3.99% | 25.0% | 3.0% | 7.5% | 1,802.8 | |
| 40.0% | 0.7x | 1.43 | 2.685% | 8.000% | 10.27% | 4.99% | 25.0% | 3.7% | 7.7% | 2,103.0 | |
| 50.0% | 1.0x | 1.67 | 2.685% | 8.000% | 11.54% | 5.99% | 25.0% | 4.5% | 8.0% | 2,523.8 | |
| 60.0% | 1.5x | 2.02 | 2.685% | 8.000% | 13.43% | 7.99% | 25.0% | 6.0% | 9.0% | 3,154.6 | |
| 70.0% | 2.3x | 2.62 | 2.685% | 8.000% | 16.59% | 9.99% | 25.0% | 7.5% | 10.2% | 4,206.2 | |
| 80.0% | 4.0x | 3.81 | 2.685% | 8.000% | 22.91% | 11.99% | 25.0% | 9.0% | 11.8% | 6,307.5 | |
| 90.0% | 9.0x | 7.35 | 2.685% | 8.000% | 41.77% | 13.99% | 25.0% | 10.5% | 13.6% | 12,582.7 | |

Source: CSET analysis.

* Beta is measure of the volatility—or systematic risk—of a security compared to the market as a whole.

† Cost of equity is calculated using the CAPM method.

Figure 10: BGI Genomics Illustrative Optimal Capital Structure (Values in millions USD, unless otherwise stated)

| Debt Ratio | D/E | Beta | Risk-Free Rate | Market Risk Premium | Cost of Equity | Interest Rate on Debt | Tax Rate | Cost of Debt (after tax) | WACC | Firm Value (G) | |
|------------|--------|------|----------------|---------------------|----------------|-----------------------|----------|--------------------------|-------|----------------|--|
| (108.6%) | (0.5x) | 0.50 | 2.685% | 8.000% | 5.34% | 2.55% | 25.0% | 1.9% | 9.1% | 663.2 | <i>Current capital structure</i> |
| 0.0% | 0.0x | 0.82 | 2.685% | 8.000% | 7.04% | 2.55% | 25.0% | 1.9% | 7.0% | 1,383.2 | |
| 10.0% | 0.1x | 0.89 | 2.685% | 8.000% | 7.41% | 2.55% | 25.0% | 1.9% | 6.9% | 1,536.8 | |
| 20.0% | 0.2x | 0.97 | 2.685% | 8.000% | 7.86% | 2.55% | 25.0% | 1.9% | 6.7% | 1,728.5 | <i>Implied optimal capital structure</i> |
| 30.0% | 0.4x | 1.08 | 2.685% | 8.000% | 8.44% | 3.55% | 25.0% | 2.7% | 6.7% | 1,974.8 | |
| 40.0% | 0.7x | 1.23 | 2.685% | 8.000% | 9.22% | 4.55% | 25.0% | 3.4% | 6.9% | 2,304.2 | |
| 50.0% | 1.0x | 1.43 | 2.685% | 8.000% | 10.31% | 5.55% | 25.0% | 4.2% | 7.2% | 2,764.2 | |
| 60.0% | 1.5x | 1.74 | 2.685% | 8.000% | 11.94% | 7.55% | 25.0% | 5.7% | 8.2% | 3,454.2 | |
| 70.0% | 2.3x | 2.26 | 2.685% | 8.000% | 14.67% | 9.55% | 25.0% | 7.2% | 9.4% | 4,609.8 | |
| 80.0% | 4.0x | 3.28 | 2.685% | 8.000% | 20.09% | 11.55% | 25.0% | 8.7% | 11.0% | 6,903.4 | |
| 90.0% | 9.0x | 6.38 | 2.685% | 8.000% | 36.60% | 13.55% | 25.0% | 10.2% | 12.8% | 13,884.5 | |

Source: CSET analysis.

The extent of BGI and MGI's global activities is inconsistent with other companies of their size. BGI Genomics and MGI Tech together have achieved remarkable global reach and operating scale that are disproportionate to their profile in the public markets. Each operates in approximately 100 countries, versus Illumina in 155. In comparison, core competitor Illumina has a market cap of around \$23 billion as of February 2024, versus under \$7 billion for BGI and MGI combined, less than 30% of Illumina's market cap. According to its 2022 Annual Report, Illumina has 47 wholly-owned direct and indirect subsidiaries, versus BGI's 177 subsidiaries, associates, and affiliates, which represents almost four times as many. For a roughly \$3 billion company to have this number of subsidiaries, investments, affiliates, and overseas activities is highly unusual.

Organizational complexity like this can obfuscate—purposefully or otherwise—the true nature of interactions and relationships between ostensibly unrelated entities, making it challenging for regulators and auditors to detect malfeasance (for example, favorable business dealings between seemingly independent but secretly-linked entities) or this case, the true extent of government ties. The presence of multiple interconnected affiliates or subsidiaries is not necessarily unusual in China or elsewhere, including the U.S.; many companies around the world use nested or siloed LLC structures to help limit liability and risk.⁷⁶ Both BGI and MGI are “mid-cap” companies, defined by having a market cap between \$2 billion and \$10 billion. Of the 200 mid-cap public companies operating in the pharmaceuticals, life sciences, and biotechnology sectors globally, the average number of current subsidiaries is 21 as of September 2023.⁷⁷ In comparison, BGI has 80 direct subsidiaries and MGI has 44, plus eight branches.

As a way to increase transparency, the U.S. Congress passed the Corporate Transparency Act in 2021, which created a new beneficial ownership* information reporting requirement as part of the U.S. government's efforts to make it harder for bad actors to hide behind or benefit from shell companies or other opaque ownership structures.⁷⁸ The act was also designed to close loopholes in current legislation that allows shell companies operated by the Chinese government to operate in the United States.⁷⁹ China does not require the same level of disclosure; ownership structure of Chinese-listed companies is disclosed in annual reports by law, but qualitative discussion of ultimate beneficial ownership is typically “boilerplate” at best.⁸⁰

* Beneficial ownership information refers to identifying information about the individuals who, directly or indirectly, (i) exercise substantial control over a reporting company or (ii) own or control at least 25 percent of the ownership interests of a reporting company.

Box 3. Would CFIUS Allow the Purchase of Complete Genomics Today?

In 2013, BGI—despite its ties to Beijing—acquired Complete Genomics, a company based in Mountain View, California. This acquisition was cleared by the federal Committee on Foreign Investment in the United States (CFIUS).⁸¹ In 2018, Complete Genomics became part of MGI. Complete Genomics has a competing DNA sequencing technology to the U.S. company Illumina. Since the acquisition, Complete Genomics and Illumina have faced off in both U.S. and international courts over patent infringement. In December 2021, Illumina received an injunction blocking BGI and any affiliated companies from advertising their sequencing platforms in the U.S. However, follow-on decisions have cleared the way for MGI Tech subsidiary Complete Genomics to begin to sell in U.S. and foreign markets with products that are subsidized by the Chinese government. Concurrently, China’s policies impact U.S. companies’ ability to sell in the China market.⁸² The unequal playing field that this creates essentially forces U.S. companies and researchers to compete against a nation-state that supports its national champions.

China’s Hybrid Economy and Implications for the U.S.

Although BGI’s sequencing capacity and solid R&D base contribute to its growing success, Chinese government industrial policies and procurements are largely responsible for its accelerated and market-distorting growth. Chinese government national plans and industrial policies, including the various Five-Year Plans, the National Medium- and Long-Term Program for S&T Development (2006-2020), Strategic Emerging Industries policies, and others, have consistently emphasized national development in the biotechnology and genomics.⁸³ Both BGI and MGI have benefitted significantly under the various national plans, through access to financing, subsidies, diplomatic support, and other forms of assistance from the Chinese government.⁸⁴

Looking to the future, understanding China’s corporate structures will likely become more difficult as the CCP continues to restrict economic data and information flows. The CCP’s increasingly restrictive actions towards technology firms, foreign companies, and the private sector broadly underline the “growing incompatibility” between the CCP’s envisaged market system on the one hand and the global capital markets “premised on open information flows and anchored in the rule of law” on the other.⁸⁵ Valuations and financial information for Chinese companies—even public ones—have

long been considered unreliable; the CCP's new regulatory changes and restrictions on private businesses will push valuations even further from market-based principles.

Beijing further cements its control of its commercial ecosystem with these changes. The Chairman of the China Securities Regulatory Commission (CSRC*), Yi Huiman, in November 2022 coined the new concept of “valuation with Chinese characteristics,” which assigns valuation premiums to firms that align with Beijing’s political priorities.⁸⁶ It is clear that this new valuation concept is designed to encourage investment in state-owned enterprises (SOEs) and companies operating in sectors favored by the Party, including biotech and other leading-edge tech sectors.^{87 88} Additionally, in December 2023, the CCP issued a detailed ideological statement in *Qiushi*, the party’s main official theoretical journal, highlighting its commitment to “building a modern financial system with Chinese characteristics” that deviates from Western financial theory and practices.⁸⁹ Chinese banks, pension funds, insurers, and other financial organizations are expected to serve government priorities more actively—a boost for companies like BGI.

This issue brief also highlights certain characteristics of development—described below—that China can leverage, exploit, and support to take the lead in key emerging technology areas. These characteristics include the need for long-term investments, support for companies through both longer time horizons and global competition, the merging of national priorities with commercial priorities, and a willingness to do things that other countries will not. Sequencing—while a cornerstone of genomics research—is not a service that the market would deliver on this scale, highlighting another area critical to national security that the private sector, however, does not invest in because the return on investment is too low.

Highlighting these characteristics—identified in the prior paragraph—and the tools that the U.S. government has successfully used in the past to support technology development can be used as a roadmap for not only strategies for the bioeconomy, but other critical and emerging technologies.

* China Securities Regulatory Commission is the approximate equivalent of the U.S.’ SEC, and is the regulator of the PRC’s securities industry. As of 2023, the CSRC is a government agency directly under China’s State Council.

First, sequencing is a key tool of discovery that is used by many actors. The purchase of and subsequent use/sharing of sequencing resources benefits not only one university, company, or research entity but spurs future development and provides access to genomic data. BGI's initial acquisition of 128 sequencers allowed it to become a global player. Additional direct and indirect subsidies the Chinese government provides has allowed it to grow into multiple different fields. The longer-time horizons necessary for advancements in genomics and the ability to make non-market decisions provide a long-term benefit to BGI.

Second, China uses market access to protect its global champion and disadvantage other global players. Data on sales/revenue in China highlight how MGI has grown from having almost none of the China market to significant growth in just five years. MGI is currently gearing up to compete—using Complete Genomics (a subsidiary of MGI)—in the U.S. market, often obscuring Complete Genomics ties to MGI, BGI, and the Chinese government. However, two main asymmetries give China advantage: China has market restrictions in place to protect its state champions, and it provides state support. This creates a lack of reciprocity in openings to foreign companies seeking to operate in China, forcing U.S. and foreign companies to have to explore partnerships and outright acquisition if they want to participate in the China market. Some additional tools used by the Chinese government to give state-favored enterprises an advantage in the domestic market include:

- Chinese government controls the commercial ecosystem and key Chinese commercial actors through the use of industrial policies and government financing and preferences.
- China's laws create an uneven playing field because they are often vague, favor the domestic actor, and compel the sharing of data or other proprietary information. Key examples include market certification/product review/licensing (disclosure of corporate secrets), antitrust, corporate structure, and overlap of corporate, party, and state entities.
- Government procurement laws also create an unequal playing field. In 2021 China's Ministry of Finance and Ministry of Industry and Information Technology's "Buy China" policy, or Order 551: Guidance of Government Procurement of Imported Products, outlined new rules for procurement that encompass MGI products.⁹⁰ MGI has openly stated that it sees this "trend of domestic substitution" as an opportunity to increase its market share.⁹¹

Third, China has shown a willingness to use genomic data and research in ways that the West has not. This includes exploring the genomic basis of race, the goal of using prenatal testing as a key pillar of its health policies to ensure the decrease in birth defects in the population, and establishing a central gene bank that includes global data that it does not share.⁹² This creates *ethical asymmetries in research and development*. Below are some examples:

- Chinese researchers have access to the same public data as researchers in the U.S. and other nations, plus all of the data China collects. However, Chinese law restricts sharing of China's genomic data, so foreign researchers don't have access to that data.
- China collects genomic data in ways that open democratic societies deem unethical, including a focus on ethnic minorities. This information is added to its already robust surveillance abilities. Researchers in the U.S. and other liberal democracies do not have access to such data, and are normally not allowed to research without approval by an Institutional Review Board to ensure the research is ethical and any risk of potential harm to research subjects is outweighed by the expected benefits that the research subjects would receive (e.g., from a medical study).
- The ability to work on research proscribed in other countries—including the use of non-human primates and human embryos—could lead to new breakthroughs in understanding pathogen-host interactions, human performance modification, and new forms of bioweapons (BW) including bio-regulators.

Competitive Tools Available to the United States and Allies

The United States, Japan, South Korea, Taiwan, and countries in Europe have historically deployed a range of tools to successfully promote the development of technologies deemed critical for economic or national security that could have cross-applicability to biotechnology and other emerging technologies. First and foremost, Washington has set ambitious technology development goals to marshal the efforts of private industry toward a national priority, and used export controls and other restrictions to prevent the transfer of technologies to strategic competitors and adversaries alike. One example is former Operation Warp Speed—the federal effort to speed development of a COVID-19 vaccine—which facilitated two U.S. firms' efforts to bring vaccines with 95 percent efficacy to market in under a year. Pfizer, despite

deciding to fund its R&D efforts itself, received a nearly \$2 billion order for 100 million doses of its vaccine in July 2020 from Washington—five months before seeking emergency approval from the U.S. Food and Drug Administration. Similarly, Moderna received a \$2.5 billion subsidy for its efforts from the program. Other examples of Washington’s use of its powers to promote and/or protect critical technology sectors include:

R&D Funding: From 1990 to 2003, the U.S. government spent approximately \$2.7 billion to sequence the human genome as part of the Human Genome Project.⁹³ That initial R&D investment laid the groundwork for U.S. private-sector DNA sequencing firms, such as Illumina and Thermo Fisher Scientific, to expand; by November 2020, the leading U.S. firms were valued at approximately \$323.8 billion.⁹⁴

Corporate Tax Incentives: The U.S. government, through the federal R&D Tax Credit, allows start-ups and small businesses to qualify for up to \$1.25 million to offset a portion of their annual payroll taxes.⁹⁵ Industry experts have called for additional incentives to be built into the U.S. tax code to incentivize long-term R&D investments.⁹⁶

Public Procurement: The U.S. government has used the power of federal procurement dollars to promote the development of nascent industries and help them reach economies of scale and commercialize their products. U.S. Air Force and NASA procurement of early integrated circuits for the Minuteman II ICBM and the Apollo program during the 1960s drove improvements in processing power and reductions in production costs, facilitating the industry’s commercialization.⁹⁷

Talent Development: The U.S. government has supported the education of human capital to bolster technology development efforts. As part of the Space Race, the U.S. government implemented a series of changes to public education to emphasize science and mathematics and hands-on laboratory experience, including through the National Defense Education Act of 1958 and National Science Foundation investments in teacher development.⁹⁸

Tech Alliances: The U.S. government has signed collaborative agreements with like-minded countries to govern the protection of and encourage the development of critical technologies.⁹⁹ In 2020, the U.S. and UK governments signed an agreement to cooperate on R&D of artificial intelligence.¹⁰⁰

Export Financing: The U.S. Export–Import Bank has long provided loans for foreign airlines to purchase U.S. commercial aircraft, helping domestic producers compete with

the rise of Airbus during the 1970s and positioning Boeing—the largest U.S. exporter by value—to compete with the Commercial Aircraft Corporation of China (COMAC), once its planes enter production.¹⁰¹

Ethical Standards: DARPA and other government agencies require companies to comply with certain ethical standards as a requirement to receive government funding.

Resource Sharing/Non-Financial Support: With the goal of advancing R&D and growing domestic manufacturing ecosystems, DoD’s Manufacturing Innovation Institutes provide companies access to costly equipment and lab resources that otherwise would not be available to early-stage start-ups.¹⁰²

Funding for Commercialization: While the Small Business Innovation Research (SBIR) program supports small businesses (including innovative start-ups) in conducting R&D, certain government agencies also award much larger amounts of money aimed at commercialization rather than research only. For example, the U.S. Air Force Strategic Funding Increase and Tactical Funding Increase, or STRATFI/TACFI programs, with awards up to \$15 million per company, are specifically “designed to bridge the ‘Valley of Death’ between SBIR/STTR Phase II efforts and Phase III scaling efforts,” allowing companies to get closer to profitability.¹⁰³

Preparing to Compete in the Genomic Future

Biology has the potential to offer solutions to the biggest challenges facing society in the 21st century, from the global climate crisis to food insecurity to materials that will transform industries and manufacturing at scale. How nations pursue the power to engineer with living systems will reshape our ways of life, including whether our strategies reflect and reinforce the values of democratic societies. The United States must be positioned to harness these developments, ensure that applications reflect our values, and protect against misuse.

Our analysis of BGI highlights the depth and breadth of China’s use of a hybrid economic model that necessitates new kinds of actions if the U.S. and like-minded countries are going to have a bioeconomy, and requires new approaches to level the playing field. Steps the U.S. (as well as its allies) can take include:

- **Secure genomic data:** Protecting our citizen’s genomic data so that it cannot be exploited by foreign entities, without overcompensating such that innovation is stifled. For example, developing sequencing capabilities that support both

research and clinical settings; regulations on foreign-funded, supported, and controlled entities access to U.S. genomic data; and creating platforms so that U.S. researchers and clinicians can share data securely.

- **Foster U.S. companies** (and companies in allied countries) so they compete with entities that are state-supported. The CCP's policies have created an ecosystem in which Chinese companies are not neutral actors* nor fair competitors.
- **Reconfigure anti-monopoly** and other laws so that they reflect the nature of global competition and incorporate the impact that state-supported companies have on U.S. companies' ability to compete.

Treat the research base as critical infrastructure, *with the goal that the U.S. should not be dependent on China for our current medicines, future medicine, or tools of discovery* by investing in and supporting not only the development of but the manufacturing of equipment necessary to conduct research. To ensure data and knowledge discovery are not outsourced and lost to strategic competitors, democratic nations should invest strategically in infrastructure that supports the bioeconomy, such as sequencing capabilities, diagnostics, and associated computing infrastructure. The ability to drive medical research, provide medicines, and ensure adequate food supplies will become more dependent on genomic data, specifically designed computing power, and access to animal models. If the current trajectory is not changed, an increasing proportion of the global gene sequencing market is or will be performed by PRC entities. This represents a precarious position for the U.S. and its allies to passively accept.

- Policymakers should undertake a detailed survey of the human capital and supply chains needed to support biotechnology R&D. Too often, policy recommendations and research projects are focused on a snapshot in time and therefore fail to take account of foundational—not necessarily the most cutting-edge—aspects of an industry. The ability to support biotechnology discovery, as well as human and animal health, is a key part of leading in this area.

* By neutral actors, we mean that they function in the same way companies, researchers, and universities function in open liberal democracies. This is not the case due to China's policies and laws.

- The U.S. is dependent on China for key parts of its pharmaceutical and research supply chains. This impacts the DOD mission in very basic ways—such as lack of access to antibiotics—to future ways, including not being able to provide lab equipment that supports research. Chinese companies and subsidiaries of western companies in China are often the sole providers of medicines, medical technologies, and basic disease surveillance kits that hospitals depend on to save lives. China could stop the export of these services and materials—as they have for rare earth metals—and bring both the medical and research system to a halt.

Support translating R&D into useful applications. Harnessing the acquisition process, the U.S. government can support not just precision medicine but the multiple areas this technology will touch. Too often the U.S. funds basic research but then does not provide an avenue for the discoveries to either be commercialized or used as a public good. Many of these technologies have longer timelines. For example, some bio-products such as vaccines have lower return on investment (ROI) and companies do not pursue them. One example of this is the mRNA vaccine technology. Initial efforts should include providing more resources to NSF and DOE to support small businesses and researchers in this area as a good start.

Think the unthinkable.¹⁰⁴ These technologies can be used in ways we would consider unethical. Understanding the depth and breadth of research globally and discussing ways to regulate—as well as to develop countermeasures—with allies and like-minded countries will ensure we are better prepared for its misuse. China’s researchers have access to the same public data as researchers in the United States, plus all of the data China collects but will not share. China also collects genomic data in ways that open democratic societies deem unethical, which may provide them with advantages in certain aspects of biological discovery. This ability to work on research proscribed in other countries—including the use of non-human primates—could lead to new breakthroughs in understanding pathogen-host interactions, human performance modification, and new forms of biological weapons including bio-regulators.

It will be important to consider not only what is possible now, but what may become possible in the future. As the field matures, what is not necessarily alarming now—access to a wide range of genomic data—may provide an advantage to researchers who have it.

Conclusion

This issue brief shows that China's all-embracing approach to dominate genomics and future biotechnology developments—a similar blueprint to the one it took in developing 5G—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. What is key to recognize is that it isn't that the U.S. and other like-minded countries can't do this; it's that the market won't do this because of the longer timelines, lower ROI, and the fact that the needed infrastructure is broader than just one company or research institution will invest in.

As Washington discusses how best to support development efforts in emerging technologies—with proposals ranging from expanding the budgets for U.S. R&D agencies, exploring export subsidies through the Export-Import Bank and the new International Development Finance Corporation, and bolstering STEM education to develop the next-generation of S&T talent—this study argues for a focus on those technologies that are most at risk of foreign adversarial competition, and deployment of a comprehensive strategic plan. For biotechnology, the winner is not yet determined, but without efforts to adjust the market incentives, the United States, allies, and like-minded nations are likely to find ourselves in a similar predicament in biotechnology as we faced in 5G and are now, retroactively, working to address.

Solutions will need to look beyond traditional trade remedies such as export controls and tariffs because in the early stages of these new technologies, there are not yet produced tradeable goods. Traditional trade remedies such as tariffs and trade sanctions probably will be ineffective at correcting all of the imbalances in biotechnology, which relies on know-how and expertise, as well as the accumulation of genomic data. They will also have limited impact on China's major national initiatives because China views this as a key part of its future and U.S.–China competition. The ultimate lesson from past successes, 5G development, and Operation Warp Speed is that the U.S. government and like-minded allies have tools that can be used to foster the development of emerging technologies and that they should not be afraid to take a proactive approach to foster the building blocks of future discovery and the national innovation base.

Authors

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Appendix 1: Detailed Ownership Analysis¹⁰⁵

| MGI Tech Co.—Current Public Shareholding | | | | |
|--|-------------|-------------------------|------------------|---|
| Shareholder | Ownership % | BGI Group Relationship? | CCP Affiliation? | Description of Entity and CCP Affiliation, if applicable |
| Wang, Jian (Chairman of the Board) | 46.78% | Yes | No | Chairman of the Board of MGI Tech Co. |
| CPE Investment (Hong Kong) 2018 Limited | 6.35% | Yes | Yes | Private equity arm of CITIC Securities, which is controlled by CITIC Group, which is state-owned ¹⁰⁶ |
| Tibet Zhiyan Venture Capital Partnership Enterprise (Limited Partnership) | 3.39% | No | Not available | Ultimate ownership unclear |
| Tianjin Kunpeng Management Consulting Partnership Enterprise (Limited Partnership) | 2.56% | No | Yes | Managed by/ affiliated with Harmony Growth Fund, a fund managed by IDG Capital, which is also a private shareholder of MGI and has state backing ¹⁰⁷ |

| | | | | |
|--|-------|----|---------------|---|
| Hubei Science Technology Investment Group Co. Ltd. | 2.43% | No | Yes | State-backed economic development agency based in Wuhan (Hubei provincial capital) ¹⁰⁸ |
| Sharp Vantage Limited | 2.39% | No | Not available | Ultimate ownership unclear |
| Shanghai Growth-FOF Co., Ltd. | 1.78% | No | Yes | Also known as Shanghai Guofang Investment (上海国方私募基金管理), backed by Shanghai International Group, which is a government agency ¹⁰⁹ |
| Huatai Zijin Investment Co. Ltd. | 1.59% | No | Yes | Subsidiary of Huatai Securities Co., Ltd., a major Chinese financial services company. LPs in HTZJ's funds include guidance funds and economic development agencies, including Nanjing New Industry Investment Group, Suqian Chanfa Venture Fund, and |

| | | | | |
|---------------------------------------|-------|----|-----|---|
| | | | | Jiangsu Jincal Investment ¹¹⁰ |
| Hillhouse Investment Management, Ltd. | 1.22% | No | No | Mostly Western LPs, including university endowments, state and company pension funds, etc. Started in 2005 with funding from Yale University's endowment by Chinese alumnus Zhang Lei, the Hong Kong-based private equity firm is one of the biggest investment firms in Asia, currently managing over \$65 billion. ¹¹¹ |
| Wanjia Asset Management Co., Ltd. | 1.08% | No | Yes | Owned by Zhongtai Securities, which is partially state-owned, and Shandong New Kinetic Energy Fund Management Co., Ltd., also known as Shandong New Growth Drivers Fund (山东省新动能基金管理有限公司), a government guidance |

| | | | | |
|--|-------|----|-----|--|
| | | | | fund in Shandong province ¹¹² |
| Shanghai Huasheng Youge Equity Investment Management Co., Ltd. | 1.03% | No | Yes | Subsidiary of affiliate of China Everbright Group, a state-owned entity ¹¹³ |
| China Universal Asset Management Company Ltd. | 1.01% | No | Yes | Orient Securities (state-affiliated) holds 35%; China Eastern Airlines (an SOE) holds 20%; Wenhui-Xinmin United Press Group (Shanghai United Media Group), which is a state media company, holds an undisclosed % stake ¹¹⁴ |
| China Asset Management Co. Ltd. | 0.88% | No | Yes | Also known as China AMC. One of China's biggest fund families. Majority owned by CITIC Securities, controlled by CITIC Group, an SOE (62.2%), as well as Power Corporation of Canada (13.9%), Mackenzie |

| | | | | |
|---|-------|----|-----|--|
| | | | | Investments (13.9%) ¹¹⁵ |
| Aegon-Industrial Fund Management Co. Ltd. | 0.80% | No | Yes | Subsidiary of Industrial Securities Co., Ltd. (SHSE:601377), which although publicly traded has numerous state-owned or state-linked investors including the Fujian Provincial Department of Finance, the Fujian Investment and Development Group, the Fujian Energy Group, and Fujian Cement, among others ¹¹⁶ |
| China Merchants Fund Management Co.,Ltd. | 0.68% | No | Yes | Subsidiary of China Merchants Bank, which though public is part of China Merchants Group, a state-owned enterprise ¹¹⁷ |
| Zhong Ou Fund Management Co., Ltd. | 0.29% | No | No | A.k.a. Lombarda China Fund Management Co., Ltd. (Lombarda China FMC). Part-owned by Intesa Sanpaola S.p.A. and |

| | | | | |
|--|-------|----|-----|--|
| | | | | Warbug Pincus (23%) ¹¹⁸ |
| Invesco Great Wall Fund Management Co., Ltd. | 0.25% | No | Yes | Main shareholders include Invesco (a U.S. investment manager) and China Great Wall Securities Co.,Ltd. (SZSE:002939), which although it trades publicly has many state-owned public and private shareholders, including China International Capital Corporation, a partially state-owned investment manager ¹¹⁹ |
| E Fund Management Co., Ltd. | 0.24% | No | Yes | One of the largest Chinese asset management companies (\$414 billion AUM). Owners/ investors include Guangdong Yuecai Investment Holdings Co.,Ltd. - 广东粤财投资控股有限公司 (controlled by People's Government of Guangdong Province) |

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| | | | | and Infore Group, an industrial holding company in Guangdong Province ¹²⁰ |
| Kuwait Investment Authority | 0.22% | No | No | Kuwait sovereign wealth fund ¹²¹ |
| CITIC Securities Company Limited, Asset Management Arm | 0.21% | Yes | Yes | Asset management arm of CITIC Securities, which is controlled by CITIC Group, which is state-owned ¹²² |
| Harvest Fund Management Co., Ltd. | 0.19% | No | Yes | Also known as Harvest Wealth Management or Harvest Global Investment. Jointly owned by Deutsche Bank Securities (30%), China Credit Trust (40%), and Lixin Investment (30%). China Credit Trust is backed by China Merchants, the People's Insurance Company, China National Coal Group, and China Pingmei |

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|--|-------|----|---------------|---|
| | | | | Shenma Group, all-state affiliated ¹²³ |
| ABC-CA Fund Management Co., Ltd. | 0.17% | No | Yes | Joint venture between the Agricultural Bank of China (ABC), Credit Agricole, and the Aluminum Corporation of China Limited (CHALCO). ABC and CHALCO are state-owned. ¹²⁴ |
| Shanghai Shenzhi Asset Management Partnership Enterprise (Limited Partnership) | 0.16% | No | Not available | Ultimate ownership unclear ¹²⁵ |
| Monetary Authority of Macao | 0.15% | No | Yes | Central Bank of Macau ¹²⁶ |
| Lion Fund Management Co., Ltd. | 0.15% | No | Yes | Owned by China Foreign Economic and Trade Trust Co., Ltd. (40%), Shenzhen Jielong Investment Co., Ltd. (40%), and Daheng New Era Technology Co., Ltd. (20%). ¹²⁷ China Foreign Economic and Trade Trust is a |

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| | | | | subsidiary of Sinochem, a state-owned enterprise, while it is unclear whether the other two investors are state-affiliated. ¹²⁸ |
| National Council for Social Security Fund | 0.12% | No | Yes | State entity that manages the National State Security Fund including equity assets from state-owned enterprises as well as Basic Old Age Insurance Funds from provincial governments ¹²⁹ |
| Huatai-Pinebridge Fund Management Co., Ltd. | 0.10% | No | Yes | Investors include Huatai Securities, which though it is publicly traded, remains at least partially controlled by the government of Jiangsu; Huatai Zijin is also a private shareholder in MGI and manages money on behalf of guidance funds ¹³⁰ ; Guohua Energy Investment Co., Ltd., an investment firm |

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| | | | | specializing in investments in the new energy and clean technology sectors; and a subsidiary of China Energy Investment Corporation Limited, which is in turn controlled by the State-owned Assets Supervision and Administration Commission of the State Council ¹³¹ ; Pinebridge Investments, a privately held investment manager under the ultimate control of Pacific Century Group, a family office in Hong Kong ¹³² ; and Suzhou New District Hi-Tech Industrial Co., Ltd., which invests in real estate, energy conservation and environmental protection, strategic emerging industries, non-bank finance and industrial investment business, and manages guidance funds on behalf of |
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| | | | | national and provincial government entities ¹³³ |
| Bank of China Investment Management Co., Ltd. | 0.06% | No | Yes | Bank of China Investment Management Co., Ltd. (BOCIM) is a joint-venture fund management company between two world-known brands: Bank of China Co., Ltd. (Bank of China) and BlackRock, Inc. (BlackRock). Bank of China is controlled by Central Huijin Investment Ltd., which in turn is controlled by the China Investment Corporation (“CIC”), one of China’s major sovereign wealth funds. However, Central Huijin’s principal shareholder rights are exercised by the State Council of the People’s Republic of China (“State Council”). The members of Central Huijin’s Board of Directors and Board of Supervisors are appointed by and are |

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| | | | | accountable to the State Council. ¹³⁴ |
| ICBC Credit Suisse Asset Management Co., Ltd. | 0.06% | No | Yes | Joint venture between the Industrial and Commercial Bank of China (ICBC), a state-owned commercial bank, and Credit Suisse, a global investment bank headquartered in Switzerland ¹³⁵ |
| All Other Public Shareholders | 0.51% | n/a | n/a | Remaining public shareholders each hold 0.05% or less of MGI Tech Co. (collectively ~0.50% stake) and therefore were not analyzed individually |
| Number of Major Shareholders | 76.84% | 29 | | <i>Note: Count of 29 major shareholders excludes "All Other Public Shareholders"</i> |
| Number of Major Shareholders Related/Affiliated | | 3 Related to BGI Group | 22 Affiliated with CCP | <i>Note: Excludes "All Other Public Shareholders"</i> |

| | | | | |
|---|--|--------------|--------------|---|
| % Affiliated (no. of major shareholders) | | 10.3% | 75.9% | <i>Note: Excludes "All Other Public Shareholders"</i> |
| % Affiliated (% stake held) | | 53.3% | 21.9% | <i>Note: Excludes "All Other Public Shareholders"</i> |

| MGI Tech Co.—Current Private Shareholding | | | | |
|--|-------------|-------------------------|------------------|---|
| Shareholder | Ownership % | BGI Group Relationship? | CCP Affiliation? | Description of Entity and CCP Affiliation, if applicable |
| Beka Asset Management, SGIIC, S.A. | n/a | No | No | An affiliate of Beka Finance, a diversified financial services company headquartered in Madrid ¹³⁶ |
| CITIC Securities Company Limited (SHSE:600030) | n/a | No | Yes | CITIC Securities is controlled by CITIC Group, which is state-owned. ¹³⁷ |
| Shanghai International Group Assets Management Co., Ltd. | n/a | No | Yes | Subsidiary of Shanghai International Group, which is backed by the State-owned Assets Supervision and Administration Commission of Shanghai Municipal Government. SIG manages state-owned capital and purports to “promote the rational flow of state-owned |

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| | | | | capital by market-oriented means” ¹³⁸ |
| CITIC GoldStone Fund Management Co., Ltd. | n/a | Yes | Yes | Subsidiary/affiliate of CITIC Securities, controlled by CITIC Group, which is state-owned ¹³⁹ |
| Huaxing Growth Capital | n/a | No | No | Fund managed by China Renaissance, an independent Chinese investment bank ¹⁴⁰ |
| China Insurance Investment | n/a | No | Yes | Affiliated with China Insurance Investment Company, Ltd. (CIIC). Administers guidance funds on behalf of the government of Shanghai and the national government ¹⁴¹ |
| Thinkfund Investment Management Co., Ltd. | n/a | No | Yes | Subsidiary of Zhongyi Dakang Investment Management Co., Ltd. ¹⁴² Thinkfund investors include insurance companies, bank subsidiaries, securities companies, central and local state-owned enterprises, and |

| | | | | |
|---|-----|-----|-----|--|
| | | | | <p>listed companies.¹⁴³</p> <p>Thinkfund invests in medical care, elderly care and biomedicine, technology and advanced manufacturing, infrastructure and real estate and has participated in at least one guidance fund.¹⁴⁴</p> |
| Beijing CGP Investment Co., Ltd. | n/a | No | Yes | <p>Manages dozens of government guidance funds in Beijing, Shanghai, Jiangsu, Zhejiang, Hunan and Chongqing, and has invested in more than 400 funds¹⁴⁵</p> |
| CITIC Securities Investment Limited | n/a | Yes | Yes | <p>Subsidiary/affiliate of CITIC Securities, controlled by CITIC Group, which is state-owned¹⁴⁶</p> |
| Shanghai Dingfeng Equity Investment Management Center (Limited Partnership) | n/a | No | Yes | <p>Hedge fund manager based in Shanghai that manages government guidance funds, among other activities¹⁴⁷</p> |

| | | | | |
|---------------------------------------|-----|----|-----|---|
| SDIC Unity Capital Co., Ltd. | n/a | No | Yes | Guidance fund of China State Development & Investment Corporation (SDIC), a state-owned investment holding company ¹⁴⁸ |
| Taikang Life Insurance Co., Ltd. | n/a | No | Yes | Taikang Life Insurance is one of the largest life insurers in China and operates as a subsidiary of Taikang Insurance Group Inc., a privately held group. ¹⁴⁹ Current investors in Taikang Insurance Group include CITIC Group, China Merchants Group, China National Instruments Import & Export (Group) Corporation, and Genertec, all of which are state-owned enterprises, as well as other private shareholders. ¹⁵⁰ |
| Shanghai Sailing High Hope Investment | n/a | No | Yes | Investors are Sailing Capital Advisors (HK) Limited, a subsidiary of Shanghai International Group, which is a |

| | | | | |
|--|--------|---------------------------|---------------------------|--|
| Management Co., Ltd. | | | | government agency ¹⁵¹ , and Jiangsu High Hope Venture Capital Co., Ltd., a subsidiary of Jiangsu High Hope International Group Corporation, which is a large provincial state-owned enterprise ^{152 153} |
| Shenzhen Lingxin Jishi Equity Investment Fund Management Partnership Enterprise (L.P.) | n/a | No | Not available | Ultimate ownership unclear |
| BGI Group | n/a | Yes | Yes | Corporate parent |
| Tibet Ti Investment Asset Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear |
| Total Shareholders | 23.16% | 16 | | |
| Number of Shareholders Related/Affiliated | | 3 Related to BGI Group | 12 Affiliated with CCP | <i>Note one shareholder is neither a BGI Group affiliate nor state affiliated</i> |

| | | | | |
|------------------------------------|--|-------|-------|--|
| % Affiliated (no. of shareholders) | | 18.8% | 75.0% | |
| % Affiliated (% stake held) | | n/a | n/a | |

| BGI Genomics—Current Public Shareholding | | | | |
|--|-------------|-------------------------|------------------|--|
| Shareholder | Ownership % | BGI Group Relationship? | CCP Affiliation? | Description of Entity and CCP Affiliation, if applicable |
| Shenzhen Huada Gene Technology Co., Ltd. | 37.25% | Yes | No | Subsidiary/ affiliate of BGI Group |
| Shenzhen Qianhai BGI Investment Enterprise (Limited Partnership) | 8.41% | Yes | No | Subsidiary/ affiliate of BGI Group |
| Wanjia Asset Management Co., Ltd. | 3.67% | No | Yes | Owned by Zhongtai Securities, which is partially state- owned, and Shandong New Growth Drivers Fund (山东省新动能基金管理有限公司), which is an economic development agency in Jinan, Shandong Province (backed by Shandong Finance Investment Group Co., Ltd., a principal investment firm specializing in managing |

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| | | | | equity investment guidance funds of the province of Shandong, China) ¹⁵⁴ |
| Hwabao WP Fund Management Co., Ltd. | 1.80% | No | Yes | Joint venture between Baowu Steel and Warbug Pincus. One of the earliest joint venture fund companies in China (launched 2003). Baowu Steel is state- owned. ¹⁵⁵ |
| China Merchants Fund Management Company Ltd. | 1.04% | No | Yes | Subsidiary of China Merchants Bank, which though public is part of China Merchants Group, a state-owned enterprise ¹⁵⁶ |
| BGI Genomics Co., Ltd., ESOP | 0.98% | Yes | No | Employee equity option pool. Subsidiary/ affiliate of BGI Group |
| E Fund Management Co., Ltd. | 0.79% | No | Yes | One of the largest Chinese asset management companies (\$414 billion AUM). Owners/investors include Guangdong Yuecai Investment Holdings Co.,Ltd. —广东粤财投资控股有限公司 (controlled |

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| | | | | by People’s Government of Guangdong Province) and Infore Group, an industrial holding company in Guangdong Province ¹⁵⁷ |
| China Southern Asset Management Co., Ltd. | 0.63% | No | Yes | Ownership includes Huatai Securities (41.16%)—state-affiliated; Shenzhen Investment Holdings (27.44%)—state-owned; Xiamen Intl Trust Co (13.72%)—state-owned; Industrial Securities Co. (9.15%); other entities related to the government of Xiamen (~9%) ¹⁵⁸ |
| Wang, Jian (Chairman) | 0.62% | Yes | No | BGI Group Insider |
| Guotai Asset Management Company Limited | 0.56% | No | Yes | Subsidiary of China Jianyin Investment Limited (中国建银投资有限责任公司), which in turn is a subsidiary of Central Huijin Investment Ltd.—中央汇金投资有限责任公司, a subsidiary of China Investment |

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|--|-------|----|-----|---|
| | | | | Corporation, China's main sovereign wealth fund ¹⁵⁹ |
| China Universal Asset Management Company Ltd. | 0.51% | No | Yes | Orient Securities (state-affiliated) holds 35%; China Eastern Airlines (an SOE) holds 20%; Wenhui-Xinmin United Press Group (Shanghai United Media Group), which is a state media company, hold an undisclosed % stake ¹⁶⁰ |
| GF Fund Management Co., Ltd. | 0.48% | No | Yes | Subsidiary of GF Securities, which was spun out of China Guangfa Bank in 1999 and now trades publicly (SHE: 000776) ¹⁶¹ |
| Barclays PLC Private Banking & Investment Banking Investment | 0.40% | No | No | British multinational bank and investment manager ¹⁶² |
| BlackRock, Inc. (NYSE: BLK) | 0.39% | No | No | American alternative asset manager ¹⁶³ |

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|-------------------------------------|-------|-----|-----|---|
| Ye Yin (Vice Chairman of the Board) | 0.26% | Yes | No | BGI Group insider |
| Tianhong Asset Management Co., Ltd. | 0.26% | No | No | Subsidiary of Ant Group (Ant Financial holds 51%) ¹⁶⁴ |
| Maxwealth Fund Management Co., Ltd. | 0.21% | No | Yes | Investors are Lion Global Investors (a member of OCBC group— Oversea-Chinese Banking Corporation Limited, a Singapore multinational banking and financial services corporation) and Bank of Ningbo. The Bank of Ningbo's largest shareholder is Ningbo Development and Investment Group, an affiliate of Ningbo Government (22%), followed by OCBC Group (20%) ¹⁶⁵ |
| Nikko Asset Management Co., Ltd. | 0.16% | No | No | Japanese asset manager ¹⁶⁶ |

| | | | | |
|----------------------------------|-------|----|-----|---|
| Dimensional Fund Advisors LP | 0.11% | No | No | U.S.-based fund ¹⁶⁷ |
| The Vanguard Group, Inc. | 0.10% | No | No | American investment manager ¹⁶⁸ |
| China Asset Management Co., Ltd. | 0.09% | No | Yes | Also known as China AMC. One of China's biggest fund families. Majority-owned by CITIC Securities, an SOE (62.2%), as well as Power Corporation of Canada (13.9%), Mackenzie Investments (13.9%) ¹⁶⁹ |
| Harvest Fund Management Co. Ltd. | 0.08% | No | Yes | Also known as Harvest Wealth Management; formerly known as Shenzhen Qiushi Huizhi Wealth Investment Management Co., Ltd. Jointly owned by Deutsche Bank Securities (30%), China Credit Trust (40%), and Lixin Investment (30%). China Credit Trust is backed by China Merchants, the People's Insurance Company, China National Coal Group, and China |

| | | | | |
|------------------------------------|-------|----|-----|--|
| | | | | Pingmei Shenma Group—all state affiliated. ¹⁷⁰ |
| Mirae Asset Global Investments | 0.06% | No | No | Large Korean asset manager ¹⁷¹ |
| Fullgoal Fund Management Co., Ltd. | 0.06% | No | Yes | Shareholders include Bank of Montreal (BMO), Fujian International Trust & Investment Company, Haitong Securities Co., Ltd. (SHSE:600837), Huatai Securities Co., Ltd. (SHSE:601688), Shandong International Trust Co., Ltd. (SEHK:1697), Shenwan Hongyuan Group Co., Ltd. (SZSE:000166). Huatai Securities, though publicly traded, remains at least partially controlled by the government of Jiangsu. Shandong International Trust Co. has shareholders affiliated with the government of Shenzhen. ¹⁷² |

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|--|--------|---------------------------|---------------------------|--|
| All Other Public Shareholders | 0.53% | n/a | n/a | Remaining public shareholders each hold 0.05% or less of BGI Genomics (collectively less than 0.50% stake) and therefore were not analyzed individually. |
| Total Shareholders | 59.33% | 24 | | <i>Note: Count of 24 shareholders excludes "All Other Public Shareholders" holding less than 0.05% stake each</i> |
| Number of Shareholders Related/ Affiliated | | 5 Related to BGI Group | 12 Affiliated with CCP | <i>Note: Excludes "All Other Public Shareholders"</i> |
| % Affiliated (no. of shareholders) | | 20.8% | 50.0% | <i>Note: Excludes "All Other Public Shareholders"</i> |
| % Affiliated (% stake held) | | 47.5% | 9.9% | <i>Note: Excludes "All Other Public Shareholders"</i> |

| BGI Genomics—Private Shareholding | | | | |
|-------------------------------------|-------------|-------------------------|------------------|---|
| Shareholder | Ownership % | BGI Group Relationship? | CCP Affiliation? | Description of Entity and CCP Affiliation, if applicable |
| Sequoia Capital Operations LLC | n/a | No | No | American venture capital firm ¹⁷³ |
| China Everbright Limited (SEHK:165) | n/a | No | Yes | Publicly listed asset management subsidiary of China Everbright Group, a state-owned enterprise ¹⁷⁴ |
| Shenzhen Capital Group Co., Ltd. | n/a | No | Yes | State-owned venture capital company based in Shenzhen ¹⁷⁵ |
| SB China Venture Capital | n/a | No | Yes | Controlled by Oriza FoFs Investment Management (which also manages Henan Province Venture Capital Guidance Fund—Launched). Oriza FoFs in turn is a subsidiary of Suzhou Oriza Holdings Co., Ltd., whose current |

| | | | | |
|---|-----|----|-----|---|
| | | | | investors are China Life Insurance Company Limited (SEHK:2628), a state-owned enterprise, and Jiangsu Guoxin Investment Group Limited, which is controlled by State-owned Assets Supervision and Administration Commission of Jiangsu Provincial Government. ¹⁷⁶ |
| Huatai Securities Co., Ltd. (SHSE:601688) | n/a | No | Yes | Huatai Securities is publicly traded, but it remains at least partially controlled by the government of Jiangsu. Other state-owned enterprises are also investors. ¹⁷⁷ |
| China Life Insurance (Group) Company | n/a | No | Yes | China Life Insurance Group is wholly owned by the Ministry of Finance of the People's Republic of China, a government institution. ¹⁷⁸ |

| | | | | |
|---|------------|-----------|------------|---|
| <p>China Merchants Securities Co., Ltd. (SHSE:600999)</p> | <p>n/a</p> | <p>No</p> | <p>Yes</p> | <p>Publicly traded, but private shareholders include PICC Life Insurance Company Limited (subsidiary of the People’s Insurance Company— state-owned), Shenzhen Chuyuan Investment Development Co., Ltd. (a subsidiary of China Merchants Finance Investment Holdings Company Limited and Shenzhen Yanqing Investment & Development Co., Ltd.), Shenzhen Jisheng Investment Development Co., Ltd., and China Merchants Finance Investment Holdings Company Limited. The latter three all roll up to China Merchants Group, which ultimately is state-owned (controlled by State-owned Asset Supervision and Administration Commission of the State Council).¹⁷⁹</p> |
|---|------------|-----------|------------|---|

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|---|-----|-----|-----|--|
| HongShan, formerly known as Sequoia China Investment Management LLP | n/a | No | No | Subsidiary of Sequoia Capital ¹⁸⁰ |
| Shenzhen Co-win Venture Capital Investments Limited | n/a | Yes | No | Shenzhen Co-win Growth Fund is a venture capital fund managed by BGI Co-Win, which is associated with BGI Group. ¹⁸¹ |
| China Life Investment Management Company Limited | n/a | No | Yes | Subsidiary or affiliate of China Life Insurance Group, which is wholly owned by the Ministry of Finance of the People's Republic of China, a government institution ¹⁸² |
| Gold Stone Investment Co., Ltd. | n/a | No | Yes | Subsidiary/affiliate of CITIC Securities, controlled by CITIC Group, which is state-owned. ¹⁸³ |
| Yunfeng Capital | n/a | No | No | Founded by Jack Ma (founder and former executive chairman of |

| | | | | |
|---|-----|----|-----|---|
| | | | | Alibaba) and David Yu (founder of Target Media). Yu remains chairman and largest shareholder (47%). ¹⁸⁴ |
| Sunbridge Investment Management Co., Ltd. | n/a | No | No | Also known as Shenzhen Shengqiao Investment Management Co., Ltd. They state publicly that they have “China Ping An Trust & Investment Co., Ltd, Aluminum Corp. of China Limited, and China, Beijing State-Owned Assets Management Co., Ltd. (BSAM), Huadian Finance Co., Ltd.,” all of which are state-affiliated. ¹⁸⁵ |
| Shanghai Prosperity Fund Management Co., Ltd. | n/a | No | Yes | Buyout fund managed by Shanghai Guohe Capital, which was set up in 2009 by Shanghai International Group, a state-owned financial institution (primary investor is State-owned Assets Supervision and Administration |

| | | | | |
|---|-----|----|---------------|--|
| | | | | Commission of Shanghai Municipal Government) ¹⁸⁶ |
| Kaiwu Capital | n/a | No | Not available | Ultimate ownership unclear ¹⁸⁷ |
| Shanghai Orient Securities Capital Investment Co., Ltd. | n/a | No | Yes | Affiliate of Orient Securities. Orient itself is publicly traded, but still 30% owned by Shenergy Group, which is state-owned (State-owned Assets Supervision and Administration Commission of Shanghai Municipal Government). ¹⁸⁸ |
| Shenzhen Sharing Growth Investment Management Co., Ltd. a.k.a Share Capital | n/a | No | Yes | “Shenzhen Sharing Growth Investment Management is also known as Share Capital (分享投资). Share Capital’s primary backer is Oriza FoFs Investment Management, which in turn is a subsidiary of Suzhou Oriza Holdings Co., Ltd., which is directly backed by China Life |

| | | | | |
|--|-----|----|-----|---|
| | | | | Insurance Company Limited (SEHK:2628) (an SOE) and Jiangsu Guoxin Investment Group Limited (backed by State- owned Assets Supervision and Administration Commission of Jiangsu Provincial Government). Investors in Share Capital’s individual funds include national and local governments, top universities, fund-of-funds (FOFs), listed companies, and established entrepreneurs. Share Capital manages guidance funds on behalf of the government of Shenzhen.” ¹⁸⁹ |
| Magic Stone Alternative Investments | n/a | No | No | Also known as MSA Capital (和玉资本). Independent investor ¹⁹⁰ |
| ShengJing360.com, Inc., Investment Arm | n/a | No | Yes | Publicly traded after 2015 IPO; however, |

| | | | | |
|--|-----|----|---------------|---|
| | | | | shareholders include Share Capital (state-affiliated, as above) ¹⁹¹ |
| Shanghai Orient Securities Innovation Investment Co., Ltd. | n/a | No | Yes | Affiliate of Orient Securities. Orient itself is publicly traded, but still 30% owned by Shenergy Group, which is state-owned (State-owned Assets Supervision and Administration Commission of Shanghai Municipal Government). ¹⁹² |
| Hotland Innovation Asset Management Co., Ltd. | n/a | No | Yes | Established by Shenzhen Capital Group (above), which is a state-owned venture capital company based in Shenzhen ¹⁹³ |
| Shenzhen Huahong Capital Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear |
| Yixing Guangkong Investment Co., Ltd. | n/a | No | Yes | Subsidiary of Everbright Investment (Shenzhen) Limited Company, which is a |

| | | | | |
|--|-----|----|---------------|---|
| | | | | subsidiary/affiliate of China Everbright Limited (SEHK:165), an affiliate of China Everbright Group, a state-owned entity ¹⁹⁴ |
| Shanghai Yunfeng Enterprise Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear |
| Shenzhen Jinsheng Capital Management Corporation | n/a | No | Yes | Also known as Jinsheng Fund of Funds (FoF), the group manages RMB 60 Bn on behalf of over 200 GPs. It maintains numerous public partnerships with SOEs and other state-affiliated entities. Jinsheng FOF is also an investor in entities that are direct shareholders in MGI, BGI, or both, including e.g., GreenPine Capital Partners, Goldstone, and Cowin Capital. Finally, in terms of government affiliations, the management team at Jinsheng FOF was |

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| | | | | appointed as an external member of the Investment Committee of the Shenzhen Qianhai Guidance Fund, a judge of the Beijing Haidian District Guidance Fund, and the co-chairman of the parent fund branch of the China International Association for the Promotion of Science and Technology. ¹⁹⁵ |
| China Life Private Equity Investment Co., Ltd. | n/a | No | Yes | The private equity subsidiary of China Life Insurance Group, which is wholly owned by the Ministry of Finance of the People's Republic of China, a government institution ¹⁹⁶ |
| Great Wall Fund Management (Shenzhen) Co., Ltd. | n/a | No | Yes | Also known as Qianhai Great Wall Fund or Qianhai Great Wall Fund Management (Shenzhen) Co. Manages guidance funds on behalf of the government of |

| | | | | |
|---|-----|-----|---------------|---|
| | | | | Shenzhen. Limited partners include Futian Guidance Fund, Shenzhen Capital Group Co., Ltd., Shenzhen Futian Guide Fund Investment Co., Ltd., Shenzhen Government Investment Guidance Fund ¹⁹⁷ |
| Shenzhen Huada Gene Technology Co., Ltd. | n/a | Yes | No | Subsidiary/affiliate of BGI Group |
| Gaolin Capital Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear |
| SME Industrial Investment Fund Management Co., Ltd. | n/a | No | Yes | “中小企业产业投资基金管理有限公司” appears to be a guidance fund associated with government of Shenzhen. ¹⁹⁸ |
| Shenzhen Guohua Sanxin Fund | n/a | No | Not available | Subsidiary of Shenzhen Guohua Investment Management, a.k.a. |

| | | | | |
|---|-----|----|---------------|---|
| Management Co., Ltd. | | | | GH Investment Management Corp., Ltd. (深圳市国华投资管理股份有限公司) ¹⁹⁹ |
| Xi'an Fusierwan Investment Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear |
| Suzhou Northern Light Tengyuan Venture Capital Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear |
| Beijing Palace Asset Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear ²⁰⁰ |
| SDIC Chuangyi Industry Fund Management Co., Ltd. | n/a | No | Yes | SDIC Chuangyi Industry Fund Management manages multiple individual guidance funds on behalf of the State Development and Investment Corporation (SDIC) ²⁰¹ |

| | | | | |
|--|-----|-----|---------------|--|
| Fusi Capital | n/a | No | Not available | Ultimate ownership unclear ²⁰² |
| Pingtang Free Trade Zone Puxi Asset Management Co., Ltd. | n/a | No | Yes | Free Trade Zone associated with the government of Fujian province ²⁰³ |
| Beijing Chuangling Capital Investment Management Co., Ltd. | n/a | No | Not available | Ultimate ownership unclear ²⁰⁴ |
| Tianjin Liren Investment Management Partnership Enterprise (Limited Partnership) | n/a | No | No | Private Fund business set up by Hillhouse Capital in 2018 ²⁰⁵ |
| BGI Group | n/a | Yes | No | Parent company |
| Youshan Capital | n/a | No | Yes | Youshan Capital was established in 2020 in partnership with professional institutions such as large state-owned enterprises, fund-of-funds funds, and private listed |

| | | | | |
|--|---------------|---------------------------------------|---------------------------------------|--|
| | | | | companies. It invests in advanced manufacturing, new energy, and medical health. A major LP is China National Petroleum (CNPC), an SOE. ²⁰⁶ |
| Total Shareholders | 40.67% | 41 | | |
| Number of Shareholders Related/Affiliated | | 3 Related to BGI Group | 22 Affiliated with CCP | |
| % Affiliated (no. of shareholders) | | 7.3% | 53.7% | |
| % Affiliated (% stake held) | | n/a | n/a | |

Appendix 2: Key Areas of Biotechnology

Bioinformatics

Bioinformatics can be described as using computation and statistics to understand biology, allowing scientists to better understand the function of genes and proteins, three-dimensional shapes of proteins and nucleic acids, and the evolution of parts of the genome. AI takes this field to the next level by enabling more efficient data processing and analysis, expediting the translation of experimental science to real-world applications. China has prioritized bioinformatics, fostering national champion BGI, as well as establishing key enabling infrastructure. Bioinformatics is inherently interdisciplinary in scope, comprised of engineering, statistical, biological, and other subdisciplines.

Synthetic biology

Described by the U.S. National Institutes of Health (NIH) as “a field of science that involves redesigning organisms for useful purposes by engineering them to have new abilities,”²⁰⁷ synthetic biology offers new ways to harness nucleic acids for a wide range of applications. The use of AI to find ways to connect genotypes with phenotypes—basically understanding what genes do and what they code for—has implications for understanding human disease, genome manipulation, and designing life-saving therapies, not to mention increasing the probability of lab accidents, violating ethical boundaries, and creating new or enhancing existing biological weapons.

Gain of function research

Research that, purposefully or not, has the effect of enhancing the virulence or transmissibility of pathogens has direct national security implications. While there are valid reasons for concern, there are also important questions this research can answer that help the biomedical sector prepare for future pandemics. The ability to better understand how pathogens and their hosts interact on the molecular level, and how proteins and other biomolecules function in the cell, will be enabled by AI, yielding potential implications for this line of research.

Agricultural biotechnology

Food security will likely become more of a national security issue as countries worldwide grapple with ways to feed their citizens. Better understanding of genomic factors that impact growth, disease resistance, and the nutritional value of plants and livestock has the potential to impact world hunger and to become a key economic driver. AI is already being used to manage fields for increased yields. Its use to study plant and animal genomics will affect our ability to grow resources for livestock and modify livestock in ways that facilitate ease of handling (e.g., hornless cows)—not to mention replacing them with plant-based substitutes. China’s AI and biotechnology plans and programs emphasize the use of AI to improve plants and livestock.

Data privacy, data security, and population surveillance

While not a facet of biotech research itself, as more genomic and other biological information becomes available, our ability to store, analyze, and protect it is increasingly important. The U.S. and like-minded countries will need to explore whether current procedures governing data privacy are sufficient, or if there are special considerations unique to genomic data. Key among these considerations will be how to maximize discovery while protecting this resource vis-à-vis other countries that do not play by the same rules for sharing and collaboration.

Appendix 3: China's Policies That Support Genomics and Biotechnology

What follows is an overview of some of the policies and programs China has put in place to support this growth:

China's National Medium and Long-Term Plan (MLP) for science and technology (S&T) Development (2006–2020).²⁰⁸ This S&T blueprint lays out a development strategy that relies on overseas returnees, foreign collaboration, and the R&D laboratories that international companies have established in China to acquire needed skills. The MLP focuses both on the process of science and the specific topic areas it seeks to develop. The plan regards the development of Chinese biotechnology as “the new revolution of the 21st century” and emphasizes the “importance of genomics, proteomics, sequencing, and discovery of the functions of genes,” all aspects that stand to be enhanced by contributions from AI.

Precision Medicine Initiative.²⁰⁹ China's Precision Medicine Initiative (精准医疗计划), launched in 2016, seeks to leverage the country's sequencing capacity and access to biomedical data to design unique and tailored therapeutics for individuals, and explore diseases endemic to China. This effort brings together information technology and biotech companies with Chinese government support (\$9.2 billion) to design and apply new AI-enabled tools that analyze genomic, health, environmental, and behavioral data for insights into human health and therapeutics. It is modeled after an initiative launched by the United States in 2015.

13th Five-Year Plan for S&T Innovation.²¹⁰ The 13th Five-Year Plan (2016–2020) introduced the relevance of AI to biotechnology, experimental design, and precision medicine. It further emphasizes the importance of interdisciplinary research and computing power: “Build high-throughput calculation, high-throughput experiment, and dedicated database platforms, research and develop the four key technologies of multi-level and cross-scale design, high-throughput preparation, high-throughput characterization and service evaluation, and material big data, achieve the transition of new materials R&D from the traditional ‘experience-guided experiment’ model to the ‘theoretical prediction, experimental verification’ model.”

The plan also underscores the importance of genomic data to biotechnology and reiterates government plans for national-level genome databases:

“Establish a national bioinformatics and sample resource database, research and develop a number of suitable basic technologies and innovative products, comprehensively improve the level of birth defect prevention and control technology, safeguard the reproductive health of the reproductive age population, and improve the quality of the birth population.”

“Accelerate breakthroughs in cutting-edge key technology in life sciences such as new genomics technologies, synthetic biotechnology, biological big data, 3D bioprinting technology, brain science and artificial intelligence, gene editing technology, and structural biology.”

“Improve the originality of cutting-edge biotechnology in China, and seize a commanding position in international biotechnology competition.”

13th Five-Year Plan for Military and Civil Fusion.²¹¹ This plan was established in 2017 and focuses on emerging technologies. It calls specifically for a cross-pollination of military and civilian technology in areas not traditionally viewed as “national security issues,” such as neuroscience and brain-inspired research, as well as biotechnology. The military-civilian fusion plan states that such projects will be supported by foreign outreach initiatives.

14th Five-Year Plan.²¹² China’s latest Five-Year Plan (2021–2025) continues to emphasize interdisciplinary research and the use of AI for biological discovery and precision medicine. The plan underscores the importance to China of merging AI and biotechnology, as well as the need for both political and financial support: “We 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.”

Strategic emerging industries.²¹³ China has designated several fields as “strategic emerging industries” (战略性新兴产业, SEIs) to foster a more entrepreneurial environment and grow indigenous companies. The effort began at the top, spearheaded in 2009 by Wen Jiabao and the State Council,¹ and included preferential tax treatment, subsidies, and government procurement initiatives. AI and biotechnology are both considered SEIs and factor heavily into China’s efforts. In 2021, China doubled down on its SEI policy to emphasize “key investments in strategic areas,” create “industrial clusters,” and accelerate the pace of innovation and development in the biotechnology industry.

As a result of its multi-decade effort and ample investments, China is having success in many areas and is currently creating a “biotech hub” that will support its success in the race from genotype to phenotype.

China’s National Genomics Data Center (国家基因组科学数据中心), founded in 2019, benefits from returned talent that have direct experience in leading U.S. universities and the 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 universities. One of its leading scientists was selected for the Chinese Academy of Sciences 100 Talents Program while still working at the NIH.

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