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Biosecurity, Military Entanglements, and Ethical Dilemmas: Unraveling the Complexities of BGI Genomics in the Global Arena



Executive Summary

1. **U.S. Implications of BGI's Activities:** The expansion of BGI and its ties with the Chinese military represent a multifaceted threat to U.S. national security, public health, and economic interests. The potential for technology transfer, misuse of genetic data, and advancements in military biotechnology are key concerns that need to be addressed.
2. **Policy Recommendations for the U.S.:** To counter these risks, the U.S. must strengthen its surveillance systems, enforce stringent biosecurity measures, and engage in international efforts to regulate and monitor biotechnological advancements. These steps are critical in protecting against the misuse of biotechnology.
3. **BGI's Role in Global Scientific Collaboration:** BGI's widespread international collaborations underscore the benefits and challenges of global scientific partnerships. Balancing the pursuit of innovation with ethical and security considerations is vital for maintaining the integrity and safety of global scientific research.
4. **Ethical Implications of Genetic Research:** The ethical dimensions of BGI's genetic research, particularly involving vulnerable populations, highlight the necessity for robust ethical frameworks and oversight mechanisms. Ensuring informed consent, privacy, and equitable benefits are paramount.
5. **Biosecurity Risks of Dual-Use Research:** BGI's involvement in research with dual-use potential presents a significant biosecurity challenge. Effective policies and international agreements are needed to prevent the repurposing of scientific research for harmful applications.
6. **U.S. Bioeconomy and Intellectual Property Concerns:** Safeguarding the U.S. bioeconomy and intellectual property rights in the face of international biotechnological collaborations is crucial. Vigilance against intellectual property theft and unfair competitive practices is necessary to protect U.S. interests.
7. **Surveillance and Intelligence Gathering:** Strengthening intelligence capabilities to monitor activities of foreign biotech firms like BGI is essential. This would enable the U.S. to preemptively identify and mitigate potential threats to national security and public health.
8. **Development in Defense Biotechnology:** Investing in defensive biotechnologies is vital for the U.S. to keep pace with potential biotreats. This includes developing countermeasures and strengthening capabilities to detect and respond to biological attacks.
9. **Global Norms for Biotechnological Research:** The U.S. should take a leadership role in establishing global norms and standards for responsible biotechnological research. This includes promoting ethical practices and preventing the misuse of biotechnology for military or harmful purposes.

10. **Education and Awareness in Biosecurity:** Educational initiatives are crucial for raising awareness about biosecurity and the ethical implications of biotechnology. Training programs for scientists, policymakers, and the public can foster a culture of responsibility and vigilance.
11. **Legislative Measures to Regulate Biotechnology:** Enacting comprehensive legislation to regulate the transfer and use of sensitive biotechnological materials is necessary for maintaining national security and preventing technology misuse.
12. **Diplomatic Engagement to Address Biosecurity Concerns:** Diplomatic efforts are key in addressing global biosecurity concerns. Engaging with international partners to promote transparency and cooperation can mitigate the risks associated with biotechnological research.
13. **Public-Private Partnerships in Biosecurity:** Collaborative efforts between government agencies, academia, and private industry are essential for sharing knowledge, fostering innovation, and developing effective biosecurity strategies.
14. **The Importance of a Balanced Approach:** In navigating the complexities of biotechnology, the U.S. must balance fostering international scientific cooperation with safeguarding national interests and global security. A holistic approach is required to harness the benefits of biotech advancements while minimizing associated risks.

National Security Concerns and U.S. Actions Against BGI Genomics' Military Ties

BGI Genomics (华大基因股份), a Chinese genetics company, has increasingly become a focal point of concern in the realm of national security, particularly in relation to its connections with the Chinese military. This concern has manifested in various actions and discussions within the U.S. political and defense sectors.

The **U.S. Department of Commerce** has placed units of BGI Genomics on a trade blacklist. This action is part of a broader effort to target entities that pose national security or foreign policy concerns for the United States. The additions to the blacklist also include entities from other countries, but the inclusion of BGI Genomics is particularly notable due to its size and influence in the genomics industry. The U.S. government has expressed concerns about the potential misuse and abuse of technology to commit human rights abuses and other acts of oppression, underscoring their commitment to scrutinizing transactions involving these blacklisted entities. In 2020, the Commerce Department specifically blacklisted two units of BGI Group over allegations that they conducted genetic analyses used to further the repression of China's minority Uyghurs, although BGI denied these allegations.¹

Furthermore, the **U.S. Department of Defense (DOD)** has listed BGI Genomics as one of the "Chinese Military Companies" operating in the United States. This listing, mandated by the Defense Authorization Act for Fiscal Year 2021, includes companies that are owned or controlled by the **Chinese People's Liberation Army (PLA)** or organizations subordinate to the **Central Military Commission of the Chinese Communist Party**. While the designation does not immediately trigger specific actions, it signals the U.S. government's recognition of the potential national security risks posed by BGI Genomics' operations in the U.S..²

This situation has broader implications for other companies as well. For instance, Natera, a company that has a joint venture with BGI Genomics, faces political and regulatory risks due to its association with BGI. The U.S. government's identification of BGI as a 'military company' raises concerns about potential future actions, such as an outright prohibition of companies like Natera from doing business with BGI. This situation is reminiscent of the U.S. government's previous actions against Chinese telecom companies like **Huawei** and **ZTE**, suggesting a pattern of increasing scrutiny and potential action against companies with ties to the Chinese military.³

In November 2023, Politico reported a significant development in the U.S. legislative landscape concerning foreign genomics firms, particularly highlighting the case of BGI. The FY24 U.S. defense authorization bill will potentially propose stringent measures, prohibiting federal procurement or funding for biotech equipment or services from companies with ties to foreign adversaries, notably China. This move was part of a broader effort to safeguard American

¹ Alexandra Alper and David Shepardson, US adds units of China's BGI, Inspur to trade blacklist, Reuters, 2023-03-16, <https://www.reuters.com/markets/us/us-adds-chinese-genetics-company-units-trade-blacklist-2023-03-02/>

² Steve Usdin, Washington Editor, BGI Genomics placed on list of Chinese military companies operating in the U.S., Biocentury, 2022-10-11, <https://www.biocentury.com/article/645477/bgi-genomics-placed-on-list-of-chinese-military-companies-operating-in-the-u-s>

³ Natera: Company's Ties with China's BGI Genomics Exposes It to Political and Regulatory Risk, Holland & Knight, 2022-12-07 <https://www.hklaw.com/en/news/intheheadlines/2022/12/nateras-ties-with-bgi-exposes-it-to-political-and-regulatory-risk>

genomic data from potential misuse by foreign entities. In response, BGI Group and other Chinese genomics firms embarked on an extensive lobbying campaign, employing prominent firms and figures to challenge the proposed restrictions. The situation underscored the growing tension between national security interests and international biotech collaborations.⁴

In summary, BGI Genomics' associations with the Chinese military have raised significant national security concerns within the U.S. These concerns have led to concrete actions such as blacklisting and close monitoring, reflecting a broader strategy of the U.S. government to safeguard against potential threats arising from the intersection of technology and foreign policy. The situation also highlights the complex interplay between global business interests and national security considerations in an increasingly interconnected world.

China's Strategic Ambitions in Biotechnology: Balancing Scientific Progress with Biosecurity and Ethical Concerns⁵

China's aggressive pursuit to dominate the biotechnology sector, as detailed in The Washington Post's '**China's Global Leap - China's quest for human genetic data spurs fears of a DNA arms race**', illustrates a strategic shift in global power dynamics, centered around the control and utilization of genetic data. This concerted effort, manifested through initiatives like the "Fire-Eye" labs developed by BGI Group, underscores a broader ambition not just to advance in the field of biotechnology, but to potentially reshape global scientific, economic, and military landscapes.

The transformation of these labs from COVID-19 testing centers to permanent genetic data repositories in countries worldwide signals China's intent to amass a diverse genetic databank. This expansive collection of human DNA, ostensibly for scientific research, could grant China unprecedented insights into genetic diseases, population health, and the development of new drugs and medical technologies. In an era where data is as valuable as tangible assets, control over such comprehensive genetic information could position China at the forefront of medical and scientific breakthroughs, potentially yielding significant economic gains and bolstering its global influence.

However, this ambitious pursuit raises profound biosecurity, privacy, and ethical concerns. The potential militarization of genetic research, a fear echoed by Western intelligence agencies, introduces the unsettling possibility of DNA being used for surveillance or even as a basis for new forms of biological weaponry. Such developments could trigger a DNA arms race, with nations scrambling to protect their genetic data from international rivals.

Moreover, the collection and potential misuse of genetic data by a state with an authoritative grip over its corporations, as seen with China's national intelligence law, poses a direct threat to individual privacy. The global reach of China's biotechnology initiatives raises alarms about the

⁴ Caitlin Oprysko, Potential crackdown on foreign genomics firms sparks a lobbying fight, Politico, 2023-11-29, <https://www.politico.com/newsletters/politico-influence/2023/11/29/potential-crackdown-on-foreign-genomics-firms-sparks-a-lobbying-fight-00129184>

⁵ China's Global Leap: China's quest for human genetic data spurs fears of a DNA arms race, The Washington Post, 2023-09-21, <https://www.washingtonpost.com/world/interactive/2023/china-dna-sequencing-bgi-covid/>

security of genetic information and the risk of it being used to further governmental control or suppress minority groups, as alleged in China's dealings with ethnic and religious minorities.

In summary, China's leap in biotechnology, while promising scientific advancements, also brings to the fore critical discussions about the ethical boundaries of genetic research, the need for stringent international regulations, and the importance of safeguarding biosecurity and genetic privacy. This scenario challenges the global community to balance the quest for scientific progress with the imperatives of ethical responsibility and security in an increasingly data-driven world.

BGI Genomics' Global Infrastructure: Bridging Innovation and Education in Genomics⁶

BGI Genomics has crafted a vast and intricate infrastructure that accelerates innovation and fosters education in genomics and related fields. This infrastructure is categorized into several key areas: research institutes, laboratories, education centers, and international locations.

Research Institutes: The heart of BGI's scientific exploration beats in institutes like the **Institute of Biointelligence Technology** and **BGI Research in Shenzhen**, where advanced research in genomics and bioinformatics is conducted. The **Lars Bolund Institute of Regenerative Medicine** and the **Qingdao-Europe Advanced Institute for Life Sciences** are examples of BGI's commitment to regenerative medicine and international scientific cooperation. Additionally, **BGI's China National GeneBank** is a cornerstone of the company's research efforts, housing a vast array of genetic data that propels research in biodiversity and conservation.

Laboratories: BGI's laboratories are key to its operational prowess, with specialized centers across China focusing on practical applications of genomics research. The **Guangdong Provincial Key Laboratory of Genome Read and Write** and the **Shenzhen Engineering Laboratory for Birth Defects Screening** are just two of BGI's many labs dedicated to advancing genomics technology and its application in healthcare. Furthermore, laboratories like the **Shenzhen Key Lab of Marine Genomics** and the **BGI Marine Research Institute** demonstrate BGI's extensive research capabilities, spanning from agriculture to marine life sciences.

Education Centers: BGI places a strong emphasis on education and talent development, collaborating with universities to nurture future scientists. **BGI College**, in collaboration with **Zhengzhou University**, and the **BGI Education Center**, in partnership with the **University of Chinese Academy of Sciences**, are integral to this educational mission. These centers provide platforms for academic exchange and training in genomics, ensuring a steady flow of skilled professionals in the field.

⁶ The API search on the Data Abyss platform is a query for the organization "BGI" using a filter based on the literal name "BGI" with an "AND" operator and vague accuracy criteria.
https://app.dataabyss.ai/search/organizations?criteria=%5B%7B%22field%22%3A%22literal_name%22%2C%22q%22%3A%22BGI%22%2C%22operator%22%3A%22AND%22%2C%22accuracy%22%3A%22Vague%22%7D%5D&publicDemo=

International Locations: BGI America, headquartered at One Broadway, 14th Floor, Cambridge, MA, exemplifies BGI's strategic expansion into the North American market, reinforcing its global presence in the field of genomics and biotechnology. Located in a hub known for its rich academic and biotech landscape, BGI America is ideally positioned to engage in collaborative research and offer cutting-edge genomic services to a diverse clientele, ranging from academic institutions to healthcare organizations.

The key services provided by BGI America underscore the company's commitment to advancing genomics research and its applications:

Whole Genome Sequencing: This service provides comprehensive analysis of the entire genome. It is crucial for understanding genetic variations and has applications in various fields, including personalized medicine, genetic research, and disease prevention.

RNA Sequencing: RNA sequencing is a powerful tool for studying gene expression. It helps in understanding the functional elements of the genome, the mechanisms of diseases, and identifying novel transcripts. This service is pivotal in research areas such as oncology, neurology, and developmental biology.

Single Cell Sequencing: Focusing on the analysis of individual cells, this service provides insights into cellular differences and a better understanding of the complexity of biological systems. This is particularly important in cancer research, immunology, and developmental biology.

Proteome Profiling (Mass Spec): Proteome profiling involves the large-scale study of proteins, which are vital parts of living organisms. Using mass spectrometry, this service helps in understanding protein functions, interactions, and their role in various biological processes.

Label-Free DIA (Mass Spec): Data-Independent Acquisition (DIA) is a mass spectrometry technique that provides a comprehensive and reproducible analysis of complex protein samples. This label-free approach is essential for quantitative proteomics and biomarker discovery.

BGI America's presence in Cambridge, Massachusetts, not only enhances BGI's research and service capabilities but also solidifies its role as a key player in the international genomics arena. Alongside its other international locations, such as **BGI San Jose California**, **BGI@UC Davis genome facility**, **GigaScience Press in Hong Kong** and **BGI-Australia in Queensland**, BGI America contributes to BGI's mission of promoting genomics for the benefit of humanity, enabling global collaboration, and fostering innovation in the field of life sciences.

Platforms: BGI Genomics has established specialized platforms that serve as the foundation for its technological and scientific advancements in genomics. These platforms are integral to BGI's ability to streamline research and development, providing the necessary tools and frameworks to push the boundaries of genomic science. The **Genome Synthesis and Editing Platform in Shenzhen** is one such initiative, demonstrating BGI's commitment to the forefront of genomic editing and synthetic biology. This platform is essential for exploring the vast potential of genomics to innovate in medicine, agriculture, and biotechnology. In the realm of single-cell genomics, the **Shenzhen Key Laboratory of Single-Cell Omics** offers a focused environment

for dissecting the complexities of cellular function and interaction. This platform is crucial for advancing personalized medicine, as it allows for a more detailed understanding of individual cellular responses to diseases and treatments.

The development of platforms such as these underlines BGI's strategic approach to genomics research. By creating specialized environments for different aspects of genomics, BGI ensures that it remains at the cutting edge of technology and scientific discovery. These platforms not only enhance BGI's research capabilities but also solidify its position as a leader in the global genomics landscape.

Biosecurity Implications of BGI Genomics' High-Risk Genetic Research and Advanced Technologies⁷

High-risk genetics research at BGI Genomics represents a significant area of biosecurity concern, particularly due to the advanced technologies being pursued and their potential implications. The exploration of technologies like CRISPR/Cpf1 for genetic modification and engineered CAR-T cell therapy, as highlighted in their publication '**High-efficiency of genetic modification using CRISPR/Cpf1 system for engineered CAR-T cell therapy**',⁸ demonstrates BGI's commitment to pushing the boundaries of genetic engineering. While these technologies hold immense promise for medical breakthroughs, including cancer treatments and gene therapy, they also pose significant biosecurity risks if misused or released unintentionally.

The utilization of shotgun metagenomics for pathogen detection, as mentioned in the publication '**Multicenter assessment of shotgun metagenomics for pathogen detection**',⁹ is another area where BGI is making strides. This technology allows for the rapid identification of pathogens, which is crucial in managing outbreaks and understanding disease epidemiology. However, the same technology could potentially be repurposed for the development of biological weapons or for the creation of novel pathogens, raising concerns about dual-use research.

BGI's work on understanding pathogenic variants, as seen in publications like '**Two Novel Pathogenic Variants of TJP2 Gene and the Underlying Molecular Mechanisms in Progressive Familial Intrahepatic Cholestasis Type 4 Patients**',¹⁰ provides valuable insights into genetic diseases and their treatment. However, the knowledge gained from such studies

⁷ The API search on the Data Abyss platform is a query for the organization "BGI-Shenzhen" using a filter based on the literal name "BGI" with an "AND" operator and vague accuracy criteria. <https://app.dataabyss.ai/affiliation/BGI-Shenzhen>

⁸ Ding R, Chao CC, Gao Q. High-efficiency of genetic modification using CRISPR/Cpf1 system for engineered CAR-T cell therapy. *Methods Cell Biol.* 2022;167:1-14. doi: 10.1016/bs.mcb.2021.08.001. Epub 2021 Sep 15. PMID: 35152989.

⁹ Liu D, Zhou H, Xu T, Yang Q, Mo X, Shi D, Ai J, Zhang J, Tao Y, Wen D, Tong Y, Ren L, Zhang W, Xie S, Chen W, Xing W, Zhao J, Wu Y, Meng X, Ouyang C, Jiang Z, Liang Z, Tan H, Fang Y, Qin N, Guan Y, Gai W, Xu S, Wu W, Zhang W, Zhang C, Wang Y. Multicenter assessment of shotgun metagenomics for pathogen detection. *EBioMedicine.* 2021 Dec;74:103649. doi: 10.1016/j.ebiom.2021.103649. Epub 2021 Nov 20. PMID: 34814051; PMCID: PMC8608867.

¹⁰ Tang J, Tan M, Deng Y, Tang H, Shi H, Li M, Ma W, Li J, Dai H, Li J, Zhou S, Li X, Wei F, Ma X, Luo L. Two Novel Pathogenic Variants of TJP2 Gene and the Underlying Molecular Mechanisms in Progressive Familial Intrahepatic Cholestasis Type 4 Patients. *Front Cell Dev Biol.* 2021 Aug 24;9:661599. doi: 10.3389/fcell.2021.661599. PMID: 34504838; PMCID: PMC8421653.

could also inform the creation of targeted genetic bioweapons, capable of causing disease or disability in specific populations based on genetic characteristics.

For the United States and the global community, the implications of such advanced biosecurity threats are profound. The potential for misuse of genetic modification and pathogen detection technologies in bioterrorism cannot be overlooked. Moreover, the globalization of biotechnology research means that advancements made in one part of the world can quickly spread, necessitating international cooperation and vigilance in biosecurity measures.

The U.S. must continue to invest in defensive measures against biological threats, including developing robust detection and response systems for potential bioweapon attacks. There is also a need for stringent regulation and oversight of high-risk genetics research to prevent misuse. International collaborations and agreements can play a vital role in ensuring that genetic research advances are used for the betterment of humanity rather than as tools for harm.

BGI's pioneering work in genetics, while commendable for its contributions to science, underscores the need for balanced and ethical considerations in research, particularly when it intersects with global biosecurity. The continuous evolution of genetic technologies requires a proactive and adaptive approach to biosecurity, ensuring that scientific progress does not inadvertently pave the way for new forms of biological threats.

BGI's high-risk genetics research demonstrates a significant focus on advanced genetic modification techniques, pathogen detection, and the understanding of genetic diseases. The research areas span a range of applications from medical therapies to pathogen identification, each carrying its own set of potential risks.

Summary of Research Thrusts:

1. **Genetic Modification and Therapies:** BGI explores cutting-edge genetic editing techniques like CRISPR/Cpf1, particularly in applications like CAR-T cell therapy, which could revolutionize cancer treatment. While promising, these technologies could be repurposed for creating genetic bioweapons or unregulated gene editing in humans.
2. **Pathogen Identification and Analysis:** Studies involving shotgun metagenomics and next-generation sequencing offer breakthroughs in rapid pathogen detection and understanding pathogen-host interactions. However, there's a risk of dual-use where such technologies could be used for developing biological weapons.

Understanding Genetic Diseases: Research on genetic variants contributing to diseases provides insights into potential treatments but also raises concerns about the creation of targeted genetic bioweapons.

Table 1 Describes the Risks of Each Research Title:

Title	Potential Risks
High-efficiency of genetic modification using CRISPR/Cpf1 system for engineered CAR-T cell therapy	Misuse in creating genetic bioweapons, ethical concerns in human gene editing
Pathogen of <i>Vibrio harveyi</i> infection and C-type lectin proteins in whiteleg shrimp (<i>Litopenaeus vannamei</i>)	Bioengineering of pathogens for harmful purposes
Multicenter assessment of shotgun metagenomics for pathogen detection	Dual-use in bioweapon development, privacy concerns in pathogen data
Two Novel Pathogenic Variants of TJP2 Gene and the Underlying Molecular Mechanisms in Progressive Familial Intrahepatic Cholestasis Type 4 Patients	Potential for targeted genetic bioweapons, ethical issues in gene therapy
Genomic characterization of four novel bacteriophages infecting the clinical pathogen <i>Klebsiella pneumoniae</i>	Bioweapon development, antibiotic resistance concerns
Multi-platform omics analysis reveals molecular signature for COVID-19 pathogenesis, prognosis and drug target discovery	Biosecurity risks in handling pathogens, misuse in bioterrorism
The clinical significance of simultaneous detection of pathogens from bronchoalveolar lavage fluid and blood samples by metagenomic next-generation sequencing in patients with severe pneumonia	Privacy and biosecurity concerns in medical data, dual-use research
Bi-Allelic Pathogenic Variations in MERTK Including Deletions Are Associated with an Early Onset Progressive Form of Retinitis Pigmentosa	Ethical implications in gene therapy, potential misuse in targeted diseases
Impact of donor lung pathogenic bacteria detected by next-generation sequencing on early post-transplant outcomes in lung transplant recipients	Privacy concerns, risks in transplant medicine
Comparison of Intraocular Antibody Measurement, Quantitative Pathogen PCR, and Metagenomic Deep Sequencing of Aqueous Humor in Secondary Glaucoma Associated with Anterior Segment Uveitis	Biosecurity risks in ocular diseases, dual-use in pathogen identification
Author Correction: Reinterpretation of common pathogenic variants in ClinVar revealed a high proportion of downgrades	Misinterpretation risks in genetic research, ethical concerns
Pathogen quantitative efficacy of different spike-in internal controls and clinical application in central nervous system infection with metagenomic sequencing	Biosecurity concerns in CNS infections, dual-use research risks
A sensitive mass spectrometry-based method to identify common respiratory pathogens in children	Privacy and biosecurity concerns in pediatric medicine, dual-use technology

Each of these studies highlights BGI's role at the forefront of genetic research, yet underscores the need for ethical oversight and robust biosecurity measures to mitigate potential risks associated with such advanced scientific endeavors.

Balancing Innovation and Biosecurity: The Dual-Use Dilemma in BGI Genomics' Advanced Research¹¹

In the ever-expanding realm of genetic research, two studies by BGI Genomics illustrate the fine line between groundbreaking scientific discovery and the potential for its misuse, a concept known as the dual-use nature of research.

The first study, titled '**Pathogen of *Vibrio harveyi* infection and C-type lectin proteins in whiteleg shrimp (*Litopenaeus vannamei*)**,'¹² delves into the intricate dynamics of pathogen-host interaction in marine biology. While the study provides invaluable insights for aquaculture, particularly in enhancing disease resistance in shrimp farming, it inadvertently opens a Pandora's box of potential risks. The detailed understanding of *Vibrio harveyi*'s pathogenic mechanisms, crucial to marine ecosystems and the aquaculture industry, also paves the way for the possible bioengineering of pathogens. This knowledge, in malevolent hands, could be repurposed to craft biological weapons, transcending beyond marine life and posing a threat to human health by adapting these findings to human pathogens. Thus, the study, while pivotal for aquaculture, treads a thin line between beneficial and harmful applications.

The second study, '**Genomic characterization of four novel bacteriophages infecting the clinical pathogen *Klebsiella pneumoniae***,'¹³ ventures into the genomic analysis of bacteriophages targeting a key human pathogen. This research is critical in the fight against antibiotic-resistant bacteria, offering a ray of hope in phage therapy development. However, it also raises significant biosecurity concerns. The creation and study of these bacteriophages, while aimed at combating bacterial infections, could be misappropriated for developing biological weapons. Additionally, there's an underlying anxiety about inadvertently enhancing bacterial resistance, a dire concern in the medical community. The potential misuse of this research to develop more resilient bacterial strains or bioweapons represents a substantial risk to public health and safety.

These two studies underscore the dual-use dilemma inherent in advanced genetic research. On one hand, they present promising solutions to pressing healthcare and environmental issues. On the other, they bear the risk of their findings being diverted for nefarious purposes. This dichotomy highlights the critical need for robust ethical guidelines and stringent regulatory

¹¹ The API search on the Data Abyss platform is a query for the organization "BGI-Shenzhen" using a filter based on the literal name "BGI" with an "AND" operator and vague accuracy criteria. <https://app.dataabyss.ai/affiliation/BGI-Shenzhen>

¹² Liu H, Guo S, Wang R, He Y, Shi Q, Song Z, Yang M. Pathogen of *Vibrio harveyi* infection and C-type lectin proteins in whiteleg shrimp (*Litopenaeus vannamei*). *Fish Shellfish Immunol.* 2021 Dec;119:554-562. doi: 10.1016/j.fsi.2021.10.040. Epub 2021 Oct 28. PMID: 34718124.

¹³ Bonilla E, Costa AR, van den Berg DF, van Rossum T, Hagedoorn S, Walinga H, Xiao M, Song W, Haas PJ, Nobrega FL, Brouns SJJ. Genomic characterization of four novel bacteriophages infecting the clinical pathogen *Klebsiella pneumoniae*. *DNA Res.* 2021 Aug 25;28(4):dsab013. doi: 10.1093/dnares/dsab013. PMID: 34390569; PMCID: PMC8386662.

frameworks to govern such research. It's imperative that both national and international bodies maintain vigilance, ensuring that these scientific advancements are harnessed for the betterment of humanity and not as tools for biosecurity threats. The U.S. and the global scientific community play a pivotal role in this, necessitating a proactive approach to monitor, regulate, and guide this research along ethical paths, thus safeguarding against the potential for misuse in a world increasingly reliant on genetic technologies.

Ethical Considerations in BGI Genomics' Research Involving Uyghur Genetic Data^{14 15}

The situation of the Uyghurs in Xinjiang, a region in northwest China, has become a focal point of international concern due to allegations of human rights abuses by the Chinese government, which some governments and human rights organizations have characterized as a genocide. The Uyghur people, a predominantly Muslim Turkic ethnic group, have faced increasing repression and surveillance within China.

Reports and investigations have revealed a systematic state campaign against the Uyghurs and other Muslim minorities in the region. This campaign includes mass detentions in what the Chinese government describes as "re-education camps." Witnesses and survivors have reported harsh conditions, indoctrination, and abuse within these camps. Estimates suggest that up to a million or more people have been detained in these facilities.

In addition to the mass detentions, there are allegations of forced labor, with Uyghurs being moved from Xinjiang to work in factories in other parts of China under conditions that have been equated to forced labor. There are also reports of widespread surveillance of the Uyghur population, restrictions on religious and cultural practices, and even allegations of forced sterilizations and birth control to reduce the Uyghur population, actions that many international observers have labeled as demographic genocide.

The Chinese government has consistently denied accusations of human rights abuses in Xinjiang, framing its actions as part of a campaign against separatism and religious extremism. They assert that the camps are vocational training centers designed to combat poverty and religious extremism.

This issue has led to international debates and actions, including sanctions by Western governments against Chinese officials and calls for investigations into human rights abuses. The situation remains a contentious and deeply complex geopolitical issue, with far-reaching implications for human rights, international relations, and global responses to allegations of genocide and systemic oppression.

¹⁴ For more on the Uyghur genocide see House Select Committee on the Chinese Communist Party Issues: <https://selectcommitteeontheccp.house.gov/issues/uyghur-genocide>

¹⁵ This API call requests the first page of works from OpenAlex, filtered to include works related to the term "Uyghur" and affiliated with the institution lineage "I100135526," sorted by relevance score in descending order. https://api.openalex.org/works?page=1&filter=authorships.institutions.lineage:I100135526,default.search:Uyghur&sort=relevance_score:desc

The research conducted by **BGI Genomics on the Uyghur ethnic group** and various genetic studies raises critical ethical concerns, especially in the context of privacy, consent, and potential misuse of genetic data.

1. **Allele Polymorphism and Haplotype Diversity of HLA-A, -B and -DRB1 Loci in Sequence-Based Typing for Chinese Uyghur Ethnic Group (2010)**¹⁶: This study focuses on the genetic diversity within the HLA (human leukocyte antigen) system of the Uyghur ethnic group. The HLA system plays a crucial role in immune response regulation. While this research can provide valuable insights into genetic predispositions to certain diseases and potential organ transplant compatibilities, it also raises ethical questions regarding the collection and use of genetic data from a minority ethnic group, especially in a region where Uyghurs have been subject to intense surveillance and control by the Chinese government.
2. **Quantitative Evaluation of Serum Proteins Uncovers a Protein Signature Related to Maturity-Onset Diabetes of the Young (MODY) (2017)**¹⁷: This article explores a protein signature associated with MODY, a form of diabetes that typically develops before the age of 25. While the study itself appears to be a general medical research effort, the underlying concern in the context of BGI's work with specific ethnic populations is whether similar techniques could be used to profile or discriminate against particular groups based on genetic predispositions to certain diseases.
3. **Genomic Analyses from Non-invasive Prenatal Testing Reveal Genetic Associations, Patterns of Viral Infections, and Chinese Population History (2018)**¹⁸: This study uses data from non-invasive prenatal testing to understand genetic associations and historical patterns. The ethical concern here revolves around the use of sensitive prenatal data, which could potentially be misused for purposes like population surveillance or even eugenics, especially considering the context of BGI's work in regions like Xinjiang.
4. **Identification of a Novel Human Leukocyte Antigen Allele B*46:34 (2013)**¹⁹: The discovery of a new HLA allele can contribute to the understanding of immune system functioning and disease resistance. However, given the sensitive nature of HLA research, particularly in ethnically diverse populations, there are ethical considerations regarding

¹⁶ Shen CM, Zhu BF, Deng YJ, Ye SH, Yan JW, Yang G, Wang HD, Qin HX, Huang QZ, Zhang JJ. Allele polymorphism and haplotype diversity of HLA-A, -B and -DRB1 loci in sequence-based typing for Chinese Uyghur ethnic group. *PLoS One*. 2010 Nov 4;5(11):e13458. doi: 10.1371/journal.pone.0013458. PMID: 21079793; PMCID: PMC2973946.

¹⁷ Tuerxunyming M, Xian F, Zi J, Yimamu Y, Abuduwayite R, Ren Y, Li Q, Abudula A, Liu S, Mohemaiti P. Quantitative Evaluation of Serum Proteins Uncovers a Protein Signature Related to Maturity-Onset Diabetes of the Young (MODY). *J Proteome Res*. 2018 Jan 5;17(1):670-679. doi: 10.1021/acs.jproteome.7b00727. Epub 2017 Dec 14. PMID: 29182332.

¹⁸ Liu S, Huang S, Chen F, Zhao L, Yuan Y, Francis SS, Fang L, Li Z, Lin L, Liu R, Zhang Y, Xu H, Li S, Zhou Y, Davies RW, Liu Q, Walters RG, Lin K, Ju J, Korneliusen T, Yang MA, Fu Q, Wang J, Zhou L, Krogh A, Zhang H, Wang W, Chen Z, Cai Z, Yin Y, Yang H, Mao M, Shendure J, Wang J, Albrechtsen A, Jin X, Nielsen R, Xu X. Genomic Analyses from Non-invasive Prenatal Testing Reveal Genetic Associations, Patterns of Viral Infections, and Chinese Population History. *Cell*. 2018 Oct 4;175(2):347-359.e14. doi: 10.1016/j.cell.2018.08.016. PMID: 30290141.

¹⁹ Shen CM, Wang HD, Deng YJ, Wang SY, Zhang LP, Zhang B, Pu HW, Wu QJ, Liu WJ, Zhu BF. Identification of a novel human leukocyte antigen allele B*46:34. *Hum Immunol*. 2013 Feb;74(2):261-2. doi: 10.1016/j.humimm.2012.10.023. Epub 2012 Nov 5. PMID: 23137878.

how this genetic information is used, stored, and potentially shared, especially in light of concerns about human rights abuses against the Uyghur population.

In all these studies, the primary ethical concerns involve informed consent, privacy, and the potential for genetic information to be used for discriminatory purposes. There is a need for strict ethical guidelines and oversight to ensure that genetic research, particularly when involving vulnerable ethnic groups, is conducted responsibly and with respect for the rights and dignity of all individuals involved.

U.S. Funding Ties with BGI Genomics and International Reach: A Comprehensive Overview and Biosecurity Implications²⁰

BGI Genomics, a major player in the global genomics landscape, has established extensive ties with various U.S. funding agencies, reflecting a deep entanglement between Chinese and American research endeavors. This relationship, while fostering scientific collaboration, raises significant concerns regarding biosecurity and the protection of sensitive genetic data.

The U.S. Funding Spectrum

- **National Institutes of Health (NIH):** With 44 instances of funding, the NIH's involvement with BGI projects is substantial. NIH, as a primary funder of medical research in the U.S., supports projects that may include sensitive genetic data, raising concerns about data security and the potential misuse of this information.
- **National Institutes of Health (NIH) Office of the Director:** With 3 instances of funding projects with BGI Genomics highlights a strategic intersection of U.S. biomedical research at the director level with international genomic expertise. This collaboration, while potentially enriching scientific understanding and innovation, necessitates careful consideration of data privacy, bioethical standards, and the broader implications of such international scientific partnerships.
- **National Science Foundation (NSF):** The NSF's 39 instances of funding underline its role in supporting basic research, which may intersect with BGI's genomic endeavors. The cross-border nature of this research necessitates careful scrutiny to ensure it aligns with U.S. national interests.
- **National Cancer Institute:** Contributing to 10 projects, their focus on cancer research intersects with BGI's genomic studies, potentially offering valuable insights but also posing risks if the data is misappropriated.

²⁰ This API call requests a list of works from OpenAlex, sorted by the number of citations in descending order, including specific columns (display name, publication year, type, open access status, and citation count), filtered by works affiliated with the institution lineage "I100135526" and located in the United States, displaying API information, with the data grouped by the works' grant funders.

https://openalex.org/works?sort=cited_by_count%3Adesc&column=display_name,publication_year,type,open_access.is_oa,cited_by_count&page=1&filter=authorships.institutions.lineage%3AI100135526,institutions.country_code%3AUS&show_api=true&group_by=grants.funder

- **U.S. Department of Energy and U.S. Department of Agriculture:** With 3 instances of funding each, these departments' collaboration with BGI extends into areas of energy and agriculture, sectors that are crucial for national security and economic stability.
- **Army Research Office:** Its engagement with **BGI Genomics**, as evidenced by two instances of funding, raises important questions about the implications of such collaborations for national security and biosecurity. Army Research Office, part of the United States Army, has a mandate to advance scientific discovery that could potentially benefit the military. The **China National GeneBank** is thanked for sequencing the DNA of environmental isolates with funding provided by the Army's award **W911NF-14-1-0490**.²¹
- **Bill and Melinda Gates Foundation, John Templeton Foundation, Gordon and Betty Moore Foundation, David and Lucile Packard Foundation, Welch Foundation, Stony Wold-Herbert Fund:** These prestigious foundations, though contributing less frequently, support high-impact research, potentially involving groundbreaking genetic studies in collaboration with BGI.
- **Howard Hughes Medical Institute and American Heart Association and American Cancer Society:** Their involvement, though limited in number, indicates BGI's reach into critical areas of health research, pivotal for understanding and treating major diseases in the U.S.

BGI International Collaboration Metrics²²

BGI Genomics, with a total of 4,909 published Science and Technology (S&T) publications as of December 2023, showcases a global footprint in the realm of scientific research. The distribution of these publications across various countries highlights the extensive collaborative network and the diverse impact of BGI's research endeavors.

Table 2 Describes BGI's top 10 international collaborating institutions country:

Country	Publications	Percentage of Total BGI Publications
United States of America	1,261	25.7%
Denmark	972	19.8%

²¹ Zhang, C., Song, W., Ma, H. R., [plus five additional authors], & You, L. (2020). Temporal encoding of bacterial identity and traits in growth dynamics. *Proceedings of the National Academy of Sciences*, 117(33), 20202-20210. <https://doi.org/10.1073/pnas.2008807117>

²² The API call to OpenAlex retrieves a sorted list of works grouping by the institutions' country code, https://openalex.org/works?sort=cited_by_count%3Adesc&column=display_name,publiation_year,type,open_access.is_oa,cited_by_count&page=1&filter=authorships.institutions.lineage%3AI100135526&show_api=true&group_by=institutions.country_code

United Kingdom of Great Britain and Northern Ireland	499	10.2%
Germany	313	6.4%
Australia	299	6.1%
Canada	257	5.2%
France	166	3.4%
Sweden	157	3.2%
Saudi Arabia	141	2.9%
Netherlands	129	2.6%

Each of these countries' contributions to BGI's total publication count not only underlines their individual commitments to scientific research but also reflects the global reach and influence of BGI in the scientific community.

Biosecurity Implications

The involvement of these U.S. entities in funding BGI research as well as the international scale of collaboration brings forth several biosecurity implications:

- **Risk of Data Misuse:** The possibility that genetic data obtained from U.S.-funded research could be misused, either for surveillance, genetic profiling, or developing bioweapons, is a pressing concern.
- **Intellectual Property Issues:** There's a risk of intellectual property theft or misuse, where research funded and developed under U.S. grants could be appropriated for commercial or strategic gains by foreign entities.
- **Dual-Use Research:** Many of these projects may fall under the category of 'dual-use research of concern' (DURC), where scientific advances could be repurposed for harmful applications.
- **Influence on U.S. Bioeconomy:** Investments in BGI research could inadvertently bolster China's competitiveness in the global bioeconomy, potentially at the expense of U.S. interests.

The extensive funding ties between U.S. agencies and BGI Genomics highlight the complexity of global scientific collaboration. While these partnerships can drive significant advancements in genomics and related fields, they also necessitate stringent oversight to safeguard against biosecurity risks and ensure alignment with U.S. national security and ethical standards. This scenario underscores the need for a balanced approach that fosters international scientific cooperation while vigilantly protecting national interests and global security.

Assessing the Dual-Use Risks of PLA and BGI Collaborative Research in Biotechnology: Implications for Biosecurity and U.S. National Security

The collaborative research projects between the PLA and BGI, while contributing to scientific knowledge, present significant concerns in the realm of biosecurity and the potential for biotechnological misuse. The participation of PLA-affiliated institutions like **the Academy of**

Military Medical Sciences (AMMS) and the **Second Military Medical University** in these projects suggests a dual-purpose approach that extends beyond civilian medical research.

The ‘**Metagenomic Analysis of Fever, Thrombocytopenia and Leukopenia Syndrome (FTLS) in Henan Province, China**’²³ led to the discovery of a new Bunyavirus. This is a notable advancement in understanding emerging infectious diseases, which is critical for public health. However, the identification and study of new viruses can have dual-use applications. There's the potential risk that such research could be repurposed for bioengineering or weaponization of viruses. The involvement of the PLA's AMMS with BGI in such research could be seen as a move to understand and possibly utilize these pathogens for military purposes.

In the study of ‘**Complete Genome Sequence of Yersinia pestis Strain 91001, an Isolate Avirulent to Humans**’²⁴ AMMS and BGI researchers sequenced the genome of a strain of the bacterium responsible for the plague. This knowledge is crucial for developing treatments and preventative measures against possible outbreaks. However, the detailed understanding of this pathogen's genetics could also provide a blueprint for developing biological weapons, raising concerns about its use in biowarfare.

The researchers from the PLA's Second Military Medical University and BGI studied ‘**Genomic and oncogenic preference of HBV integration in hepatocellular carcinoma**’²⁵ which provides valuable insights into liver cancer treatment. However, understanding the mechanisms of viral integration into human DNA could be potentially applied to develop bioweapons that could target specific genetic profiles.

The study of between AMMS and BGI on ‘**A Glimpse of Streptococcal Toxic Shock Syndrome from Comparative Genomics of S. suis 2 Chinese Isolates**’²⁶ offers important insights into a severe infectious disease, but this research could potentially be used to enhance the virulence of pathogens, thereby creating more potent biological threats.

Finally, the research on ‘**H5N1 avian influenza re-emergence of Lake Qinghai: phylogenetic and antigenic analyses of the newly isolated viruses and roles of migratory birds in virus**

²³ Xu B, Liu L, Huang X, Ma H, Zhang Y, Du Y, Wang P, Tang X, Wang H, Kang K, Zhang S, Zhao G, Wu W, Yang Y, Chen H, Mu F, Chen W. Metagenomic analysis of fever, thrombocytopenia and leukopenia syndrome (FTLS) in Henan Province, China: discovery of a new bunyavirus. *PLoS Pathog.* 2011 Nov;7(11):e1002369. doi: 10.1371/journal.ppat.1002369. Epub 2011 Nov 17. PMID: 22114553; PMCID: PMC3219706.

²⁴ Song Y, Tong Z, Wang J, Wang L, Guo Z, Han Y, Zhang J, Pei D, Zhou D, Qin H, Pang X, Han Y, Zhai J, Li M, Cui B, Qi Z, Jin L, Dai R, Chen F, Li S, Ye C, Du Z, Lin W, Wang J, Yu J, Yang H, Wang J, Huang P, Yang R. Complete genome sequence of Yersinia pestis strain 91001, an isolate avirulent to humans. *DNA Res.* 2004 Jun 30;11(3):179-97. doi: 10.1093/dnares/11.3.179. PMID: 15368893.

²⁵ Zhao LH, Liu X, Yan HX, Li WY, Zeng X, Yang Y, Zhao J, Liu SP, Zhuang XH, Lin C, Qin CJ, Zhao Y, Pan ZY, Huang G, Liu H, Zhang J, Wang RY, Yang Y, Wen W, Lv GS, Zhang HL, Wu H, Huang S, Wang MD, Tang L, Cao HZ, Wang L, Lee TL, Jiang H, Tan YX, Yuan SX, Hou GJ, Tao QF, Xu QG, Zhang XQ, Wu MC, Xu X, Wang J, Yang HM, Zhou WP, Wang HY. Genomic and oncogenic preference of HBV integration in hepatocellular carcinoma. *Nat Commun.* 2016 Oct 5;7:12992. doi: 10.1038/ncomms12992. Erratum in: *Nat Commun.* 2016 Nov 08;7:13591. Lee, TP [corrected to Lee, TL]. PMID: 27703150; PMCID: PMC5059470.

²⁶ Chen C, Tang J, Dong W, Wang C, Feng Y, Wang J, Zheng F, Pan X, Liu D, Li M, Song Y, Zhu X, Sun H, Feng T, Guo Z, Ju A, Ge J, Dong Y, Sun W, Jiang Y, Wang J, Yan J, Yang H, Wang X, Gao GF, Yang R, Wang J, Yu J. A glimpse of streptococcal toxic shock syndrome from comparative genomics of S. suis 2 Chinese isolates. *PLoS One.* 2007 Mar 21;2(3):e315. doi: 10.1371/journal.pone.0000315. PMID: 17375201; PMCID: PMC1820848.

circulation²⁷ is critical for pandemic control and prevention. However, the insights AMMS and BGI gained from this research could also be used to create more virulent strains of the virus, potentially leading to a more effective biological weapon.

For the U.S. military and broader national security, these research endeavors represent significant concerns. The sophisticated understanding of pathogen behavior, genetics, and interactions with human biology could be exploited to develop targeted biological weapons, posing threats to military forces and civilian populations. The PLA's involvement in these research projects underlines the potential for military applications and the dual-use nature of such scientific endeavors. Therefore, it's imperative for the U.S. to intensify its focus on biosecurity measures, enhance surveillance capabilities, and support research that safeguards against biological threats.

U.S. Implications and Risks of Biothreats Posed by China: Policy Recommendations for Mitigation

Understanding the Risks

The rise of China as a global power in biotechnology, exemplified by the activities of companies like BGI Genomics, presents significant biosecurity risks for the United States. The dual-use nature of biotechnological research, where scientific advancements can be applied for both beneficial and harmful purposes, is a primary concern. The potential misuse of genetic data and biotechnologies by state actors for surveillance, repression, or even biological warfare cannot be ignored. Furthermore, the collaboration between Chinese military institutions and civilian biotech firms like BGI Genomics adds a layer of complexity, raising concerns about the military application of biotechnological research.

U.S. Implications

1. **National Security:** Advanced biotechnological capabilities could enable the development of new forms of biological warfare, potentially targeting specific genetic profiles. This poses a direct threat to U.S. national security.
2. **Economic Security:** The theft or misuse of intellectual property in biotechnology can undermine the competitive advantage of U.S. firms, impacting the economy significantly.
3. **Public Health:** Biothreats do not respect national borders. A biologically engineered pathogen could easily spread globally, causing a public health crisis.

Policy Recommendations

To mitigate these risks, the United States should consider the following policy actions:

²⁷ Wang G, Zhan D, Li L, Lei F, Liu B, Liu D, Xiao H, Feng Y, Li J, Yang B, Yin Z, Song X, Zhu X, Cong Y, Pu J, Wang J, Liu J, Gao GF, Zhu Q. H5N1 avian influenza re-emergence of Lake Qinghai: phylogenetic and antigenic analyses of the newly isolated viruses and roles of migratory birds in virus circulation. *J Gen Virol.* 2008 Mar;89(Pt 3):697-702. doi: 10.1099/vir.0.83419-0. PMID: 18272760; PMCID: PMC2885753.

1. **Enhanced Surveillance and Intelligence Gathering:** Invest in intelligence capabilities to monitor the activities of foreign biotech firms and their collaborations with military institutions. This includes cyberspace monitoring for potential theft of genetic data and intellectual property.
2. **Strengthening Biosecurity Measures:** Develop and implement robust biosecurity protocols at national labs and biotech firms. Encourage the adoption of these standards globally through international cooperation.
3. **Research and Development in Defense Biotechnology:** Increase funding for research in defensive biotechnologies and biosecurity. This includes developing countermeasures against potential biological threats.
4. **International Collaboration and Norm Setting:** Work with allies and international bodies to develop and enforce global norms and regulations for responsible biotechnological research, ensuring transparency and ethical practices.
5. **Public-Private Partnerships:** Foster collaborations between government agencies, academia, and the biotech industry to enhance innovation in biosecurity and to share knowledge about emerging threats and countermeasures.
6. **Education and Training:** Invest in education programs to raise awareness about biosecurity, emphasizing the ethical implications of biotechnological research.
7. **Legislative Measures:** Enact laws that regulate the transfer of sensitive biotechnological materials and knowledge, particularly with nations that have a track record of misusing such information.
8. **Diplomatic Engagement:** Utilize diplomatic channels to address concerns directly with China and other countries engaged in dual-use biotech research, aiming to promote transparency and prevent the militarization of biotechnology.

By implementing these measures, the United States can enhance its preparedness against biothreats, safeguard its national interests, and contribute to the establishment of a safer global biotechnological landscape.