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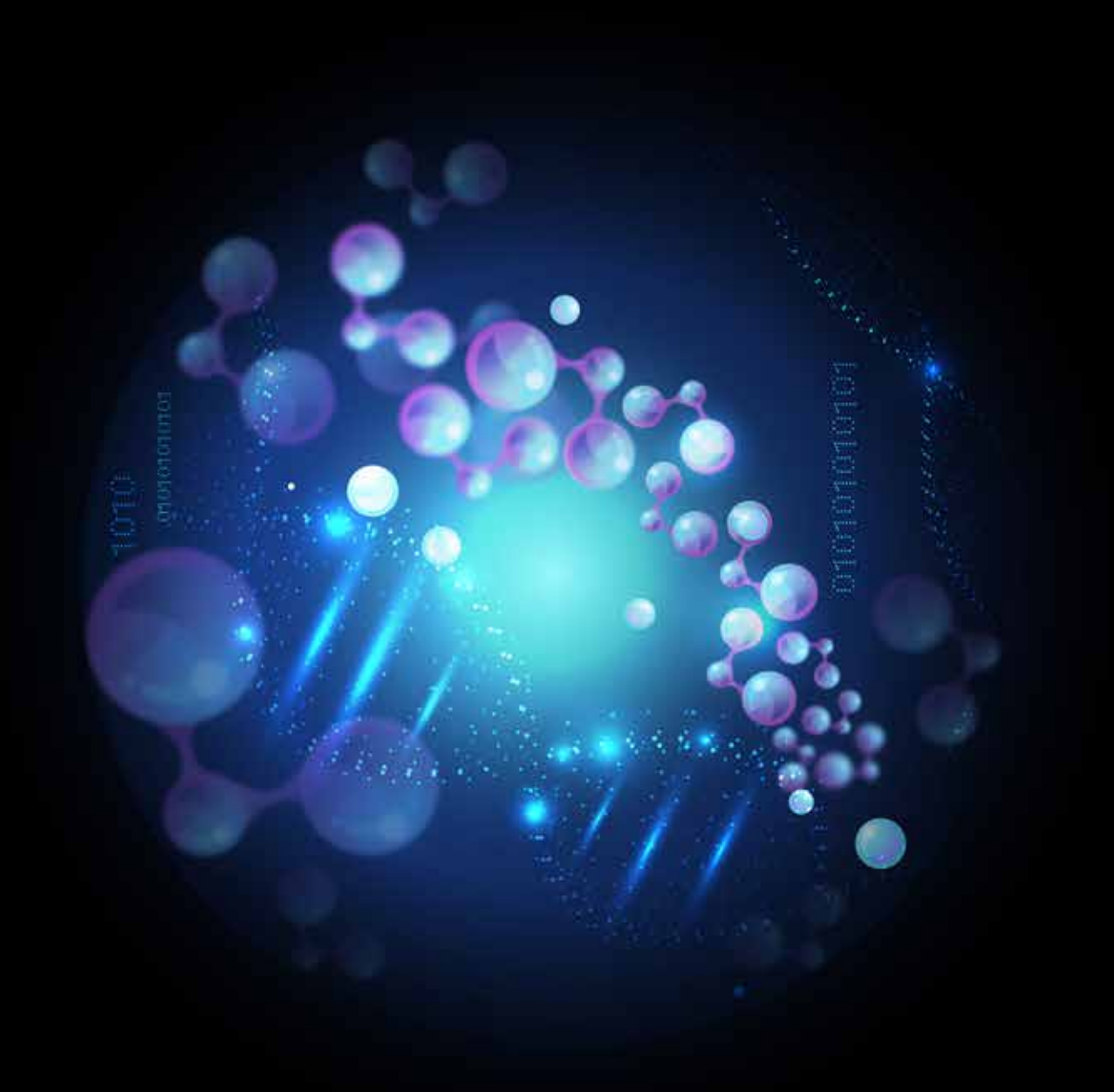


Outlook on biopharma innovation trends in China

July 2021

MAKING AN IMPACT THAT MATTERS since 1845

Contents

Preface

"Innovation" is a major driver of industrial development across the world and a vital force in biopharma sector transformation and advancement.

Over recent years, China's biopharma industry has been actively innovating in technologies, business models, and enterprise management. Innovation occurs constantly, from using science and technology to empower new concepts and develop new therapeutic targets and options, to biopharma distribution and information interactions.

As China's biopharma industry continues to boom, its technical innovations are increasingly aligned with those globally. Meanwhile, the government has enacted extensive reforms to support innovation in the sector. These developments, coupled with the rapid development of digital technology in China, have made other countries optimistic about the prospects for China's biopharma market, with many multinational pharmaceutical giants building and expanding their presence in the country. New business strategies and tactics "conforming to Chinese characteristics" will emerge to drive innovation and transformation in China's biopharma industry.

The imperative transformation in the global biopharma market has only become stronger in the wake of COVID-19. It has two levels, the application and empowerment of innovative technology, and explorations and breakthroughs in innovative R&D. Since the COVID-19 outbreak began, digital technology has been advancing much more rapidly, powering the innovative development of biopharma companies to meet public demand for more precise, personalized medical services in the post-pandemic era[1].

- Application and empowerment of innovative technology: Before COVID-19, biopharma companies adopted innovative technology to drive the entire biopharma industrial chain. The application scenarios included assistance with R&D, efficient clinical trials, real-time supervision and precise collection of clinical data, big data support, smart workflow, and other digital transformations. Since COVID-19 emerged, digital transformation has been forced to accelerate from long-term transformation to short-term necessity[2].
- Explorations and breakthroughs in innovative R&D: At the end of 2020, Deloitte analyzed and set out the predictions for the biopharma market to 2025, forecasting a major shift in medical diagnosis and treatment, with clinicians making decisions based on therapies that include "4P" elements, which are predictive, preventative, personalized, and participatory. The main 4P products are digital diagnosis and treatment (e.g. AI and nanotechnology, etc.) and cell and gene therapy (e.g. epigenetics, cell therapy, and gene editing). Both are drawing widespread attention as new-generation treatments and many related studies are underway[3].

This report, produced in conjunction with the Shanghai Association for Science and Technology, is based on long-term observations of the biopharma industry. It explores biopharma innovation globally and in China, assesses the opportunities and challenges facing China's biopharma industry's innovative development, and analyzes and envisages biopharma innovation trends through the views of thought leaders in the sector.

The innovative development of global biopharma is concentrated in Europe, the US, and other pharmaceutical powers. Innovative breakthroughs, including first-generation innovative biologics in the 1980s and advanced CGTs in 2021, have been powered by digital and intelligent technologies, particularly artificial intelligence (AI).

Biopharma's digital transformation has accelerated since the COVID-19 pandemic began, and AI has been applied more extensively. There has also been a surge in new medicine development, with the number of discovered innovative targets reaching 139, its highest-ever level, in 2020. Furthermore, investment in the development of new-generation therapies such as CGTs is rising across the world.

China's biopharma industry has also witnessed an innovation boom, with the market expected to exceed RMB4 trillion by 2022, up from RMB3 trillion in 2018.

Driven by global trends and China's dual circulation development model, innovation in China's biopharma industry has distinctive features such as heightened government emphasis on innovative biologics, advances in digital transformation, and the increasing power of AI throughout the biopharma industrial chain. China's biopharma enterprises are now at the forefront of the industry's global development, embracing comprehensive innovation and working towards becoming leading innovators themselves, rather than just following global leaders as they did before.

To capitalize on this momentum, China's biopharma companies are receiving favorable inputs from government agencies, institutional investors, and tech companies. These include policy and regulatory reforms, capital inflow, and digital technologies. But they also face challenges, including weak basic research and a shortage of skilled employees in innovative technologies.

Given these challenges, Deloitte believes four factors–enhanced basic research, stronger commercialization, increased government-enterprise cooperation to ensure efficient use of capital, and comprehensive talent enhancement–are essential if innovative development in China's biopharma industry is to succeed.

In addition to industry development in China and globally, this report looks at biopharma conditions and trends in the Yangtze River Delta. A leading region for biopharma innovation and R&D, the Yangtze River Delta has clear advantages in research capacity, talent, and the completeness of its industry chain. However, like elsewhere in China, it also faces challenges, including insufficient basic research and the need to attract a highly skilled workforce.

To boost the biopharma industry's innovative development in the Yangtze River Delta, basic research must be given more emphasis and the resources of industry stakeholders must be deployed to attract and develop talent.

Quotes from thought leaders in China's biopharma industry

"China's biopharma industry can come to the forefront of the world if it can better capitalize on the enabling opportunity provided by digital medicine."

—Shengli Yang, Academician, Chinese Academy of Engineering; Researcher, Shanghai Institute of Life Sciences, Chinese Academy of Sciences

"The government should purposefully enable more small businesses to become more courageous to make innovations and go full steam ahead."

—Bin Li, Distinguished Professor and Doctoral Supervisor, Shanghai Jiaotong University, Deputy Director; Shanghai Institute of Immunology, Shanghai Jiaotong University School of Medicine

"The government can guide the basic research of the biopharma industry, but commercialization still entails market mechanisms."

—Ruilin Song, Executive Chairman, China Pharmaceutical Innovation and Research Development Association; PhD

"Given high technical barriers, the key to driving biopharma innovation lies in talent, which is a major advantage of the Yangtze River Delta."

—Ingrid Zhang, President, Novartis Pharmaceuticals China

"The reasonable utilization of big data in new medicine development, discovery of targets, clinical testing and pharmacoeconomics is the priority in future development ."

—Jason Yang, Chief Medical Officer, CStone Pharmaceuticals; Doctor of Medicine

"Scientific innovation is about discovering something unknown previously. We should think what the government wants and meet market needs."

—Guoliang Yu, Founder, Innoforce Pharmaceuticals; PhD in molecular biology

"Biopharma innovation is borderless, but we need to find out innovation that conforms to China's national conditions."

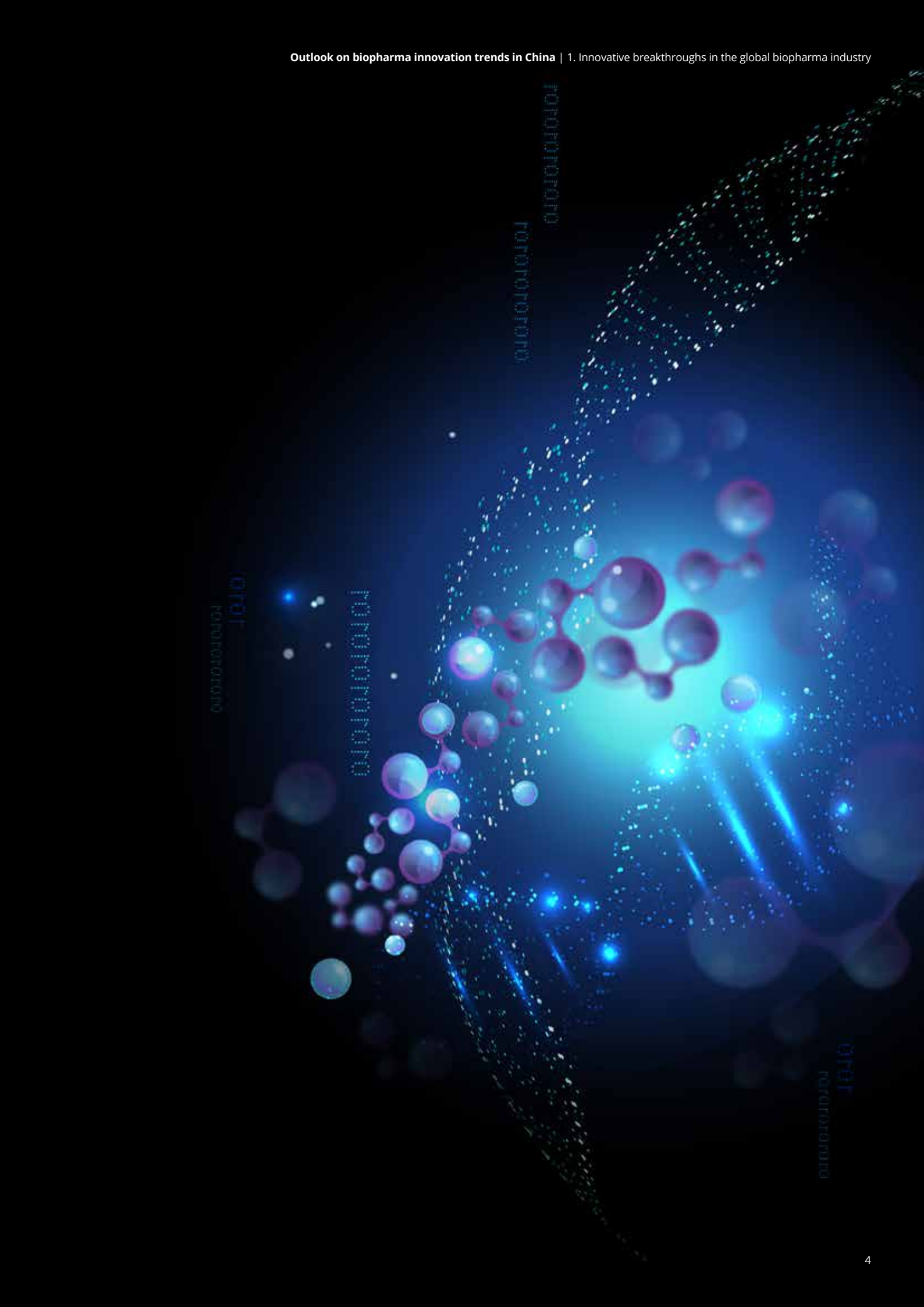
—Yingfei Wei, Chief Science Officer, Innoforce Pharmaceuticals; Doctor of Biochemistry

"Currently, China has quite few biopharma innovation projects that are genuinely first-class. This is because investment institutions are concerned about the risk-return on original R&D."

—Kenneth Sun, Managing Director, Medical Industry Team, Investment Banking Division of Morgan Stanley Asia-Pacific

"Innovation is built on failure. The government should be more willing to take the risk associated with innovation."

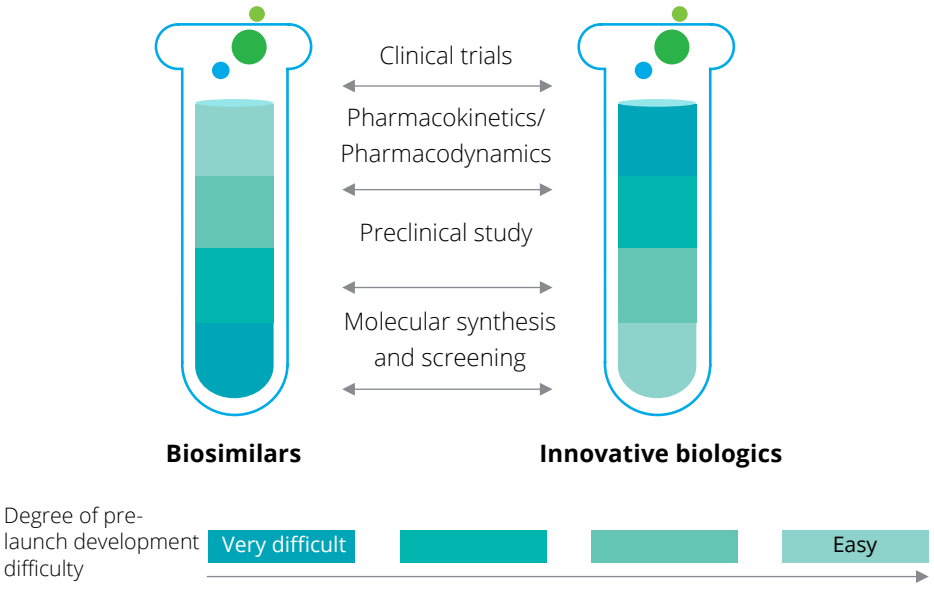
—Richard Mao, Managing Director for Medical Investment, Orchid Asia



1. Innovative breakthroughs in the global biopharma industry

Biologics, the major biomedicine products, can be divided into innovative biologics (with R&D focused on providing the efficacy and safety of products) and biosimilars (where R&D emphasizes whether products and controls have comparable pharmacokinetics, pharmacodynamics, safety, and immunogenicity). Their development is compared in Figure 1.1 and Table 1.1 below[4].

Figure 1.1 The Difficulty of Pre-market Development for Innovative Biologics and Biosimilars



Source: mAbxience, *Generics, Biologics, Biosimilars: Who's Who?* Curated by Deloitte

Table 1.1 The Development Process for Innovative Biologics and Biosimilars

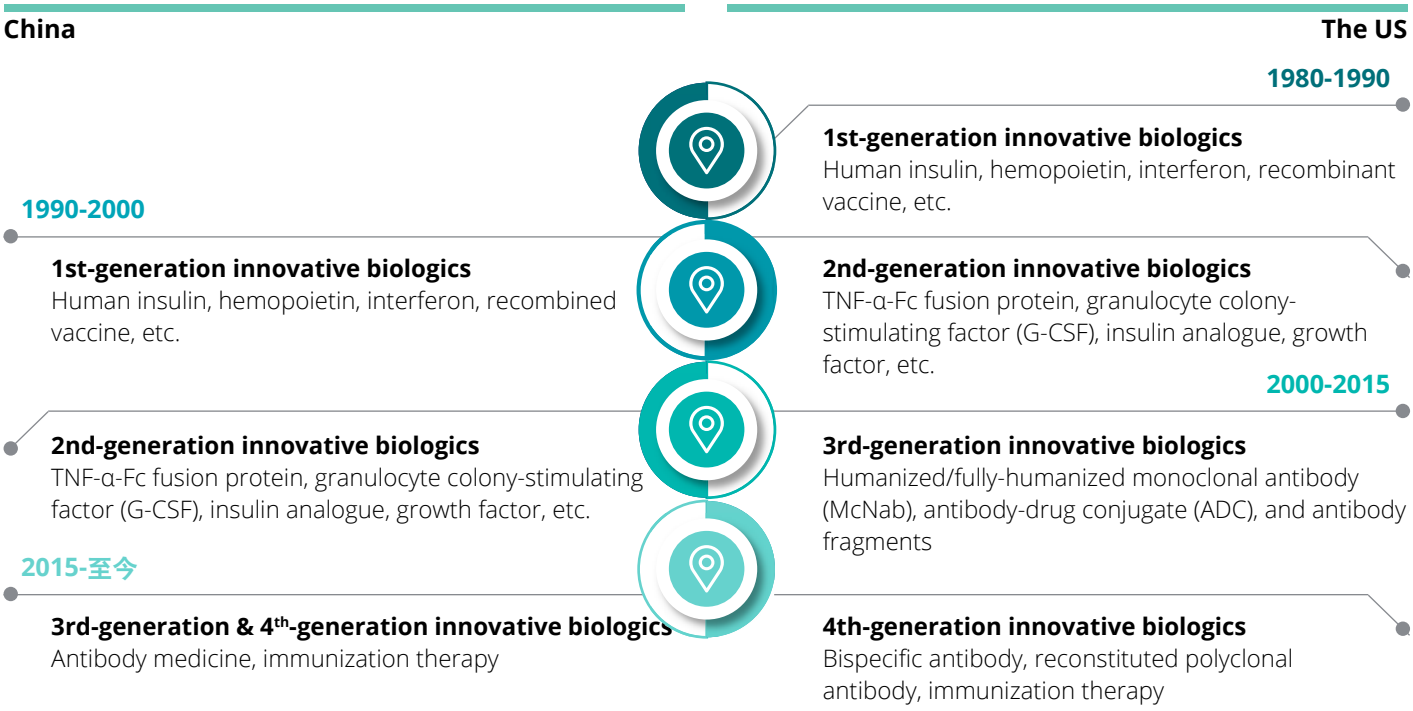
	Innovative Biologics	Biosimilars
Development cost (USD)	800 million	100-300 million
Time to market (years)	At least 8-10 years	At least 7-8 years
Focus of clinical trial study	Efficacy and safety Phase I-III clinical study	Pharmacokinetic controlling clinical trial Phase III
Patient size	800-1,000	100-500
Post-launch research	Phase IV, risk management plan, including pharmacovigilance	Phase IV, risk management plan, including pharmacovigilance

Source: mAbxience, *Generics, Biologics, Biosimilars: Who's Who?* Curated by Deloitte

Innovative biologics are undergoing constant iteration, development, and breakthroughs – from the earliest first-generation products in the 1980s, such as human insulin, interferon and recombinant vaccines, to fourth-generation products introduced since 2015, including bispecific antibodies, recombinant polyclonal antibodies, and immunization therapy5 (Figure 1.2). Today, the development of new-generation innovative biologics, such as CGTs, is well underway.

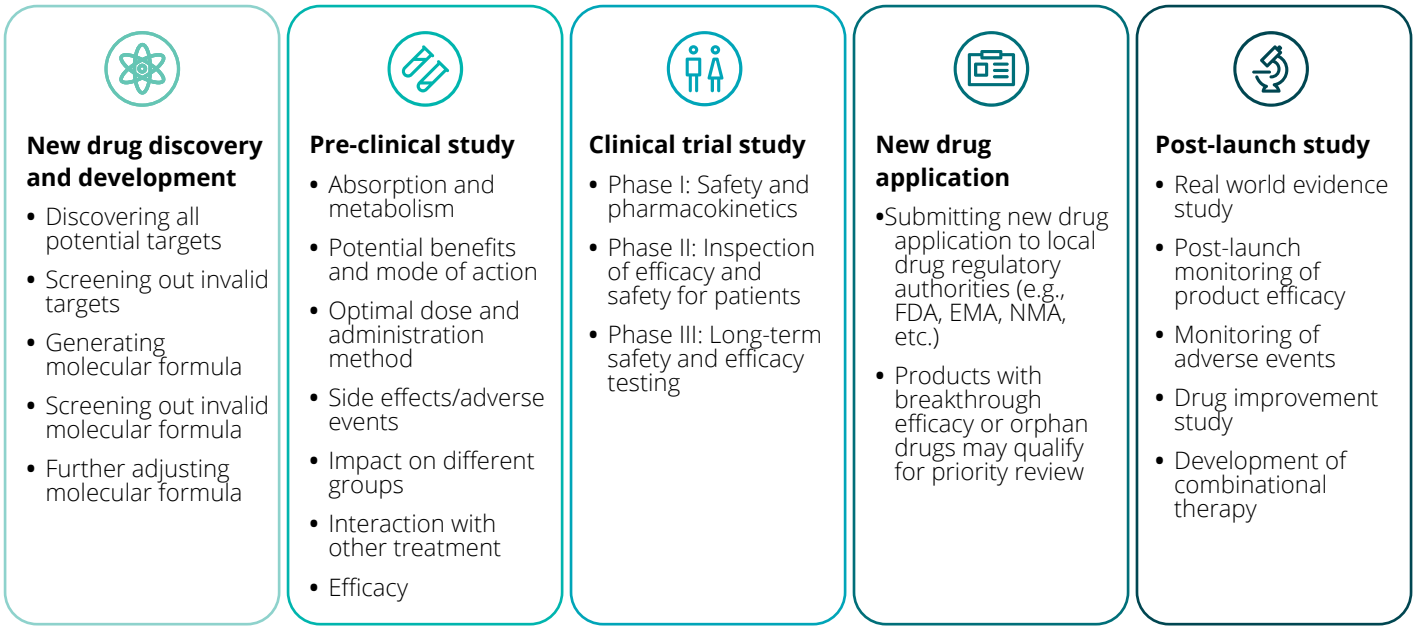
R&D projects on innovative pharmaceuticals typically have five stages (Figure 1.3): new drug discovery and development; preclinical study; clinical trial study; new drug application (NDA); and post-launch study6, 7. According to the Pharmaceutical Research and Manufacturers of America (PhRMA), in 2015 the average development cycle of innovative medicines for ordinary biopharmaceutical companies was at least 10 years, with the clinical trial study stage lasting 6-7 years. Accelerating development is therefore critical to promote global biopharma innovation.

Figure 1.2 Comparison of Innovative Biologics Development in China and the US



Source: Southwest Securities: *Biopharmaceuticals: Domestic Investment Faces Historical Opportunity Amid In-depth Deployment of Global Giants*, curated by Deloitte

Figure 1.3 Areas of Potential Acceleration in Each Stage of Innovative Biologics Development



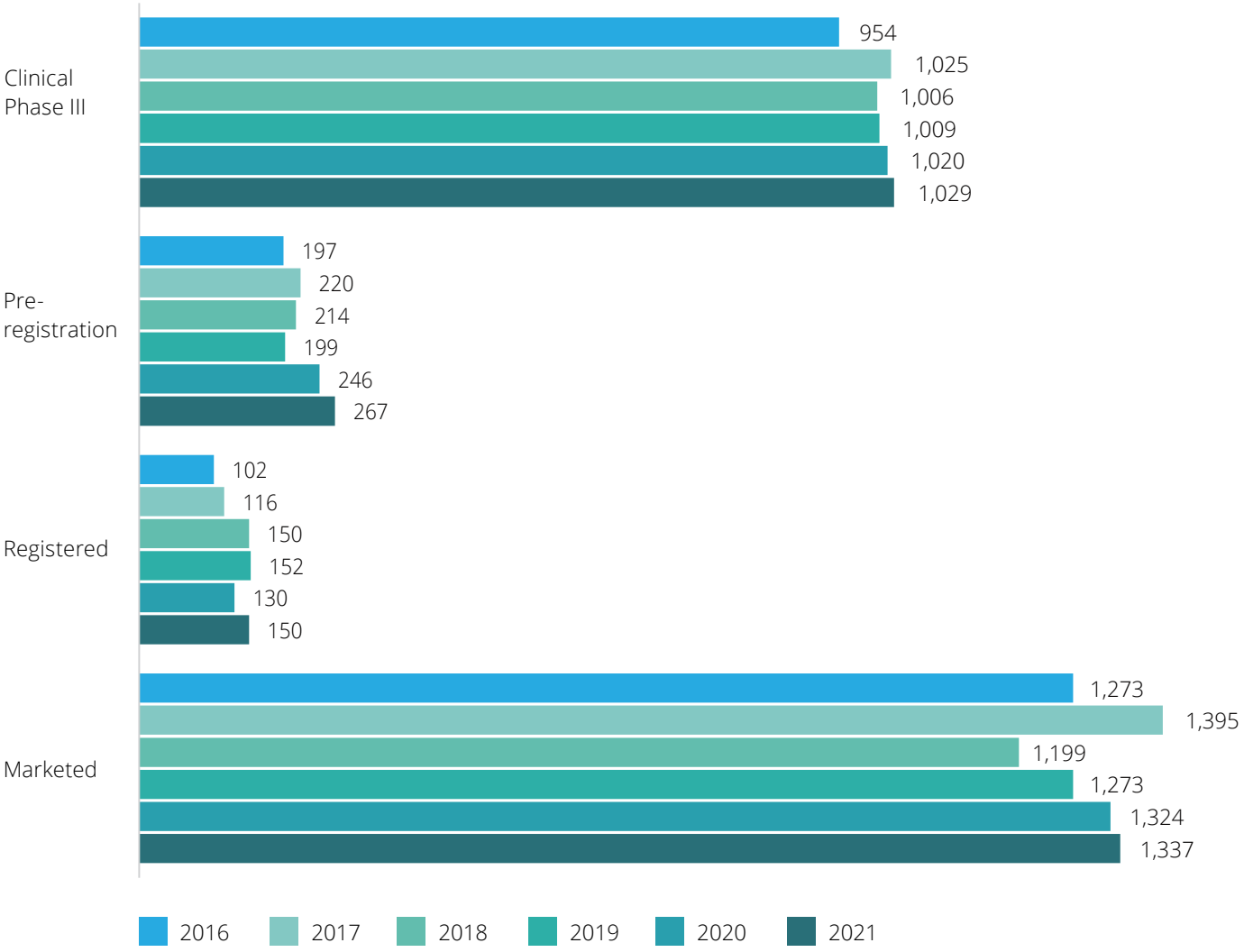
Source: Deloitte research and analytics

With technological development and breakthroughs, the number of innovative medicines approved globally has increased every year, except for 2020 when market-entry reviews of new drugs were delayed due to COVID-19[8, 9, 10, 11] (Figure 1.4).

Since 2016, the number of new drugs moving from clinical late-stage period (Phase III and pre-registration) and NDA approval to successful launch has steadily increased. Deloitte's analysis of the number of innovative biologics authorized to market in China and the US (Figure 1.5) found it has increased in both countries, but China outpaced the US in 2019 and 2020[12], and is expected to retain this momentum in 2021. This is mainly due to China's wide-ranging policies on the marketing of innovative medicines, regulatory reforms, and commercialization of innovative medicines by domestic pharmaceutical companies.

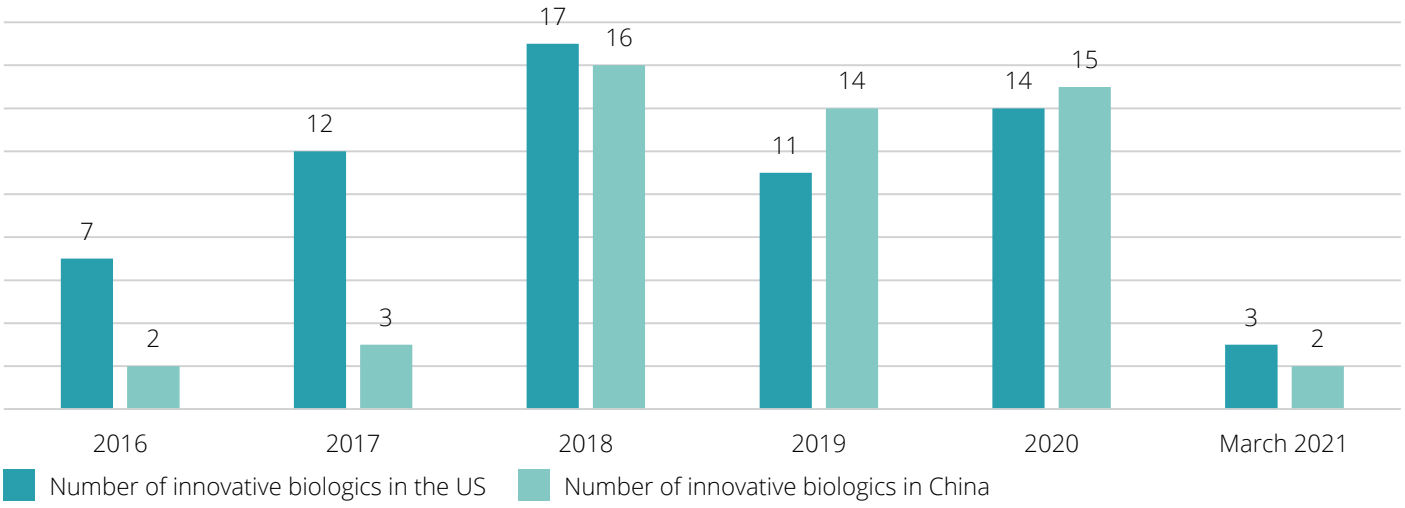
Application of digital technology to biologics innovation and rising dominance of medical outsourcing service providers such as CROs (contract research organizations) and CDMOs (contract development and manufacturing organizations), will accelerate the number of innovative biologics across the globe.

Figure 1.4 Global Comparison of the Number of Product Pipelines in Later Clinical Development (2016-2021)



Source: PharmaProjects, curated by Deloitte

Figure 1.5 The Comparison of the Number of Authorized Innovative Biologics in China and the US (2016-March 2021)



Source: Pharmcube.com, curated by Deloitte

Biopharma innovation is accelerating amid digital transformation

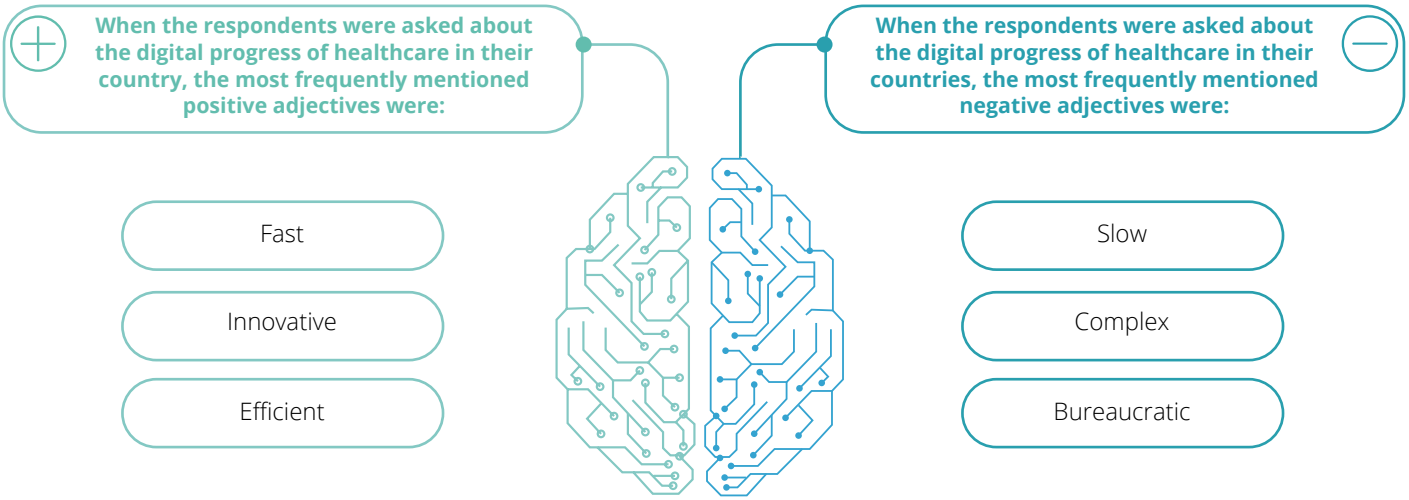
Digital transformation is a hot topic in every industry, including healthcare. The concept of "internet + healthcare" is becoming the mainstream in many countries. Digital applications covering online consultation, remote medical services, online pharmacy, internet hospitals, and the collection of clinical information have far-reaching influence. Digital technology has been more rapidly applied since the COVID-19 outbreak began. Many pharmaceutical multinationals and medical establishments have stepped up investment in digital technology, with a view to ensuring this can be adopted rapidly. In an interview with Deloitte, academician Shengli Yang emphasized the rapid biopharma development driven by the application of digital technology in medical science.

In 2020, digital technology empowered healthcare services in multiple areas, providing better service integration, assisting in early discovery and reducing operative risk, predicting and helping to manage health demand, and optimizing clinical data quality. This in turn has delivered faster, more effective, and safer healthcare services. In addition, digital transformation can enable management reforms linked with technical improvements and increase the efficiency and effectiveness of service delivery to benefit patients and clinicians.

However, given the healthcare industry's demanding requirements for compliance in service provision and clinical information, and the complexity of healthcare provision, digital transformation remains in its infancy. Digitalized processes have accelerated sharply due to COVID-19, and technology has been applied more widely, especially in the way doctors and patients interact, and pharmaceutical products are distributed.

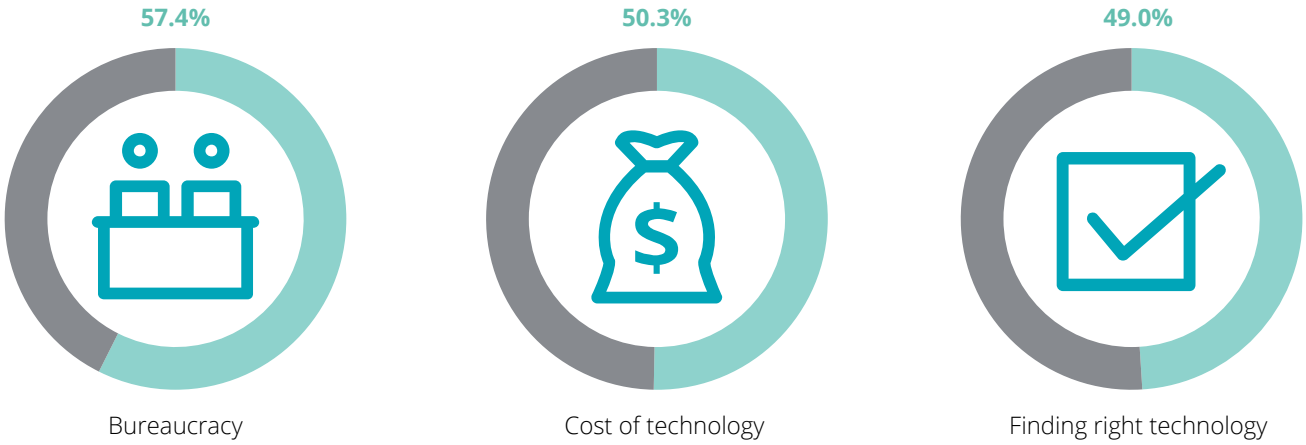
The Deloitte Center for Health Solutions surveyed 1,800 healthcare professionals in Europe, and interviewed more than 40 medical treatment and healthcare stakeholders in Denmark, Germany, Italy, Holland, Norway, Portugal, and the UK, to understand how they view the clinical application of digital technology in biopharmaceutical industry (Figure 1.6) and major challenges of enhancing its application (Figure 1.7). Doctors tend to focus on improvements in speed and convenience when it comes to digital technology[13].

Figure 1.6 The Description of Digital Technology by European Medical Practitioners in Their Respective Countries



Source: Deloitte Center for Health Solutions, *Digital transformation: Shaping the future of European healthcare*

Figure 1.7 Three Major Challenges for European Doctors in the Empowerment of Digital Technology Application



Source: Deloitte Center for Health Solutions, *Digital transformation: Shaping the future of European healthcare*

Deloitte also evaluated the application of digital healthcare in Europe (Table 1.2). Electronic health records (EHRs) (81%) are the most common application of digital transformation, followed by electronic prescriptions (62%). The application of new-generation technologies such as robotics, genomics data, and virtual reality accounted for only a tiny share.

Table 1.2 Digital Technologies Used by Clinicians

	Europe	Denmark	Germany	Italy	Holland	Norway	Portugal	The UK
EMR	81%	95%	77%	69%	97%	89%	74%	87%
Electronic prescription	62%	73%	13%	67%	97%	86%	96%	69%
Online registration	54%	61%	38%	53%	67%	41%	66%	62%
Software used by clinicians	51%	54%	44%	53%	70%	40%	55%	52%
Online access platform/tool (for community-level healthcare or diagnosis and treatment of hospitals)	46%	50%	23%	47%	49%	51%	68%	57%
Remote healthcare	43%	61%	30%	38%	59%	40%	45%	47%
Scheduling	37%	29%	52%	14%	46%	39%	23%	49%
Automation of drugstore and drug distribution	30%	38%	23%	25%	62%	34%	13%	35%
Nursing diagnosis points	26%	24%	31%	10%	43%	35%	9%	37%
Software or wearable equipment for patients	22%	26%	21%	18%	35%	15%	17%	26%
Remote monitoring of key indicators	22%	24%	22%	21%	24%	20%	13%	25%
Automation of other clinical tasks	19%	26%	25%	9%	28%	15%	12%	22%
Speech recognition tool	16%	16%	26%	8%	10%	26%	1%	20%
Robotics	8%	8%	13%	8%	5%	6%	3%	8%
Genomics data (storage or usage)	8%	14%	11%	6%	1%	5%	3%	10%
Radio frequency identification technology (RFID)	6%	3%	8%	3%	3%	2%	5%	9%
AI technology	5%	7%	7%	5%	5%	6%	2%	5%
Virtual reality	5%	4%	4%	5%	5%	5%	0%	7%

Source: Deloitte Center for Health Solutions, *Digital transformation: Shaping the future of European healthcare*

With digital healthcare and "internet + healthcare" growing rapidly, the development of biologics as well as the prescription and distribution channels have been transformed. As technologies become mature, digital healthcare will play an increasingly important role in penetrating every link of the "top-down" biopharma industrial chain, not only driving application transformation on the enterprise side, but also promoting comprehensive acceleration of the entire biopharma industrial chain. Given that COVID-19 is not yet effectively controlled, it is imperative that global biopharma companies engage in digital transformation and comprehensive reforms, from R&D and manufacturing, to sales of biologics. This will lead to a growing number of commercial partnerships with technology companies.

Biopharma companies are also expected to shift their business models from the previous dominance of offline model to an integrated online-offline approach.

Case studies of biopharma multinationals using science and technology to empower innovative development

Takeda partners with medical technology company Seqster on digital solutions for patients

On 29 October 2020, Takeda and Seqster announced an agreement to improve treatment efficacy through better access to and understanding of patient data. Seqster provides Takeda with instant access to its secure platform for visualizing longitudinal EHRs of individual patients, genetic profiles, and health data from wearable devices. Through this collaboration, Takeda will improve capability of collecting real-world evidence and applying it in new drug development plans and patient services[14].

Boehringer-Ingelheim and Science 37 cooperate to accelerate new drug development via digital technology

Science 37 employed digital technology to build decentralized operating model—Metasite, with a mobile platform of cloud service platform—Network Oriented Research Assistant (NORA)—at its core. This platform removes geographical restrictions and provides comprehensive, patient-centric support for comprehensive clinical trials, from patient recruitment to the completion of remote trials. While recruiting a diverse range of participants, it can improve the effectiveness and speed of clinical trials. On 8 January 2019, Boehringer-Ingelheim and Science 37 reached a cooperation agreement in which Science 37's NORA system will facilitate the acceleration of Boehringer-Ingelheim's clinical trials to achieve faster development of new drugs[15].

Application of AI in the entire medical industrial chain is accelerating technical breakthroughs

The Deloitte Center for Health Solutions studied how AI is empowering new drug discovery and found five major considerations in biopharma enterprises' use of the technology (Figure 1.8)[16].

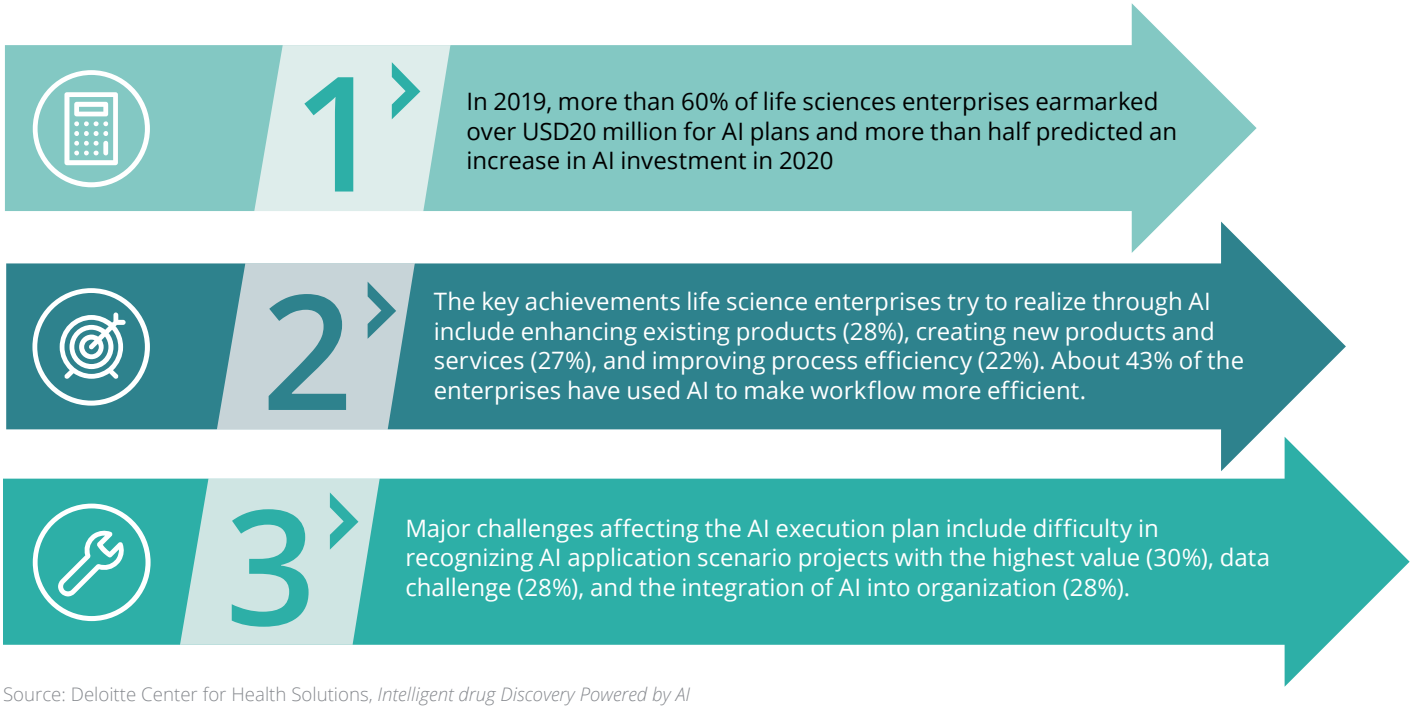
Figure 1.8 Five Considerations in Biopharma Enterprises' use of AI

Improving access to powerful and credible data through strong partnerships	Recognizing the disruptive potential of tech giants	Increasing diversification of drug pipeline discovery	Acquiring new AI skills and talent	Establishing new KPIs and design thinking
Biopharma companies effectively utilize big data via cross-sectoral cooperation, realize better new drug development process, bring better product pipeline portfolios and promote the development efficiency of new drugs.	Technological companies can access big data, and most of them have invested in the application of AI to the healthcare industry.	AI can provide better prediction models and more flexible study, thus making the development of innovative medicines more diversified.	AI experts are needed to implement the solutions and assess the cooperation with third parties.	New standards are required to assess and discover milestones.

Source: Deloitte Center for Health Solutions, *Intelligent drug Discovery Powered by AI*

Deloitte Insight surveyed biopharma companies' AI deployment and costs in 2020 and found three development trends (Figure 1.9)[17].

Figure 1.9 Global Biopharma Companies' AI Deployment and Costs



Source: Deloitte Center for Health Solutions, *Intelligent drug Discovery Powered by AI*

With constant breakthroughs and rapid iterations, every industry, including healthcare, is embracing science and technology to achieve innovation. AI can be deployed and used in various upstream and downstream functions of the entire value chain in the biopharma industry. Some companies in the industry have generated revenue by applying AI technology. Since the COVID-19 pandemic began, an increasing number of biopharma companies and research institutes have completed innovative breakthroughs by using AI in new drug development, production, operation and even business strategy. AI assists many areas of the biopharma industry, including medicine R&D, therapy development, and gene therapy analysis. Medicine R&D, a key application, now accounts for at least 35% of the AI healthcare market[18].

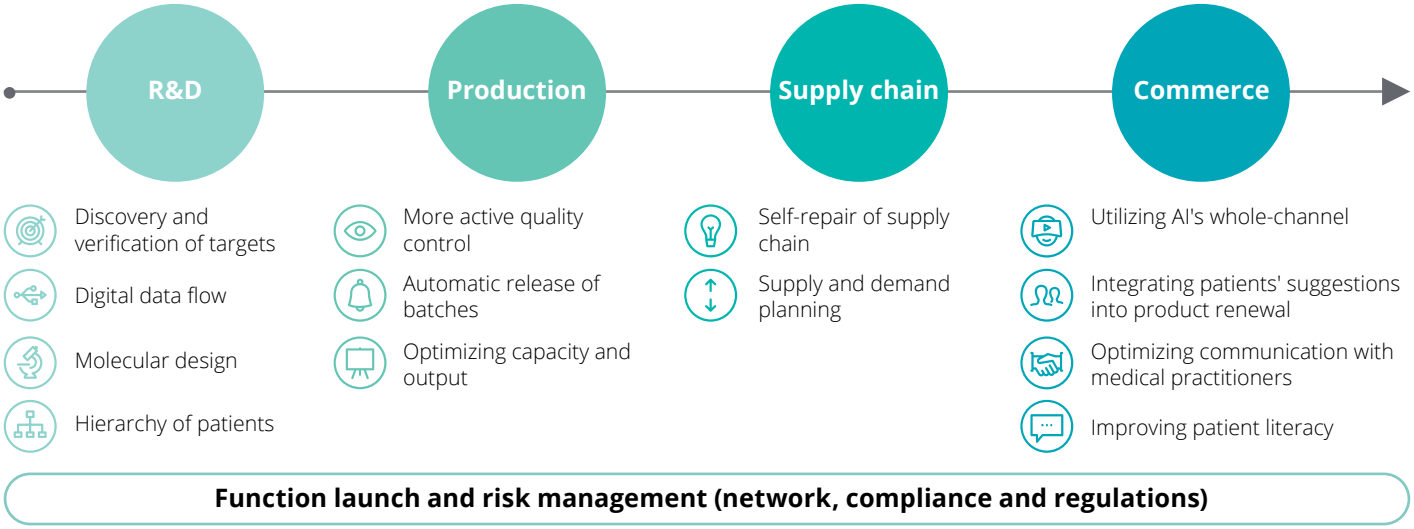
The application of modern science and technology has resolved concerns about new drug R&D. Many pharmaceutical companies build partnerships with technology firms to develop new drugs through AI. Discovery, research and development, clinical trials, and regulatory approval for new biologics takes 12 years and costs around USD1.40 billion. This lengthy development process and high cost makes it very difficult for pharmaceutical companies to develop new medicines.

Furthermore, out of every 10,000 molecular formulae that pass preliminary screening, a mere 1% eventually enter clinical trials, highlighting concerns that new drug development consumes too much time, energy, and money[19]. However, the use of AI in new drug development can resolve these concerns. AI can shorten the R&D cycle of ordinary new biological drugs through the analysis of data in literature and other information, and the exploration of new therapeutic targets, reducing the cost of medicine R&D.

Statistics indicate that AI could save about USD28 billion a year globally in new drug R&D costs and increase efficiency in dissemination of medical information[20].

In 2020, AI was widely used in the life sciences industry, and the AI utilization rate has grown constantly. In the coming 3-5 years, even more AI will be used in new drug R&D, expanding the industrial chain of biopharma companies from molecular development to market launch (Figure 1.10).

Figure 1.10 AI Application Scenarios in the Biopharma Industrial Chain



Source: Deloitte Center for Health Solutions, *Intelligent drug Discovery Powered by AI*

Case studies of AI assisting with the development of innovative medicines

AlphaFold2 predicts protein structure based on amino acid

AlphaFold2, an AI product developed by Google's DeepMind team, defeated hundreds of players in the biennial competition of Critical Assessment of Protein Structure Prediction (CASP) in 2020 and gained a score of nearly 90 in the hundred-mark system[21]. Its prediction result was close to the experimental data. AlphaFold2 correctly predicted protein structure based on amino acid sequence, and the prediction accuracy matched that of cryo-electron microscope (cryo-EM), magnetic resonance imaging or X-ray crystallography, and other experimental techniques. Prof. Zhang, Yang of the University of Michigan commented that AlphaFold2 achieved a breakthrough. AlphaFold2 was trained directly from the atomic coordinates in the structure. It also proved that the issue of predicting protein structure can be addressed at the CASP competition.

Prof. Xinqi Gong, from Institute of Mathematical Sciences at Renmin University of China, believed that AlphaFold2 proved three successes to the world: 1) The accuracy of prediction comparable to experimental crystal structure, which will replace crystal structure; 2) Some complex and lengthy single-chain structures including some structural domains reach the degree that are fully comparable to experimental structure; 3) Assisted with the analysis of X-ray crystal and cryo-EM structure, which was involved in the competition but was not obtained in experiment for years. For example, for the structure of T1058 membrane protein was successfully analyzed together with the original crystallographic data after Alphafold2 prediction model was used[22].

The MELLODDY (Machine Learning Ledger Orchestration for Drug Discovery) project

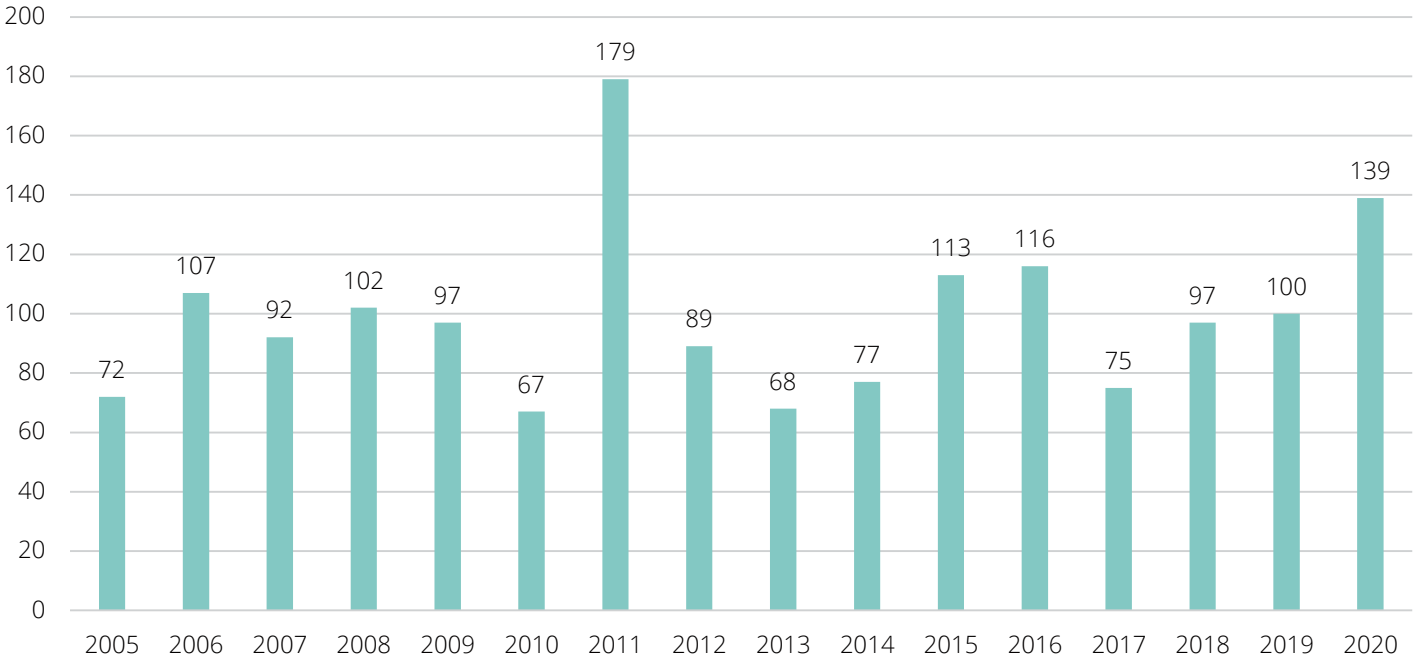
MELLODDY project executes new drug discovery through machine learning ledger orchestration. Composed of 17 partners (10 top-notch biopharma companies including Amgen, Astellas, AstraZeneca, Bayer, Boehringer-Ingelheim, GlaxoSmithKline, Janssen Pharmaceuticals, Merck, Novartis, and Servier; two European universities including University of Leuven and Budapest University of Technology and Economics; four start-ups including Owkin, Iktos, Kubermatic, and Substrate Foundation; and one AI company, NVIDIA), this project is committed to effectively share the data set of 10 biopharma enterprises, especially the application of AI to new drug discovery. This cooperation model is based on the utilization of blockchain technology to improve prediction accuracy and help screen better candidate products. Launched in 2019, this three-year project is predicted to cost EUR184 million. It also received funding from partner IMI (Innovative Medicines Initiative)[23].

Biopharma enterprises' R&D priorities are shifting to innovation of targets and the development of new-generation therapies

New discovery of targets for innovative biologics is on going

The discovery and development of new targets have long been central to the development of innovative biologics. Developing new, effective targets and bringing them to the market can lead to huge profits and prospects for pharmaceutical companies. According to Pharma Projects, 139 new targets were added worldwide in 2020 (Figure 1.11). This increase in 2020 was second only to that in 2011 (the surge in 2011 was mainly because it was the first year when bacterial targets were included), representing a very positive outcome from the industry's perspective. Continuous growth in the number of innovative targets will also deliver a more diverse product pipeline of innovative biologics.

Figure 1.11 Number of New Targets Discovered Each Year (2005-2020)



Source: PharmaProjects, *Pharma R&D Annual Review 2021*

As of January 2021, erb-b2 receptor tyrosine kinase 2 (Her-2) is the most pursued innovative target in the world. It was the subject of 158 projects in 2020, with five added in 2021, securing its top position for a second consecutive year. It is mainly because of rising demand from a rapid increase in the number of breast cancer patients. There are several emerging popular targets, such as CD3e, which moved up four places with 53 new products, and GLP-1, which has risen five places with eight new products. However, some targets declined in its popularity, such as opioid receptor mu 1, which is mainly due to the impact of negative publicity about opioid addiction causing enterprises to retreat from opioid R&D (Table 1.3)[8].

Table 1.3 Top 15 Innovative Protein Targets in the World

2021 (2020) Ranking	Targets	2021 (2020) Number of drugs
1 (1)	erb-b2 receptor tyrosine kinase 2 [Her-2]	163 (158)
2 (3)	epidermal growth factor receptor	151 (148)
3 (7)	CD3e molecule	149 (116)
4 (5)	CD19 molecule	144 (121)
5 (4)	vascular endothelial growth factor A	142 (143)
6 (6)	CD274 molecule [PD-L1]	141 (116)
7 (9)	programmed cell death 1 [PD-1]	122 (111)
8 (2)	opioid receptor mu 1	112 (148)
9 (8)	nuclear receptor subfamily 3 group C member 1 [glucocorticoid receptor]	100 (112)
10 (15)	glucagon-like peptide 1 receptor [GLP-1]	98 (90)
11 (13)	cannabinoid receptor 1	96 (97)
12 (10)	prostaglandin-endoperoxide synthase 2 [COX-2]	96 (107)
13 (11)	tumor necrosis factor	89 (101)
14 (14)	opioid receptor kappa 1	84 (97)
15 (16)	membrane spanning 4-domains A1	82 (78)

Source: PharmaProjects, *Pharma R&D Annual Review 2021*

Global R&D on innovative targets is growing constantly. Leading pharmaceutical MNCs are increasing their inputs into innovative biologics, which now account for half of their medicines in R&D (Table 1.4)[8]. Driven by increased inputs into the application of science and technology, particularly AI, prospects for the discovery, R&D and marketing of new targets are now more promising.

Table 1.4 Top 10 Biopharma Companies by the Size of Product Pipeline

2021 (2020) Ranking	Companies	2021 (2020) Number of drugs in pipeline	2021 Number of innovative drugs
1 (1)	Novartis	232 (222)	145 (63%)
2 (5)	Roche	227 (174)	137 (60%)
3 (2)	Takeda	199 (198)	86 (43%)
4 (3)	Bristol Myers Squibb	177 (189)	99 (56%)
5 (8)	Merck	176 (157)	91 (52%)
6 (6)	Pfizer	170 (170)	113 (66%)
7 (4)	Johnson & Johnson	162 (182)	85 (52%)
8 (16)	Abbvie	160 (89)	64 (40%)
9 (7)	AstraZeneca	157 (164)	89 (57%)
10 (11)	Sanofi	141 (137)	71 (50%)

Source: PharmaProjects, *Pharma R&D Annual Review 2021*

CGT: The rising star in next-generation biological therapy

Constant breakthroughs and innovations in treatment options, from compounds to McNab biological preparations and new-generation CGTs, have provided many new treatment options for diseases once regarded as incurable.

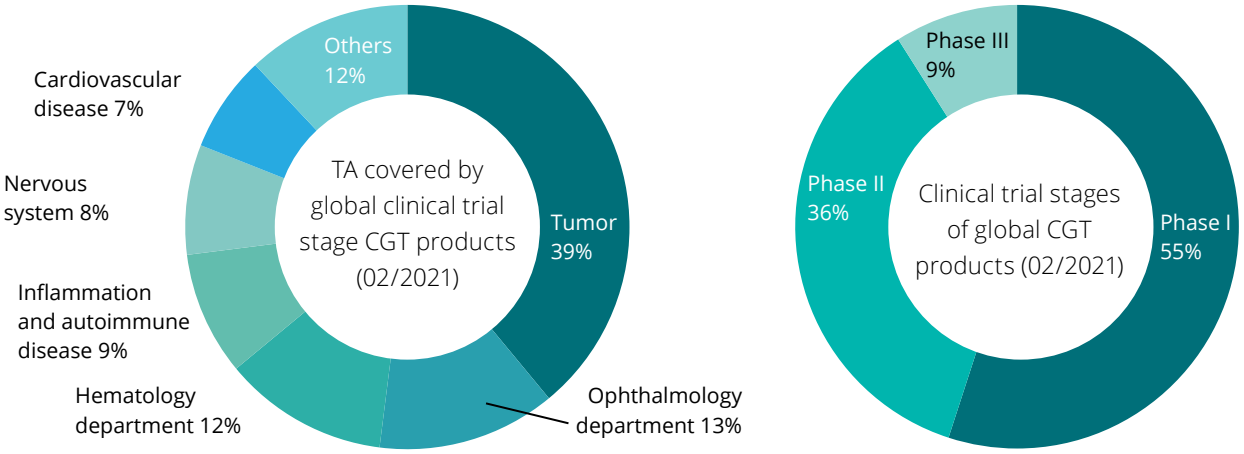
Many CGT treatment products, including CAR-T therapy, stem cell therapy, and adenovirus gene therapy, have been approved in countries across the world (Table 1.5)[24]. They have provided new remedies for many intractable diseases, such as tumors and hereditary genopathy (Figures 1.12 and 1.13)[25].

Table 1.5 Statistics of CGT Therapies Currently Approved in the US, Japan and Europe

Country/region	Approving authority	Number of CGT products approved
The US	FDA	18
Japan	PMDA	11
European Union	EMA	14

Source: Pharma Boardroom, *InFocus Cell & Gene Therapy*

Figure 1.12 Coverage Ratio of Indicators of CGT Therapies in the World; Figure 1.13 Statistics of Proportion of Clinical Stages of CGT Products in the World



Source: Haoyue Capital, *2020 Haoyue Insights Bio-pharmaceuticals: China's Innovation, Global Perspective [Part I]*

CGT therapy development also needs huge amounts of funding. Statistics shows that the FDA approved the marketing of four CGT treatment products from 2018 to 2020. Enterprises and investment institutions invested more than USD13 billion in a transformational pharmaceutical study in 2018. By 2030, 40-60 new CGT products are expected to be approved for listing24. Currently, the discovery and preclinical R&D cost of a CGT treatment product is around USD 0.9-1.1 billion, and the cost of clinical stage stands at USD 0.8-1.2 billion[26].

The development, production, order, and delivery of CGT therapies are at a nascent stage, and enterprises are constantly designing and building new operating models to support CGT. Deloitte Insights surveyed the development of CGT treatment in 2020, interviewing 19 cross-functional leaders involved in the CGT value chain. They made the following five points about CGT development models[27]:

- **Establishment of operating model:** The purpose of CGT is overcoming traditional treatment barriers to realize the development and commercialization of macromolecular and micromolecular products. Industry leaders face the dilemmas of whether to establish an internal development team or outsource this function; centralized or decentralized management of development and production; and whether to invest capital in unprecedented products in the market. Any single decision can have far-reaching and irreversible consequences. When tackling these issues, enterprises consider the nature of CGT treatment and how to access capital, utilize existing external capabilities, and rapidly deliver products.
- **Business process optimization:** CGT enterprises participate in top-down and intricate product flows from the upstream to the downstream, ranging from raw materials gathering and product tracking, to the safe delivery of CGT products to patients. Their leaders are therefore striving to find well-coordinated value chains that can synchronize all functions.
- **Establishment of digital capabilities:** CGT enterprises generally need a complex set of digital tools from the outset, to follow the flow of biological materials, key patient information and funds along the patient journey. Leaders now focus on finding available tools to enhance the experience of doctors and patients, and on supporting long- term data collection to assess safety and efficacy.

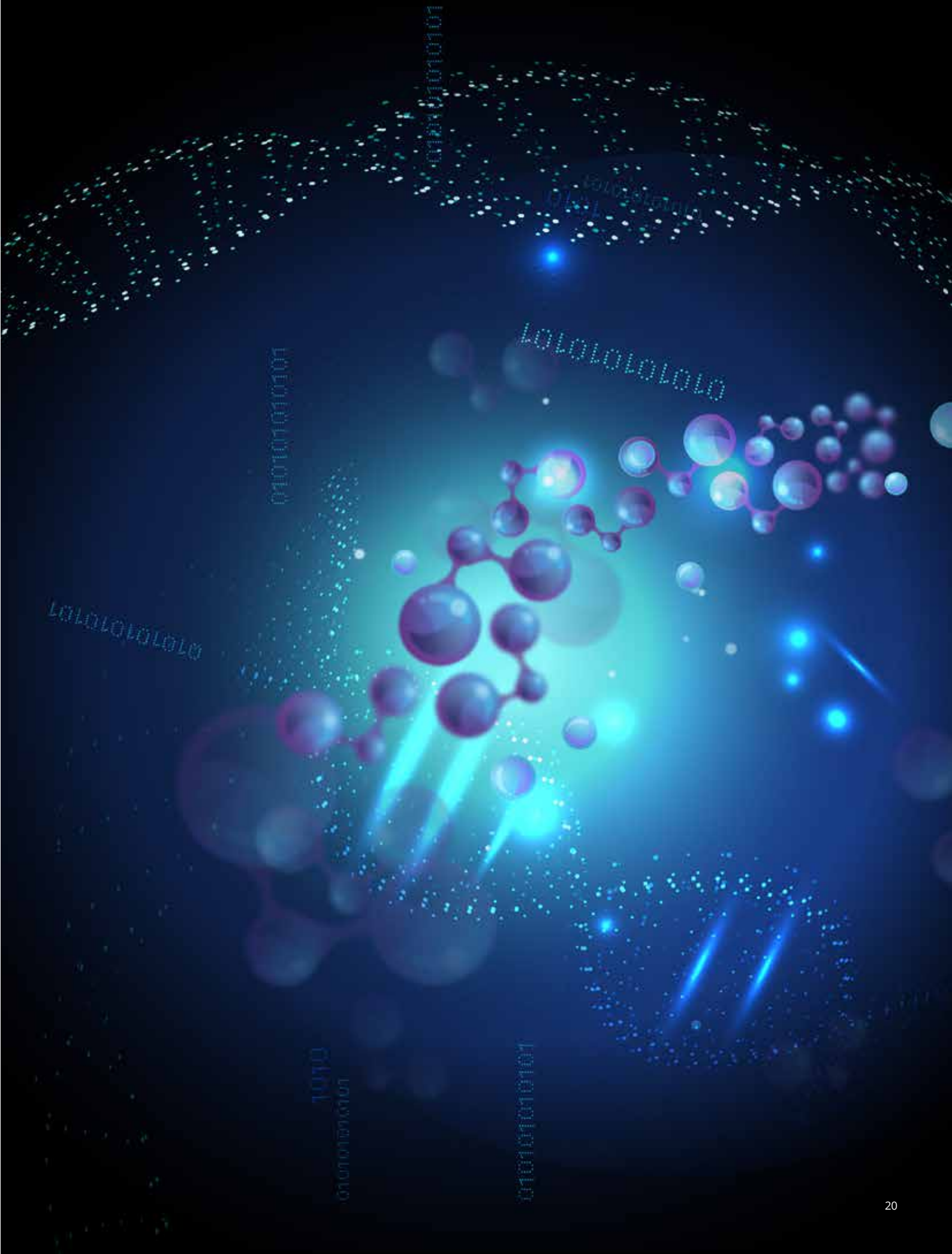
- **Improvement of risk tolerance:** Leaders in every link of the value chain emphasize the importance of flexibility, risk tolerance, and rapid decision-making capability of CGT enterprises. When merging with or acquiring CGT companies, most leading biopharma sector participants use a ring-fencing strategy to maintain their operations and a certain degree of autonomy.
- **Experimenting with new payment mechanisms:** Although CGT treatments can have remarkable efficacy, the high cost and uncertainties involved in maintaining this efficacy have yet to be addressed. CGT enterprises and payers are considering paying CGT treatment fees via value-based contracts or alternative financing mechanisms.

Given the COVID-19 pandemic is not yet under control, development of CGT treatments has slowed down, but the overall market is growing consistently.

In an interview with Deloitte, Ingrid Zhang, President of Novartis Pharmaceuticals China, said the industry and the entire ecosystem should focus on and consider three questions when considering the development of CGT treatments:

- Typically, CGT is a one-off treatment. **How can we establish a value assessment mechanism of the long-term effect?**
- CGT not only has high standards for product quality, but also involves complex and rigid procedures. **How can we ensure high-quality production, execution of treatments, and safety control?**
- **What is the profit-generating model for CGT as a new-generation treatment method, and how can we maintain a sustainable business while benefiting patients?**

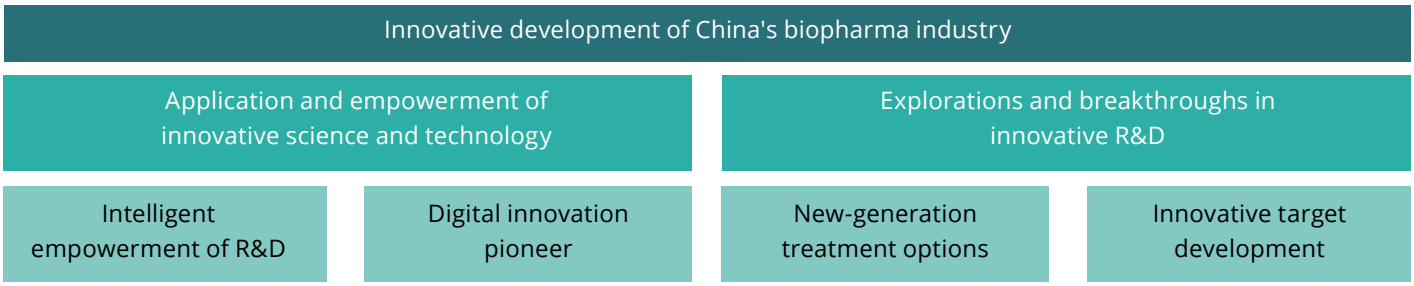
Deloitte expects more funds and resources to be injected into the development of CGT treatments, bringing about more innovation in biopharmaceutical industry. The respondents in Deloitte's global CGT survey are optimistic about development prospects for CGT treatments. By leveraging the competitive advantage of CGT treatments and foreseeing industry standardization, companies will embrace new opportunities. Maintaining a high level of safety while focusing on efficacy and designing a special value chain for CGT treatments will be the key.



2. Innovation trends in China's biopharma industry

The biopharma industry is highly oriented towards policy and technology. Compared with most other industries, innovative biopharma development can face many technical and capital barriers. Influenced by global biopharma innovation trends and driven by the national dual circulation development model, China's biopharma market is conforming to global development and embracing international innovation. At the same time, it is enhancing its own innovation capacity to prove the innovation power of China's biopharma companies to the world. Within these general tendencies, China's biopharma innovation can be divided into four specific trends (Figure 2.1), all of which demonstrate self-innovation breakthroughs and industrial upgrading.

Figure 2.1 Innovation Trends in China's Biopharma Industry



Source: Deloitte research and analysis

Innovative biologics are increasingly valued by government agencies; R&D and market access are accelerating

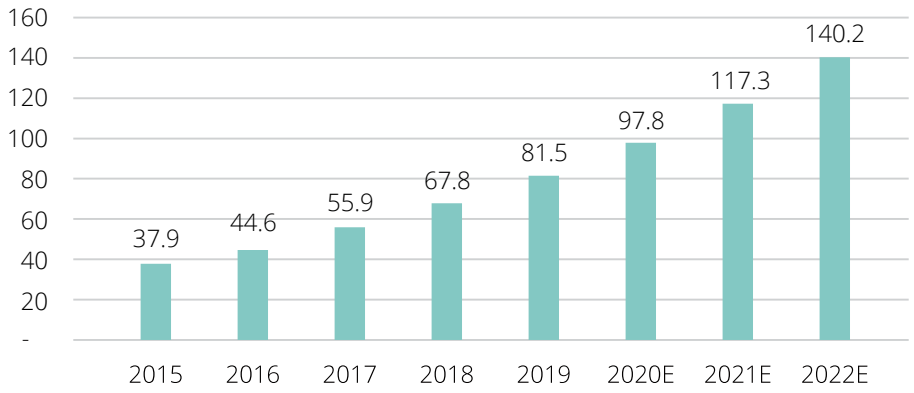
Thanks to the implementation of a host of regulations and policies in connection with the biopharma industry, innovative medicines are now reaching the market much more rapidly in China. Before 2015, it took 5-7 years longer for innovative medicines to be approved in China than it did in countries with advanced healthcare systems, which was mostly due to slow approvals of clinical trials and difficulty in promoting trials[28]. Table 2.1 below summarizes the impact of medical reforms in recent years.

Table 2.1 How Medical Reforms Accelerated the Speed to Market of Innovative Biologics in China

Measure/s	Impact on accelerated time to market of innovative biopharmaceuticals
Revision to the *Measures for the Administration of Drug Registration*	The *2020 Measures for the Administration of Drug Registration* defines four evaluation acceleration channels, including breakthrough treatment, preferential evaluation and approval, conditional market approval and special approval, refining application channels for subsequent marketing of innovative medicines. Different evaluation and approval schemes are required for different product types.
Shortening the evaluation and approval procedures of the clinical trial application	In 2018, the National Medical Products Administration issued the *Announcement on Adjusting the Evaluation and Approval Procedures for Clinical Drug Trials (No. 50 of 2018)*, with a view to encouraging the R&D of innovative medicines via the clinical trial application process and shortening the duration necessary for the clinical trials.
Joining the International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use (ICH) [31]	In 2017, the former State Food and Drug Administration joined the ICH and was elected as a member of the management committee in 2018. China's accession to the ICH has allowed its systems, procedures, and standards to be more aligned with international ones, helping enhance China's international competitiveness and attract many international innovative medicine companies to choose China as one of the first batch of countries to market their products.
Increasing the number of clinical trial institutes and centers and practicing register management [31]	The appraisal of clinical trial conditions and capabilities is included into the rating of medical establishments, which aims to encourage set up of a higher number of clinical trial departments to facilitate more trials, promote the qualification and registration management system for clinical trial institutes, and to make medical establishments more capable and interested in getting involved in clinical trials. The number of clinical trial centers rose from 375 in 2015 to 1,072 in 2019.
Revision of the *Patent Law* safeguards patents and extends the protection period of patents	The latest version of the *Patent Law* was passed on 17 October 2020 and implemented as of 1 June 2021. A compensation system for the term of patents was proposed at the legislative level for the first time. It offers patent term compensation to innovative medicines to enhance China's position as one of the first batch of countries to market innovative medicines, and spur local innovative medicine companies to invest more in R&D to promote local innovation[31].
Evaluation and approval capacity strengthened to facilitate scientific supervision	The Center for Drug Evaluation increased its number of evaluation staff from 150 in 2015 to 700 in 2018 and established an assessment expert panel composed of 626 external experts. It promotes the release and formation of the evaluation and approval system under the principles of "scientific supervision", "justice and equity" and "openness and transparency" and beefs up support for innovative medicines.

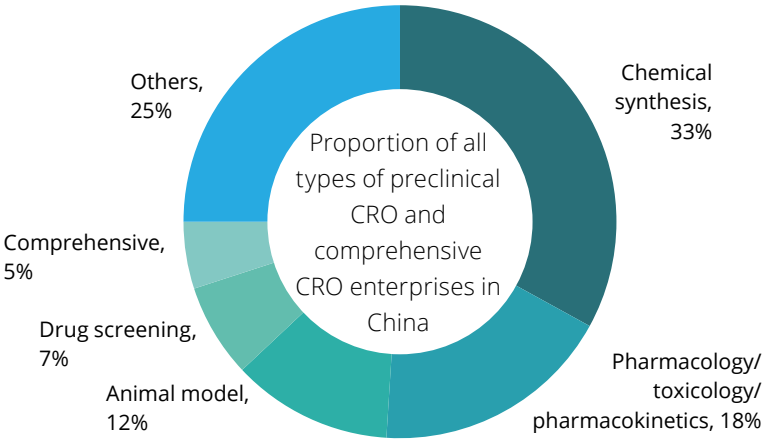
Source: Public data, Deloitte research and analysis

Figure 2.2 Size of Drug CRO Market in China and Prediction (2015-2022E, RMB billion)



Source: AskCI.com, curated by Deloitte

Figure 2.3 Proportion of All Types of Preclinical CRO and Comprehensive CRO Enterprises in China



Source: AskCI.com

China's CRO industry has been growing since 2015, and the market is expected to exceed RMB100 billion in 2021[29] (Figure 2.2). Previously, users of CRO and CDMO services in China's pharmaceutical industry were mainly enterprises developing generic drugs and biosimilars (Figure 2.3). However, with government agencies emphasis on promoting innovative medicines, the market for generic drugs and biosimilars has declined and new innovative medicine companies are constantly emerging.

A growing number of innovative medicine start-ups are choosing CRO and CDMO services to make up for a lack of in-house personnel and resources. CRO demand and the CRO penetration are expected to keep growing[30]. At the same time, more multinational pharmaceutical companies are shifting their demand for CRO and CDMO services to China because China's CRO and CDMO enterprises have cost advantages over those in Europe and the US.

With China's supervisory standards now benchmarked against international standards and domestic quality requirements for innovative medicines having risen, requirements for the quality of CRO and CDMO services have elevated accordingly. CRO and CDMO services are likely to meet the development needs of China's innovative medicine start-ups in the short run. However, amid the ongoing push for innovative medicines development, China's pharmaceutical companies have built up their in-house capacity for innovation. It will be challenging for CRO and CDMO companies to continue to meet China's innovative medicine companies' growing demand for hardware and services. If this demand cannot be met by CROs and CDMOs, China's innovative medicine companies could meet it through M&A or by assembling their own clinical teams.

China becoming a digital transformation powerhouse for biopharma enterprises

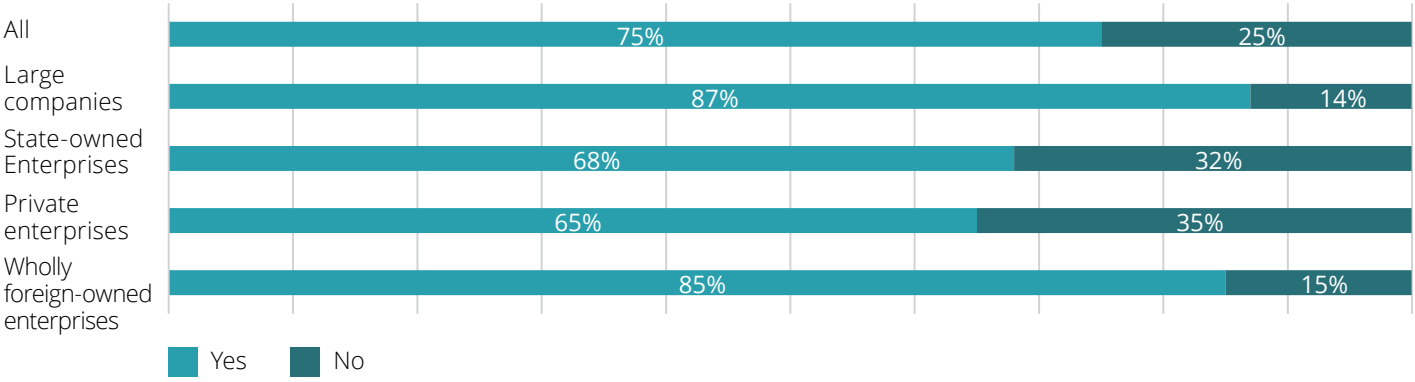
Digital transformation, already a popular trend in China and worldwide, has accelerated since the COVID-19 outbreak began. In addition to being applied in early-stage biologics R&D, digital technology has been used in multiple areas of healthcare, including supply chains, doctor and patient education, and data collection, granted by China's rapid technological development. One-package services based on digital technology have been made available over time. In an interview with Deloitte on China's biopharma industry, experts said that digital healthcare is a megatrend and a positive accelerator for innovative development of China's biopharma industry.

At the beginning of 2021, Deloitte surveyed 150 respondents from biopharma companies based out of China who shared their insights on development prospects for the life sciences industry, including their opinions and expectations for digital development. Three-quarter of the enterprises surveyed are increasing or willing to increase investment in the development of online channels[31].

Private and state-owned enterprises are less willing to increase their investment in online channels (Figure 2.4). Of the enterprises who are willing to increase investment in new digital channels, large enterprises prefer to invest in self-establishment and partnerships with third parties. In contrast, domestic enterprises would rather develop their own online channels, and foreign-funded enterprises prefer a cooperative development model (Figure 2.5).

Figure 2.4 The Willingness to Invest in New Digital Channels

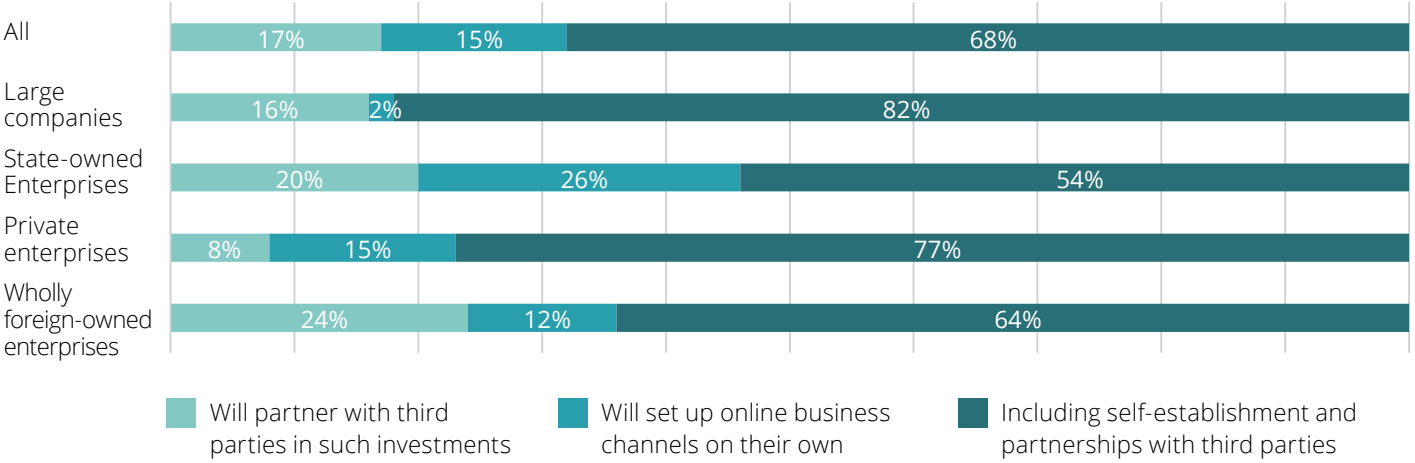
Are you willing to increase investment in new digital channels?



Source: Deloitte, *Survey Findings of the Life Sciences and Healthcare Industries in China in 2021: Status Quo and Outlook*

Figure 2.5 Investment Preference in New Digital Channels

What is your digital channel investment preference?

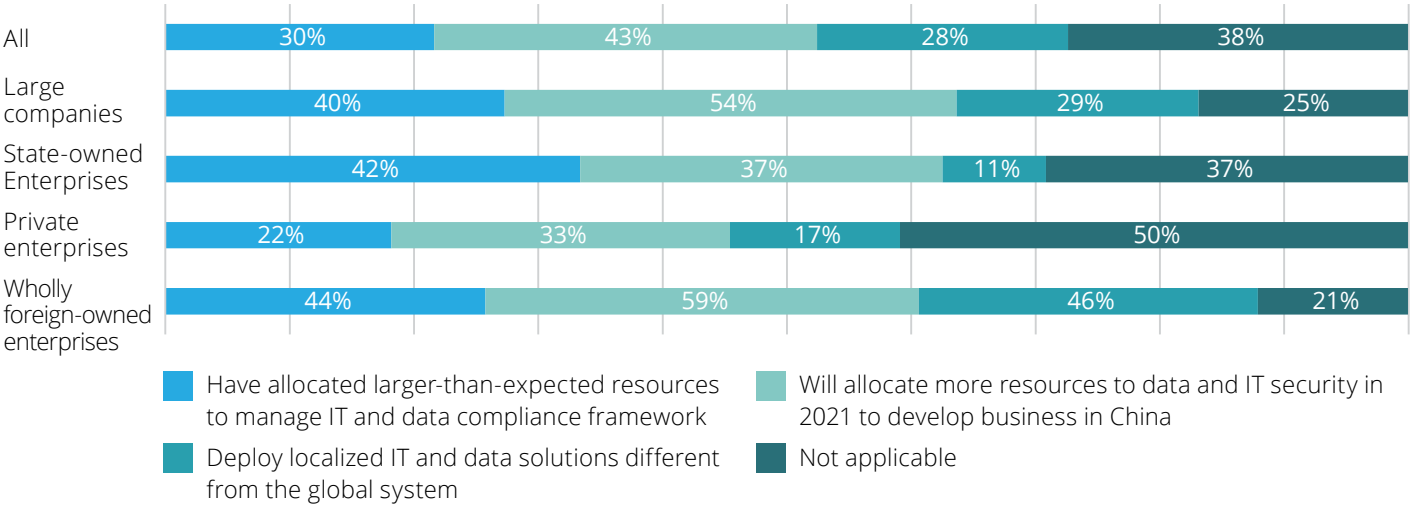


Source: Deloitte, *Survey Findings of the Life Sciences and Healthcare Industries in China in 2021: Status Quo and Outlook*

Deloitte also learned that among companies other than private enterprises, nearly 50% of respondents said their companies have earmarked larger-than-expected resources for IT and data compliance frameworks. Meanwhile, most large enterprises and wholly foreign-owned enterprises will allocate more resources to data, IT security and compliance in 2021, to address China's rapid growth in digital healthcare. Clinical data compliance has long been a pain point in the digital transformations of biopharma companies. The collection, management and utilization of patient health, diagnosis and treatment data are subject to both information safety and medical safety risks. This challenges enterprises, medical establishments, and regulatory authorities to establish specifically targeted risk control plans to safeguard the privacy of patients while ensuring the legal and reasonable use of patient data. In the context of big data connectivity, they also need to balance information security guarantees and open use[32].

In Deloitte's survey, 43% of respondents (more than 50% of them are from large enterprises and wholly foreign-owned enterprises) said their companies will allocate more resources to data and IT security in 2021 than in 2020 to support the digital transformation of their businesses in China (Figure 2.6)[31].

Figure 2.6 Investment Related to China's Data and Security Environment



Source: Deloitte, *Survey Findings of the Life Sciences and Healthcare Industries in China in 2021: Status Quo and Outlook*

Local and multinational biopharma companies in China are paying more attention and scaling up digital transformation. They are increasingly willing to use digital innovation and apply it to a wider range of fields (Figure 2.7). They are also expanding their investment and application scenarios for digital technology in China. Dr. Ruilin Song, executive chairman of the China Pharmaceutical Innovation and Research Development Association, and Ingrid Zhang, President of Novartis Pharmaceuticals China, said the empowerment of digital technology in China's biopharma industry is expected to develop further, stimulating more advanced innovation. Kenneth Sun, managing director of the Medical Industry Team in the Investment Banking Division of Morgan Stanley Asia-Pacific, believes China's digital technology adoption promises to drive its biopharma industry to catch up rapidly with European and US counterparts, enabling China to become a global power in pharmaceuticals.

Figure 2.7 Digital Application Scenarios in China's Biopharma Industry

Digitalization speeds up innovative R&D
- AI empowers new drug discovery by intelligent screening of scientific literature research and protein model prediction

Personalized digital service
- Big data is used to refine service types based on patients' demands and provide more precise assistance plans

Digital marketing
- Online medication consultation service
- Online academic seminars to cover more medical experts

Intelligent management of clinical trial
- Precise monitoring of clinical trial data
- Intelligent management and analysis of clinical trial data

Digital transformation of production process
- Digital management of production supply chain
- Intelligent detection of production line and stabilization of manufacturing quality

Electronic prescription
- Remote healthcare and issuance of electronic prescription in online healthcare
- Increasing the sales volume and expanding the sales channel of drugs

Source: Public data, research and curated by Deloitte

Innovation breakthroughs as AI empowers the entire biopharma industrial chain

AI, a key link in the digital transformation of the biopharmaceutical industry, is extensively applied in biopharma in China, facilitating the innovative development of biologics from product R&D and screening, to modes of patient interaction. However, in international terms, the application of AI in China's biopharma industry is still nascent. As pharmaceutical and tech giants race to enact their business plans, China's investment market for "AI + biological technology" is changing dynamically. Its early industry development stage boasts huge market potential. Domestic companies need to build up their ability to engage in technical cooperation with pharmaceutical companies to constantly accumulate data and develop their business models.

In February 2020, the Ministry of Industry and Information Technology (MIIT) released the Initiative on Fully Utilizing the Empowerment Effectiveness of AI to Jointly Fight against COVID-19, calling for the empowerment of AI to be used to promote technical R&D and facilitate production. R&D breakthroughs in biopharma, including main virus gene sequencing, vaccine and drug research and development, and protein screening. In doing so, drug R&D could be accelerated even under the impact of COVID-19[33].

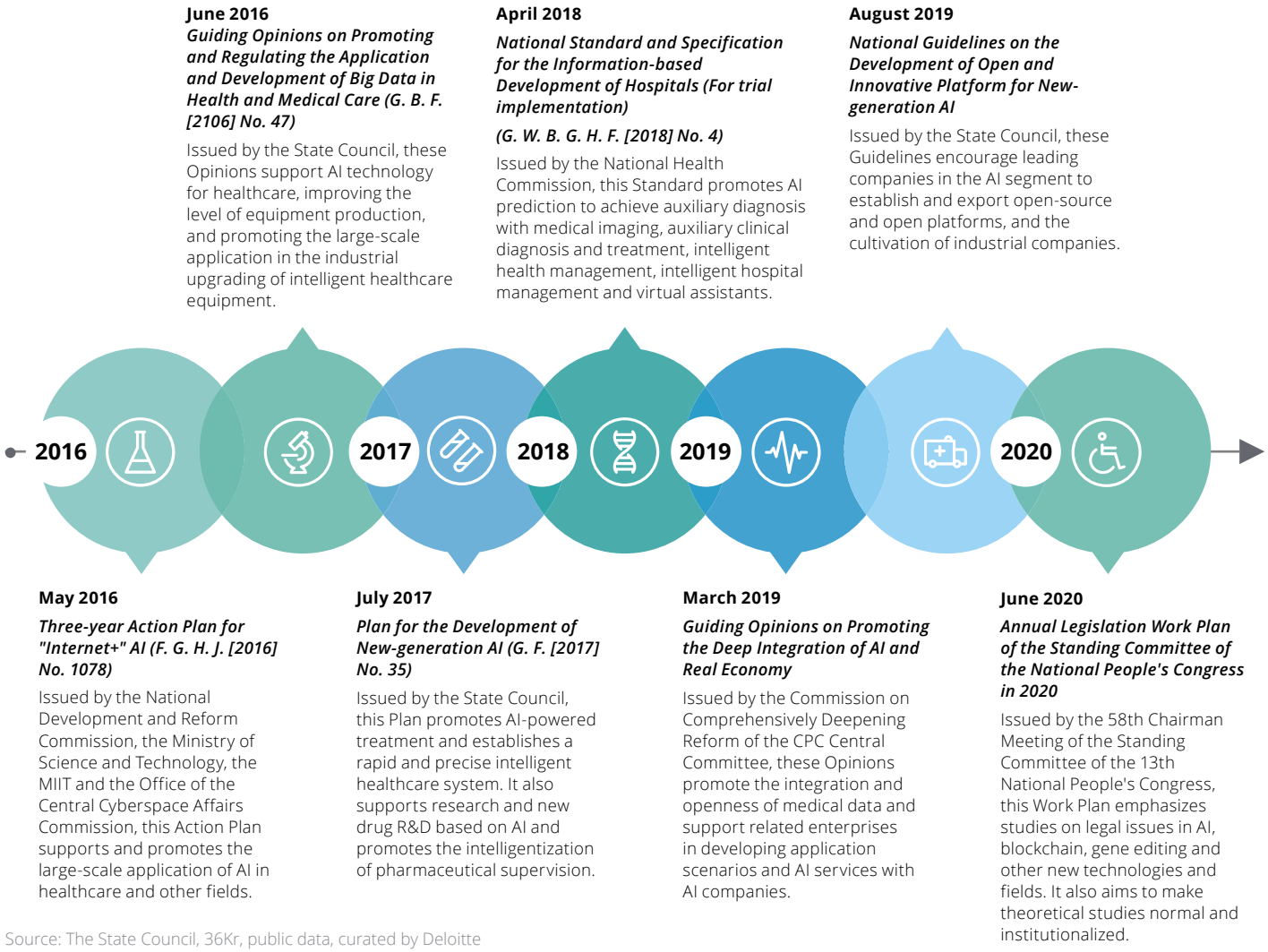
Policy changes

The Made in China 2025 strategy, which was issued in 2015, contained the earliest policy support for AI's use in healthcare and proposed intelligent manufacturing for the first time. In the 13th Five-year Plan adopted at the 4th Session of the 12th National People's Congress in March 2016, the concept of AI was included in key projects.

In May 2016, the National Development and Reform Commission, Ministry of Science and Technology, MIIT and the Office of the Central Cyberspace Affairs Commission jointly issued the *Three-year Action Plan for "internet + AI"*, proposing to promote comprehensive development of AI in six areas: capital, standardization, intellectual property protection, talent development, and international cooperation. This was the first well-articulated support policy for the development of AI applications.

The development of AI-powered healthcare is chiefly driven by top-down policy. The priorities include using AI to accelerate drug R&D, intelligentization of drug supervision, and informatization of medication monitoring data (Figure 2.8).

Figure 2.8 The Evolution of Policy for the AI-powered Innovative Development Relating to China's Biopharma Industry



Source: The State Council, 36Kr, public data, curated by Deloitte

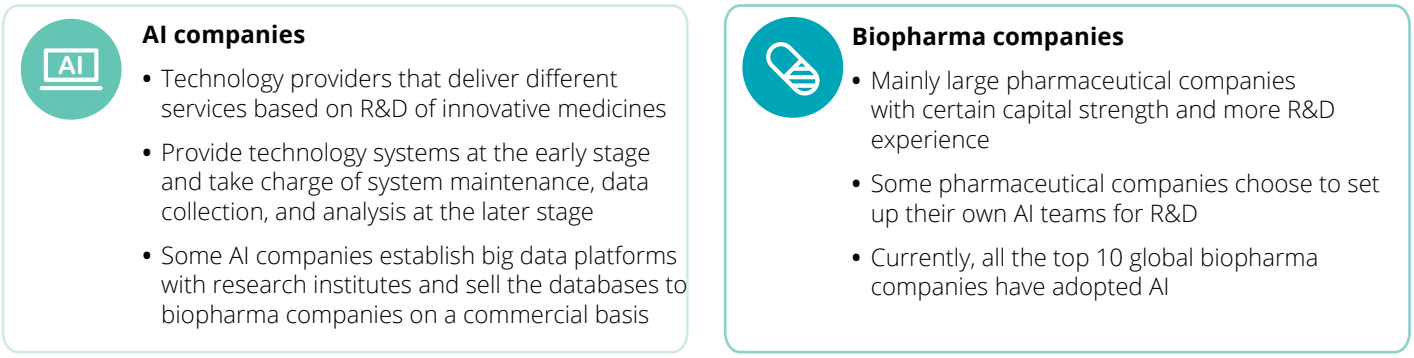
The application of AI in China's biopharma industry

AI can meet the comprehensive application demands of R&D on innovative biologics, from drug discovery, preclinical study and clinical trial, to marketing examination and approval. It can also cover the entire industrial chain, including target discovery, pharmacology assessment, preparatory R&D, clinical trial recruitment, trial optimization, and production. Nonetheless, the application of AI by China's biopharma companies remains limited, as they primarily focus on medical imaging.

In Europe and the US, AI is more common than it is in China for drug R&D. However, over the recent years, more AI companies and funds have been invested in new drug R&D. Moreover, a growing cohort of overseas talent returning to China with technical knowledge are set to inject new impetus into AI-driven R&D for innovative medicines. In an interview with Deloitte, Richard Mao, managing director of investment group Orchid Asia, emphasized that AI technologies allow biopharma companies to develop new drugs more quickly and efficiently.

According to 36Kr and the China Academy of Information and Communications Technology, more local biopharma companies will form partnerships with AI, with a view to advancing R&D on innovative medicines[18] (Figure 2.9).

Figure 2.9 Cooperative Models between AI Companies and Biopharma Companies in China



Source: Deloitte research and analysis

Case studies of China-based AI developers assisting with the development of innovative medicines

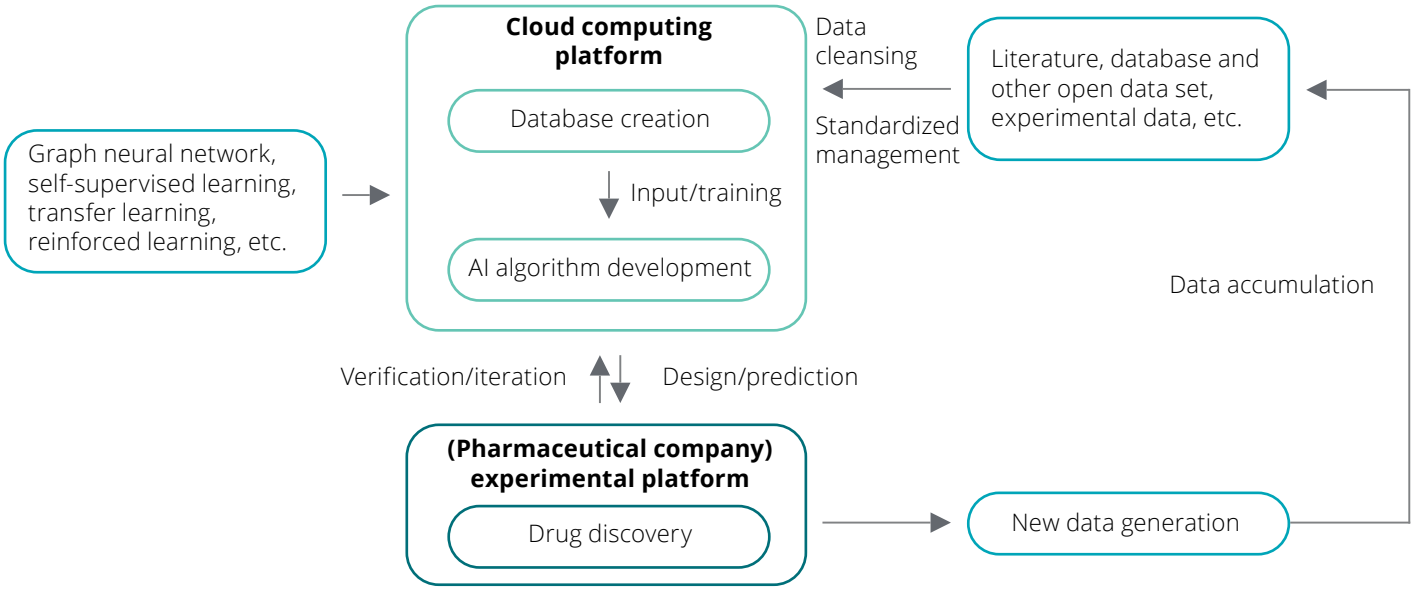
PharmMind

Infinite Intelligence Pharma, designer of the PharmMind AI drug R&D system, announced in February 2021 that it received a Pre-A round of investment from Livzon Pharmaceutical. Before this, Infinite Intelligence Pharma had gained angel investments from CASSTAR and WI Harper Group in August 2019[34]. Based on AI drug development (AIDD) technology and computer-assisted drug design (CADD) technology, PharmMind covers target discovery to preclinical study, assisting with new drug development. PharmMind's functions include simulation of molecular discovery, molecular optimization, molecular search, molecular assessment, virtual screening, retrosynthetic analysis, interactive molecular design, and molecular data mining.

iDrug

In July 2020, Tencent AI Lab released the first AI-powered R&D platform, iDrug, at the Cloud Summit of the 2020 World AI Conference[35]. iDrug's functions include protein structure prediction, virtual screening, molecular production, ADMET prediction, and planning of synthesis routes, providing whole-process services up to preclinical studies (Figure 2.10). On 17 November 2020, Tencent AI Lab analyzed Type II 5a reductase (SRD5A2) using its self-developed method of improving the prediction accuracy of protein structures. The analysis revealed the inhibition mechanism of finasteride, the pharmaceutical molecule for treating alopecia and benign prostatic hyperplasia. This advance is of great help for studies on the pathological mechanisms of related diseases and drug optimization. The project was also covered in *Nature Communication*, the sub-journal of *Nature*[36].

Figure 2.10 The Framework of iDrug



Source: 36Kr, *Tencent Releases the First AI Drug Discovery Platform, iDrug, to Facilitate the R&D of medicines for COVID-19*

New-generation therapy: China, a burgeoning market for CGT

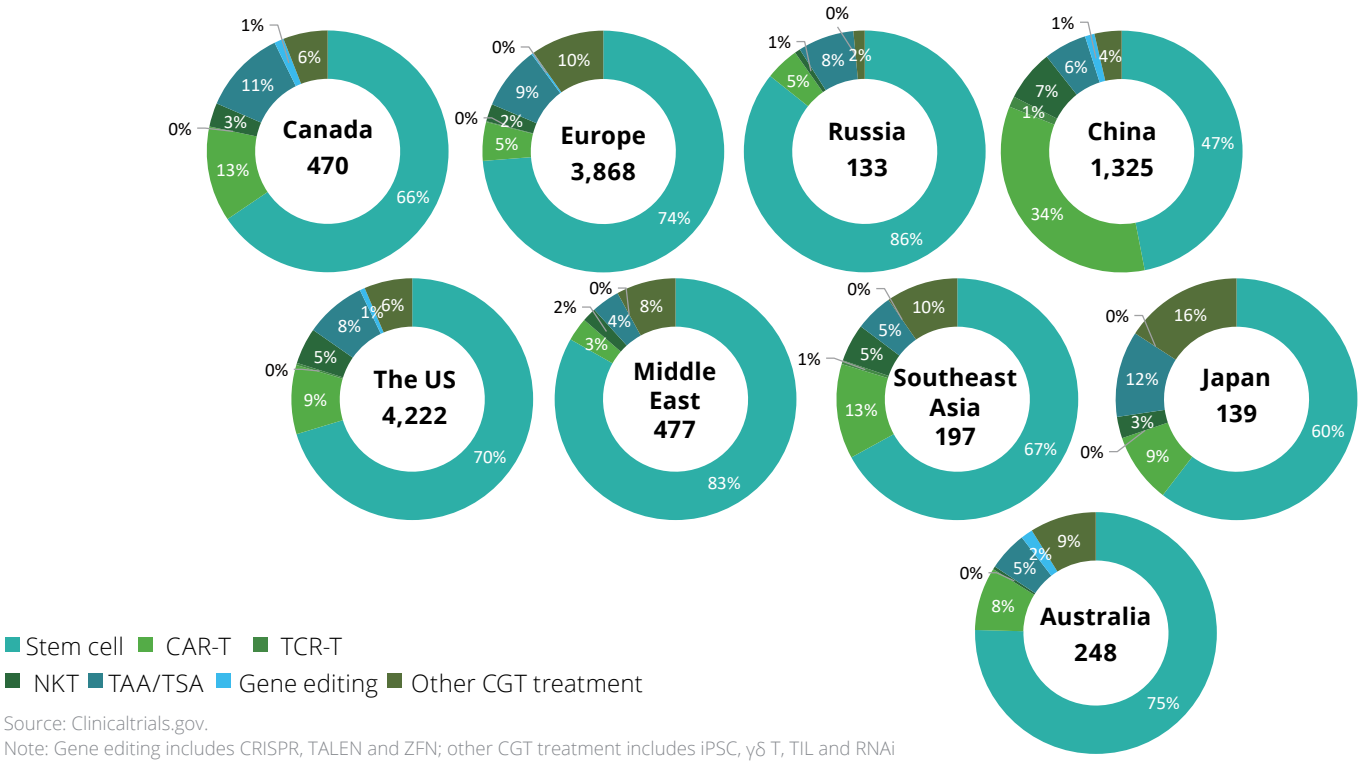
The Yescarta new drug application, a CAR-T product introduced by Fosun Kite of Kite Pharma, has been officially accepted by the National Medical Products Administration and could become the first CAR-T product approved in China[37]. As a country with many patients suitable for CGT, China's CGT enterprises have huge commercialization potential. The number of CGT clinical trials conducted in China is second only to the US[38] (Figure 2.11).

In 2020, Deloitte studied the development of CGT treatments in China's biopharma market, concluding that there are three critical factors for the promotion of CGT development in China[39]:

- **Clear regulatory rules and industrial quality standard specifications:** China's CGT regulatory system has seen an explosive growth after 2016. Such trend continued into 2019, when the National Health Commission and the National Medical Products Administration released a host of regulatory policies on the clinical research and application of CGT and made clear the responsibilities of different institutions. In 2020, authorities released guiding principles for cell therapy and gene therapy, including the *Technical Guidelines for the Clinical Trial of Immune Cell Treatment Products (Exposure Draft),* the *Technical Guidelines for the Pharmaceutical Research and Appraisal of Gene Treatment Products (Exposure Draft),* and the *Technical Guidelines for the Clinical Trial of Humanized Stem Cell and Derivative Cell Treatment Products (Exposure Draft).* Further standardized regulations on CGT product R&D have also been rolled out.
- **The number of global multi-center clinical researches, including China, is on the rise; China's clinical research infrastructure increasingly sophisticated over time:** Statistics indicate that by the end of April 2021, China had conducted 1,325 CGT-related clinical trials (including stem cell, CAR-T, TCR-T, NKT, TAA/TSA, gene editing and other CGT) and is becoming one of the world's leading countries for the registration of clinical CGT trials. Built on this, China has access to world-class data on CGT treatment development and has accumulated profound CGT development knowledge and hands-on experience.

- **Cross-sectoral cooperation is pushing China's CGT treatments towards highly innovative CGT intellectual property rights, facilitating the rapid growth of the CGT ecosystem in China:** Driven by the previous two points, China's local biopharma companies are witnessing a CGT boom, with more than 3,100 CGT-related patents now registered in the country[40]. In addition, many local biopharma companies are partnering with overseas CGT companies to obtain development rights, such as Fosun Kite/Kite Pharma and WuXi AppTec/ Juno. Both models mean CGT treatment development is thriving, and there are expected to be more cooperation projects, promoting CGT commercialization and industrialization in China.

Figure 2.11 Statistics about CGT Treatment-related Clinical Trials in the World by April 2021



Source: Clinicaltrials.gov.
Note: Gene editing includes CRISPR, TALEN and ZFN; other CGT treatment includes iPSC, γδ T, TIL and RNAi

Due to these three main driving forces, funds are now flooding China's CGT segment, and the number and diversity of domestic CGT products surged in 2020. Statistics indicate that trial applications for 20 innovative domestic CGT products were submitted in 2020. As of 29 March 2021, five clinical trial applications have been approved (Table 2.1). Altogether there are 16 cell treatment products: immune cell (12) and stem cell (4), and four gene treatment products, gene editing (1) and oncolytic virus (3) [41, 42].

Table 2.2 Domestic CGT Products with Clinical Trial Applications Submitted in 2020

Segments	Drug name	Company name	Status of acceptance
Immune cell	Autologous T-cell Injection Modified by Target CD30 Chimeric Antigen Receptor Gene	Wuhan Bio-Raid Biotechnology	Approval issued
	pCAR-19B Autologous Cell Feedback Preparation	Chongqing Precision Biotech	Approval issued
	T-cell Injection with CBM.BCMA Chimeric Antigen Receptor	Cellular Biomedicine Group (CBMG)	Under review (at the Center for Drug Evaluation)
	CTO41 Autologous CART Cell Injection	Shanghai Carsgen Therapeutics	Approval issued
	Autologous CD8+T Lymphocyte Preparation	Jiangxi Xidier Biotechnology	Under review (at the Center for Drug Evaluation)
	T-cell Injection with GB5005 Chimeric Antigen Receptor	Shanghai Genbase Biotechnology	Under review (at the Center for Drug Evaluation)
	Anti-HIV-1 T-cell Injection with Chimeric Antigen Receptor	Shenzhen City of Regeneration Biology	Under review (at the Center for Drug Evaluation)
	Autologous T-cell Injection Activated by Dendritic Cell of Complex Antigen Sensitization for Non-small Cell Lung Cancer	Shenzhen Immuclin Biomed, Inc.	Under review (at the Center for Drug Evaluation)
	C-4-29 Cell Preparation	Chongqing Precision Biotech	Under review (at the Center for Drug Evaluation)
	Antihuman CD19-CD22 T-cell Injection	Shanghai Hrain Biotechnology	Under review (at the Center for Drug Evaluation)
	LY007 Cell Injection	Shanghai Longyao Biotechnology	Under review (at the Center for Drug Evaluation)
	Autologous Memory Lymphocyte Injection	Newishes Technology	Under review (at the Center for Drug Evaluation)
Stem cell	Human Umbilical Cord Mesenchymal Stem Cell Injection	Beijing Baylx, Inc.	Approval issued
	M-021001 Cell Injection	Beijing Zephyrm Biotechnologies/Institute of Zoology, Chinese Academy of Sciences	Under review (at the Center for Drug Evaluation)
	Human Umbilical Cord Mesenchymal Stem Cell for Injection	Shenzhen Beike Biotechnology	Under review (at the Center for Drug Evaluation)
	Mesenchymal Stem Cell for Injection (Umbilical Cord)	Tianjin Amcellgene Engineering	Under review (at the Center for Drug Evaluation)
Gene editing	Autologous CD34+ Hematopoietic Stem Ancestral Cell Injection of BCL11A Erythroid Hadron Modified by CRISPR/Cas9 Gene	Guangzhou EdiGene MedTech	Under review (at the Center for Drug Evaluation)
Oncolytic virus	Recombinant Human GM-CSF Oncolytic Type-II Herpesvirus Hominis (OH2) Injection (Vero Cell)	Wuhan Binhui Biopharm	Under review (at the Center for Drug Evaluation)
	Recombinant Human IL12/15-PDL1B Oncolytic Type-I Herpesvirus Hominis Virus Injection (Vero Cell)	Sinopharm Funuojian Biotechnology	Approval issued
	Recombinant Human nsIL12 Oncolytic Adenovirus Injection	Beijing Biottt	Under review (at the Center for Drug Evaluation)

Source: Hsmap.com, Yaozh.com, curated by Deloitte

Against this backdrop of rapid development, China's CGT segment faces the dilemma of who should be paying for the expensive CGT treatments. Kenneth Sun from, Morgan Stanley Asia-Pacific notes that approved cell treatment products are expensive and very few patients in China can afford them. Furthermore, commercial health insurance is not widespread in China, and it is unclear if CGT therapy is covered by national medical insurance. Deloitte suggests that innovative biopharma companies with CGTs in China should consider diversified and innovative payment models to ensure patients have sufficient sources of payment when receiving CGT treatment. This is the only way to ensure a steady and long-term development of CGT products[39].

Raising CGT treatment output while ensuring quality is another challenge. The production of CGT treatments is highly sensitive to environmental factors, including temperature, humidity, and CO_2 concentration. The production quality requirements for CGT treatments are higher than those for traditional pharmaceutical chemicals and biological preparations. One of the dilemmas that global CGT development enterprises face is a stable and sufficient carrier supply from small-scale to large-scale commercialization, and one possible solution is to utilize CDMO services.

Earlier in this report, we discussed the accelerated marketing of biopharma products driven by CRO and CDMO services. CDMOs, equipped with sophisticated technology and professionals, have become the carrier suppliers of CGT treatments, especially gene products. Alongside the rapid growth of CGT treatments, filling gaps in the viral vector manufacturing will also become a business growth point for CDMOs.

With a growing proportion of CGT product companies using CDMOs to prepare for commercialization, CDMOs will play a vital role in the marketing of CGT products. While using CDMOs, some enterprises are also making substantial investments in automatic processes to lower cell production cost. CDMO services and automatic production are vital solutions to resolve bottlenecks in CGT treatment production[43, 44].

Apart from participating in the burgeoning international market for CGT products, China is playing a critical role in their development and commercialization. The main roles of China's CGT enterprises in international CGT development are:

- **Developing and commercializing self-developed CGT products in conjunction with pharma MNCs.** Many CGT enterprises in China with solid R&D capacity have developed CGT products with commercialization potential that have entered clinical trials. Several pharmaceutical MNCs have entered strategic partnerships with these local CGT enterprises to expand their product deployment. Examples include the strategic cooperation on CAR-T product development of Nanjing Legend Biotech and Johnson & Johnson. Together, they are developing and commercializing LCAR-B38M, a CAR-T product for multiple myeloma created by Nanjing Legend Biotech. Johnson & Johnson will bear the costs of and gain profits from LCAR-B38M sales everywhere except China and will pay some of the costs and receive proportional profits[45] in China. These partnerships highlight the rise of China's local CGT enterprises to international prominence.
- **China and multinational pharmaceutical companies jointly developing and commercializing MNCs' CGT products.** Chinese pharmaceutical companies without self-developed CGT products partner with a pharmaceutical multinational company to develop and commercialize the MNC's CGT products, and strengthen their CGT R&D and production capacity, while supporting global development. The strategic cooperation between CBMG and Novartis is one example. Under this agreement signed in September 2018, CBMG became responsible for the production and supply of Kymriah (Novartis' CAR-T product) in China, and Novartis obtained a stake of around 9% in CBMG[46].
- **Helping CGT products available internationally to enter the Chinese market**. Chinese patients have unique health profiles, representing greater market potential for CGT products available on the international market, such as treatments for gastric and intestinal cancer and other solid tumors and hereditary diseases commonly observed in Asian communities. Many diseases without curative therapies are potentially lucrative markets for international CGT enterprises. However, due to strict regulations and restrictions on market access, data transfer and data privacy, overseas CGT companies often prefer to avoid these barriers by working with Chinese pharmaceutical companies. Chinese pharmaceutical firms can leverage this opportunity to obtain world-leading CGT R&D and production technology, creating win-win scenarios[39].

Innovation and implementation capabilities are shifting from MNCs to local enterprises

Fueled by the Chinese government and drug testing agencies, China's biopharma companies have made great progress in innovation and delivered superior performance since the COVID-19 outbreak began. The development and roll-out of COVID-19 vaccines demonstrate the progress of China's biopharma companies' innovation.

The first COVID-19 vaccine in the world to gain regulatory approval was the inactivated vaccine from Sinopharm's CNBG Beijing Institute of Biological Products. The rapid availability of vaccines was not only helping to bring COVID-19 under control, but also demonstrated the R&D strength of China's biopharma companies. In addition to Sinopharm vaccine, several domestic COVID-19 vaccines have been approved as of March 2021 and some have entered clinical trials with the potential to hit the market soon (Figure 2.12)[38]. Of China's domestic COVID-19 vaccines, four have been approved and one has been authorized for emergency use. Of the 12 COVID-19 vaccines in use worldwide, the largest proportion originated from China (Table 2.2).

Figure 2.12 The Overview of Home-made Vaccines under Development by March 2021

Products	Developer	Vaccine type	Companies						Expected annual output (doses)
			Preclinical	Phase I	Phase II	Phase III	Authorized for emergency use	Gaining the approval for market	
COVID-19 inactivated vaccine	CNBG Beijing Institute of Sinopharm	Inactivated				Approved on 31 December 2020			300 million [1]
CoronaVac	Sinovac	Inactivated				Approved on 5 February 2021			300 million
Adenovirus-vectored COVID-19 vaccine	CanSino/Academy of Military Sciences	Virus vector				Approved on 25 February 2021			100-200 million [2]
COVID-19 inactivated vaccine	CNBG Wuhan Institute of Sinopharm	Inactivated				Approved on 25 February 2021			300 million [1]
Recombinant protein subunit vaccine for COVID-19 (CHO cell)	Anhui Zhifei/Institute of Microbiology, Chinese Academy of Sciences	Recombinant protein				Authorized for emergency use on 24 March 2021			300 million
COVID-19 inactivated vaccine	Chinese Academy of Medical Sciences	Inactivated			Phase III underway				Not made public
COVID-19 mRNA vaccine (ARCoV)	Yunnan Walvax/ Abogen Bio/ Academy of Military Medical Sciences, Academy of Military Sciences	mRNA		Phase II underway					Not made public
Recombinant COVID-19 vaccine (Sf9 cell)	Huaxi Hospital	Recombinant protein		Phase II underway					Not made public
COVID-19 inactivated vaccine (Vero cell)	Kangtai Biological Products	Inactivated		Phase II underway					Not made public
Recombinant protein subunit vaccine for COVID-19	Zhongyianke	Recombinant protein		Phase II underway					Not made public
L lentiviral vector modified DC vaccine (V-SMENP-DC)	Shenzhen Geno-immune Medical Institute	Virus vector		Phase I/II underway					Not made public
"S-tripolymer" recombinant protein subunit vaccine for COVID-19 (SCB-2019)	Clover Biopharmaceuticals/ GSK/Dynavax	Recombinant protein		Phase I completed					Not made public
Pathogen specific aAPC vaccine	Shenzhen Geno-immune Medical Institute	Virus vector		Phase I underway					Not made public
Nasal spray influenza virus vector vaccine for COVID-19 (DelNS1-2019- nCoV-RBD-OPT1)	Beijing Wantai	Virus vector		Phase I underway					Not made public

Source: Clinicaltrials.gov, public data, Deloitte research and analysis
Note: [1] The output of Sinopharm is the total output from Beijing and Shanghai. Sinopharm plans to expand output to 1 billion doses; [2] CanSino plans to expand its output to 500-600 million doses by the end of 2021.

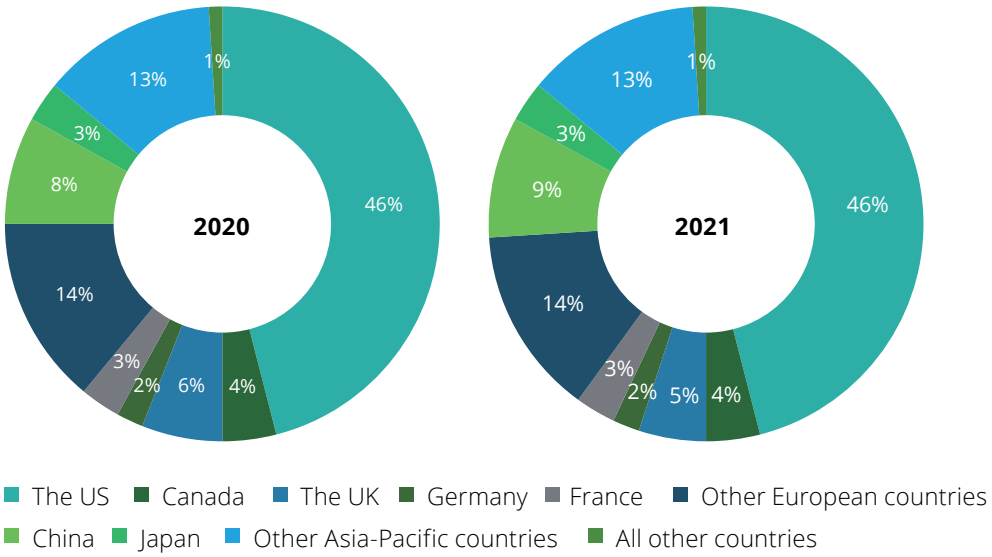
Table 2.3 COVID-19 Vaccines Approved or Authorized for Emergency Use

Countries	Vaccines	Vaccine developer/s
China	COVID-19 inactivated vaccine	CNBG Beijing Institute of Sinopharm
	CoronaVac	Sinovac
	Adenovirus-vectored COVID-19 vaccine	CanSino/Academy of Military Sciences
	COVID-19 inactivated vaccine	CNBG Wuhan Institute of Sinopharm
	Recombinant protein subunit vaccine for COVID-19 (CHO cell)	Anhui Zhifei/Institute of Microbiology, Chinese Academy of Sciences
US	Moderna COVID-19 Vaccine	Moderna
	Janssen COVID-19 Vaccine	Janssen
US/Germany	Pfizer-BioNTech COVID-19 Vaccine	Pfizer/BioNTech
Russia	Sputnik V	Gamaleya Research Institute
	Vector Institute COVID-19 Vaccine	Vector Institute
UK	COVAX	AstraZeneca/Oxford
India	Covaxin	Bharat Biotech

Source: Public Data, curated by Deloitte

China's status in innovative biologics R&D has been rising, thanks to the reform and improvement of a host of healthcare policies and strong support from government agencies. Biopharma companies in China have injected substantial resources into innovative R&D, which has paid off in recent years. This has elevated the position of China in global biologics R&D and strengthened innovation in China's biopharma industry[8] (Figure 2.13).

Figure 2.13 Geographical Distribution of New Drug Development Companies (2020-2021)



Source: PharmaProjects, *Pharma R&D Annual Review 2021*

Drug R&D innovation in China is homogenous, with only a small number of originated targets. Of the 37 new Type-I drugs to hit the market in China from 2017 to 2020, only three had an original mechanism of action, and of the 401 targets in development worldwide, only 80 (around 20%) are being developed in China. Of the 10 most-common targets, 47% of drugs in development are in China, compared to just 22% for other regions.

This is mainly due to an insufficient accumulation of original creativity and investors viewing the risk-return of capital invested as unattractive. Generally, Chinese institutional investors focus more on the payback period than overseas institutions do, and they favor investing in fields with global success stories rather than new areas.

However, with long-term stable investment and focus on innovation in the domestic market, innovation should become less homogenous28. Ingrid Zhang, from Novartis Pharmaceuticals China says the homogeneity of innovation in China was unavoidable during the biopharma industry's rapid development phase, when huge amounts of capital were being pumped into local companies, but the sector must now prove its ability and accelerate the demonstration of R&D results.

As innovative development in China advances and technologies are accumulated, local biopharma companies are set to shift from matching their global peers to outperforming them. They will invest more in R&D to enter a development stage that places more emphasis on R&D of original innovations.

In 2020, there were nine main targets undergoing R&D development in China: PD1/L1, GLP-1R, BTK, JAK, CDK4/6, IL- 17A, PARP, PCSK9, and CGRP/CGRPR 47 (Figure 2.14; Table 2.3)

- As of March 2021, 30 products for these nine targets are launched in China, compared to 53 products globally.
- Among the 30 products launched in China, only 10 were innovative products independently developed by local biopharma companies.
- These 10 innovative products only covered four of the targets, highlighting the homogeneity of local biopharma companies in selecting R&D on innovative products.

Figure 2.14 Statistics about the Number of Drugs Released Corresponding to Nine Hot Spots in the World in 2020 (unit: number)

Source: Pharcube.com, public data, curated by Deloitte

Table 2.4 Products Released in China Corresponding to the Nine Main Targets

Target	Generic Name	Brand Name	Developer/s	Status in China
PD1/L1	Durvalumab	Imfinzi	AstraZeneca	Launched
	Pembrolizumab	Keytruda	Merck	Launched
	Ipilimumab	Opdivo	Bristol Myers Squibb	Launched
	Atezolizumab	Tecentriq	Roche	Launched
	Toripalimab	Tuoyi	Junshi Biosciences	Launched
	Sintilimab	Daboshu	Innovent Biologics	Launched
	Tislelizumab	Baizean	BeiGene	Launched
	Camrelizumab	Ailituo	Hengrui Medicine	Launched
GLP-1R	Exenatide	Baimida	AstraZeneca	Launched
	Liraglutide	Victoza	Novo Nordisk	Launched
	Lixisenatide	Lyxumia	Sanofi	Launched
	Exenatide microsphere	Bydureon	AstraZeneca	Launched
	Dulaglutide	Trulicity	Eli Lilly	Launched
	Beinaglutide	Yishengtai	Benemae Pharmaceutical	Launched
	Loxenatide	Fulaimei	Hansoh	Launched
BTK	Ibrutinib	Imbruvica	Johnson & Johnson/ AbbVie	Launched
	Zanubrutinib	Brukinsa	BeiGene	Launched
	Orelabrutinib	Yinuokai	Innocare Pharma	Launched
JAK	Ruxolitinib	Jakafi/Jakavi	Novartis/Incyte	Launched
	Tofacitinib	Xeljanz	Pfizer	Launched
	Baricitinib	Olumiant	Eli Lilly/Incyte	Launched
CDK4/6	Atezolizumab	Tecentriq	Pfizer	Launched
	Abemaciclib	Verzenios	Eli Lilly	Launched
IL-17A	Secukinumab	Cosentyx	Novartis	Launched
	Ixekizumab	Taltz	Eli Lilly	Launched
PARP	Olaparib	Lynparza	AstraZeneca	Launched
	Niraparib	Zejula	Zai Lab	Launched
	Fluzoparib	Airuiyi	Hengrui/Hansoh	Launched
PCSK9	Evolocumab	Repatha	Amgen	Launched
	Alirocumab	Praluent	Sanofi/Regeneron	Launched
CGRP/CGRPR	Erenumab	/	Amgen/Novartis	New drug application under review
	Galcanezumab	/	Eli Lilly	New drug application under review

Source: Pharcube.com, public data, curated by Deloitte.
Note: Blue text indicates innovative biologics from Chinas.

China tightened requirements for biopharma innovation in its 14th Five-year Plan. In the coming years, we expect constant innovation breakthroughs in China's biopharma companies, mainly driven by:

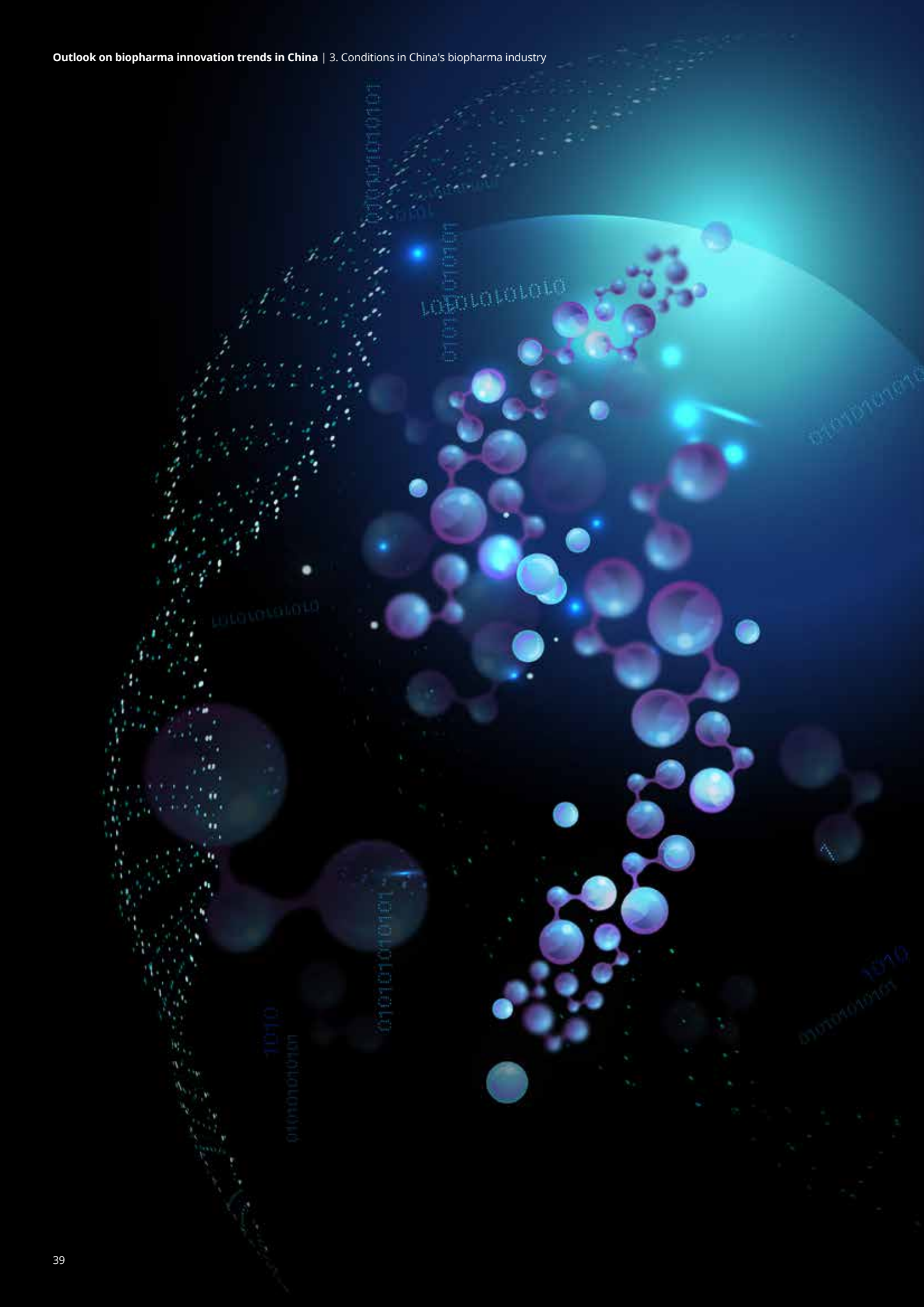
- **Talent and technology accumulation:** Constant technology accumulation and the return of overseas talent to China will prompt China's innovative biopharma companies to start benchmarking themselves against international standards in technology, enhancing their innovation power.
- **Long-term government inputs and policy support:** Continuous increases in government R&D inputs will lower the cost barrier that local biopharma companies face in innovative R&D, while preferential policy measures will attract these companies to invest more in the related areas.

With China attaching more importance to the biopharma industry, serving the needs of local patients has become critical for domestic and foreign biopharma companies alike. The disease mapping of MNCs, most of which are from Europe and the US, is different to that for patients in the Asia-Pacific region. They cannot therefore understand the needs of Chinese patients as local biopharma companies can. This is one area in which China's local biopharma companies can outperform their overseas counterparts in innovative medicines and rapidly occupy the Chinese market.

Overseas biopharma companies need to subject their innovative medicines to separate bridging experiments and even new clinical trials before introducing them into China. Local biopharma companies do not have to do this, which gives them a unique advantage in developing innovative biologics that conform to China's national conditions. A domestic PD-1 product has been included in the *National Medical Insurance Catalogue* for two years in a row (2019 and 2020), but no PD-1 product from a pharma multinational was included. This proves that domestic innovative biologics have the quality to compete against medicines from MNCs.

Local biopharma companies also have an advantage in supply and production. They can input innovation by correctly targeting unmet disease demands and pain points in China's biopharma market under relatively few market restrictions, so that they can conduct research and develop world-class innovative biologics. Dr. Yingfei Wei, Chief Science Officer, Innoforce Pharmaceuticals, believes that China's biopharma industry needs more innovative products which conform to national conditions, and that innovative development should be based on China's environment and industrial foundations. Li Bin, professor at the Shanghai Institute of Immunology, Shanghai Jiaotong University School of Medicine, underscored the importance of innovative development based on the "China paradigm".

One such example is Camrelizumab, the PD-1 product independently developed by Hengrui Medicine. Research findings that Camrelizumab could be used in the treatment of terminal liver cancer were carried by *The Lancet Oncology* in February 2020, making it the first innovative biologics for liver cancer immunotherapy from China so recognized. In the same month, Hengrui announced that Camrelizumab was approved by the National Medical Products Administration for use in treating second-line terminal liver cancer[48]. In October 2021, Hengrui Medicine conducted a clinical trial on combining Camrelizumab with Apatinib, another of its products, for the treatment of first-line terminal liver cancer[49]. In 2020, Camrelizumab also became the first innovative biologics in China to be included in guidelines on clinical diagnosis and treatment of lung cancer, liver cancer, esophagus cancer, and lymphoma[50]. Hengrui Medicine has developed innovative biologics based on domestic disease mapping and local patient needs, emerging as a major player in China's biopharma innovation.

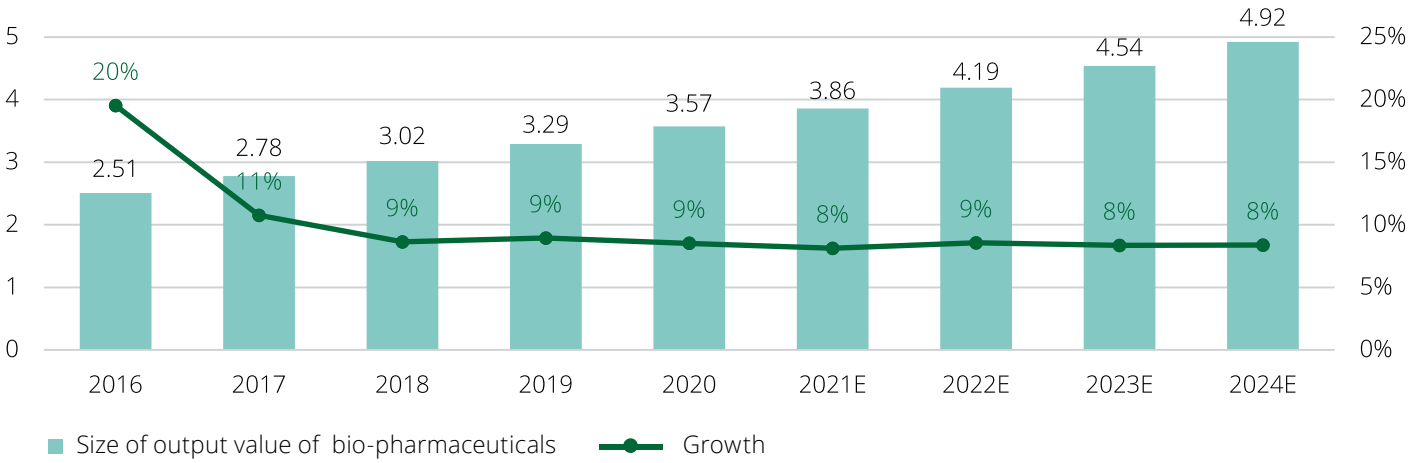


3. Conditions in China's biopharma industry

China, the second-largest economy in the world, has seen rapid development of its biopharma market and is gaining favor among biopharmaceutical MNCs, some of which view it as their key strategic market. The domestic biopharma industry has witnessed remarkable developments, including an increasingly sophisticated network of institutions and R&D capabilities along with diverse product pipelines.

Biopharma development was mentioned repeatedly in the government work report released at the 4th Meeting of the 13th National People's Congress in 2021. According to the China Industrial Development Research Institute, China's biopharmaceutical market will exceed RMB4 trillion in 2022[51] (Figure 3.1).

Figure 3.1 China Biologics Industry Output and Growth (2016-2024E, RMB1 trillion)



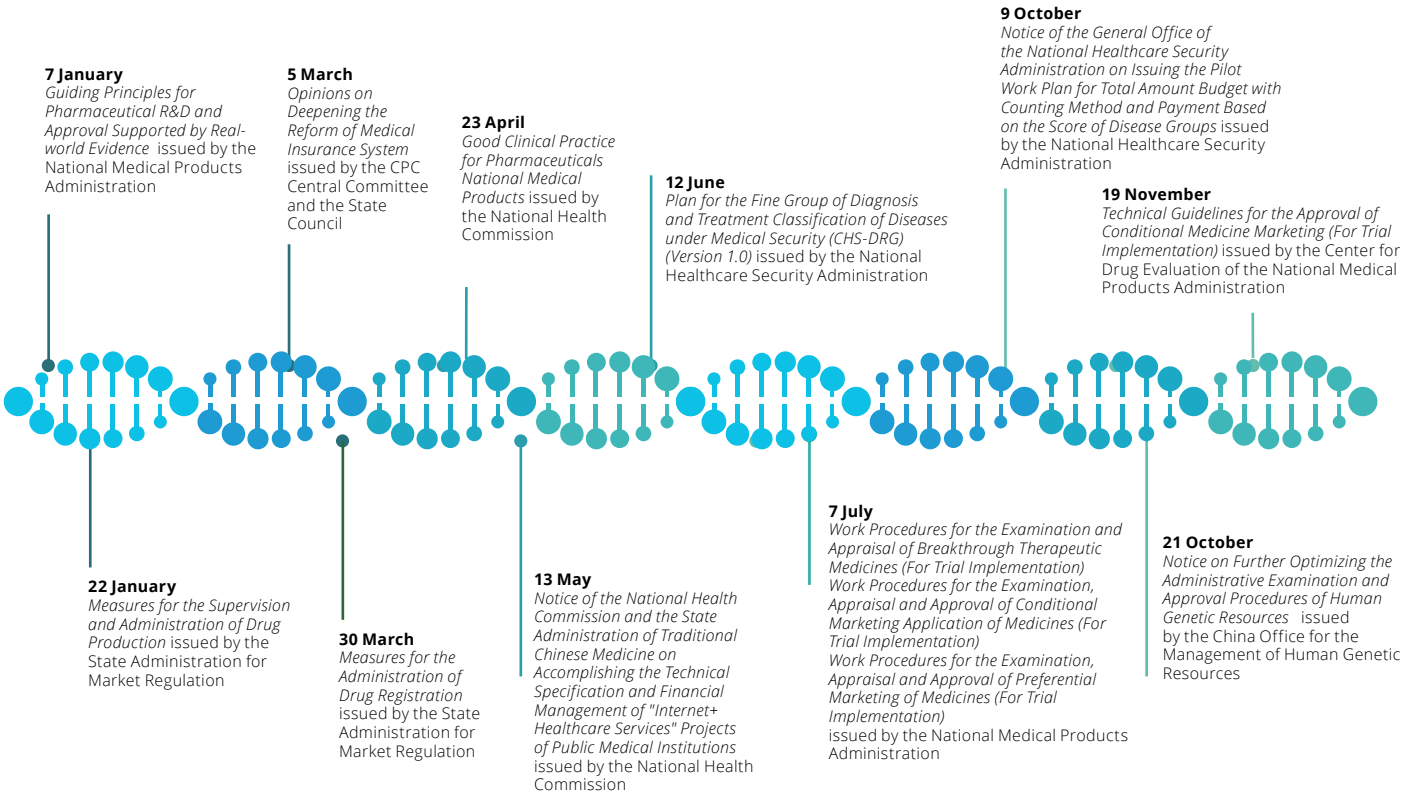
Source: China Industrial Development Research Institute, *Prediction for Development Prospects and the Investment Research Report on China's Biopharma Industry in 2021*

This report looks at three aspects of current conditions in China's biopharma industry – regulatory policies, R&D models, and launched products types.

Regulatory policies reform: the main areas and core policies

The Proposals for Formulating the 14th Five-Year Plan for National Economic and Social Development and Long-range Goals for 2035 released by the State Council at the 2021 Two Sessions emphasize the need for "adhering to innovation-driven development and speeding up the development of modern industrial systems", including in the domestic biopharma industry. Pharmaceutical companies and regulators will further develop and support innovative products in the coming years. In 2020, the Center for Drug Evaluation of the National Medical Products Administration launched a host of reforms of the examination and approval system for innovative medicines (Figure 3.2, Table 3.1). This extended from clinics and examinations, to marketing prices and costs. Reforms will have an increasingly powerful impact on innovative medicines. Dr. Guoliang Yu from Innoforce Pharmaceuticals says few other national governments provide such strong support for biopharmaceutical industry development. The activism of China's drug evaluation authorities is a strong driver of the country's biopharma innovation and reform.

Figure 3.2 Policies in Biologics in 2020



Source: Public data, Deloitte research and analysis

Table 3.1 Summary of Key Regulatory Policies Regarding Innovative Medicines in 2020

Policy	Topic
Guiding Principles for Pharmaceutical R&D and Approval Supported by Real-world Evidence	Appraisal system
Measures for the Supervision and Administration of Drug Production	Production management
Opinions on Deepening the Reform of Medical Insurance System	Medical insurance system
Measures for the Administration of Drug Registration	Appraisal system
Good Clinical Practice for Pharmaceuticals	Clinical test
Notice of the National Health Commission and the State Administration of Traditional Chinese Medicine on Accomplishing the Technical Specification and Financial Management of "Internet+ Healthcare Services" Projects of Public Medical Institutions	Price and cost
Plan for the Fine Group of Diagnosis and Treatment Classification of Diseases under Medical Security (CHS-DRG) (Version 1.0)	Price and cost
Work Procedure for the Examination and Appraisal of Breakthrough Therapeutic Medicines (For Trial Implementation) Work Procedures for the Examination, Appraisal and Approval of Conditional Marketing Application of Medicines (For Trial Implementation) Work Procedures for the Examination, Appraisal and Approval of Preferential Marketing of Medicines (For Trial Implementation)	Appraisal system
Notice of the General Office of the National Healthcare Security Administration on Issuing the Pilot Work Plan for Total Amount Budget with Counting Method and Payment Based on the Score of Disease Groups	Price and cost
Notice on Further Optimizing the Administrative Examination and Approval Procedures of Human Genetic Resources	Appraisal system
Technical Guidelines for the Approval of Conditional Medicine Marketing (For Trial Implementation)	Appraisal system

Data: Haoyue Capital, Public data, curated by Deloitte

The impact of two major regulatory policies on China's innovative development of biopharma industry:

The revisions to the *Measures for the Administration of Drug Registration*

The Measures for the Administration of Drug Registration were promulgated in 2007. Over time, those measures have become unable to support scientific development or the rapidly growing demands in China's pharmaceutical industry. The National Medical Products Administration revised the Measures, which were approved by the State Administration for Market Regulation in March 2020 before coming into force on 1 July 2020.

Strengthening full-lifecycle medicine management and the registration process for innovative medicines helped to enhance the entire regulatory system, from the development and marketing of medicines and post-marketing management, to the revocation of drug registration certificates[52]. The new Measures also add a chapter on accelerated drug registration procedures, introducing four accelerated evaluation and approval items – a channel for breakthrough therapeutic drugs, conditional approvals, preferential evaluation and approvals, and special approvals.

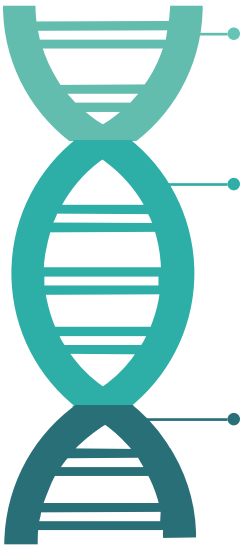
The Work Procedures for the Examination and Appraisal of Breakthrough Therapeutic Medicines (For Trial Implementation) and two other documents

On 8 July 2020, the National Medical Products Administration (NMPA) issued the *Work Procedures for the Examination and Appraisal of Breakthrough Therapeutic Medicines (For Trial Implementation), the Work Procedures for the Examination, Appraisal and Approval of Conditional Marketing Application of Medicines (For Trial Implementation)* and the *Work Procedures for the Examination, Appraisal and Approval of Preferential Marketing of Medicines (For Trial Implementation).* The *Opinions on Encouraging Preferential Evaluation and Approval of Drug Innovation* were repealed at the same time.

As the reform of the new drug evaluation system has deepened in recent years, the NMPA has constantly explored ways to accelerate the regulatory approvals of innovative medicines. The three documents clarify previously controversial areas of uncertainty – the identification scope of breakthrough therapeutic drugs, application conditions for conditional regulatory approvals, and the applicability of preferential approvals. These new routes have brought systematic improvements for accelerated evaluation and approval processes (Figure 3.3).

"Extraordinary Evaluation" is designed for drugs to respond to public health emergencies, "Special Evaluation" focuses on innovative medicines and new drugs for stubborn and critical diseases, and "Preferential Evaluation and Approval" is for medicines that meet clinical demands and have clinical advantages. In combination, these measures mean the NMPA now prioritizes the development of leading drugs in the market with high clinical value and can meet previously unmet clinical needs[53].

Biopharma innovation trends

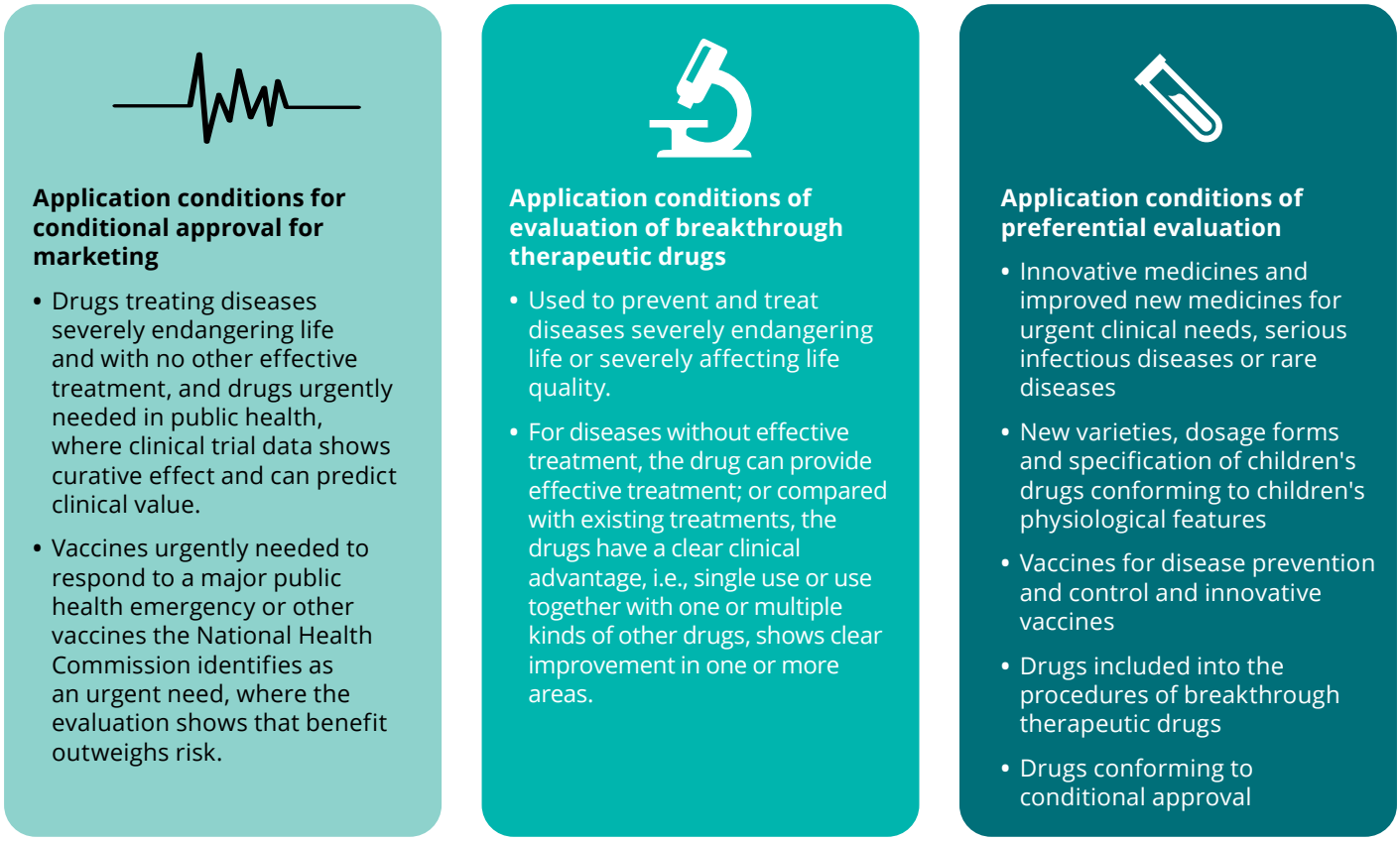


Innovative Medicines

Innovative medicines treating diseases severely endangering life

Innovative medicines with high clinical value or medicines treating serious diseases and clinically needed

Figure 3.3 Three Accelerated Channels of Marketing Approval and Evaluation



Source: Public data, Deloitte research and analysis

The main impacts of the abovementioned reforms on China's development of innovative biologics are:

- It takes much less time for drugs with a breakthrough curative effect to move from clinical trials to regulatory approval. New drug applications can be submitted as soon as Phase I clinical trials are completed. The process could become five years faster, emphasizing how the NMPA has stepped up support for innovative drugs with high clinical value.
- Large-scale procurement is shrinking the market for, and previously high margins of, generic drugs and biosimilars, making innovative transformation imperative.
- Faster evaluation and the higher value placed on innovative products will drive the rise to prominence of domestic pharmaceutical companies with superior innovation power.

R&D models: innovative transformation and international cooperation

The biopharma industry has been hindered by barriers to capital and technology for many years. As China's economy booms, many local pharmaceutical companies now have bundles of cash, but their scientific and technological development lags. Those that wish to develop innovative biologics are in no position to do so. Many of the biopharma industry thought leaders Deloitte spoke to repeatedly mentioned biological technology barriers. As innovative medicines have become dominant in recent years, a growing number of local pharmaceutical companies are choosing to enrich their product pipelines via in-licensing.

Jason Yang, Chief Medical Officer of CStone Pharmaceuticals, said in-licensing has two benefits, accelerating innovative biopharma products' speed to enter in China to meet previously unmet demand and building up the innovation strength of local biopharma companies. Ingrid Zhang from Novartis Pharmaceuticals China added that in-licensing and out-licensing can enhance cooperation and communication between multinational and domestic biopharma companies.

- **In-licensing cooperation dominates**
  In 2020, oncology had the most in-licensed projects (47%), followed by infectious diseases (23%). Together they made up over two thirds of transaction volume[25] (Figure 3.4).

Many biopharma start-ups in China partner with overseas companies when they do not have strong pipeline, seeking to acquire exclusive product development rights in Mainland China and even Greater China to make up for their deficiencies in innovation capacity. Many foreign pharmaceutical companies are happy to work with local biopharma firms in exchange for the access to the Chinese market. This way of cooperation with local biopharma companies allows foreign players to gain local influence and market familiarity of local biopharma companies, which alleviate their growing pains when entering the Chinese market and reduce the risk of non-acclimatization.

Figure 3.4 Proportion of Disease Areas Covered by License-in Projects in China in 2020

Source: Haoyue Capital, *2020 Joymeo Annual Report, Biopharmaceuticals: China's Innovation, Global Perspective [Part 1]*

In 2020, a CAR-T and TCT double-antibody project by Innovent Biologics and Roche was the largest in-licensed transaction, involving USD2 billion and highlighting the high value of CGT products. Among the top 15 in-license transactions, 12 involved oncology treatments, two infectious diseases and one autoimmune disease. This showed that tumor-related diseases remain a common research topic, and that oncology is the development focus of many innovative biologics studies[54, 55] (Table 3.2).

Table 3.2 China's Top 15 In-licensing Transactions in 2020 by Value

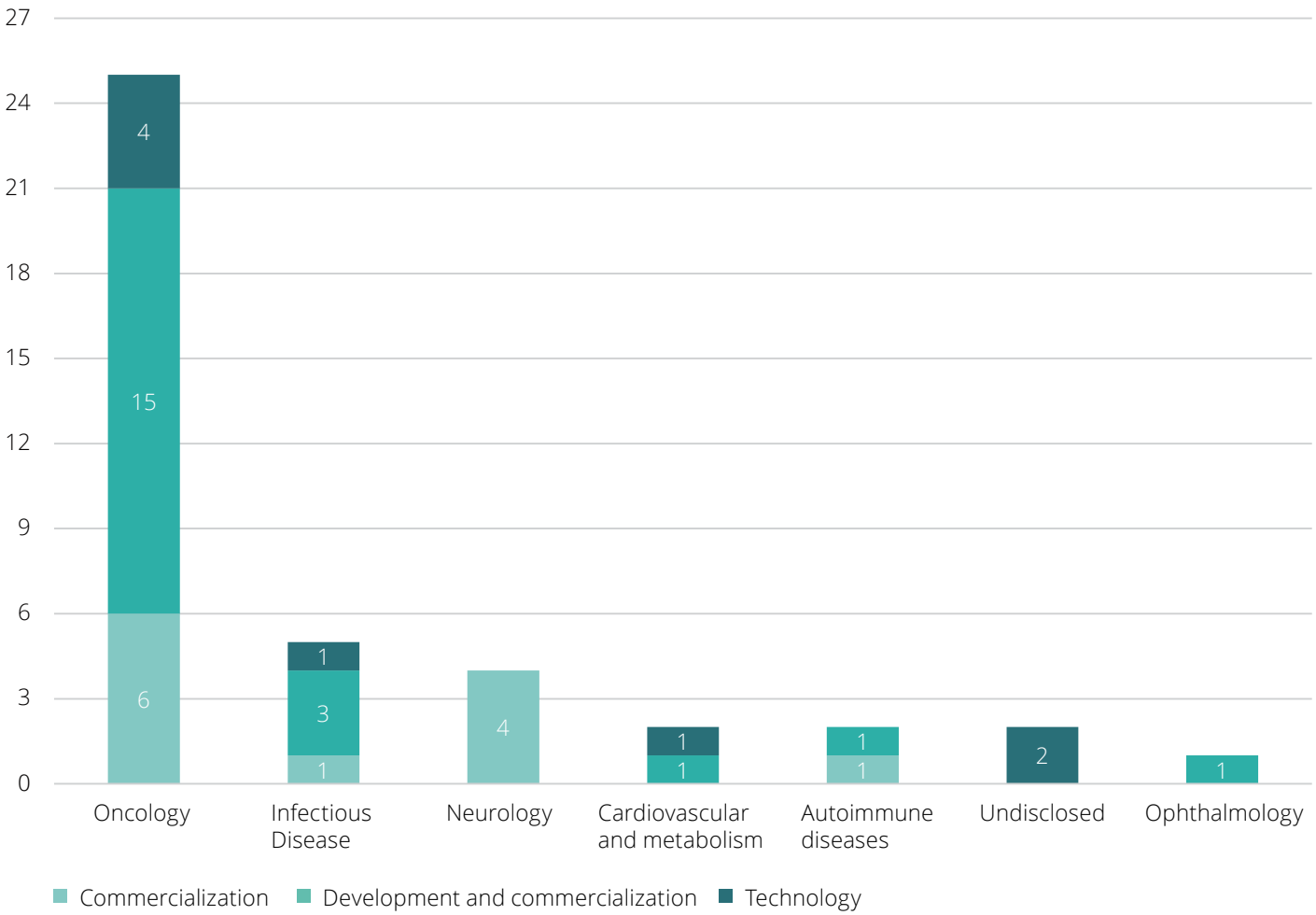
Introducer	Authorizer	Product	Disease area	Transaction amount
Innovent Biologics	Roche	Developing universal CAR-T therapy and TCT double-antibody, including glofitamab	Oncology	USD2 billion
Shanghai Junshi	Revitope Oncology	"Global new" T-cell chimeric activation cancer therapy with double-antibody as the target	Oncology	USD810 million
BeiGene	Assembly Biosciences	Vebicorvir; ABI-H2158; ABI-H3733	Hepatitis B virus	USD540 million
LianBio	BridgeBio Pharma	Infigratinib; BBP-398	Oncology	USD530 million
CStone Pharmaceuticals	LegoChem Biosciences	ABL202	Oncology	USD360 million
Huadong Medicine	ImmunoGen	Mirvetuximab Soravtansine	Oncology	USD310 million
Fosun Pharma	BioNTech	BNT162	COVID-19	USD300 million
Grand Pharma (China)	Telix Pharmaceuticals	TLX591; TLX250; TLX101; TLX591-CDx; TLX250-CDx; TLX599-CDx	Oncology	USD280 million
Zai Lab	Cullinan Oncology	CLN-081	Oncology	USD230 million
Inmagene Biopharmaceuticals	Affibody	ABY-035	Autoimmune diseases	USD230 million
3DMed	Aravive	AVB-500	Oncology	USD220 million
3DMed	SELLAS	Galimpepimut-S (GPS); GPS+	Oncology	USD210 million
BioNova Pharma	Cama Biosciences	AS-1769	Oncology	USD210 million
Apollomics	GlycoMimetics	Uproleselan; GMI-1687	Oncology	USD200 million
Zai Lab	Regeneron Pharmaceuticals	REGN1979	Oncology	USD190 million

Source: Pharcube.com, Cnpharm.com, curated by Deloitte

- **Out-license innovative medicine projects go global**
  With accumulated strengths and returned overseas talent, a growing number of domestic biopharma companies in China are specializing in independent R&D and innovative product development that can optimize their product pipelines. However, many of them are yet to set up sophisticated sales and marketing teamsand are unfamiliar with the overseas markets. To penetrate overseas markets, they often opt to work with foreign enterprises via out-licensing.

  Most of the out-licensing projects (25) in 2020 were in the oncology field (Figure 3.5), with more than half involving development and commercialization rights, primarily to avert risk at the early clinical stage and access to capital. The cooperation between Singlomics Biopharmaceuticals and BeiGene US showed that early-stage out-licensing is beneficial to local companies that are inclined to venture into the international market[55].

Figure 3.5 Diseases Covered by Chinese Biopharma Companies' Licensing-out Projects in 2020 (Unit：Number of Projects)



Source: Cnpharm.com, curated by Deloitte

In 2020, the cooperation between IMAB and AbbVie achieved the highest transaction value (USD3 billion) of any out-licensed project involving a domestic biopharma company. Of the 15 highest value projects, 12 involved oncology products. The highest value projects in innovative biologics, whether in China or in elsewhere, tend to target cancer treatments. Unlike in-licensed projects, however, out-license deals still focus on traditional biologics mainly, rather than new-generation treatments such as CGT[54, 55] (Table 3.3).

Table 3.3 The Top 15 Domestic Out-license Transactions by Value in 2020

Authorizer	Introducer	Product	Disease area	Transaction amount
IMAB	AbbVie	Lemzoparlimab (TJC4)	Oncology	USD3 billion
Innovent Biologics	Roche	Several double specific antibody and cell treatment products for hematologic tumor and solid tumor	Oncology	USD2.1 billion
CStone Pharmaceuticals	EQRx	Sugemalimab	Oncology	USD1.3 billion
Innovent Biologics	Eli Lilly	Sintilimab*	Oncology	USD1 billion
Jacobio Pharmaceuticals	AbbVie	JAB-3068; JAB-3312	Oncology	USD860 million
Henlius	Binacea Pharma	HLX-35	Oncology	USD760 million
Hua Medicine	Bayer	dorzagliatin	Diabetes	USD690 million
Oneness Biotech Microbio (Shanghai)	LEO Pharma A/S	FB825	Atopic dermatitis/ asthma	USD570 million
Fochon Pharmaceuticals	Eli Lilly & Co	FCN-338	Oncology	USD440 million
TransThera	LG Chem Ltd	TT-01025	Nonalcoholic steatosis heptitis	USD350 million
IMAB	Kalbe Farma	TJD	Oncology	USD340 million
Gen House Bio	HUYA Bioscience	HBI-2376	Oncology	USD280 million
Junshi Biosciences	Eli Lilly & Co	COVID-19 neutralizing antibody	Virus	USD250 million
Shanghai Origincell Biotech	Undisclosed	Double-antibody product	Oncology	USD140 million
Jiangsu Hengrui	Dong-A Pharma	SHR-1701	Oncology	USD140 million
Jiangsu Hengrui	HLF Life Science	Pyrotinib	Oncology	USD110 million

Source: Pharcube.com, Cnpharm.com, curated by Deloitte
Note: The cooperation between Innovent Biologics and Eli Lilly in Sintilimab began in 2015, and under the agreement, they jointly own the rights to develop and commercialize Sintilimab in China. Their cooperation aims to give Eli Lily the exclusive license outside China

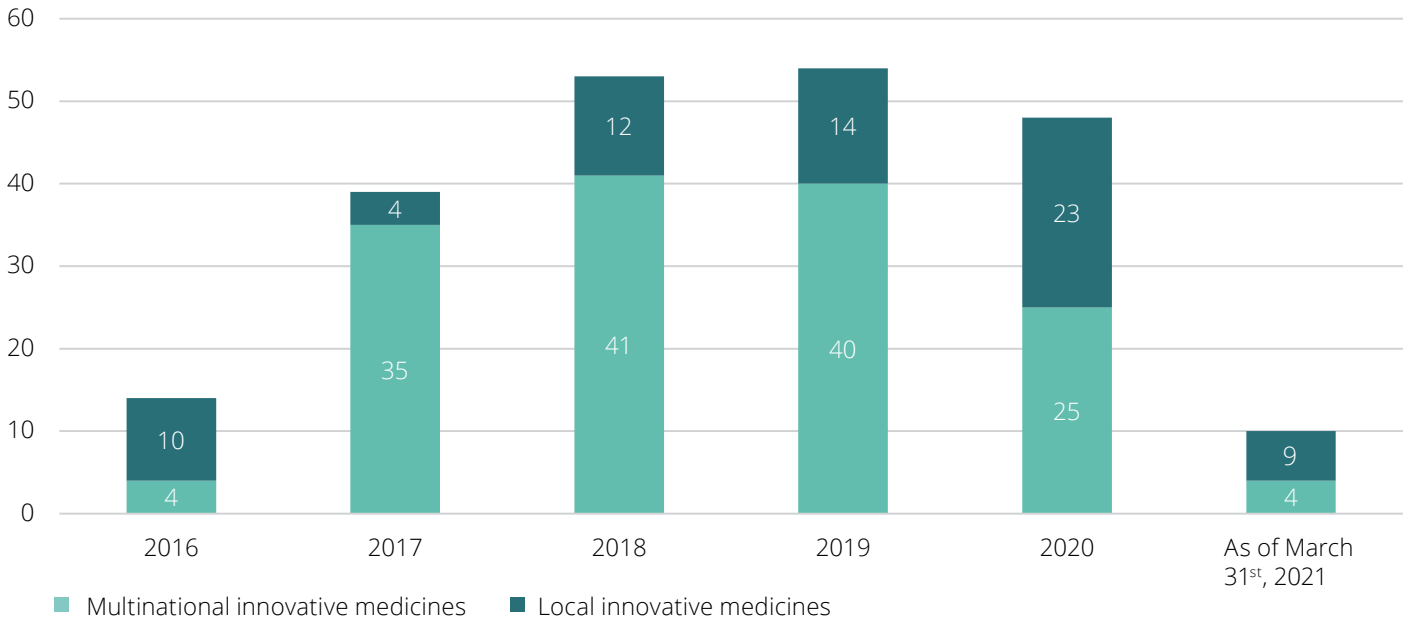
Launched products types: From universal innovation to leading innovation

As innovative biologics have become more highly valued, the innovation biologics type of domestic biopharma companies has shifted from me-too/ me-better to universal innovative (best-in-class) and innovative medicines with high value and urgent clinical demand (first-in-class). This indicates that requirements for innovative medicines have risen constantly. China's biopharma approval and evaluation system was reformed for the first time in 2015, the same year that the State Council first listed biopharma as a pillar industry. The most radical reform was in 2017 when the general offices of the CPC Central Committee and State Council released the *Opinions on Deepening the Reform of the Evaluation and Approval Systems and Encouraging Innovation on Drugs and Medical Devices*, promoting the alignment of China's biopharma industry with the rest of the world. After the release of a series of medical system reforms in 2020, innovative medicines have been set to reach a peak.

Since the *Opinions of the State Council on Reform of the System of Evaluation, Review and Approval of Drugs and Medical Devices* were released in August 2015, the number of innovative drugs approved in China, most of them from MNCs, has been growing. In 2020, COVID-19 prompted a decline in the number of innovative medicines approved, but domestic pharmaceutical companies and multinationals neared parity in approvals for the first time. As of 19 March 2021, domestic companies had outpaced multinationals in innovative medicine approvals (Figure 3.6)[56].

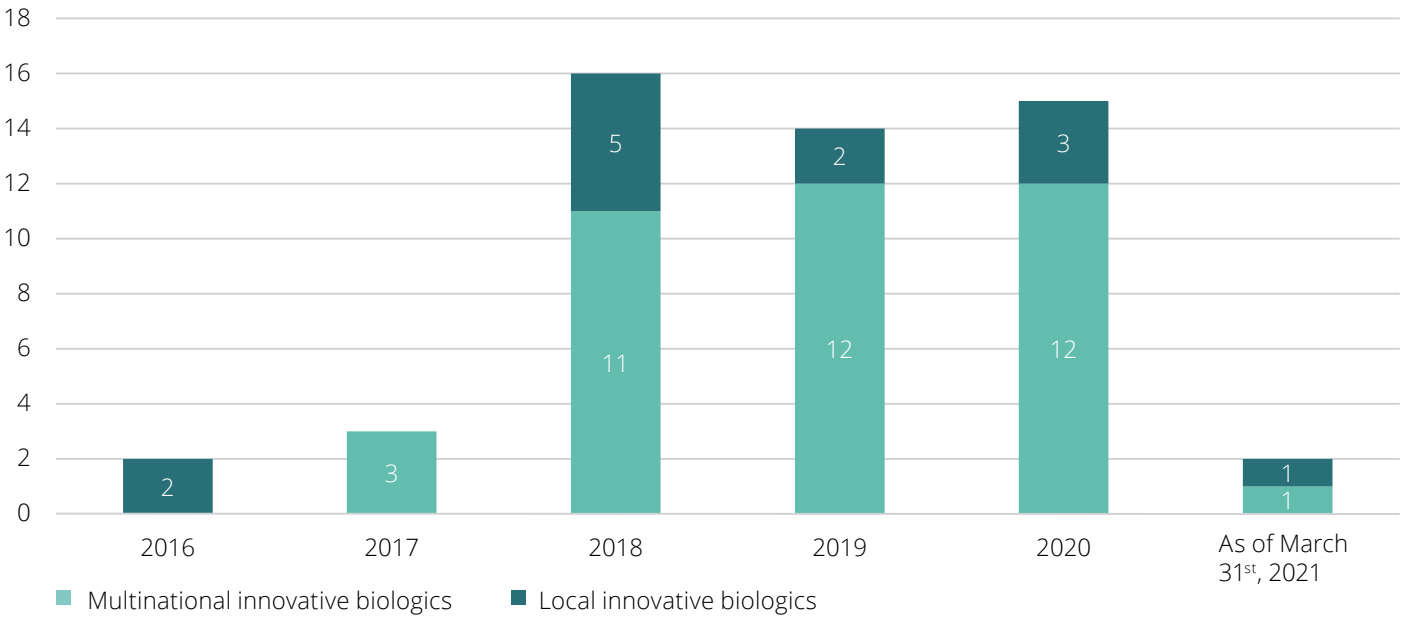
Nonetheless, available innovative biologics tend to be products from MNCs, pointing to the necessity of increasing investment in local R&D. Only few of the innovative medicines approved before 2018 were biologics (Figure 3.7), and most domestic innovative medicines were mainly chemicals. From 2018 to 2020, the number of approved innovative biologics has grown at a swift pace. However, these were predominantly from MNCs, with only 13 domestic products (Table 3.4)[56].

Figure 3.6 Innovative Medicines Approvals (2016-March 2021)



Source: Pharmcube.com, curated by Deloitte

Figure 3.7 Innovative Biologics Approvals (2016-March 2021)



Source: Pharcube.com, curated by Deloitte
Note: Excludes vaccine products

Table 3.4 Local Innovative Biologics Approved in China Since 2016

Drug	Commodity	Company	Approval	Indications
Telitacicept	Taiai	RemeGen	10 Mar 2021	Systematic Lupus Erythematosus
Idursulfase-beta	Hunterase	CANbridge	3 Sept 2020	Ramsay-Hunt syndrome
Inetetamab	Cipterbin	Sunshine Guojian	19 June 2020	Breast cancer
Recombinant Mycobacterium Tuberculosis Fusion Protein (EC)	Yika	Zhi Fei Biological	24 Apr 2020	Diagnosis of tubercle bacillus infection; clinical auxiliary diagnosis of tuberculosis patients
Tislelizumab	Baizean	BeiGene	27 Dec 2019	Classical Hodgkin lymphoma
Camrelizumab	AiRuiKa	Hengrui Medicine	30 May 2019	Classical Hodgkin lymphoma
Sintilimab	Tyvyt	Innovent Biologics	27 Dec 2018	Classical Hodgkin lymphoma
Toripalimab	TUOYI	Junshi Biosciences	17 Dec 2018	Melanoma
Recombinant Human Interferon Alfa 2b Injection	Paiyisheng	Kawin	6 July 2018	It is indicated for treatment of some viral diseases, such as acute and chronic viral hepatitis, herpes zoster and genital warts; it can also be used for treatment of some cancers, such as hairy cell leukemia, chronic myeloid leukemia, multiple myeloma, non-Hodgkin lymphoma, malignant melanoma, renal cell carcinoma, laryngeal papilloma, Sarcoma, ovarian cancer, basal cell carcinoma and superficial bladder cancer.
Mecapegfilgrastim Injection	Aiduo	Hengrui Medicine	17 May 2018	Reducing the rate of infection represented by febrile neutropenia for adult patients with non-myeloid malignant tumor
Recombinant Cytokine Gene Derived Protein Injection	Lefuneng	GENOVA	20 Apr 2018	Chronic hepatitis B
Beinaglutide Injection	Yishengtai	BENEMAE	13 Dec 2016	Type 2 Diabetes in Adults
Peginterferon Alfa-2b Injection	Paigebin	Amoytop Biotech	9 Sept 2016	Chronic hepatitis C

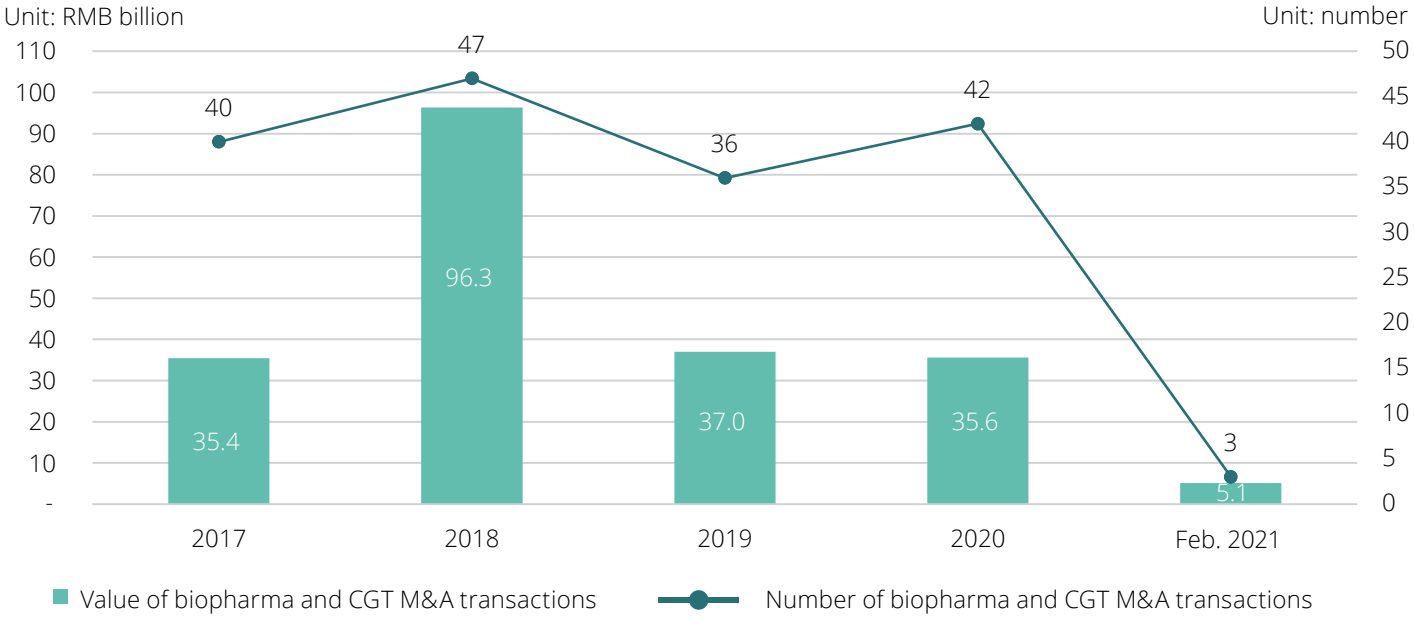
Source: Pharcube.com, curated by Deloitte Research

In 2020, MNCs continued to dominate innovative biologics approved for marketing in China. Dr. Ruilin Song of the China Pharmaceutical Innovation and Research Development Association expects China's biopharma industry to become a pioneering innovator in the next 10 to 15 years, with breakthroughs fueled by increased investment in basic research and the development of research talent to upgrade China from a strong pharmaceuticals manufacturer to a global powerhouse.

Investment and M&A are creating innovative biopharma portfolios

To keep up with the fast-developing biopharma industry in China, many domestic biopharma enterprises without the R&D capacity for innovative products are prioritizing investment and M&A to innovate their pipeline portfolios and diversify their development. In 2020, there were 42 biopharma and CGT M&A deals in China with a combined transaction value of RMB35.58 billion, with both volume and value increasing from 2019's levels, indicating a growth trend rather than a decline in biopharma deal activity, despite the impact of COVID-19. The main reasons for this growth were increased attention paid on healthcare amid the pandemic and China's rising status in the global biopharma market (Figure 3.8)[57].

Figure 3.8 The Trend of Biopharma and CGT M&As (2017-February 2021)



Source: Mergermarket, curated by Deloitte Research
Note: Transaction volume includes deals in which the value was not disclosed

The boom in China's biopharma market has also attracted the attention of businesses in other sectors, with several intra- and cross-industry deals in 2020. Among the top 10 investment and M&A transactions in 2020, two cross-industry deals brought new entrants into the biopharma sector, four intra-industry deals were motivated by business expansion, and four capital injections into biopharma enterprises by institutional investors sought to boost the commercialization of innovative biopharma products (Table 3.5)[57].

Table 3.5: The Top 10 Investment and M&A Transactions Related to Chinese Biopharma Enterprises in 2020

Announced	Target company	Bidder	Transaction value (RMB1 billion)	Transaction purpose
7 Dec 2020	Sinovac Life Sciences Co., Ltd.	Sino Biopharmaceutical Limited	3.4	Promoting commercialization of COVID-19 vaccines
30 May 2020	Zhejiang Jinhua Conba Bio-pharm. Co., Ltd.	Zhejiang Traditional Chinese Medicine & Health Industry Group Co., Ltd.	3.3	Building main platform for traditional Chinese medicine and health industry in Zhejiang Province
13 Oct 2020	Boya Biopharma Group Co., Ltd	China Resources Pharmaceutical Group Limited	2.6	Expanding blood product pipeline and developing the biopharma business segment
5 Sept 2020	North China Pharmaceutical Group Corporation	Jizhong Energy Resources Co., Ltd.	2.5	Expanding biopharma business segment
10 Sept 2020	Tonghua Dongbao Pharmaceutical Co., Ltd.	DCP	1.9	Investing in biopharma enterprises
10 Sept 2020	Hubei Changjiangxing Pharmaceutical Co., Ltd.	Kangyue Technology Co., Ltd.	1.9	Expanding biopharma business segment
1 Sept 2020	Shenzhen Salubris Pharmaceuticals Co., Ltd.	Carlyle Group	1.8	Investing in innovative medicine development and international commercialization
17 Nov 2020	D3 Bio, Inc.	WuXi AppTec and other investors	1.3	Investing in biopharma start-ups to develop innovative biopharma products
24 July 2020	Haihe Biopharma Co., Ltd.	Warburg Pincus	1.2	Accelerating global R&D and launch of numerous new anti-tumor drugs
18 Feb 2020	Hebei Daan Pharmaceutical Co., Ltd.	Lhasa Shengtai Company	1.1	Expanding blood product pipeline and biopharma business segment

Source: MergerMarket, curated by Deloitte Research

At the same time, many well-capitalized domestic biopharma companies in China have sought strategic cooperation with MNCs to innovate their product portfolios and expand their global businesses. Some domestic biopharma enterprises have also launched original products that attracted the attention of MNCs, signaling China's ascent to the top echelon of innovative biopharma industries (Table 3.6).

Table 3.6: Cases of Cooperation between Chinese Biopharma Companies and Multinational Pharmaceutical Companies

Announcement	Chinese biopharma co.	Multinational pharmaceutical co.	Nature of cooperation
28 Feb 2021	Junshi Biosciences	AstraZeneca	AstraZeneca obtained rights to Junshi Biosciences' Toripalimab Injection in non-core markets of the Chinese Mainland, and exclusive promotion rights in China related to UC indications to be approved subsequently for marketing. Junshi Biosciences retained control of Toripalimab in core markets of Chinese Mainland in relation to all approved indicators, except UC.
18 Aug 2020	Innovent Biologics	Eli Lilly	Innovent and Eli Lilly expanded cooperation on Sintilimab Injection developed by Innovent. Innovent granted Eli Lilly exclusive license of sintilimab outside China, and Eli Lilly will promote Sintilimab in North America, Europe and other regions.
21 May 2020	CanSinoBIO	Precision NanoSystems (PNI)	CanSinoBIO and PNI agreed to co-develop a COVID-19 vaccine based on mRNA-LNP leveraging PNI's proprietary RNA vaccine technology platform.
4 May 2020	Junshi Biosciences	Eli Lilly	Junshi Biosciences and Eli Lilly will co-develop and commercialize SARS-CoV-2 neutralizing antibodies (Junshi SARS-CoV-2 Antibodies). Eli Lilly granted exclusive license to develop, manufacture and sell Junshi SARS-CoV-2 antibodies outside Greater China.

Source: Public data, curated by Deloitte Research

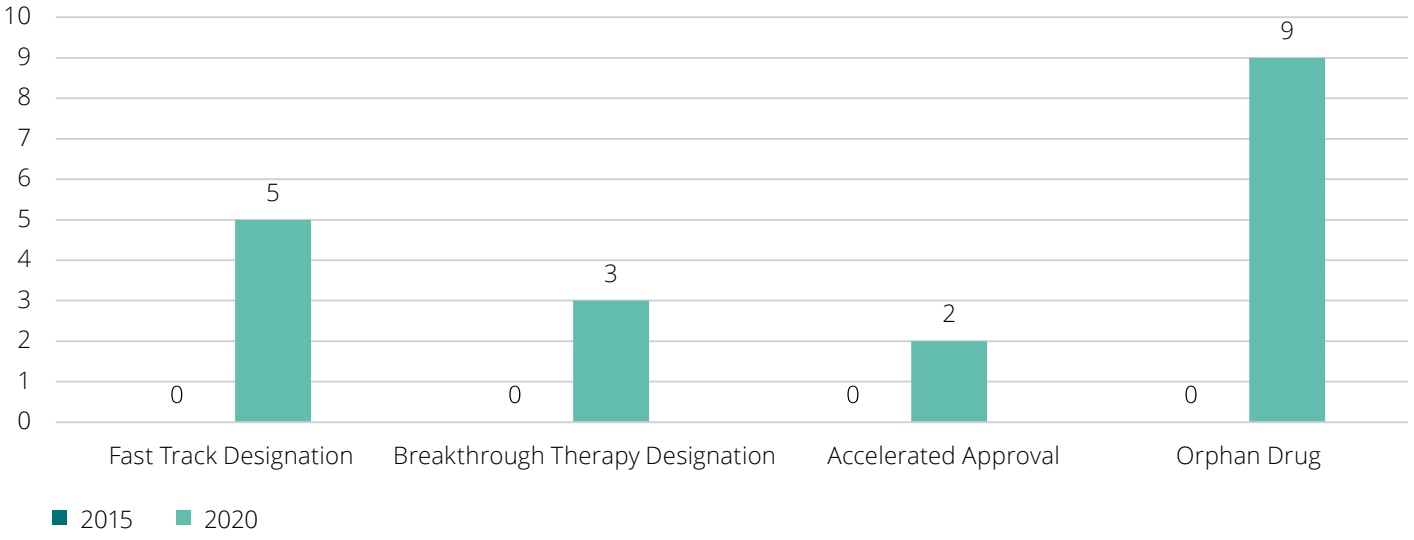
From "Importing to China" to "Exported from China"

As China's domestic R&D capacity has become stronger, more domestic pharmaceutical companies are expanding globally and offering independently developed products, leading the industry's transformation from generics-oriented development to a new model focused on high-quality, original products, and driving the market away from me-too/me-better towards first-in-class. According to Building China's Pharmaceutical Innovation Ecosystem, the average annual R&D input of China's listed innovative biopharma companies has exceeded RMB1 billion.

During the COVID-19 pandemic, domestic biopharma companies also demonstrated their innovative power to the world — developing a range of COVID-19 vaccines and supplying these to many countries, which helped to effectively alleviate the spread of the pandemic and win global recognition. In addition, many innovative products from Chinese biopharma companies have been granted qualifications in the US (Figure 3.9; Table 3.7)[28], proving R&D and innovation power of domestic biopharma companies to the world. Zanubrutinib, an innovative drug developed by China's BeiGene, was approved for marketing by the FDA in 2019, marking the first launch of an innovative medicine from China in the world's pharmaceuticals powerhouse.

In the next five years, more innovative biopharma products from domestic companies will be approved for marketing across the world. Ingrid Zhang from Novartis Pharmaceuticals China notes that with the expanding biopharma market in China, many pharmaceuticals MNCs have come to understand the uniqueness of the Chinese market, and will start to prioritize demand and seek to meet the needs of domestic patients in China.

Figure 3.9: Number of Special Qualifications Granted to the Innovative Biologics of Chinese Pharmaceutical Companies in the US (2015 vs. 2020)

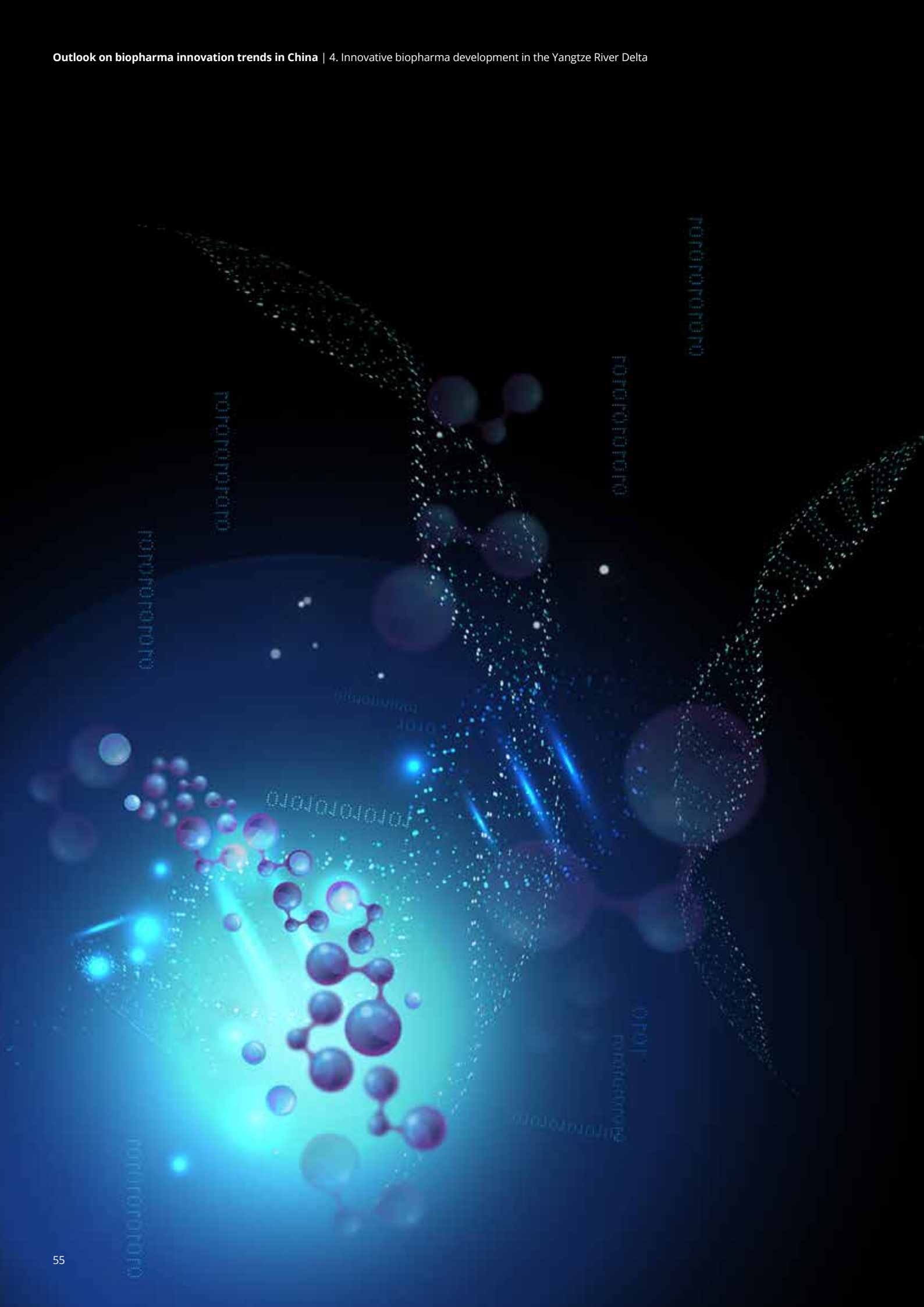


Source: PhIRDA & RDPAC, *Building China's Pharmaceutical Innovation Ecosystem-Part One of the Series Research Reports: 2015-2020 Development Review and Future Prospects*

Table 3.7 China's Innovative Biologics Going Global

Innovative products (commodity)	Chinese biopharma co	Cases of going global
Toripalimab Injection (TUOYI)	Junshi Biosciences	• On 1 February 2021, Junshi Biosciences announced a strategic cooperation with Coherus BioSciences on the development and commercialization of the Toripalimab injection developed by Junshi Biosciences in the US and Canada. Junshi Biosciences will grant Coherus the license for Toripalimab and two optional projects (if executed), and receive up to an aggregate of USD1.11 billion in an upfront payment, and exercise fee and milestone payments from Coherus. • Toripalimab has been granted a Breakthrough Therapy Designation by the FDA for the treatment of nasopharyngeal carcinoma. Junshi Biosciences is expected to submit the first application for approval of biological product for this indication to the FDA in 2021. The FDA also granted Toripalimab a Fast Track Designation (mucosal melanoma) and Orphan Drug Designation (mucosal melanoma, nasopharyngeal carcinoma and soft tissue sarcoma).
Tislelizumab Injection (Baizean)	BeiGene	• On 11 January 2021, BeiGene announced a strategic partnership with Novartis, granting Novartis the right to develop, produce and commercialize Tislelizumab in the US, Canada, Mexico, EU Member States, UK, Norway, Switzerland, Iceland, Liechtenstein, Russia and Japan. The upfront payment could be as high as USD650 million, and the total transaction value is more than USD2.2 billion, the largest sum related to the external authorization of a single drug in China.
Sugemalimab	CStone Pharmaceuticals	• On 22 October 2020, Cstone Pharmaceuticals announced that the FDA had granted a Breakthrough Therapy Designation to Sugemalimab for the treatment of adult patients with relapsed or refractory extranodal natural killer/T-cell lymphoma (R/R ENKTL), making this the first domestic PD-L1 product granted a Breakthrough Therapy Designation by the FDA. • In the same month, the FDA also granted an Orphan Drug Designation to Sugemalimab. Cstone Pharmaceuticals said that the development and commercialization of Sugemalimab in the US will be accelerated thanks to the two designations.
Multiple products such as bispecific antibodies and cell therapies	Innovent Biologics	• On 9 June 2020, Innovent Biologics and Roche announced strategic research and development collaboration to discover and develop bispecific antibodies and immune cell therapies. The milestone payments are estimated at USD1.96 billion. This is also a technical platform collaboration between Roche and a local Chinese biopharma company, covering a range of preclinical research products, primarily for cancer.

Source: Public data, curated by Deloitte Research



4. Innovative biopharma development in the Yangtze River Delta

Given the promising prospects for China's biopharma industry, every region of the country is promoting its development, and the Yangtze River Delta is in a leading position.

Many domestic innovative biopharma enterprises and biopharma MNCs are building R&D centers in the region. In 2020, there were 136,000 biopharma-related enterprises newly registered in the Yangtze River Delta, with an annual increase of 30.6%[58]. A sequence of far-reaching national and provincial policies has created a promising blueprint for biopharma innovation in the region. The value of biopharma production in Shanghai reached RMB383.3 billion in 2019. In 2020, the value of biopharma production in Jiangsu Province was estimated to exceed RMB600 billion, Zhejiang planned to achieve RMB215 billion in industrial production, and Anhui expected the main business income of the pharmaceutical industry to reach RMB200 billion[58].

All the thought leaders from China's biopharma industry that we interviewed said the Yangtze River Delta has considerable advantages in biopharma development, including a huge talent pool, multiple universities, and a favorable location.

At the first China International Import Expo on 5 November 2018, President Xi Jinping elevated the integrated development of the Yangtze River Delta to a national strategy. With its developed economy, high degree of openness and strong innovation capacity, the region will benefit greatly from further integration to leverage complementary advantages and realize the sustainable growth.

Kenneth Sun from Morgan Stanley Asia-Pacific said the Yangtze River Delta's biopharma sector has two main competitive advantages, continuous policy support from the government agencies and strong capital advantages. Powered by the government and enterprise, innovation and reform in this region's biopharma market is only set to accelerate.

Policy support: National and provincial policies promote regional integration

As a leading region in China's economic development, the Yangtze River Delta has always had demonstrative significance, and its innovative development has been a focus of the national and provincial governments. Biopharma, being one of China's key innovation and development industries, has benefitted from a range of supportive policies introduced by national and provincial agencies to promote its development and advancement in the Yangtze River Delta.

Deloitte collated policies related to innovative biopharma industry development in the Yangtze River Delta introduced over the past five years (Figure 4.1, Table 4.1) to establish a four-stage process of the integrated development – independent development by different provinces, exploration of inter-provincial cooperation, the rapid development of inter-provincial cooperation, and Yangtze River Delta integration takes off.

- **Independent development by different provinces:** Shanghai Municipality, Zhejiang, Jiangsu, and Anhui provinces strived to promote the continuous development of the biopharma industry, and constantly strengthened the requirements for the innovation capacity of local biopharma enterprises. However, this effort promoted internal development alone and had no external influence.
- **Exploration of inter-provincial cooperation:** From about 2019, Shanghai, Zhejiang, Jiangsu, and Anhui no longer confined the innovative biopharma development to their own locales and began to explore the expansion of industrial development policies to nearby provinces and cities. This marked the start of the exploration period for inter-provincial cooperation, which emphasized "high-quality", "refined" development and created sub-categories of regional biopharma development.
- **Rapid development of inter-provincial cooperation:** In December 2019, the Communist Party of China Central Committee and the State Council issued the *Outline of Integrated Development of the Yangtze River Delta*, which set out strategic plans for the region's integrated development. Around the same time, provincial governments began to cooperate for biopharma industry development, launching a series of polices to promote this across the Yangtze River Delta and ushering in a period of rapid development.
- **Yangtze River Delta integration takes off:** In December 2020, the Ministry of Science and Technology issued the *Yangtze River Delta Science and Technology Innovation Community Construction and Development Plan*, which once again elevated the significance of the region's integrated innovative development. It puts forward further requirements for breakthroughs in science and technology, aims to enhance the leading role of Shanghai as an innovation center, and seeks to strengthen the innovation advantages of Jiangsu, Zhejiang, and Anhui, making the Yangtze River Delta a national and even international pioneer in biopharma innovation. At the Fourth Session of the 13th National People's Congress in March 2021, Premier Li Keqiang highlighted that the *Government Work Report* established biopharma industry innovation and reform as a policy priority. These national policies illustrate the government's continuous emphasis on the integrated development of the Yangtze River Delta and industrial innovation.

Figure 4.1: The Trajectory of Integrated Development of the Biopharma Industry in the Yangtze River Delta and Some Representative Policies

Independent development by different provinces

The provinces and cities in the Yangtze River Delta mainly focused on the promotion and development of biopharma within their own territories, and policies were limited to their own regions.

Shanghai

- General Office of Shanghai Municipal People's Government issued the *Action Plan to Promote the High-quality Development of the Biopharma Industry in Shanghai (2018-2020).*

Jiangsu

- Jiangsu Provincial People's Government issued the *Opinions of the Provincial Government on Promoting the High-quality Development of the Biopharma Industry.*
- *Several Measures for Accelerating the High-quality Development of the Biopharma Industry in Suzhou*.

Exploration of inter-provincial cooperation

Provinces and cities in the region began to actively drive innovative biopharma development and started to try inter-provincial cooperation to promote this.

- Medical products administrations of Shanghai, Jiangsu, Zhejiang, and Anhui jointly issued the *Implementation Plan for the Pilot of Medical Device Registrant System in the Yangtze River Delta.*
- Zhejiang Provincial Development and Reform Commission issued *Action Plan for Bioeconomy Development in Zhejiang Province (2019-2022).*
- **Communist Party of China Central Committee and the State Council jointly issued the Outline of Integrated Development of Yangtze River Delta.**

Rapid development of inter-provincial cooperation

After the State Council issued the Outline of Integrated Development of the Yangtze River Delta, biopharma innovation and cooperation in the region accelerated rapidly.

- People's governments of Shanghai, Jiangsu, and Zhejiang issued *Several Policies and Measures for Supporting the High-quality Development in the Yangtze River Delta Integrated Ecological and Green Development Demonstration Zone.*
- **The Ministry of Science and Technology issued the Yangtze River Delta Science and Technology Innovation Community Construction and Development Plan.**

Yangtze River Delta integration takes off

At the 4th Session of the 13th National People's Congress in March 2021, Premier Keqiang LI stressed the significance of innovative development of the biopharma industry in the Yangtze River Delta, marking its official take-off.

Source: Official websites of Shanghai Municipal People's Government, People's Government of Zhejiang Province, Jiangsu Provincial People's Government and People's Government of Zhejiang Province, curated by Deloitte Research

Table 4.1 Policies Supporting Innovative Development of Biopharma Industry in the Yangtze River Delta

Region	Level	Policy
Shanghai	Provincial	Action Plan for Biopharma Industry Development in Shanghai (2014-2017)
		Implementation Opinions of the General Office of Shanghai Municipal People's Government on Promoting the Healthy Development of the Biopharma Industry in Shanghai
		Measures of Shanghai Municipality on the Administration of Special Funds for Promoting High-quality Industrial Development (Interim)
		Implementation Plan for Promoting the Characteristic Development of Biopharma Industrial Park
		Action Plan to Promote the High-quality Development of the Biopharma Industry in Shanghai (2018-2020)
	District	Opinions of Minhang District on Special Policies for Accelerating the Development of Biopharma Industry
		Action Plan to Promote the High-quality Development of the Biopharma Industry in Qingpu District (2019-2020)
		Three-year Action Plan to Promote the High-quality Development of the Biopharma Industry in Jinshan District (2019-2021)
		Several Policies for Promoting the High-quality Development of the Healthcare Industry in Fengxian District of Shanghai
		Several Measures for the Concentrated Development of Biopharma Industry in Lin-gang Special Area of China (Shanghai) Pilot Free Trade Zone
Zhejiang	Provincial	Action Plan for Bioeconomy Development in Zhejiang Province (2019-2022)
		Several Opinions on Promoting the High-quality Development of Pharmaceutical Industry in Zhejiang Province
	Municipal	Implementation Opinions on Promoting the Innovative Development of the Biopharma Industry in Hangzhou
		Measures for Promoting Investment Attraction for Biopharma Industry in Jinhua Economic & Technological Development Zone (for Trial Implementation)
		Opinions of the General Office of the People's Government of Ningbo Municipality on Accelerating the Development of Biopharma Industry
		Plan of Jinhua for Biopharma Industry Talents (2018-2022)
		Biopharma Industry Cultivation Plan of Jinhua (2019-2021)
		Measures for Health Bio-industrial Park Project Access in Jinhua
Jiangsu	Provincial	Opinions of the Provincial Government on Promoting the High-quality Development of the Biopharma Industry
	Municipal	Several Measures for Accelerating the High-quality Development of the Biopharma Industry in Suzhou
		Several Measures for Accelerating the Development of the Modern Biopharma Industry in Wuxi
	District	Several Policies for Accelerating the High-quality Development of the Biopharma Industry in Jiangning District of Nanjing
		Opinions of Taizhou Medical New & Hi-tech Industrial Development Zone on Promoting the High-quality Development of the Big Health Industry
		Policies for Promoting the Development of Biopharma Industry in Nanjing Jiangbei New Area
Anhui	Provincial	Notice of the People's Government of Anhui Province on Issuing Several Policies for Supporting the Development of Modern Medical and Pharmaceutical Industry
	Municipal	Notice of Bozhou Municipal People's Government on Issuing Several Policies for Supporting Medical Products Research and Development, Production and Operation
		Disclosure of Information Concerning the Fund Arrangement Plan for Policy Supporting Items of the Promotion of "Major Emerging Industrial Bases, Major Emerging Industrial Projects, Special Projects for Major Emerging Industries, and Innovative Modern Industrial System" and the Development of Modern Medical and Pharmaceutical Industry in Bozhou in 2020
	County	Plan for the Utilization of Special Guiding Fund for Concentrated Development Base of Modern Pharmaceutical Industry in Taihe County

Source: Official websites of Shanghai Municipal People's Government, People's Government of Zhejiang Province, Jiangsu Provincial People's Government and People's Government of Anhui Province, and Deloitte Research

Medical product inspection authorities in the Yangtze River Delta are also providing more support for the launch of innovative biopharma products, while provincial government authorities are cooperating to optimize the product launch process. On 22 December 2020, the National Medical Products Administration established two evaluation and inspection sub-centers in Shanghai, one for medical products and the other for medical devices. These sub-centers have shortened the period of administrative review, reduced the costs of enterprises, and improved the commercialization of achievements in biopharma innovation and R&D for the high-quality development of biopharma in the Yangtze River Delta[59].

Talent accumulation: Top industrial talent is being brought in to accelerate scientific innovation and reform

Biopharma development in the Yangtze River Delta is diverse, with each part of the region having its own advantages (Figure 4.2). This diverse industry layout is attractive to biopharma talent and governments are supporting talent introduction. At a forum on integrated HR development in December 2020, two suggestions were put forward to boost the introduction of international and domestic biopharma industry talent in the Yangtze River Delta[60]:

- Promote practical cooperation on talent projects and talent development through a school-enterprise model
- Support biopharma start-ups and create a favorable corporate and regulatory environment to enable talent to thrive

In September 2020, the Executive Committee of the Yangtze River Delta Integrated Ecological and Green Development Demonstration Zone, in conjunction with overseas science and technology experts in Shanghai, Jiangsu, and Zhejiang issued the *Implementation Plan for Mutual Recognition of Work Permits of Foreign High-end Talent,* aiming to facilitate more open talent cooperation mechanism and boost high-quality development[61].

Dr. Guoliang Yu from Innoforce Pharmaceuticals noted that China's biopharma industry has previously faced an acute shortage of production talent. As China-US trade tensions have intensified, numerous senior technical personnel and researchers, including production talent having left their jobs at biopharma enterprises in the US to return home, providing a huge boost to biopharma production technology and injecting new vitality into biopharma innovation in China.

Figure 4.2 Local Distinctiveness of Biopharma Industry in Yangtze River Delta

Source: China.org.cn, *Suggestions and Strategies for the Coordinated and Innovative Development of Biopharma Industrial Clusters in the Yangtze River Delta*

Capital strength: Substantial capital support is being provided to enable innovative corporate development in the Yangtze River Delta

Governments in the Yangtze River Delta are also providing capital support to biopharma enterprises within their jurisdiction. The support includes subsidies for R&D, financial assistance through cooperation with third parties, and financial incentives to attract biopharma enterprises and talent.

Deloitte's research found that local governments in the Yangtze River Delta provide financial support for the R&D and the launch of innovative medicines, and many of them are also subsidizing the settlement of innovative R&D centers (Table 4.2). More financial support is expected to pour in to fill existing gaps.

Table 4.2 Capital Support Policies for the Development of Biopharma Industry in the Yangtze River Delta

Official document	Issuer	Type of project with capital support				
		Investment in innovative biopharma R&D	Launch of innovative biopharma products	Establishment of biopharma R&D centers	Implementation of biopharma manufacturing	Introduction of biopharma talents
Action Plan to Promote the High-quality Development of the Biopharma Industry in Shanghai (2018-2020)	Shanghai Municipal People's Government	✓	✓		✓	
Several Policies for Supporting the Development of Modern Medical and Pharmaceutical Industry	Anhui Provincial People's Government	✓	✓	✓	✓	
Implementation Opinions of the General Office of Hangzhou Municipal Government on Promoting the Innovative Development of the Biopharma Industry in Hangzhou	Hangzhou Municipal People's Government	✓	✓	✓	✓	
Opinions of the General Office of the People's Government of Ningbo Municipality on Accelerating the Development of Biopharma Industry	Ningbo Municipal People's Government	✓	✓	✓		
Several Measures for Accelerating the High-quality Development of the Biopharma Industry in Suzhou	Suzhou Municipal People's Government	✓	✓	✓	✓	✓
Several Measures for Accelerating the Development of the Modern Biopharma Industry in Wuxi	Wuxi Municipal People's Government	✓	✓	✓	✓	
Several Policies for the Development of Biopharma Industry	Xuzhou Municipal People's Government	✓	✓		✓	

Source: Published on the official websites of local governments, curated by Deloitte Research

In addition to government financial support, biopharma enterprises in the Yangtze River Delta received substantial sums in private capital from PE and VC firms and IPOs. Since 2017, of the 42 pre-profit Chinese biopharma enterprises that listed on NASDAQ, the SSE STAR Market, and HKEX, 27 (64%) are based in the Yangtze River Delta, highlighting the prowess of the region's biopharma industry (Table 4.3)[62].

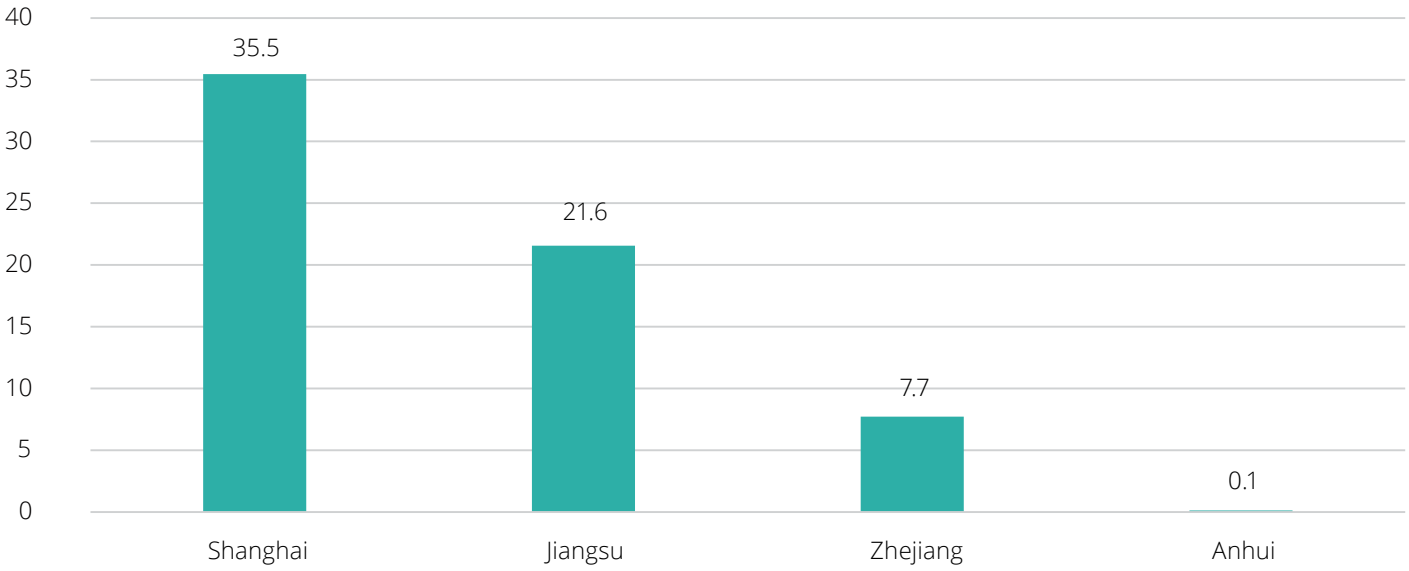
Table 4.3 Biopharma Enterprises in Yangtze River Delta Listed without a Record of Profitability

Company	Market	Time of listing	Pipeline and segment	Province
BeyondSpring	NASDAQ	9 Mar 2017	Cancer immunotherapy	Anhui
Zai Lab	NASDAQ	20 Sept 2017	Medicines for cancer, autoimmune and infectious diseases	Shanghai
	HKEX	28 Sept 2020		
Ascletis	HKEX	1 Aug 2018	Anti-viral drugs	Zhejiang
Hua Medicine	HKEX	14 Sept 2018	Diabetes	Shanghai
Innovent	HKEX	31 Oct 2018	Bio-pharmaceuticals for the treatment of cancer	Jiangsu
Junshi Biosciences	HKEX	24 Dec 2018	Medicines for cancer, chronic, autoimmune, nervous system and infectious diseases	Shanghai
	SSE STAR Market	15 July 2020		
CStone Pharmaceuticals	HKEX	26 Feb 2019	Bio-pharmaceuticals for the treatment of cancer	Jiangsu
Mabpharm	HKEX	31 May 2019	New antibody drugs, biosimilars	Shanghai/ Jiangsu
Henlius	HKEX	25 Sept 2019	Biosimilars, innovative bio-pharmaceuticals	Shanghai
Ascentage Pharma	HKEX	28 Oct 2019	Small molecule drugs for the treatment of cancer	Jiangsu
TOT BIOPHARM	HKEX	8 Nov 2019	Medicines for the treatment of cancer	Jiangsu
Alphamab Oncology	HKEX	12 Dec 2019	Bio-pharmaceuticals	Jiangsu
I-Mab Biopharma	NASDAQ	17 Jan 2020	Cancer immunotherapy	Shanghai
Zelgen	SSE STAR Market	23 Jan 2020	Treatment for cancer, hemorrhage and hematological diseases, hepatobiliary diseases and immune inflammation	Jiangsu
Kintor	HKEX	22 May 2020	Drugs for cancer and other AR-related diseases	Jiangsu
Legend Biotech	NASDAQ	5 June 2020	Drugs for cancer and infectious diseases	Jiangsu
OcuMension	HKEX	10 July 2020	Ophthalmic therapies	Jiangsu
Genor Biopharma	HKEX	7 Oct 2020	Cancer immunotherapy	Shanghai
Everest Medicines	HKEX	9 Oct 2020	Drugs for oncology, internal, cardiorenal and infectious diseases	Zhejiang
Frontier	SSE STAR Market	28 Oct 2020	Long-acting polypeptide drugs	Jiangsu
JW Therapeutics	HKEX	3 Nov 2020	Immunotherapies for hematological cancers and solid tumors	Shanghai
Antengene	HKEX	20 Nov 2020	Anti-cancer drugs	Shanghai
Allist	SSE STAR Market	2 Dec 2020	Anti-cancer drugs	Shanghai
Harbour BioMed	HKEX	10 Dec 2020	Cancer immunotherapy	Shanghai
Gracell Biotechnologies	NASDAQ	8 Jan 2021	Breakthrough cell therapies	Jiangsu
Adagene	NASDAQ	9 Feb 2021	Cancer immunotherapy and targeted therapy	Jiangsu
Connect Biopharma	NASDAQ	19 Mar 2021	Inflammatory immunological diseases	Jiangsu

Source: Wind and official websites of the enterprises, curated by Deloitte Research

From January 2018 to March 2021, there were 171 investment and financing transactions with a combined value of RMB63.9 billion involving biopharma enterprises from the Yangtze River Delta (Figure 4.3)[61]. The distribution of these transactions reflects 2019's *Outline of Integrated Development of the Yangtze River Delta*, with Shanghai playing a leading role and Jiangsu, Zhejiang, and Anhui provinces leveraging their respective advantages.

Figure 4.3 Investment and Financing Transactions Involving Biopharma Enterprises in the Yangtze River Delta from 2018 to March 2021 (Unit: RMB billion)



Source: Wind, statistics conducted by Deloitte

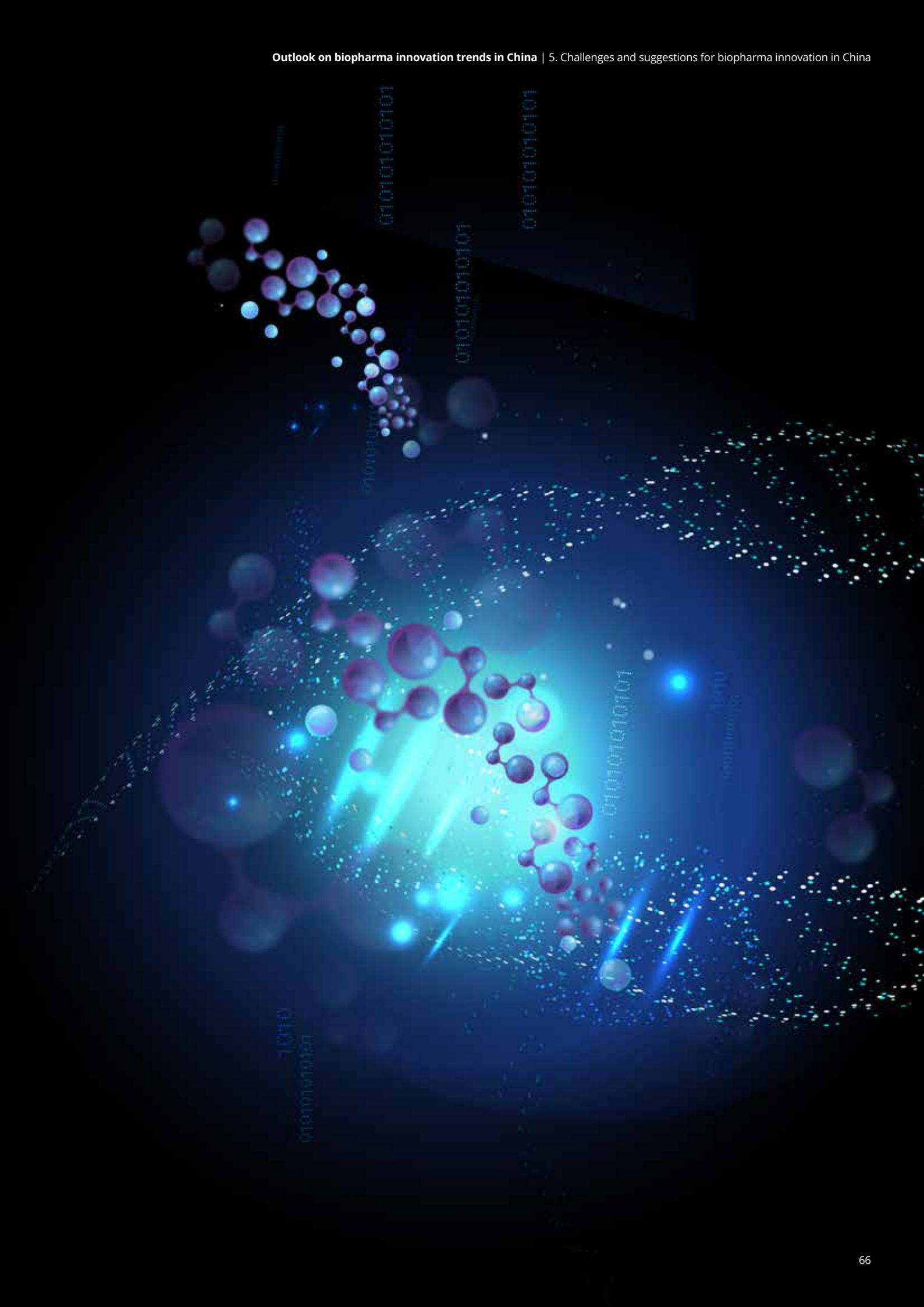
Deloitte's horizontal comparison of China's three major integrated development regions shows that the Yangtze River Delta has leading advantages when it comes to positioning its biopharma industry at a global level, mainly thanks to its complete pharmaceutical industry chain comprising a rich, diverse range of life sciences and healthcare enterprises (Table 4.4). However, the comparison also reveals some areas of homogeneous innovation, which could challenge Yangtze River Delta biopharma innovation in future[63].

Table 4.4: Comparison among Yangtze River Delta, Beijing-Tianjin-Hebei Region and Guangdong-Hong Kong-Macao Greater Bay Area in Terms of Biopharma Industry Development

	Yangtze River Delta [59 60 61 63]	Beijing-Tianjin-Hebei [64 65]	Guangdong-Hong Kong-Macao GBA [66 67 68]
Priority	• Building a Shanghai-led pattern, driving the increase of innovation advantages of Jiangsu, Zhejiang, and Anhui provinces.	• Building a regional pattern with Beijing as the industry axis, and Tianjin and Hebei developing in a coordinated manner.	• Building GZ-SZ-HK and GZ-Zhuhai-Macau biopharma sci-tech innovation clusters with Guangzhou and Shenzhen at their core and based on the existing resources and expertise in Hong Kong and Macao.
Strength	• Has the most diverse development of any region, with each city having its own unique characteristics, from biopharma and medical devices, to chemical medicines and traditional Chinese medicine. • Home to numerous enterprises in life sciences and healthcare across the entire industrial chain, which brings comparative advantages in innovation and industry integration. • With more biopharma talents, especially high-end overseas returnees, the accumulation of talents will contribute to more cutting-edge international innovation.	• Took the lead in regional integration development. Beijing, as the political center of China, has won the strongest policy support for the biopharma industry in Beijing-Tianjin-Hebei. • Beijing-Tianjin-Hebei has several national medical institutions; compared with the other regions, it has more advantages in cooperative development involving government, enterprises, and medical institutions, and its examination and approval system; the integration of infrastructure is relatively complete.	• Hong Kong and Macao have quite clear, well-established markets, and development within the Guangdong-Hong Kong-Macao GBA has fewer overlaps than the other two regions, which is conducive to direct cooperation with an appropriate division of labor and reducing internal competition. • As favorable policies are introduced and many small biopharma enterprises settle in the region successively, the GBA has strong prospects.
Weaknesses	• The product innovation types are highly overlapped in the Yangtze River Delta, leading to homogenization. Internal competition will become a barrier to integrated development in the future. • Compared with Beijing-Tianjin-Hebei, the region needs to keep reforming and innovating its examination and approval system to continuously improve the commercialization rate of achievements by life sciences and healthcare enterprises. • Facing the high cost of talent, how to retain talent and avoid outflows is a problem to be addressed.	• Regional resources are unevenly distributed with most concentrated in Beijing. This has partially inhibited the development of Tianjin and Hebei. • Flow within the region still needs to be strengthened, and it is necessary to further plan and optimize the introduction and distribution of human resources.	• Talent acquisition is a key challenge for biopharma industry development in this region. Local governments and enterprises need to plan to attract and develop talent. • Compared with the Yangtze River Delta and Beijing-Tianjin-Hebei Region, the region faces a gap in the industrial chain, which requires further improvement. Imbalanced enterprise types lead to the absence of certain types of biopharma enterprises, such as CRO and CDMO.
Future development	• Rich industrial chains bring more possibilities for development. • The focus will be on integrated development, as well as industrial deepening and institutional reform taking reference from international standards. • As a hub for high-end biopharma talent in China, controlling talent cost and the development environment will be the key.	• The focus should be on removing regional barriers, rationally planning the industry layout, and actively coordinating connections between different areas. • In terms of talent attraction, the environment of the Yangtze River Delta can be used as a reference to reinforce talent attraction and long-term maintenance using appealing policies and solid resources.	• Should focus on removing barriers in its administrative system and advancing diversification. • Should introduce more types of enterprises and diverse talent to the biopharma industry to catch up with the Yangtze River Delta and Beijing-Tianjin-Hebei in development.

Source: Public data, curated by Deloitte Research

The Yangtze River Delta's biopharma industry will inevitably face challenges, and its weaknesses in innovative development are consistent with those across China. More importance should be given to investing in basic research and commercialization, and further progress should be made in attracting and developing well-rounded talent.



5. Challenges and Suggestions for biopharma innovation in China

China's biopharma industry has seen dramatic development in recent years. Global and domestic biopharma companies are expanding their footprints in the country, while cross-sectoral players are swarming into the industry. Government agencies are working with the biopharma innovation ecosystem to create a conducive environment for the innovative development of domestic biopharma enterprises, showing their commitment to transform China from a great generics manufacturer into a pharmaceuticals innovator, and even a global pharmaceuticals powerhouse, in the coming years. Meanwhile, the Yangtze River Delta, with its booming biopharma sector, not only exports innovation to national biopharma enterprises, but also connects Chinese enterprises with innovative biopharma development across the world.

More innovative cooperation between China and the rest of the world is expected to generate continuous breakthroughs and propel the global biopharma industry to a higher level.

Factors driving innovation in China's biopharma industry

- **Policy and system reforms strengthen innovative R&D and accelerate commercialization:** Government policies and regulatory reform can drive the innovative development of China's biopharma industry, guiding its transformation towards innovative R&D and opening multiple channels of support for the commercialization of innovative products.
- **Capital continues to flow into the biopharma industry:** Capital continues to flow into the biopharma industry and investment by government and enterprises is increasing. In addition, Chapter 18A of the HKEX listing regime, and new systems on the SSE STAR Market and NASDAQ have created more financing channels for pre-profit biopharma enterprises in China.
- **Digital technologies shorten the R&D cycle:** The flexible application of digital technology is addressing the historical bugbear of the biopharma industry—its long R&D cycle. China's unique digital technologies—from AI applications in predicting new protein models to accurate collection of clinical big data—are powerful accelerants of biopharma innovation.
- **Accelerated return of top talent enabling China's biopharma industry to break through barriers to innovation:** COVID-19 and China-US trade tensions have prompted the return of high-end biopharma talent to China, forming the backbone of sector upgrades and innovation. The return of talent to the Yangtze River Delta has made it the center of R&D and innovation in China's biopharma industry.

Challenges to innovation in China's biopharma industry

- **Basic research remains weak:** Development of China's biopharma industry has tended to be in "fast-follow" mode, with insufficient attention paid to basic research. As a result, China has a small cohort of top basic research talent and few original scientific research achievements. Although China produces more scientific papers than anywhere else in the world, first in terms of the number of papers, it lags in the international pharmaceutical powerhouses in the number of papers published in top biopharma industry journals such as *The Lancet*, *Nature*, and *Cell*.
- **Commercialization of research achievements needs to be strengthened:** The commercialization challenge in China's biopharma industry is mainly due to a lack of evaluation standards and commercialization expertise. This hinders the development of original, innovative innovation products and leads to homogenous innovation.

- **Insufficient innovative talent:** Biopharma has high technological barriers, and technical talent is key to innovative R&D. However, there is not enough high-end biopharma talent in China to meet rapidly growing demand and R&D costs, including the cost of personnel is rising.
- **Attitudes towards risk and return on innovative biopharma innovation studies need adjustment:** Institutional investors in China tend to focus on fast monetization, which conflicts with biopharma's long R&D cycle and risk of failure. This means many innovative biopharma studies have no access to investment or their access to funding is uncertain.

(3) Recommendations for innovative development of China's biopharma industry

	Government	Investors and enterprises
Conduct more basic research to consolidate the foundation for innovative development	• Construction of the basic research system should be strengthened to ensure the output of "high-quality" original achievements. • The attribution and cleaning of clinical data should be regulated by laws and regulations to promote the transfer of clinical data to public ownership, so a more comprehensive clinical database will become available at the basic research stage.	• Institutional investors should build more professional teams in biopharma technology support promising biopharma innovation projects at an earlier basic research stage and thereby facilitate smooth development of R&D.
Work harder to commercialize research achievements to ensure the smooth commercialization of more research achievements	• An evaluation system for the commercialization of scientific research achievements at the national level should be established, setting high thresholds to enhance innovation. • More opportunities for patent addition should be provided to more comprehensively protect new discoveries derived from innovative R&D.	• Enterprises should actively participate in commercialization research, provide services across the whole industrial chain such as production services, medicine registration, clinical consultation, etc. in the commercialization of scientific research achievements, assist research institutes in gaining insights into market demand, carry out targeted initiation of new scientific research projects, and obtain the rights of transferees related to products after commercialization.
Build a robust talent pipeline by attracting international talents and cultivating local young ones	• The government should promote talent development, developing all-round biopharma talent starting from university education, attaching equal importance to the technology and management, and enhancing the development of young talents. • More efforts should be made to attract overseas talents to return to China by providing support such as preferential visa treatment, easier access to settlement, and other support to ensure a smooth transition.	• Enterprises should introduce talent referral rewards for existing talent, accurately recruit the talent they lack, and improve the efficiency of candidate screening.
The government and investment institutions should cooperate to inject funds to commission innovative studies and enhance the professionalism of investment in the biopharma sector	• The government should take the lead in undertaking the investment risk of original innovation, especially given the social benefits from the successful development and launch of original innovative biopharmaceuticals and should guide commercial investment institutions to invest in original innovation projects.	• Investors should be well prepared to make long-term investments and recruit a professional biopharma team to better evaluate innovation projects. • Investees should become more proactive to dynamically update commercialization and product development with investors to maintain long-term cooperative relationships and mutual trust.

(4) Future breakthroughs and development recommendations for innovative biopharma development in the Yangtze River Delta

	Government	Investors and enterprises
Industry layout	• Government should define the positioning of each province in the Yangtze River Delta and make Shanghai the scientific and technological leader. Shanghai should drive the development of coordinated production and manufacturing in Jiangsu, Zhejiang, and Anhui while going global itself. • Promote integrated development. Each area should build on its own strengths to expand the advantages of its industrial chain, reduce internal competition, and boost overall development of the biopharma industry in the Yangtze River Delta.	• Enterprises should shift their focus from individual provinces to the integrated region, allocating the functions in each link of biopharma innovation and development to appropriate areas, leveraging the advantages of each area, and building industrial chains or carrying out cooperation within the region according to their needs, thereby enhancing the development of the regional industrial chain.
Government-enterprise cooperation	• Government should increase investment in basic and commercialization research at biopharma colleges and universities and vigorously facilitate communication between researchers and enterprises to promote commercialization of scientific achievements.	• The industry players should focus on the front end, increase support for basic and commercialization research, and invest at earlier stages. By doing this, companies can better explore early-stage innovative R&D projects with commercial potential.
Talent development	• The government should roll out targeted policies to attract more overseas talent to the Yangtze River Delta. The favorable policies include preferential visa treatment, family subsidies, and school access channels, etc. • The government should promote the cultivation of young talent and local employment, and formulate more targeted policies in settlement, housing, salaries, living allowances, etc. to support young talent.	• Enterprises should use the abundant resources of biopharma colleges in the Yangtze River Delta to conduct targeted talent development. By cooperating with universities and colleges to establish collaborative projects or schools, enterprises can participate in developing the talent they need at an earlier stage, creating long-term, stable support for innovative development.

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