Data Brief

China's Industrial Clusters

Building AI-Driven Bio-Discovery Capacity

Authors
Anna Puglisi
Daniel Chou

CSET CENTER *for* SECURITY *and* EMERGING TECHNOLOGY

June 2022

Executive Summary

China has a robust research effort to merge human and artificial intelligence to realize a first-mover advantage in AI competition. However, what is often overlooked is the importance of AI to the biological sciences (bio), especially as biological experimentation produces a growing amount of data. AI is becoming a key enabler to modern biological research, helping scientists design more effective experiments, analyze their data, and use it to create groundbreaking therapeutics and materials. This work will impact fields as different as biomedicine, agriculture, energy, and materials.

As a way to foster development and capture the benefits of these new applications, the Chinese government at the central, provincial, and local level has put in place policies to support biotechnology and its bioeconomy, intended to foster "Big Science" facilities, national "champions" (i.e., favored companies), talent recruitment, and basic research. A new aspect of this effort is the creation of "industrial clusters," as a way to "accelerate the pace of innovation and development in the biotechnology industry," which China views as a "Strategic Emerging Industry."[*1]

This issue brief explores the efforts China has made to co-locate key AI and biotechnology facilities into "industrial clusters" to incentivize multi-disciplinary research. We examine the physical locations of the different AI and biotechnology clusters and compare that with publication outputs in Chinese language publications. Key findings include:

- Chinese policies have co-located AI and biotechnology researchers, with the goal of fostering bio research using AI.
- The Chinese government has established 17 biomedical clusters—still in their nascent stages—located in Beijing (2), Chengdu, Chongqing, Guangzhou, Hangzhou, Harbin, Linyi, Shanghai, Shijiazhuang, Suzhou, Tianjin, Tonghua, Wuhan, Xiamen, Yantai, and Zhuhai to foster biological research. They are also home to key research entities and companies that use AI in biodiscovery.[2]

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[*] China has designated several fields as "Strategic Emerging Industries" (战略性新兴产业, SEI), 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, and included preferential tax treatment, subsidies and government procurement initiatives. AI and biotech are both considered to be SEIs and factor heavily into China's efforts.

- In addition to evidence of co-location, we have seen evidence of a growing number of papers that combine bio and AI.
- Given the broad commercial, ethical, and national security implications of these technologies, the country that leads and or dominates in these technologies will obtain distinct advantages.

The United States and its partners should forge a common agenda for the development and governance of both AI use in biotechnologies, as well as the use of genomic data.

Introduction

The exponential growth of data from biological research in medicine, agriculture, and genomics has necessitated the development of new AI algorithms for analysis and understanding of biological processes and applications. Examples of how AI is used in biological discovery include elucidating the structure of molecules such as proteins and RNA, screening novel drug candidates, and the ability to combine weather and soil data with a knowledge of plant genomics to enhance crop yields. AI is also becoming a key enabler for designing more effective experiments, saving researchers and companies time and money.

To both foster and possibly accelerate the use of AI in different biological fields, the Chinese government at the central, provincial, and local levels has put in place policies and programs to incentivize the co-development of AI and biotechnology. These include China's National Medium and Long Term Plan (MLP) for S&T Development (2006–2020), its Precision Medicine Initiative, and its 13th Five-Year Plan for S&T Innovation.[3] China's newest effort focuses on building "industrial clusters" (产业集群) with the central government providing funding, space, talent, and other resources to the cluster as a way to incentivize the integration of researchers, technology developers, and government entities.

For the purposes of this brief, we examined this emerging trend of co-location of AI and biotechnology researchers. This is a relatively new effort highlighted in recent Chinese government documents that we are just beginning to explore and analyze.[4] The subsets of biotechnology we explored include synthetic biology, bioinformatics, and genome editing—specifically CRISPR. In addition, we want to highlight the following:

- China has put policies in place to co-locate AI and bio researchers and industry with government research facilities, with the goal of creating an environment that would generate research combining AI and bio.
- While still an emerging trend, we find bio researchers and AI researchers emerging in the same places by analyzing the geolocation of paper authors.
- Papers involving AI and bio are growing over time and in number.
- While the impact of this research is still unknown, our research demonstrates that China did co-locate researchers and the goal of this relocation—growing amount of AI-and-bio research papers—is starting to happen.

We searched CSET's merged corpus of scholarly literature including Digital Science Dimensions, Clarivate's Web of Science, Microsoft Academic Graph, China National Knowledge Infrastructure, arXiv, and Papers With Code to identify research articles relevant to AI and certain subsets of biotechnology using domain-specific keywords.[5] We then extracted city and county location information from papers' organization and author affiliation metadata to link papers to geographic coordinates at the city and county level, using a CSET-developed geocoding database that combines geocoding data from GeoNames, Wikipedia, and Google Maps API. Finally, we aggregated location and research subject pairs to visualize these tallies as bubbles on a map. Geo-visualizations reveal hubs of industrial clusters and hubs of research hidden in tabular presentations of the same data.

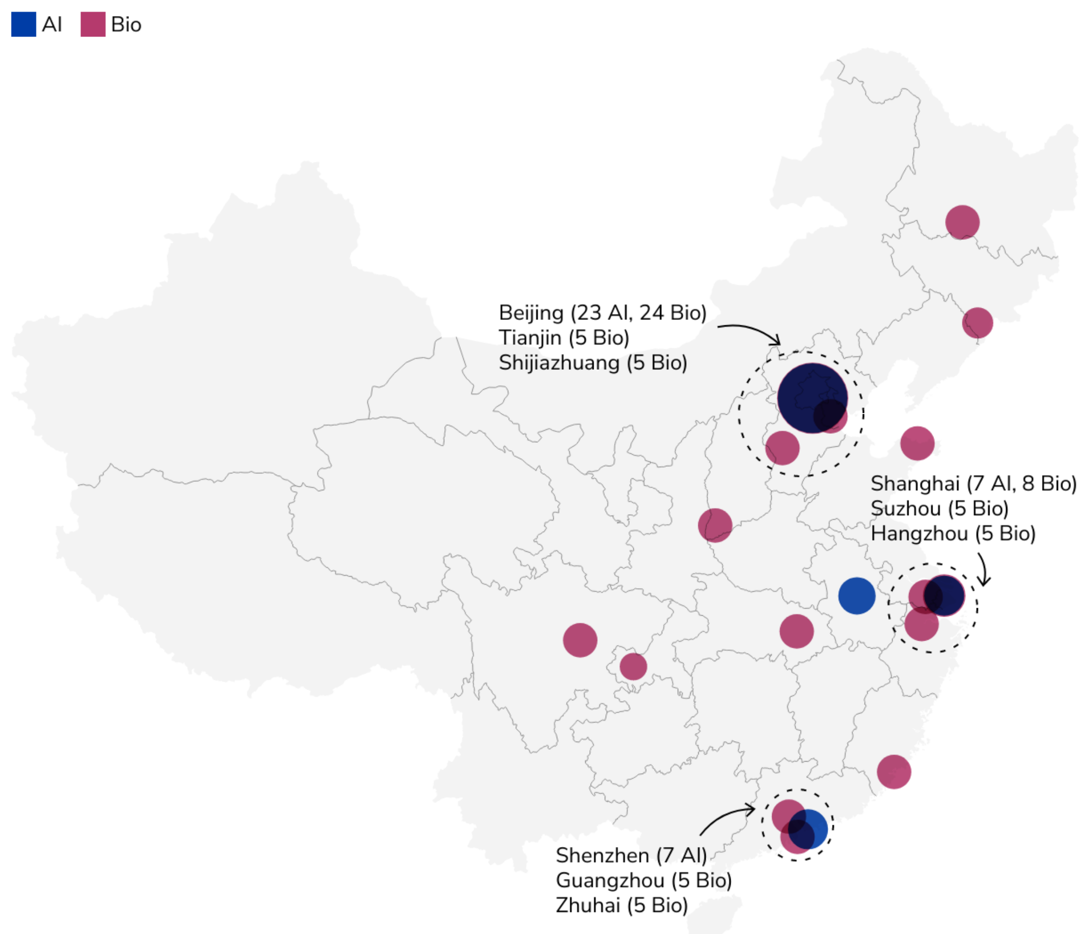
AI and Biology: A Convergence of Disciplines

China's central government has established 17 biomedical clusters located in Beijing (2), Chengdu, Chongqing, Guangzhou, Hangzhou, Harbin, Linyi, Shanghai, Shijiazhuang, Suzhou, Tianjin, Tonghua, Wuhan, Xiamen, Yantai, and Zhuhai to foster biological research.[6] The "cluster" construct is an effort to build synergies among small and medium enterprises and research entities to produce leading companies in the fields China has designated a "strategic emerging industry." Central and local governments provide funding, space, talent, and other resources, and have committees of experts to help guide the efforts. China's National Development and Reform Commission oversees the development of the clusters, and China's financial institutions help support them. They can best be described as similar to "tech corridors" in the United States that focus on a specific technology area such as the biotech sector in Boston or Research Triangle Park in North Carolina. The difference is the role of the state in setting priorities and that they are slated to receive more subsidies and sustained support from the Chinese government over time. As a way to begin analyzing the emerging trend of using AI in biodiscovery, we examined the location of these designated clusters to see if they were co-located with China's AI-related efforts.

CSET collected and curated data from online sources to compile structured metadata on China's Industrial Clusters.[7] Figure 1 is an overlay of 17 known biomedical industrial clusters (99 enterprises) with four known AI industrial clusters (43 enterprises), where the bubble size indicates the number of enterprises in a cluster. In tabular form, Beijing and Shanghai are the only two cities hosting both AI and bio clusters.[*] However, the overlay map reveals hubs (dotted circles) of industrial clusters grouped in nearby cities. The Guangzhou-Shenzhen-Zhuhai region in the south, home to many of China's leading biomedical research facilities and foreign joint-venture contract research organizations (CRO), is another well-developed area. Each of these locations hosts a diverse mix of AI companies, labs, university programs, and government research facilities. While co-location alone is not an indicator of collaboration, past studies have shown that close proximity of researchers, universities, and companies, paired with financial incentives, can facilitate multi-disciplinary research and the exploration of difficult problems.[8]

[*] These bio clusters include medicine, genetics and genomics, and biomedical engineering. They include different kinds of companies across a wide range of biological sciences. In the following sections we select the keywords to mirror the kinds of companies.

Figure 1. AI and Bio Industrial Clusters in Selected PRC Cities



Note: The numbers in parentheses refer to the number of enterprises of a specific type located in the city.
Source: CSET curated data on PRC Industrial Clusters.

Another potential indicator of collaboration in these areas is research paper output. The following sections compare areas of concentrated AI research and bio research ("research hubs")[*] on the basis of their Chinese-authored publications as a way to gauge both research intensity within AI and different disciplines of biotechnology, as well as their overlap.[9]

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[*] Research hubs are areas of concentrated research output.

AI-Bio Research Hubs: Synthetic Biology

Synthetic biology is a key area of biotechnology that will benefit from the application of AI. Described by NIH as "a field of science that involves redesigning organisms for useful purposes by engineering them to have new abilities," synthetic biology offers new ways to harness nucleic acids for a wide range of applications.[10] It is also a key discipline highlighted in many of China's S&T development programs.[11] In Table 1, we tabulate the growth of papers on synthetic biology in the China National Knowledge Infrastructure (CNKI) database from 2015–2020 by authors' location to analyze trends and assess any geographical correspondence.[12] These locations show considerable overlap with the industrial clusters that are visually displayed in Figure 1.

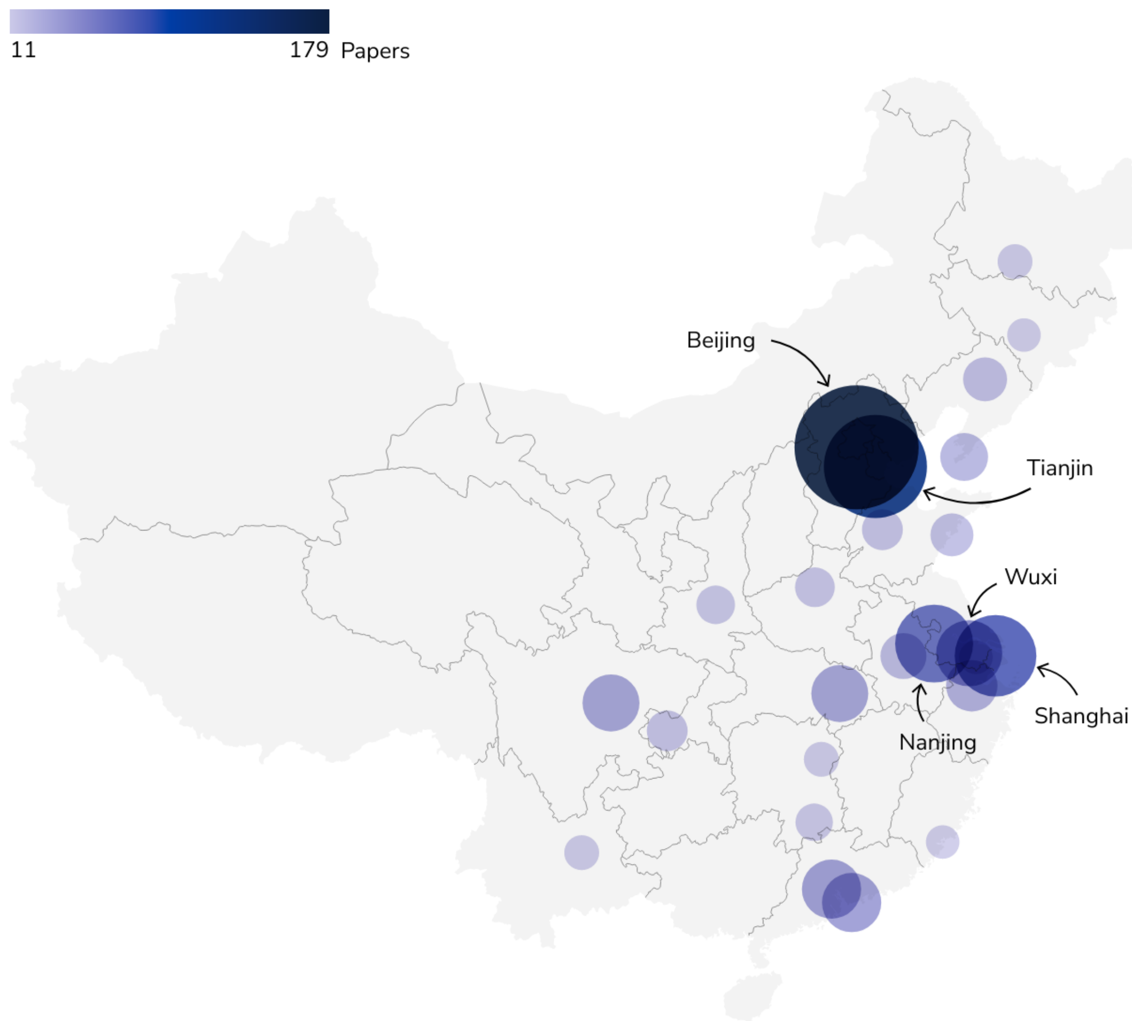
Table 1: Synthetic Biology Papers—Average Year-to-Year Growth—2015 to 2020

City	2015 Papers	2016 Papers	2017 Papers	2018 Papers	2019 Papers	2020 Papers	Average Y-to-Y Growth
Wuxi	14	20	20	22	26	48	31%
Wuhan	14	30	24	31	38	35	28%
Shenzhen	14	12	15	14	27	38	28%
Hangzhou	15	15	10	23	20	28	25%
Tianjin	48	63	62	55	79	122	23%
Chengdu	15	19	19	15	27	35	23%
Nanjing	30	36	28	35	42	68	21%
Guangzhou	19	17	22	23	44	38	20%
Beijing	78	96	111	138	145	179	18%
Dalian	14	15	13	19	19	24	13%
Qingdao	17	19	13	23	13	19	12%
Shanghai	60	50	87	70	74	75	9%
Xi'an	11	12	11	10	13	15	7%
Changsha	12	13	17	14	16	12	2%

Source: CNKI.

Figure 2 maps the geographical distribution of authors' locations (affiliations) for synthetic biology papers published in CNKI in 2020. Both bubble size and color intensity correspond with the number of papers. In particular, areas showing groups of larger and darker bubbles illustrate the locations of research hubs.

Figure 2: China's Synthetic Biology Research Hubs According to 2020 Paper Output



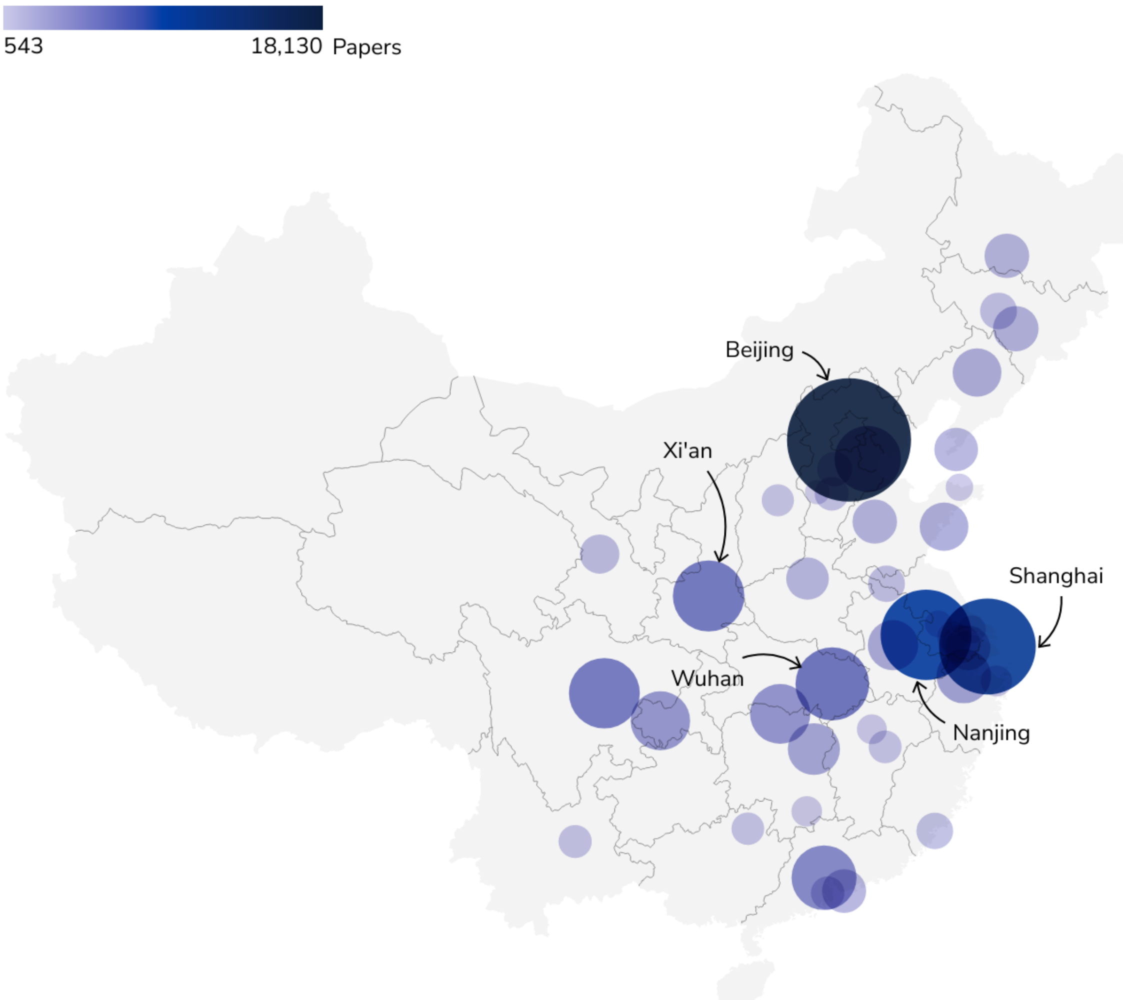
Source: CNKI.

We then compared the synthetic biology* research hubs in Figure 2 to the distribution of AI papers published in CNKI in 2020, displayed in Figure 3.[13] While the

* We specifically chose a sub-specialization of biology because of the magnitude of ongoing research across all areas of biology.

correspondence is not exact, the co-location in larger municipalities of hubs for both research disciplines is evident. Although not a direct measure of cross-fertilization, it suggests both cross-fertilization and potential for growth. A similar correspondence was generated for bioinformatics (not shown).

Figure 3: China's AI Research Hubs According to 2020 Paper Output



Source: CNKI.

We reorganize the data illustrated in Figure 2 and Figure 3 to focus on cities (research hubs) with the most AI and synthetic biology publications in 2020. An overlay of clusters similar to Figure 1 is impractical, because the number of AI papers in each city is two orders of magnitude more than the corresponding number of synthetic biology papers. Instead, in Table 2 we compute the ratios of synthetic biology to AI papers of top research hubs. The rank ordering in Table 2 corroborates with co-location patterns in Figure 1 and synthetic biology publication growth trends in Table 1.

Table 2: China's Research Hubs with High AI and Synthetic Biology Cross-Fertilization Potential According to 2020 Paper Output

City	SynthBio-to-AI Ratio	SynthBio Papers	AI Papers
Wuxi	0.0323	48	1,488
Tianjin	0.0248	122	4,917
Shenzhen	0.0188	38	2,026
Beijing	0.0099	179	18,130
Hangzhou	0.0087	28	3,215
Guangzhou	0.0081	38	4,692
Nanjing	0.0072	68	9,508
Shanghai	0.0069	75	10,808
Chengdu	0.0062	35	5,642
Wuhan	0.0057	35	6,109
Chongqing	0.0044	17	3,886
Xi'an	0.0026	15	5,759

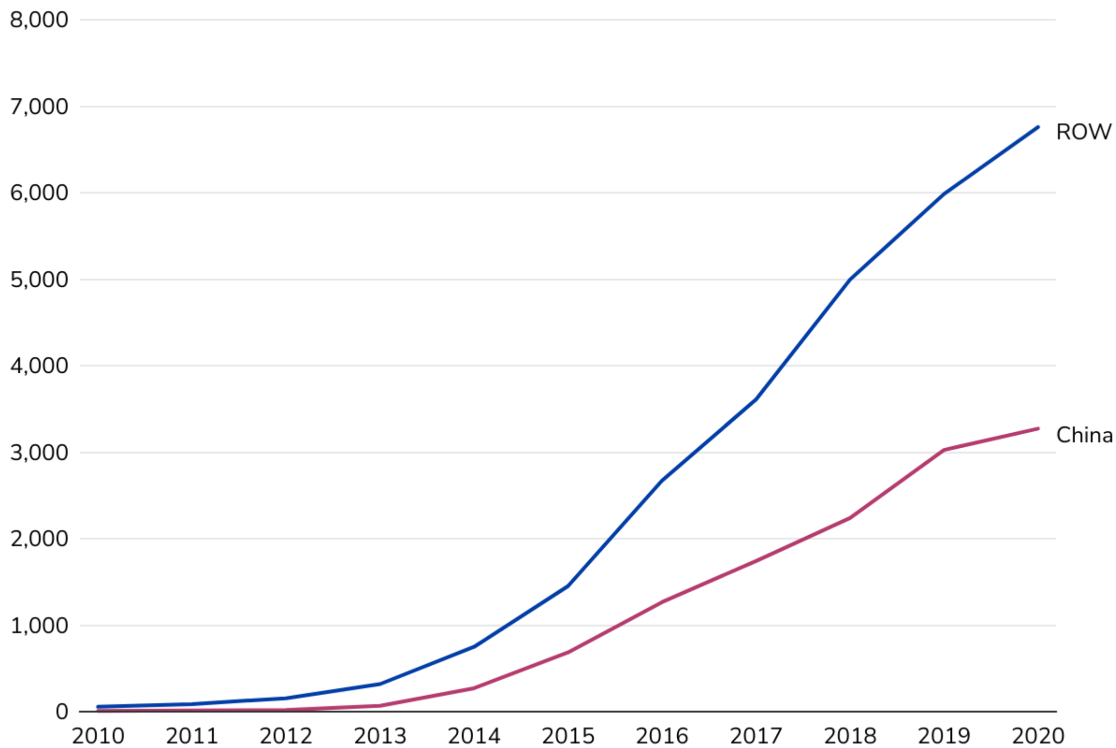
Source: CNKI.

These two types of analysis, one based on hubs of industrial clusters and the other based on hubs of research paper output, present an initial accounting of cross-disciplinary co-location of researchers in AI and synthetic biology. This is backed by known examples, such as Wuxi Nextcode (now Genuity) and Huawei working together to develop a cloud computing infrastructure to support China's precision medicine initiative, as well as iCarbonX's use of AI and data mining tools to formulate drugs and therapeutics.[14] Both examples corroborate with China's policy for nurturing "strategic emerging industry."

CRISPR and AI

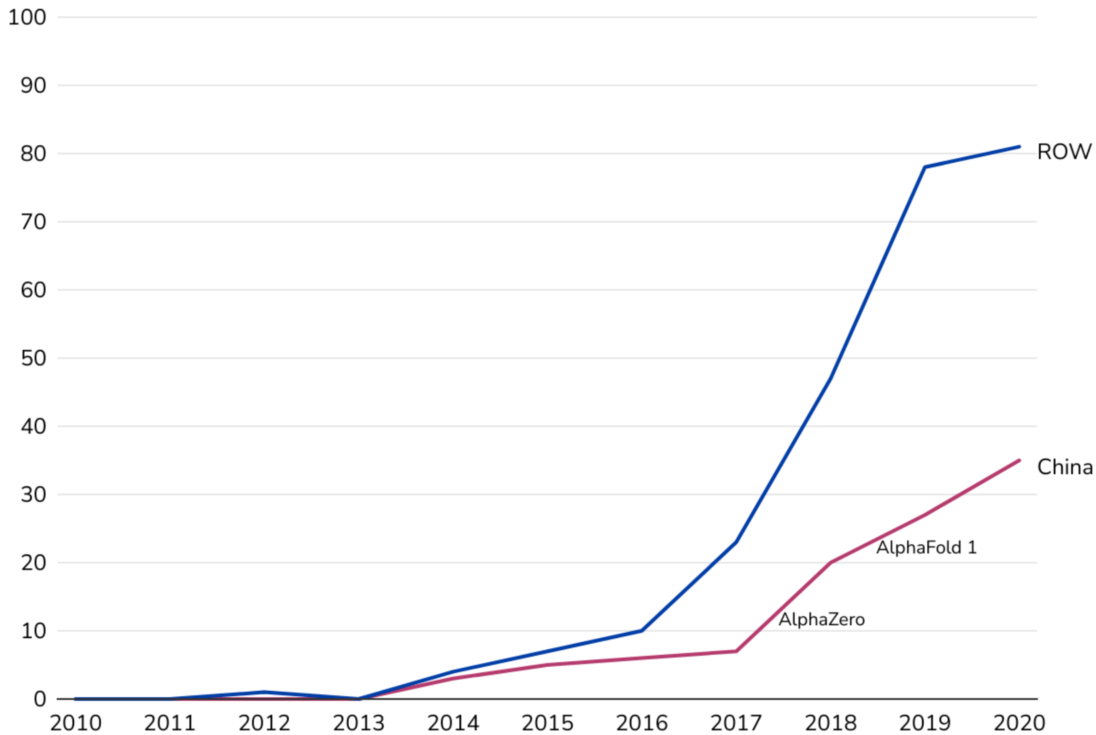
CRISPR (clustered regularly interspaced short palindromic repeats) is a tool used to edit the genome in precise ways. It is a foundational aspect of next generation biological discovery, allowing scientists to better understand what genes code for. AI has the potential to serve as a key enabler, helping scientists elucidate which genes code for which characteristics in order to enable better targeting and editing of the genome. We examine this specific intersection of genomics and AI by searching for papers in CSET's merged corpus containing both "CRISPR" and "learning."[15] "Learning" is used as a proxy for "AI" to match "machine/deep/reinforcement learning," which in today's terms are near-synonyms for AI. Our aim is to trace both the baseline growth of CRISPR papers and the growth of CRISPR-and-AI papers for the sake of comparison.

Figure 4: CRISPR Publications—China vs. the Rest of the World (ROW)



Source: CSET Merged Corpus.

Figure 5: CRISPR-and-Learning (AI) Publications—China vs. the Rest of the World (ROW)



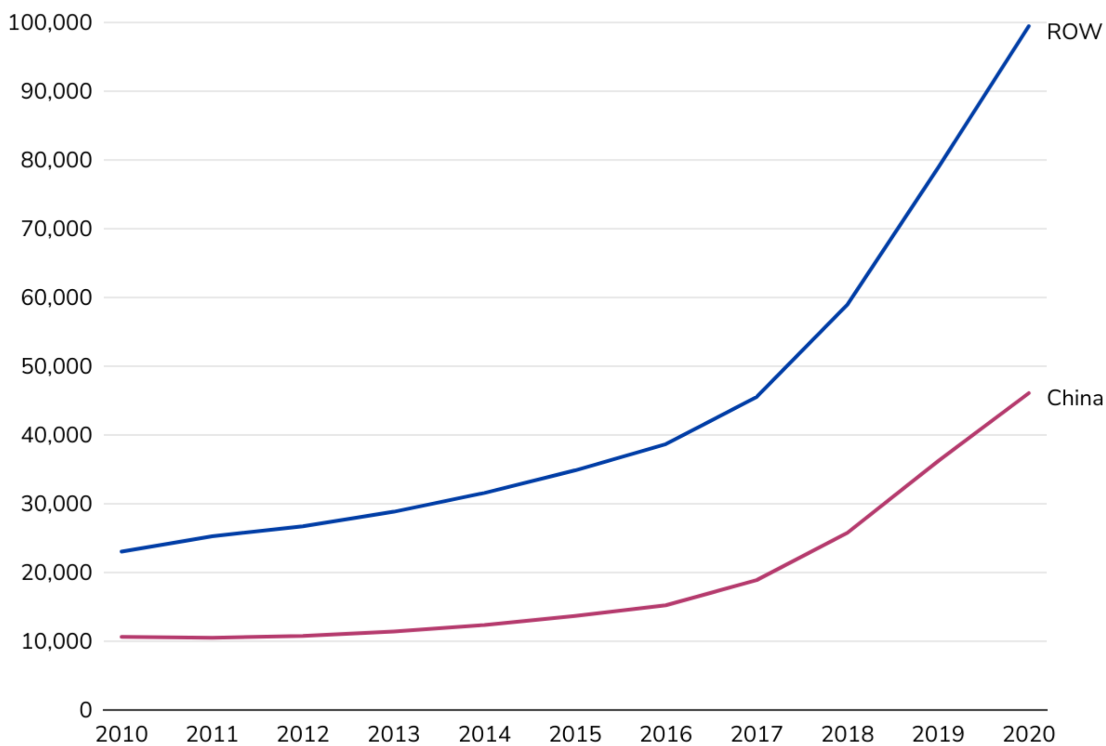
Source: CSET Merged Corpus.

Figure 4 shows continuing growth of CRISPR publications in China and elsewhere since the tool's introduction around 2010. Figure 5 shows China's accelerated growth in using AI to enhance CRISPR research around 2017. This trend coincides with the breakthrough performance results of OpenAI's AlphaZero in 2017 and AlphaFold 1 in 2018 and suggests Chinese researchers innovate and build on advancements from the rest of the world. Thus, we see that papers combining CRISPR and AI are beginning to emerge—China produced roughly 25 percent of all CRISPR-and-AI papers in 2020. While still an emerging trend, this is an example of a field where China's objective to foster the mixing of AI and bio research appears to be happening.

Evidence from Trends in AI and Bio Research Output

Finally, we extend our analysis of CNKI publications and examine publications from CSET's merged corpus of scholarly literature that match bilingual keywords identified with AI and biology-related disciplines as a measure of their growing interdependence. Both AI and bio bilingual keywords are selected and filtered to avoid counting papers in other disciplines using identical terms. Figure 6 displays the number of AI-and-bio papers from 2010–2020 with Chinese organizations, compared to such papers with no Chinese organization contributions.

Figure 6: Academic Journal Articles Containing both Bio- and AI-related Keywords



Source: CSET Merged Corpus.

While the upward trends are expected, we have already shown that China has co-located AI and bio researchers, and now we see China producing significant volumes of AI-and-bio publications. Approximately a third of all such publications are China affiliated. Again, while still in its nascent stages, China's government has implemented its industrial cluster policies, and the AI-and-bio production it wanted to foster is beginning to happen. As this research is in its early stages, its impact is yet to be determined. However, these trends illustrate that China's efforts in this area incorporate the foundational research that we would expect if they were trying to foster synergies. These foundational research areas include genomics and proteomics, biomarker identification, precision medicine, protein structure prediction, protein structure-to-function prediction, protein-protein interactions, and genome-type-to-phenotype research.

This examination highlights the importance of accessing both Chinese- and English-language aggregated academic literature datasets and curated online sources to evaluating China's capabilities in these areas. While some of this research is published in English, the full depth and breadth, as well as its location, is only made possible by looking at the Chinese-language material as well.

AI and Bio in Practice: Clusters Foster Research and Commercial Developments

China's efforts and policies have fostered co-development of some key players in biotechnology discovery that are utilizing AI in their work. Some notable examples of companies and institutes that belong to AI or bio industrial clusters include:

BGI Group (华大集团) is a Shenzhen-based gene sequencing company with a global network of more than 100 subsidiaries.[16] The growth and success of BGI demonstrates not only the holistic nature of China's S&T system, combining private and public sectors and the military, but also how sustained support can impact a key emerging industry. BGI is using AI to help develop better phenotype prediction models and using machine learning to analyze sequence data. Its collaborations give BGI—and China—access to genomic data worldwide.[17]

neoX Biotech (北京星亢原生物科技有限公司)—a Beijing based company—is another example of a multi-disciplinary approach to AI-bio. Co-founded by MIT and Caltech graduates, it seeks to use AI to shorten the timeline for pre-clinical drug design.[18]

Shanghai Jiaotong University's Artificial Intelligence Institute houses a Center for Smart Healthcare (智慧医疗研究中心), which "aims to empower clinical medicine and medical services with AI technology," researches "new paradigms of human-machine interaction," and develops "deep learning services for clinical diagnosis." The center applies AI to disease prediction and a variety of health-related tasks.[19]

Nankai University College of Artificial Intelligence (南开大学人工智能学院) hosts the Tianjin Municipal Key Laboratory of Intelligent Robotics (天津市智能机器人技术重点实验室). R&D conducted at this laboratory includes medical and service robotics (surgery and rehabilitation support), brain-computer interfaces, and micro and nano detection for life sciences.[20]

Conclusion

While still in its nascent stage, China's emphasis on clustering different aspects of the development cycle appears to be having an impact on multidisciplinary research. China is banking on applying AI to biotechnology research to achieve a "transformation of China from a biotech power (生物技术大国) to a biotech superpower (生物技术强国)."[21] It is laying the groundwork to do this—much like with its strategy to develop 5G—by having a long-term commitment, building an innovation base that includes industrial clusters and interdisciplinary research labs, attracting talent, and leveraging its collaborations with foreign entities.

The application of AI to biological discovery will have broad commercial, ethical, and national security implications. The country that leads or dominates in these technologies will obtain distinct advantages in driving the ethical discussion on how to use them. They will also have the potential to control key medical discoveries.

The United States and its partners should forge a common agenda for the development and governance of AI use in biotechnologies, as well as the use of genomic data. This agenda must go beyond defensive and restrictive measures by fostering the strategic investments needed for foundational technologies and the platforms that enable growth in this field.

Authors

Anna Puglisi is a senior fellow and the director of biotechnology programs at CSET, where Daniel Chou is a data scientist.

Acknowledgments

The authors are especially grateful to Karen Sutter, Norm Kahn, and Mark Kazmierczak for their comprehensive reviews.

The authors would also like to thank Alex Friedland, Igor Mikolic-Torreira, William Hannas, Huey-Meei Chang, Catherine Aiken, Dewey Murdick, and Lynne Weil for their suggestions on style and content.

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Document Identifier: doi: 10.51593/20220012

Endnotes

[1] Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035" [中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要], original CSET translation (Center for Security and Emerging Technology, May 13, 2021), https://cset.georgetown.edu/publication/china-14th-five-year-plan/; Office of the PRC State Council, "温家宝主持召开三次新兴战略性产业发展座谈会" (Wen Jiabao Hosted Three Emerging Strategic Industry Development Symposiums), September 22, 2009; PRC State Council, 国务院关于加快培育和发展战略性新兴产业的决定 (State Council Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries), SC 32, 2010; PRC National Development and Reform Commission (中华人民共和国国家发展和改革委员会), "关于扩大战略性新兴产业投资培养壮大新增长点增长极的指导意见" (Guiding Opinions on Expanding Investment in Strategic Emerging Industries, and Cultivating New Growth Points and Poles), NDRC 1409, 2020.

[2] PRC National Development and Reform Commission (中华人民共和国国家发展和改革委员会), 加快推进战略性新兴产业产业集群建设有关工作通知 (Notice on accelerating the construction of industrial clusters in strategic emerging industries), NDRC 1473, 2019.

[3] PRC State Council, 国家中长期科学和技术发展规划纲要 (2006—2020年), SC 9, 2006; Brian Wang, "China's $9.2 Billion Precision Medicine Initiative Could See about 100 Million Whole Human Genomes Sequenced by 2030 and More If Sequencing Costs Drop," NextBIGfuture.com, June 7, 2016, https://www.nextbigfuture.com/2016/06/chinas-92-billion-precision-medicine.html; PRC State Council, 国务院关于印发"十三五"国家科技创新规划的通知, SC 43 2016.

[4] PRC National Development and Reform Commission (中华人民共和国国家发展和改革委员会), 加快推进战略性新兴产业产业集群建设有关工作通知 (Notice on accelerating the construction of industrial clusters in strategic emerging industries), NDRC 1473, 2019.

[5] Data sourced from Dimensions, an inter-linked research information system provided by Digital Science (http://dimensions.ai). All China National Knowledge Infrastructure content is furnished for use in the United States by East View Information Services, Minneapolis, MN, USA.

[6] "Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035" [中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要], original CSET translation; Wang, "China's $9.2 Billion Precision Medicine Initiative Could See about 100 Million Whole Human Genomes Sequenced by 2030 and More If Sequencing Costs Drop."

[7] PRC National Development and Reform Commission (中华人民共和国国家发展和改革委员会), 加快推进战略性新兴产业产业集群建设有关工作通知 (Notice on accelerating the construction of industrial clusters in strategic emerging industries), NDRC 1473, 2019.

[8] Jon Gertner, *The Idea Factory: Bell Labs and the Great Age of American Innovation* (London, UK: Penguin Books, 2013).

[9] "Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035" [中华人民共和国国民经济和社会发展第十四个五年规

划和2035年远景目标纲要], original CSET translation; Wang, "China's $9.2 Billion Precision Medicine Initiative Could See about 100 Million Whole Human Genomes Sequenced by 2030 and More If Sequencing Costs Drop."

[10] National Human Genome Research Institute, "Synthetic Biology," National Institutes of Health, https://www.genome.gov/about-genomics/policy-issues/Synthetic-Biology.

[11] Wang, "China's $9.2 Billion Precision Medicine Initiative Could See about 100 Million Whole Human Genomes Sequenced by 2030 and More If Sequencing Costs Drop"; David Cyranoski, "China Embraces Precision Medicine on a Massive Scale," *Nature* 529 (2016): 9-10; PRC State Council, 国家中长期科学和技术发展规划纲要(2006—2020年), SC 9, 2006; PRC State Council, 国务院关于印发"十三五"国家科技创新规划的通知, SC 43 2016.

[12] China National Knowledge Infrastructure is furnished for CSET use in the United States by East View Information Services, Minneapolis, MN, USA.

[13] Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035" [中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要], original CSET translation; PRC State Council, 国务院关于印发"十三五"国家科技创新规划的通知, SC 43 2016.

[14] Wuxi shares geographic proximity with the Shanghai-Suzhou-Hangzhou hub of AI and Bio industrial clusters identified in Figure 1.

[15] Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035" [中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要], original CSET translation.

[16] BGI 华大 in Chinese. The Beijing Genomics Institute, forerunner of the BGI Group, began in 1999 and continues some of its earlier activities in the Chinese Academy of Sciences as the Beijing Institute of Genomics (北京基因组研究所, BIG). We use the term "BGI" interchangeably to refer to the composite entities.

[17] Reuters reported BGI used a military supercomputer to analyze genetic data obtained from its sales of prenatal tests to map the prevalence of viruses in Chinese women, look for indicators of mental illness, and genetically identify Tibetan and Uyghur minorities. BGI has published at least 12 joint studies on the tests with the PLA since 2010. Kirsty Needham and Clare Baldwin, "Special Report: China's Gene Giant Harvests Data from Millions of Women," Reuters, July 7, 2021, https://www.reuters.com/article/us-health-china-bgi-dna-idUSKCN2ED1A6.

[18] China Money AI, "AI-Driven Biotech Company neoX Raises $10M Pre-A Round," July 6, 2020, https://www.chinamoneynetwork.com/2020/07/06/ai-driven-biotech-company-neox-raises-10m-pre-a-round.

[19] Artificial Intelligence Institute, "人工智能研究院智慧医疗研究中心, " Shanghai Jiao Tong University, https://ai.sjtu.edu.cn/center.

[20] Nankai University College of Artificial Intelligence, “南开大学人工智能学院天津市智能机器人技术重点实验室,” https://ai.nankai.edu.cn/xszx/tjsznjqrjszdsys.htm.

[21] PRC State Council, 国务院关于印发”十三五”国家科技创新规划的通知, SC 43 2016.