

POINT Review of Biohealth Industrial Transition of Daejeon City, South Korea

Towards Advancing the Regional Biohealth Industry by unlocking AI/Big Data, Digital Technologies, and the Startup Ecosystem

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Korea Advanced Institute of Science and Technology (KAIST)

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European Commission Joint Research Centre (EC JRC)



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Executive Summary

Countries and regions around the world are gearing up for the industrial transitions necessary to move towards sustainable production and consumption. National and regional policies increasingly embrace the challenges of fostering and supporting these transitions. There is thus room to exchange different experiences and approaches to understanding and implementing transitions in different contexts.

In response to the changes triggered by the COVID-19 pandemic, the South Korean national policy, the Korean New Deal aims to revitalize Korea over the next century using green and digital initiatives. This resonates strongly with the EU post-COVID Recovery Plan, which has the stated aim to make Europe greener, more digital, and more resilient and builds on European Commission priorities for 2019-24, particularly the European Green Deal, becoming the first climate-neutral continent and Europe fit for the digital age, empowering people with a new generation of technologies.

This review of industrial transition in Daejeon is a study that takes a closer view of the existing biohealth systems, actors, resources and dependencies, and interdependences in Daejeon city. Through extensive interviews and analysis, the review explores how emerging technologies can be leveraged to transition Daejeon's biohealth system to next generation innovation ecosystem.

It been undertaken by the KAIST Korea Policy Center for the Fourth Industrial Revolution (KPC4IR), Daejeon Institute of Science and Technology for Enterprise and People (DISTEP), and the European Commission Joint Research Centre (EC JRC). It clearly reflects the key policy challenges common to both South Korea and the EU and the benefits of sharing expertise and experience to address them.

Its main aim is to study how the artificial intelligence (AI), big data, and biohealth startup ecosystem capabilities in Daejeon can be leveraged to advance South Korea's biohealth industry. While institutions in Daejeon and adjacent provinces are at the forefront of these areas, fragmentation of activities impedes their ability to harness the power of convergence, symbiotic knowledge, shared data and resources necessary to advance South Korea's biohealth industry. Recent digital innovations such as telemedicine, AI-powered wearable devices, contact tracing applications and services, blockchain-powered vaccine passports, have been at the frontline of the battle against the pandemic and are set to play increasingly major roles in transforming the biohealth and healthcare industries in South Korea and across the world.

The transition of the biohealth industry driven by AI, big data, and digital innovations requires bold policies, investments, and institutional reforms. Policymakers and stakeholders must work together to design and orchestrate an ecosystem that brings together the full range of stakeholders, including the biohealth industry and startups, academia, investors,

and manufacturers. This review seeks to propose a regional agenda and policy actions to position Daejeon and Chungcheong province as the biohealth "Silicon Valley" of Korea.

This review builds on the POINT¹⁾ (Projecting Opportunities for INDUSTRIAL Transitions) methodology developed by the Joint Research Centre of the European Commission (EC JRC). Aimed at improved understanding and management of industrial transitions, the POINT methodology is a systematic place-based approach to the framing, procedure and conduct of reviews on industrial themes of growing global importance.

It presents an analysis of the current situation and possible future directions for the development of industrial capabilities in Daejeon and Chungcheong provinces. This analysis is based on regional and country level data collection and analysis, wide stakeholder interviews and consultations with various experts. It has also developed the first database of all the key players in the AI, big data, and biohealth industries in Daejeon and Chungcheong Province.

It brings together key stakeholders across the ecosystem to co-curate a shared vision of how to transform the regional biohealth industry. This vision underpins the formulation of a concrete set of policies, strategic investments, and other relevant actions to ensure this transformation can take place.

The analysis of the current situation explores the composition and operation of the ecosystem, including existing strategies and initiatives, levels of governance, the availability and mobilisation of key resources, and national and global biohealth consumption. Together with gap analyses, the review can thus identify where progress has been made, and what needs to be changed to take the biohealth industry to the next level.

The key actors in Daejeon's bio-industry ecosystem

National and local government agencies, including the Korean Intellectual Property Office, the Ministry of SMES and Startups (MSS), and Daejeon Metropolitan City Future Industry Division.

Government-funded research institutions (GRIs), active in basic and applied research, including the Korea Research Institute of Bioscience and Biotechnology, which has been involved in the establishment of nearly 50 biotech companies in and around Daejeon, the Korea Research Institute of Chemical Technology (KRICT),

1) (<https://europa.eu/!Gr34Ng>)

and the Electronics and Telecommunications Research Institute (ETRI).

Support institutions, with strengths in commercialisation support, including the Daejeon Techno Park, National NanoFAB Center, Daejeon Business Agency, and the Bio-Healthcare Association, which promote collaboration between industry, university and research institutes, attracts corporate investment, industry promotion, as well education and training.

Universities, such as KAIST, Chungnam, Daejeon and Woosong Universities, providing high-quality human resources as well expertise and experience in relevant research fields.

Companies, particularly SMEs, active in biopharmaceuticals, bio-diagnostics, and bio-materials, many of which have been established with the support of GRIs, affiliates of large corporations, and universities. Of particular relevance are companies using AI for new drug development and those developing COVID-19 antigen tests.

Hospitals, which together with GRIs, actively support tasks that are difficult for companies to carry out, such as the collection of specimens and clinical trials, and thus accelerating the commercialisation of research results.

National and local policy initiatives

Policy initiatives targeting both industry and academia have impacted the development of Daejeon's biohealth ecosystem, seeking to foster start-up activity and the supply of high level specialised human resources.

Under Korean government, the promotion and advancement of the biohealth industry, regulatory improvement, and human resource development have received significant attention. Amidst the surge in demand for vaccines and diagnostic tools during the COVID-19 pandemic, the government increasingly recognises the need for industrial development and systematisation.

The 2019 Biohealth Industry Innovation Strategy by Korean government targets convergence with AI and big data, implementing infrastructure and R&D investment plans and establishing a cooperative system for the rapid development of the biohealth industry. Plans include building five big data platforms; increased government investment for the development of AI drug development platforms and innovative drugs and medical devices; and developing human resources for AI drug development.

Biohealth was included as one of the government's innovative growth BIG3 industries, announced at the end of 2020. Since then, plans have been established to

build a Korean-style lab central, create an AI- and big data-based research environment, provide additional large-scale funds to foster ventures and startups, and nurture talent in AI and biohealth fields.

At the local level, the 2021 Regional Industry Promotion Plan for Daejeon, and the 2030 Biohealth Innovative Growth Master Plan both aim at promoting the biomedical industry as one of the city's major industries, targeting stakeholder networking, infrastructure, human resource development, investment attraction, and global expansion. The geographic structure of Daejeon favours cooperation between venture companies, universities, and government agencies. The presence of many "mentor" companies and related infrastructure in Daejeon provides good conditions for new business ventures. In 2019 Daejeon was designated a "regulation-free special zone," to create jobs and revitalise the local economy by promoting the growth of the local bioindustry.

Convergence technology-based biohealth companies face more difficulties than conventional biohealth companies in linking experimental and verification institutions and production facilities, as they use very different production methods. The biohealth ecosystem in Daejeon is conducive to performing testing and verification, but needs policy promotion for AI-based drug development. This will further contribute to the establishment and growth of related convergence technology companies.

The future biohealth industry in Daejeon

The effective transformation of the biohealth industry requires stakeholders' cooperation to promote the development of a functional ecosystem. Daejeon already has infrastructure, capabilities and experience to foster bio-industry in the region, including strong public and private sector R&D performance, extensive bio-company experience, with a high level of start-up support facilities, active venture investment, and skilled bio-professionals in Daejeon. To build on these elements and support transformation requires enhanced support for together with good communication and coordination between stakeholders.

The transition can build on existing local government support initiatives to foster bio-industry established in 2000 with a mid- to long term perspective. The aim is to grow into a global TOP 5 bio cluster through various projects to maximize the growth potential of the local bio-industry, strengthening the bio-specific competitiveness, expanding the investment value, and enhancing sustainable growth value, with the preparation of a master plan in biohealth innovation growth for 2030.

"One-stop" integrated support is needed for the full development cycle of bio-venture products from the initial generation of ideas to sales and marketing, through research and development (R&D), prototype development, testing

and trials, licensing, and production. It is difficult for startups to acquire the infrastructure necessary for product development, as well as to negotiate the testing, trials, and licensing processes. This support can include:

- Convenient access to shared laboratories and associated support services.
- A platform and open space for interactive networking.
- High-end infrastructure and consulting support, provided by GRIs.
- Support to testing, ensuring effective cooperation with hospitals and certified testing laboratories in the region.
- Support for the licensing process, including international application.
- Operation and support of a shared Good Manufacturing Practice (GMP) production centre to manufacture trial products
- Support for global networking and expansion, with online meeting spaces and interpretation services, as well as support for international exchanges and support for strategies for overseas expansion.

Also open innovation support infrastructure is needed for technology-based startups, including:

- An administrative system to support corporate startups, including investment network connection and communication and guidelines on patenting and profit distribution.
- Access to technical and management advice and problem-solving, support for project planning and management, progress and performance management, and commercialisation.
- A system for research institutes and companies located in Daejeon to share information and cooperate on difficult technology.
- Support for the digital transformation of traditional biohealth companies, providing practical education and consulting in utilising AI/big data.
- A joint utilisation infrastructure for technology that is difficult for individual companies to handle.

Improvements are needed to the Biohealth Data Infrastructure to collect, consolidate, share and facilitate access to data among stakeholders in Daejeon. A large amount of high-quality data together with digital technologies are needed to obtain meaningful research results. This should be a long term undertaking, and should take into account sensitivities in data use and protection, particularly with regard to patient medical data.

The establishment of and support for demonstration complexes can address the lack of infrastructure for clinical trials and the increased demand from a growing number of

startups. Relatedly, a regulatory-free testbed enables practical empirical support and can accelerate commercialisation. The design and operation of a large-scale demonstration programme can help establish a virtuous cycle system between regional innovators. A more global orientation can benefit from the engagement of experts with global backgrounds, particularly from the private sector, promoting local companies through the establishment of global networks.

This transformation also needs to be accompanied by improvement of those elements of the ecosystem related to regulatory dimensions, particularly concerning tests and trials, data protection, and licensing. Such changes would enable greater use of medical big data held by hospitals or institutions in the development of new drugs and medical devices.

A good supply of high quality convergence professionals is required, combining and going beyond existing fields of expertise. In addition to developing and nurturing talent within industry, it is necessary to develop university education and training programmes to cultivate the full range of necessary competences needed across the full product cycle. There should be greater emphasis on practice, such as field-based learning, as well knowledge on testing, trials, and regulatory dimensions. While larger companies may provide a range of employee training, start-up ventures cannot. Working conditions must improve to attract and retain talent, including overseas personnel to help develop global networks.

Enhanced cooperation and networking will accelerate convergence, with organic communication among the full range of stakeholders. Stronger, more integrated cooperation requires dedicated coordination that encompasses existing cooperative networks.

A cooperative platform for new drug development based on AI/Big Data can help foster start-ups and support companies through the convergence and cooperation of heterogeneous research fields and technologies, inducing researchers to start a business, and secure original technologies for new drugs. This brings together the expertise and capabilities of various contributing research institutes and universities in Daejeon across a range of complementary fields, such as artificial intelligence, and big data, as well as the development of nanomaterials and nanocomposites, important in the development of new drugs and drug delivery technologies, and measurement technologies better tailored to the advanced measurement standards. It should also seek to overcome difficulties in communication and collaboration across traditional disciplinary boundaries.

A regional innovation network centred on technoparks, innovation centres, universities, and research institutes located in the region can help foster open innovation.

Pan-ministerial cooperation will harmonise R&D, certification and standards, and market creation, and provide support for global expansion.

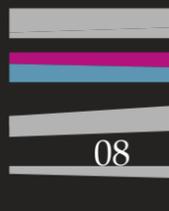
The changing paradigm of medical care needs a platform for public debate to engage patients, industry, and viewpoints from social science, humanities, and ethics. The end consumers of biohealth products often adhere to a very conservative position, while personal data protection can be a highly sensitive issue. In Daejeon, this can build on the activities of the Bio Healthcare Forum, which has been active since 2019 and centre on industries and hospitals.

The review concludes with a policy proposal to create an ecosystem for biohealth industry transformation based on AI/Big Data, and centred on five main elements:

1. The creation of a biohealth ecosystem led by local governments that can drive the transformation of the biohealth industry by incorporating advanced technology.
2. The need for a support system to foster and develop the full cycle of biohealth innovation from research and development to licensing and product launch.
3. The establishment of legal systems and policies to foster and support startups and companies that develop biohealth products combining advanced technologies of the 4th Industrial Revolution, such as AI/Big Data.
4. The reorganisation and establishment of a legal system to utilise big data on healthcare owned by government agencies, local governments, and hospitals to transform the biohealth industry.
5. Support for human resource development through both national and local government policies to enhance the supply of professionals with advanced convergence expertise (such as R&D experts and domestic and foreign licensing experts).

01

Introduction



The review of biohealth industrial transition in Daejeon is a collaborative project undertaken by the Daejeon Institute of Science and Technology for Enterprise and People (DISTEP), KAIST Korea Policy Center for the Fourth Industrial Revolution (KPC4IR), and the European Commission Joint Research Centre (EC JRC). This review aims to explore how Daejeon's artificial intelligence (AI), big data, and biohealth startup ecosystem capabilities can be leveraged to advance South Korea's biohealth industry. The review will build on concrete evidence, stakeholder consultations, public and industrial data, and ongoing initiatives, to propose a regional agenda and policy actions that can be undertaken by relevant authorities to position Daejeon and Chungcheong province as the biohealth "Silicon Valley" of Korea. The review will also bring together institutions such as KAIST, Korea Research Institute of Bioscience and Biotechnology (KRIBB), LG Chem, Daejeon TechnoPark Bio Convergence Center, and startups to co-curate a shared vision of exchanging information, knowledge, and knowhow to transform the regional biohealth industry.

The theme of the review is *Advancing AI, Big Data, and the Startup Ecosystem to Revitalize the Biohealth Industry in Daejeon and Chungcheong Province*.

The review mainly focuses on Daejeon due to the region's ecosystem and building blocks that can be leveraged to promote the biohealth industrial transition. Moreover, Daejeon and adjacent provinces are home to institutions at the forefront of biohealth, AI, big data, and bio-related research infrastructure. However, the majority of these initiatives are scattered and fragmented, which makes existing institutions unable to harness the power of convergence, symbiotic knowledge, data sharing, and shared resources to advance South Korea's biohealth industry.

1.1. Methodology



This review is based on secondary information, regional and country level data-analysis, and wide stakeholder interviews and consultations from experts in academia, biohealth industry, public and private sector organizations as well as civil society organizations. The data on biohealth industry was sourced from multiple sources including surveys, publicly available data and government data sources both from Daejeon city government and national biohealth datasets.

The project is also inspired by the POINT methodology which was developed by the Joint Research Centre of the European Commission (EC JRC) - one of the organizations participating in this multi-stakeholder project. Aimed at improved understanding and management of industrial transitions, the POINT methodology is a systematic place-based approach to the framing, procedure and conduct of reviews on industrial themes of growing global importance. It specifically focuses on analysis of the current situation and sketching future directions for the development of industrial capabilities that a region or country may undertake. Previously applied to industrial sector in a number of EU territories, the focus of this project is understanding and managing transitions of biohealth industry in Daejeon and Chungcheong province to provide pathways for revitalizing the industry. The application of the POINT methodology in this context reflects the key policy challenges common to both South Korea and the EU and the benefits of sharing expertise and experience to address them.

1.2. Reasons for the Transition

1.2.1. COVID-19 and the transformation of the biohealth industry

— The COVID-19 pandemic triggered a considerable change in the use of digital technologies, AI and big data in the biohealth industry. For instance, the world has witnessed the emergence of AI, big data, and digital innovations that continue to play a critical role in fighting this deadly pandemic. According to a recent OECD report,

"AI tools, Big data, and digital applications are deployed in almost every front to stop Coronavirus: from fast tracking medical research and treatment to better understanding of coronavirus; from detecting and diagnosing the virus to predicting its evolution; these innovations are also critical in prevention, monitoring and slowing the spread of diseases through disease surveillance and contact tracing; responding to health crisis through personalized information and learning and monitoring the recovery and improving early warning systems".

— It is evident to everyone in the biohealth industry that these technologies will continue to mature and play even greater roles in transforming the industry. Thus, policymakers and stakeholders must start designing and orchestrating an ecosystem that brings different players together, including the biohealth industry and startups, academia, investors, manufacturers, etc., to leverage these new technologies and take the biohealth sector to new levels. This requires bold policies, investments, and institutional reforms. Furthermore, realizing the full potential of AI, big data, and related digital innovations requires the creation of new platforms for sharing medical, molecular, and scientific data to enable effective biohealth innovations.

— Similarly, recent digital innovations such as telemedicine, AI-powered wearable devices, contact tracing applications and services, blockchain-powered vaccine passports, are now at the frontline of the battle against the pandemic, and will doubtlessly play increasingly major roles in re-engineering the biohealth and healthcare industries in South Korea and the world. Their emergence has enabled policy makers to imagine the era of a "hybridtact" healthcare industry, where the traditional "contact" hospital and healthcare systems are "married" to digital and online systems ("untact" healthcare), revolutionizing the delivery of biohealth and healthcare services.

— Furthermore, these digital innovations and their integration with biohealth will play prominent roles in the detection and control of dangerous diseases, and in the management of healthcare systems. However, their full potential will not be realized without efforts to rethink existing innovation ecosystems, including human resource development, promotion of biohealth innovators and startups, R&D institutions, and academia, as well as their smooth coordination. In other words, serious attention must be given to the transition of the traditional biohealth industry to a new era driven by AI, big data, and digital innovations.

1.2.2. New structural changes in Korea

— In response to the above-mentioned structural changes triggered by the COVID-19 pandemic, the South Korean government came up with the Korean New Deal — a massive plan to revitalize Korea over the next "100 years" using "green and digital initiatives." Part of the New Deal initiative is the Digital New Deal, under which a total of 12 projects have been proposed to reboot the Korean economy and prepare for the future.

— In relation to healthcare and biohealth, the Digital New Deal proposed a stronger integration of Data, Network, and AI (DNA) throughout the economy, including improving the collection, disclosure, and utilization of data in areas closely related to people's lives, and expanding the integration of 5G and AI into industries. Such initiatives, when implemented, will have ripple effects on the biohealth industry ecosystem. In addition, the government has proposed fostering the "untact industry" including the building of smart medical and healthcare infrastructures.

— Similarly, the South Korean government developed the National AI Strategy to promote a full-scale plan for utilizing industry-specific AI. As part of this strategy, the government aims to unlock the biomedical industries by (1) establishing a phased new drug development AI platform at each stage (~2021), (2) supporting medical data-oriented hospitals and field demonstration of medical AI services and products (2020–), and (3) establishing sample data and a professional review system for clinical verification of AI-based medical devices (~2021). The government has also established four AI graduate schools to develop human resource competencies in South Korea. All of these strategies feed into the agenda to promote AI, big data, and the biohealth industry.

1.2.2.1. Government strategy to develop high-growth bioindustry

— Recently, the government held an Innovation Growth Strategy Meeting presided over by Nam-ki Hong, Deputy Prime Minister and Minister of Strategy and Finance, and discussed the policy directions and core tasks for bioindustry innovation prepared by the BioIndustry Innovation Task Force. The central government sees the bioindustry as one of the next growth engines. The global bio-market is expected to grow rapidly by 6% on an annual average from \$8.6 trillion in 2016, to \$14.4 trillion in 2025. However, the domestic market was \$150 billion (as of 2017), which is only 2% of the total, and the national competitiveness of the domestic bio-industry declined from 15th in 2009, to 26th in 2018. Accordingly, the government decided to expand the scope of the bioindustry to not only "red bio (health and medical)", but also "green bio (food and resources)" and "white bio (environment and energy)", and foster it as a next-generation flagship industry.

— The government is planning to expand large-scale research and development in the biohealth field, such as new drugs and medical devices, and promote the development of "new healthcare" technologies that combine data and AI.

1.2.3. Growing investments in biohealth: Snapshot of biohealth landscape

— The Korean government defines bioindustry as all categories that fall under bio-medicine, bio-food, bio-chemical and energy industry, bio-environment, bio-medicine, bio-instruments, bio-resources, and bio services. As described in <Table 1> most of the companies related to the bio-industry are concentrated in the Gyeonggi-do and Seoul areas.

— In terms of the number of employees, (see Table 2 below), companies in the bio-industry are mostly small (from one to five employees), accounting for 62.2% of the whole industry. However, many mid-size (50 to 300 employees) and large (above 300 employees) companies make up 26.1% and 11.6% of the industry, respectively. The total number of employees in 2018 reached 47,047, of which 31.6% were researchers, 35.0% were manufacturers, and 33.3% were in other professions. Professionals holding a bachelor's or equivalent degree constitute 47.7% of the total employees, while professionals with a master's or equivalent degree make up 19.5%, and Ph.D. or equivalent degree holders form a total of 6%.

	1 st	2 nd	3 rd
Bio-pharmaceutics	Gyeonggi-do 38.5%	Seoul 28.6%	Chungcheongbuk-do 9.6%
Bio-chemical and energy industry	Gyeonggi-do 25.4%	Seoul 15.9%	Daejeon 12.7%
Bio-food	Gyeonggi-do 24.7%	Chungcheongbuk-do 12.1%	Seoul 9.9%
Bio-environment	Gyeonggi-do 34.2%	Kangwon-do 9.6%	Jeonnam 8.2%
Bio-medicine	Gyeonggi-do 35.3%	Seoul 27.1%	Kangwon-do / Daejeon 9.4%
Bio-instruments and	Gyeonggi-do 42.1%	Seoul 24.6%	Daejeon 14.0%
Bio-resources	Gyeonggi-do 36.8%	Chungcheongbuk-do 15.8%	Daejeon / Jeollabuk-do 10.5%
Bio-services	Seoul 54.5%	Gyeonggi-do 24.2%	Daejeon 6.1%

Table 1. Biohealth Industry Fields in South Korea

	Ph.D.	Master's	Bachelor's
Bio-pharmaceutics	1,584	4,588	9,556
Bio-chemical and energy industry	329	1,234	2,898
Bio-food	335	946	2,821
Bio-environment	57	166	785
Bio-medicine	207	904	1,976
Bio-instruments and	59	157	806
Bio-resources	35	140	722
Bio-services	258	1,079	2,902

Table 2. Biohealth Human Resources in Each Field in South Korea



Figure 1. Daejeon Biohealth Industry Snapshot

The total investment in the bioindustry reached 2,344 billion KRW, and a high portion of this funding is dedicated to R&D. Investment in infrastructure is relatively low, with a total of only 703 billion KRW. Korean R&D investment in the bioindustry is highly concentrated in the bio-pharmaceutical field, reaching 1,641 billion KRW. Korea has a relatively good production rate, achieving a total of 10,476 KRW, of which 49.5% is exported, and 50.5% is consumed locally. The Korean bioindustry is considerably healthy, given that imports constitute only 24.4% of its total consumption.

In order to transform the biohealth industry, this POINT review seeks to align Daejeon's biohealth industry with the national agendas mentioned above. By leveraging new technologies and innovation systems, Daejeon can be a major contributor to the Korean and global biohealth industry.

Daejeon ranks fourth in most bioindustry subfields. The region has a total of 1,679 employees, Daejeon also ranks fourth in the total number of employees after Gyeonggi-do, Seoul, and Incheon. Daejeon further possesses a relatively high proportion of Ph.D. holders, with 188 Ph.Ds., 465 masters, and 722 bachelors. While the region ranks fifth in its total bio-R&D investment at 70 billion KRW, its investment in infrastructure is even larger than that of Seoul, at 94 billion KRW.

1.2.4. Daejeon Biohealth Ecosystem

- Chungnam National University opened its AI research center in 2020, with 4.2 billion KRW funded by MSIT, 600 million KRW from Daejeon City, and 400 million KRW from Chungnam National University. It will establish a bio-AI integrated graduate program with a focus on bio-AI-Cure, bio-AI-Animal, and bio-AI-Plant.

- Tomocube, a startup founded in 2015, opened a new era of HoloTomography integrated with AI. They successfully launched their 3D holotomography technology and recently developed a new cell therapy for cancer in collaboration with KAIST and Curocell (another bio-company based in Daejeon).

- Another representative bio-AI startup is 'Kai-i Company,' which is a smart dental solution platform. It uses big data to collect dental service data not only from individuals but also from dentists or public services. Its vision is to provide accessible, curated healthcare support across all ages and income levels.

- Daejeon is also home to numerous companies at the frontline of fighting COVID-19. For example, Solgent located in Daedok R&D Complex is one of the companies that received fast-track approval for manufacturing COVID test kits.

- According to the biohealthcare cluster diagram released by the Bio-Healthcare Association, the number of companies increased significantly in 2000, 2005, 2010, 2015, and 2021. Bio-startups were created centering around KRIBB, LG Life Sciences (now part of LG Chem), and the Daejeon Bio Convergence Center, resulting in the creation of a self-sustaining community.

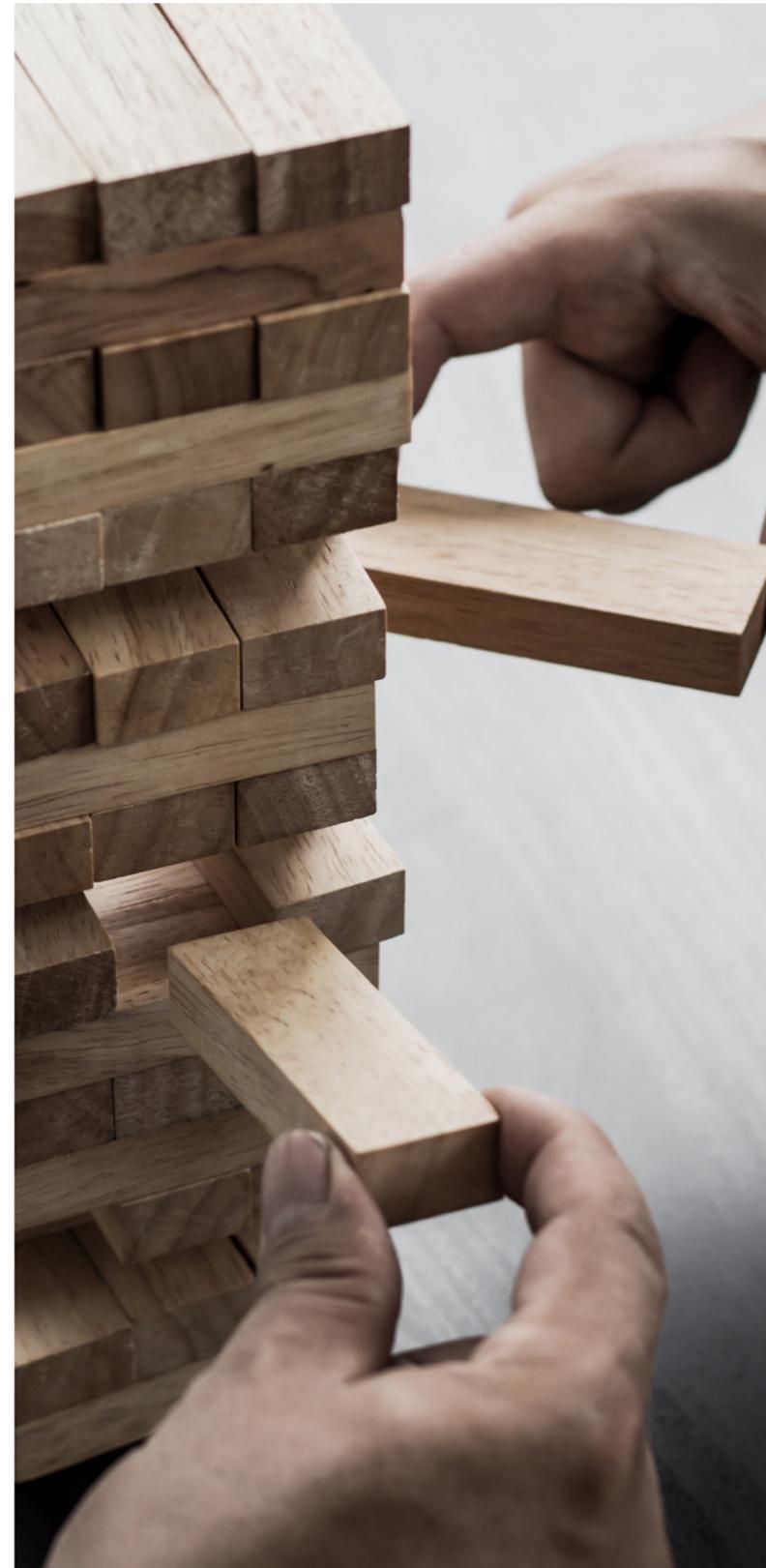
- There has been active cooperation between biohealth companies, regional hospitals, government-funded research institutions, and local governments. Daejeon City was designated a Regulation Free Special Zone in the biomedical field in 2019, and a Regulation Free Special Zone for Infectious Diseases in 2020. Based on this, cooperation among hospitals such as Chungnam National University Hospital, Eulji University Medical Center, Konyang University Hospital, and government-funded research institutes (GRIs) such as KRIBB, and Korea Research Institute of Chemical Technology (KRICT), and bio-ventures is also rapidly gaining momentum. Hospitals and GRIs actively support tasks that are difficult for companies to carry out, such as (collecting) specimens, clinical trials, and experiments, which also accelerate the commercialization of research results.

- Moreover, while accompanying the Daejeon Mayor during a visit to Boston, the Bio-Healthcare Association

signed an MOU with the Korean American Bio-Industry Council (KABIC) located in Boston and Daejeon Techno Park on April 17, 2019, for training, R&D, personnel exchanges, and cooperation on holding an academic conference.

1.2.4.1. The POINT Review: Leveraging AI, Big Data, and the startup ecosystem to revitalize the biohealth industry in Daejeon and Chungcheong provinces.

- We propose to conduct a POINT review based on the South Korean government's efforts to revitalize the biohealth sectors through the Digital New Deal and the National AI Strategy, and Daejeon's decades of putting in place the springboard infrastructure and ecosystem, which, when harnessed, will unlock the power of AI, big data, and the startup ecosystem to revitalize the country's biohealth industry. The focus of this review is twofold. First, we focus on bringing main key stakeholders in Daejeon and Chungcheong Province to co-create a shared vision of leveraging the convergence of technologies, data, and untapped entrepreneur talents to propel the biohealth industry forward. Second, we will develop the first database of the key players in the AI, big data, and biohealth industries in Daejeon and Chungcheong Province. Finally, based on stakeholder engagement, soliciting of inputs, and analysis of ecosystem data, we will map the as-is analysis of the biohealth industry, and develop a shared to-be model, benchmarked against the LabCentral model of the USA. The final output of our efforts is expected to provide a concrete set of policies, strategic investments, and actions required to establish Daejeon as an optimal city for a "Silicon Valley" of biohealth in Korea.



1.3. System Definition and Boundaries

- After careful consideration of the national and regional biohealth agendas, this review covers several priority issues for revitalizing Daejeon's biohealth industries. The review considers existing regional initiatives to promote the biohealth industry and the emergence of AI and startup ecosystems. In this way, the review explores how these can be leveraged to open new frontiers **to revitalize the biohealth industry**. The review undertakes a comprehensive analysis of the as-is and gap analyses to identify where progress has been made, and what needs to be changed to take the biohealth industry to the next level. To this end, the analysis includes exploring existing strategies and initiatives, different levels of governance, how critical resources are mobilized, regional and national bio-human resources, and national and global biohealth consumption.

- To keep pace with the South Korean government's promotion of the Korean New Deal, the National AI Strategy, and three new industries (promotion of system semiconductors, biohealth, and future cars), Daejeon City announced the 2030 Biohealth Innovation Growth Master Plan (2021–2030), which focuses on bioindustry as Daejeon's major industrial field to drive the city's innovative growth. This basic plan establishes the identity and future directions of the Daejeon Bio Cluster based on the strengths and characteristics of Daejeon, enabling it to become a global bio-startup hub city. As a concrete plan for this, Daejeon City will invest 544.3 billion KRW over the next ten years to promote five strategies to create a virtuous cycle of bioindustry growth:

- Establishing an advanced infrastructure for a virtuous cycle of bio startup and growth
 - Cultivating bio experts and attracting excellent human resources
 - Promoting investment in biotech
 - Establishing a foundation for promoting global outreach
 - Facilitating the network of industries-academia-research institutes-hospitals
- In addition, two strategies will support these five strategies, namely:
- Designation of a free economic zone
 - Strategic development of biohealth technology

- A total of 5+2 strategies and 21 tasks will be promoted. In particular, as priority tasks for this year, the following will be promoted to spur the creation of advanced infrastructure, enabling a virtuous cycle of bio-startup and growth: 1) Building a Korean biolab central, 2) building a shared research facility for pathogen resources, and 3) building a platform for rapid manufacturing of genetically based drugs.

- It is envisaged that such a platform will facilitate the integration of Daejeon's fragmented biohealth system into a shared biohealth ecosystem that provides targeted support for innovators and innovations. As an illustration, biohealth pioneers will have a place where they can receive mentoring to take their innovations from R&D to market; currently, this is done at the university and public GRI levels, but should be scaled to the regional level. This shared platform will also enable the cross-pollination of ideas in diverse fields of biohealth. Finally, a shared platform for sharing knowledge on AI, big data, and applications in healthcare, and a platform for sharing critical data to fix data fragmentation in existing systems will be provided.

Topic	Description
Promotion of Biohealth	Developing a platform that provides full cycle support to promote biohealth in Daejeon and Korea. It may bring together technology companies, software developers, public research institutes, Biotech R&D institutes, startups and business ventures, and research and teaching hospitals.
Artificial intelligence and biohealth	Innovative biohealth products and businesses that apply artificial intelligence, and big and small product and business developments, for example, drug discovery, diagnosis, vaccines and therapeutics research and development, disease detection, treatment, precision medicine, etc.
Advanced biohealth ecosystems	Development of advanced biohealth ecosystems for research and development, startup ecosystems, development of new biohealth products utilizing new techniques in AI and data, advanced biohealth manufacturing, and ecosystems that bring different actors together.
Digital innovations and biohealth	Integrating digital innovations and groundbreaking applications in the biohealthcare sector in the development of biohealth products, including drug development, vaccines, and designing targeted responses, among others.

Table 3.
Key areas selected for the POINT Review

Source. Authors' compilation



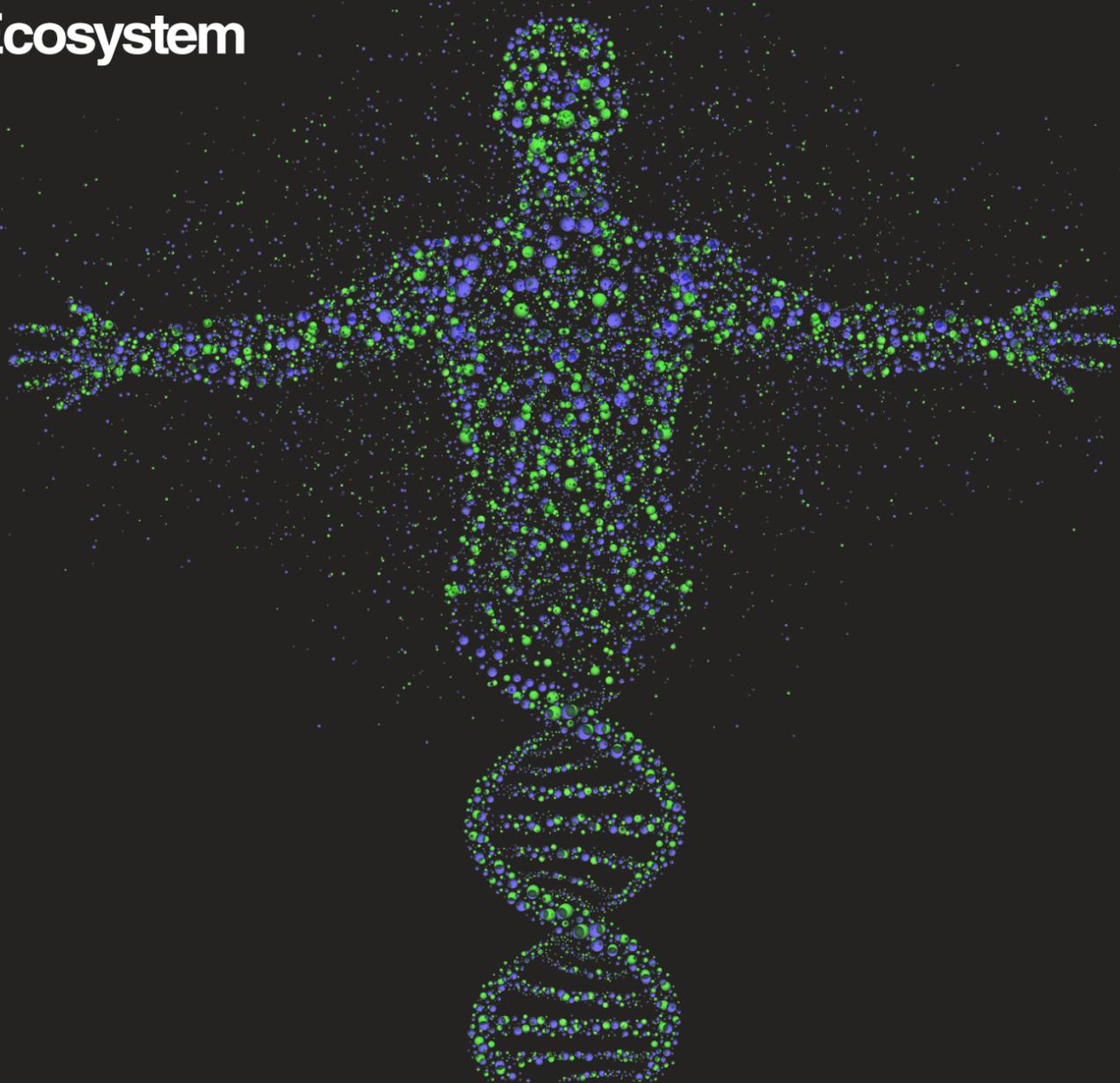
Table 4. Biohealth Innovation Categories with the thematic definitions

Biohealth Innovations categories	Products/ artefacts and / or services	Examples of AI applications	Market	Public Actors
1.1 Bio-pharmaceutics	Drugs, therapeutics, and vaccines	AI diagnostics (AI for BoneAge, Deepbrain, LungCT, Chest X-ray, Fundus AI, Deep ASR	BioHA-Bio-healthcare Association	Daejeon and Chungcheong province regional governments, DISTEP
1.2 Bio-chemical and industry	Diagnosis products	Target identification and validation Optogenetics-based brain stimulation, Electrophysiological recording	Bio-Pharmaceuticals (e.g. Alteogen, BiocurePharm, BioLeaders, ChongAng Vaccine Lab, Ensol Biosciences, Bioneer, Kainos Medicine, Legochem, Pepton, PharmAbcine,VUNO, etc.)	Government research institutes such is KRIBB, KRICK, KRIS, ETRI, KBSI, KIMM, KIOM etc
1.3 Bio-medicine	Treatment products and services	Nano Technologies for healthcare Multifunctional and Ultrasensitive Nanomaterials, Smart Electronics and Sensors, Biomolecular signal Amplifications, Nanobiosystems engineering	Finance & Allied Business Financing (e.g., Atinum Investment, Bluepoint Partners, Born2global, DAYLI Partners, KB Investments, Magellan, Mirae Asset, Samsung Securities, Wadiz etc.)	Public funded institutes- KAIST Institute (KI for BioCentury, KI for Health Science and Technology, KI for Artificial Intelligence, KPC4IR)
1.4 Bio-instruments	Diagnosis, prevention, monitoring, treatment	Wearable Device for healthcare Personal Physical and Mental Health Record & Services, Digital Phenotype for healthcare, cloud based Big-data platform Therapeutic bioengineering(Smart Nano medicine for individualized and targeted disease treatments, innovative biomedical devices for monitoring Therapeutical response in patients	Allied Business ANSCO, CHC Lab, JEIO TECH, KumSungBaekJoe Construction etc. BioSpector, DaeDeok Net etc.	Academia and training focused (KAIST Graduate School of AI, KAIST Bio and Brain Engineering, Chungnam University Department of BIO &AI Convergence, Konyang University Department of Medicinal Bioscience, others include Hannam University, Paichai University, Daejeon University)
1.5 Bio services	Supporting or Sustaining life	Drug delivery platform technology for Drug Discovery and Development		Hospitals and healthcare providers CNU Hospital, Eulji University Hospital, Daejeon Wellness Hospital etc
Bio-resources	Control of conception, birth control	CAR-T Cell therapy		KAIST Startup Institute
Bio-food	Disinfection of medical devices	Bio Big Data Platform Technology		
Bio-environment	Vitro examination of species derived from human body	DeepZema, a deep learning-based drug discovery platform technology		
		Digital tools and applications in biohealth		

Source. Authors' compilation from multiple data sources

02

The Current State of the Regional Innovation Ecosystem



2.1. Major Characteristics and Elements

2.1.1. Major Innovative Organizations and their Core Competency

The types of innovative organizations related to Daejeon's biotech industry include government agencies, government-funded research institutions, universities, supporting institutions, related organizations, and general hospitals (Table 5). Tables 6 and 7 list the innovative organizations in the biomedical field and the competency level of each institution in Daejeon City, respectively, as illustrated in the 2021 Regional Industry Promotion Plan for Daejeon.

Table 5. Major Innovative Organizations of Biohealth in Daejeon City

Type	Organization name
Government agencies	Korean Intellectual Property Office, Ministry of SMEs and Startups, Daejeon Metropolitan City
Government-funded research institutions	Korea Research Institute of Bioscience and Biotechnology (KRIBB), Korea Research Institute of Chemical Technology (KRICT), Korea Research Institute of Standards and Science (KRISS), Korea Basic Science Institute (KBSI), Electronics and Telecommunications Research Institute (ETRI), National NanoFAB Center, Korea Institute of Energy Research (KIER), Institute for Basic Science (IBS)
Universities	Korea Advanced Institute of Science and Technology (KAIST), University of Science and Technology (UST), Hanbat National University, Daejeon University, Woosong University, Chungnam National University, Hannam University, Mokwon University, Pai Chai University, Daejeon Health Institute of Technology (HIT)
Supporting organizations	Daejeon Technopark, National NanoFAB Center, Daejeon Business Agency, Daejeon Institute of Science & Technology for Enterprise & People (DISTEP), Korea Innovation Foundation (INNOPOLIS), Daejeon International Marketing Enterprise (DIME), Korea Technology and Information Promotion Agency (TIPA), Daejeon Information & Culture Industry Promotion Agency
Related organizations	Bio-Healthcare Association, Daedeok Innopolis Venture Association
General hospitals	Chungnam National University Hospital, Daejeon Eulji Medical Center, Konyang University Hospital, Sun Medical Center

Source: Hwang Hye-ran (2020), with some revisions.

Major national and local government agencies include the Korean Intellectual Property Office, the Ministry of SMEs and Startups, and Daejeon Metropolitan City. In Daejeon Metropolitan City, the Future Industry Division is in charge of the local government policies related to the biohealth industry. Major GRIs include the Korea Research Institute of Bioscience and Biotechnology (KRIBB), Korea Research Institute of Chemical Technology (KRICT), and the Electronics and Telecommunications Research Institute (ETRI). Among these, KRIBB has been directly or indirectly involved in the establishment of nearly 50 biotech companies in and around Daejeon, including Bioneer, the first biotech venture company in South Korea, as well

as Inbionet, Biologics, Bio R&S, and Bioleaders (Hwang Hye-ran, 2020). Furthermore, Daejeon TechnoPark, an industry support organization under the BIO Convergence Center, promotes networking among innovation actors in the field of biotechnology from industries, universities, institutes, agencies, and hospitals in Daejeon through business support services, new business creation, joint R&D, prototype production support, and commercialization support (Daejeon Technopark, n.d.). The Bio-Healthcare Association, one of the major related organizations in the region, promotes industry-university-institute collaboration for research and business development (R&BD), revitalizes joint research among companies, attracts corporate investment, and conducts industry promotion planning, consulting, and employee education and training. As of the first half of 2021, the association has been associated with 72 biotech companies: 20 organizations in related industries, such as research institutes, hospitals, financial companies, and media companies, and 80 individuals as members.

As shown in Table 6, research institutes have strengths in “technology development” through basic and applied research in general, while related organizations, such as the Daejeon TechnoPark, National NanoFAB Center, and Daejeon Business Agency, have strengths in “commercialization support,” including prototyping, equipment utilization, networking, and marketing. Typically, universities have strengths in “human resource development” (except for those that have strengths in various fields). This trend is also apparent in Table 7, which compares the R&D and non-R&D capabilities of the listed institutions. While the relative-

ly clear division of strength and competency level by sector and type of each institution reflects its original function and purpose of establishment, it also highlights the importance of inter-organizational cooperation and complementarity in achieving industrial innovation.

According to the Bio-Healthcare Association, biotech companies can be broadly classified into three categories: biopharmaceutical companies (therapeutic agents, vaccines, and AI-linked platforms), bio-diagnostic companies (diagnosis and testing), and bio-material companies. Table 8 presents the classification of the member companies of the Bio-Healthcare Association in Daejeon into these three categories. The present report is focused on the AI- or big data-based bio-health industry, and companies that use AI for new drug development include SyntekaBio, GHBIO, and Healinnols.

As shown in Figure 2, biotech companies in Daejeon are mainly established with the support of GRIs, such as KRIBB and KRICT, affiliates of large corporations, such as LG Life Sciences, universities such as the Korea Advanced Institute of Science and Technology (KAIST), and Pai Chai University (Bio Diagnostic Convergence Technology Center), and Daejeon TechnoPark (BIO Convergence Center). The Daedeok Biocommunity is a private-led coalition of GRIs, large research institutes, and bioventures built around Inbionet. As a first-generation bioventure company founded in 1996, the Daedeok Biocommunity has made a great contribution to the formation and growth of a self-sustaining network of bio-clusters in Daejeon (Hwang Hye-ran, 2020), and numerous companies have been established through this community.

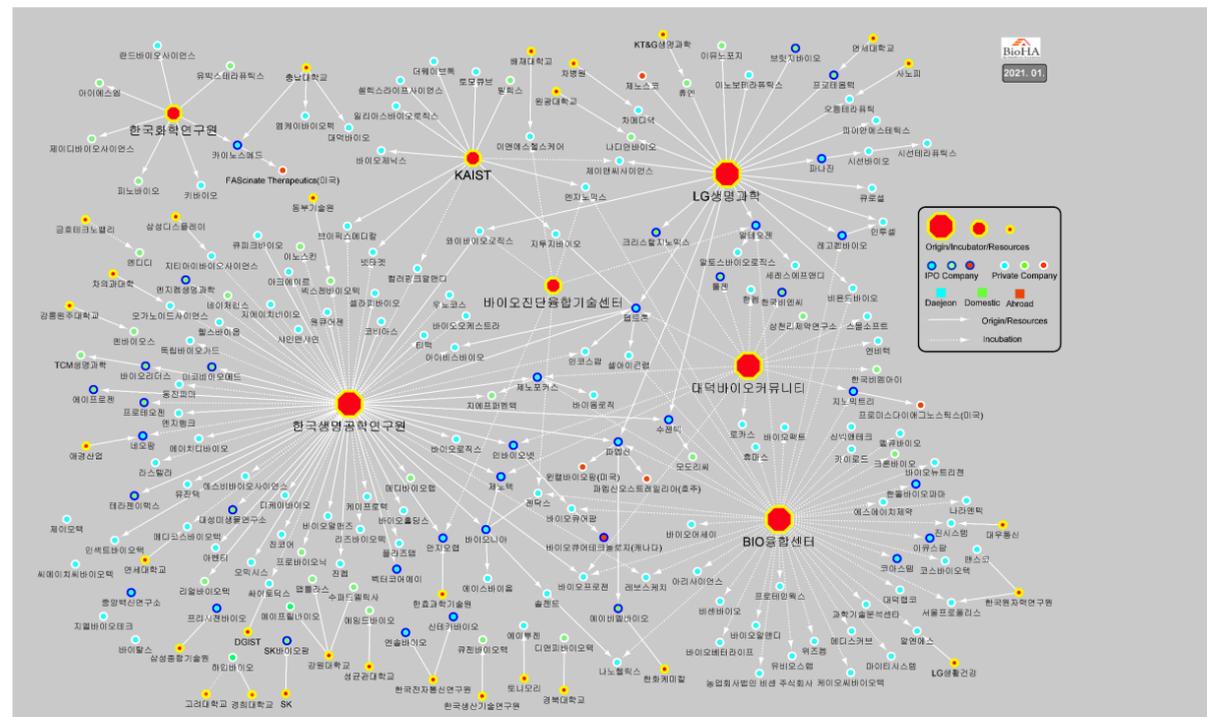


Figure 2. Tree of Daejeon Biotech Company Ecosystem (as of January 2021)

*Light blue circles indicate Daejeon-based companies. Source: Bio-Healthcare Association (2021).

Table 6. Core Competency of the Innovative Organizations in Daejeon City

Division	Organization name	Technology development		Commercialization support					Human resources support		Funding
		Basic research	Applied research	Prototyping production	Equipment utilization	Commercialization support	Network	Marketing	Startup support	Human resource development	
Research institute	Korea Basic Science Institute	●	●	●	●		◎			◎	
	Korea Research Institute of Bioscience and Biotechnology	●		●	●	◎				◎	
	Korea Atomic Energy Research Institute		●		○					○	
	Korea Research Institute of Standards and Science	●	●			●					
	Korea Institute of Oriental Medicine	●		◎	○						
	Korea Research Institute of Chemical Technology		●			◎			○	◎	
	Institute for Basic Science	●									
Organization	Daejeon Technopark			●	●	●	●	●	●	◎	○
	National NanoFAB Center		○	●	●	●			○	◎	
	Daejeon Business Agency					◎	●	●	●		●
	Korea Innovation Foundation						●				
	Daejeon International Marketing Enterprise					◎			◎		
	Daedeok Innopolis Venture Association									◎	
	Korea Technology and Information Promotion Agency										
University	Daejeon University/ Industry-Academic Cooperation Foundation	◎	◎	○		○	○	○		●	
	Mokwon University/ Industry-Academic Cooperation Foundation	○	○	○		○	○	●	○	●	
	Pai Chai University/ Industry-Academic Cooperation Foundation	○	○	◎	○	◎	◎	◎	○	◎	
	Chungnam National University/ Industry-Academic Cooperation Foundation	◎	●	○	○	◎	◎	◎	○	●	
	Hannam University/ Industry-Academic Cooperation Foundation	○	○	●		●	●	●	○	●	
	Hanbat National University/ Industry-Academic Cooperation Foundation	◎	◎	●	◎	◎	◎	○	○	◎	
Korea Advanced Institute of Science and Technology	●	●		●					●		

*Very strong (●), strong (◎), normal (○) Source: Daejeon Metropolitan City (2020).

Table 7. Major Competency of the Organizations related to Biohealth in Daejeon City (R&D and non-R&D)

Organization name	R&D competency				Non-R&D competency				
	Basic source research	New product development	Existing product improvement	New process development	Equipment support	Technical support	Commercialization support	Human resource development	
University	Korea Advanced Institute of Science and Technology	●	◎	◎	●	○	◎	◎	●
	Chungnam National University	◎	◎	◎	●	◎	◎	◎	●
	Hannam University	○	○	◎	◎	○	◎	◎	●
	Pai Chai University	○	○	◎	◎	○	◎	◎	●
	Daejeon University	○	○	○	○	◎	◎	◎	●
	Mokwon University	○	○	○	○	○	◎	○	●
Research institute	Korea Research Institute of Bioscience and Biotechnology	◎	●	●	●	◎	◎	◎	○
	Korea Research Institute of Chemical Technology	●	◎	◎	◎	○	○	◎	◎
	Korea Institute of Oriental Medicine	●	◎	◎	◎	○	◎	◎	◎
	Korea Atomic Energy Research Institute	○	○	○	○	○	○	○	○
	Korea Research Institute of Standards and Science	●	○	○	○	○	○	◎	◎
	Korea Basic Science Institute	●	○	○	○	●	◎	◎	○
	Electronics and Telecommunications Research Institute	○	◎	○	○	○	◎	○	◎
	National NanoFAB Center	○	◎	◎	◎	●	◎	○	◎
Organization	Daejeon Technopark Bio Center	○	○	○	◎	●	●	●	◎
	Daejeon Technopark Functional Material Center	○	○	○	◎	●	●	●	◎

*Very strong (●), strong (◎), normal (○) Source: Daejeon Metropolitan City (2020).

Table 8. Major Biohealth Companies with their fields in Daejeon City

Field	Major companies
Treatments, vaccines, and AI linked platforms	Biobetter/Biosimilar ALTEOGEN, Peptron, BiocurePharm, G2GBIO
	Anticancer drugs (targeted therapy and immunotherapy) PharmAbcine, Orum Therapeutics, Y-Biologics, BeyondBio, Aervisbio, EnsolBio Sciences, ILIAS Biologics, IntoCell, J&C Sciences
	Brain and neurological disease treatments (Alzheimer's and Parkinson's disease) BeyondBio, Peptron, BIORCHESTRA, Aervisbio, EnsolBio Sciences, G2GBIO, MKbiotech
	Degenerative, intractable, and infectious disease treatments PharmAbcine, AngioLab, AVENTI, EnsolBio Sciences, ILIAS Biologics, Innovotherapeutics, J&C Sciences, LegoChem Biosciences, Incospharm Corporation, Healinnols
	Microbiome GenoFocus
	Cell/gene/nucleic acid treatment Kyuloseel, Bioneer Corporation, BiocurePharm, BIORCHESTRA, MKbiotech, Seasun Therapeutics
	Antibody treatment Y-Biologics, PharmAbcine, Orum Therapeutics
	Antibody-drug conjugates (ADCs) LegoChem Biosciences, Y-Biologics, ALTEOGEN, Peptron, IntoCell
	Virus vaccines PioneerVaccine, CAVAC
	AI and new drug development materials SyntekaBio, GHBIO, Healinnols
Diagnostics and tests	Cancer diagnostics Genomictree, Panagene, E&S Healthcare, Seasun Biomaterials
	Infectious disease diagnostics Bioneer Corporation, Sugentech, SolGent, Seasun Biomaterials, GeneSystem, Genomictree
	Degenerative and intractable disease diagnostics Sugentech, E&S Healthcare, GeneSystem, Precision Biosensor, Seasun Biomaterials
	Molecular diagnostic platforms and materials Bioneer Corporation, Sugentech, Precision Biosensor, ATO Korea, Enzymomics, Tomocube, IVIM Technology, VITALS
Biomaterials	Functional cosmetic materials Incospharm Corporation, BIOGENICS, Cellicon Lab, Cha Meditech, GL BIO TEC, Insect Biotech, RNS
	Functional food materials GeneChem, Insect Biotech
	Medical and industrial enzymes GenoFocus, Insect Biotech

*Only Bio-Healthcare Association members were included. Source: Bio-Healthcare Association (2021), some revisions.

2.1.2. Important Policy Trends of the National and Local Government

— Korean government and Daejeon Metropolitan City policies related to the biohealth industry are summarized in Tables 9 and 10. First, the Third Basic Plan for the Promotion of Biotechnology in 2017 and the Fourth Basic Plan for Science and Technology in 2018 were announced to establish cross-ministerial, mid-to-long-term promotion strategies in the fields of biotechnology, science, and technology, signifying the potential for development in the fields of red, green, and white biotechnology, as well as bio-convergence. In 2019 and 2021, biohealth R&D investment strategies I and II were established, through which the biohealth industry was segmented to present appropriate short-, mid-, and long-term support strategies at the national level, considering the characteristics of each field (see section 2.2.1 for details on Biohealth R&D Investment Strategies I and II).

— Notable government policies related to the biohealth industry and the convergence of AI and big data include the innovation strategy of the 2019 Biohealth Industry Innovation Strategy. Through this policy, the Ministry of Science and ICT, the Ministry of Economy and Finance, and the Ministry of SMEs and Startups implemented infrastructure and R&D investment plans and established a cooperative system essential for the rapid development of the biohealth industry. The announced key content included building five big data platforms, such as national bio big data and new drug candidate big data; expanding government R&D investment for the development of AI drug development platforms and innovative drugs and medical devices; and developing human resources for AI drug development. In 2019, the priority review in the fourth industrial revolution-related technology field was expanded, and breakthrough therapy and personalized healthcare were introduced as its subject areas. At the beginning of the following year, to improve core biohealth regulations, virtual reality (VR) and augmented reality (AR) medical devices were newly established, announcing that medical devices integrating novel technologies, such as AI imaging devices, will be prioritized for approval by the Ministry of Food and

Drug Safety. Biohealth was included as one of the government's innovative growth BIG3 industries, announced at the end of 2020. Since then, plans have been established to build a Korean-style lab central (K-Bio Lab Hub), create an AI- and big data-based research environment, provide additional large-scale funds to foster ventures and startups, and nurture talent in AI and biohealth fields.

— The major relevant local government policies include the 2021 Regional Industry Promotion Plan for Daejeon, and the 2030 Biohealth Innovative Growth Master Plan announced by the Daejeon Metropolitan City. The former is aimed at fostering the biomedical industry as one of the city's major industries, through a platform to foster and support linkages between organizations on both the demand and supply sides, as well as companies working diagnostic and bioconvergence systems. Meanwhile, the latter devised specific biohealth industry innovation strategies related to infrastructure, human resource development, investment attraction, global expansion of companies, and stakeholder networking, among others, with a budget of KRW 544.3 billion over 10 years (Table 7). However, the Daejeon Metropolitan City-level strategy for the AI and big data-based biohealth industry is limited to providing only bio-big data analytical and utilization services to support personalized medicine, and new drug development as part of the biohealth initiative for Daejeon in the 2030 Biohealth Innovative Growth Master Plan (Daejeon Metropolitan City, 2021).

— Overall, in the five years since the establishment of the government led by President Moon Jae-in in 2017, various policies aimed at the promotion and advancement of the biohealth industry, regulatory improvement, and human resource training have been announced. In addition, from the convergence of the biohealth industry viewpoint, cross-ministerial policies involving the Ministry of Science and ICT, Ministry of Economy and Finance, Ministry of Trade, Industry, and Energy, Ministry of SMEs and Startups, Ministry of Health and Welfare, and Ministry of Education have been implemented. Furthermore,

following national and international discussions regarding the possibility of using fourth industrial revolution technology, the potential of the AI- and big data-based biohealth industry has garnered much attention from the government since 2016. Amidst a surge in demand for vaccine candidate discovery and diagnostic device development during the COVID-19 pandemic, the government recognizes the need for industrial development and systematization. Given the above internal and external trends, Daejeon Metropolitan City visited the bio cluster and lab central in Boston in 2019, and an MOU was signed by the Boston Korean American Bio-Industry Council (KABIC), Bio-Healthcare Association, and Daejeon Techno Park for education, R&D, business, human exchange, and cooperation in holding academic conferences in the biotech industry, showing great interest in fostering the biohealth industry for several years at the local government level (Kang Min-goo, 2019). This interest was further reflected in the introduction of a mid-to-long-term 2030 Bio-health Innovative Growth Master Plan for the biohealth industry.

2.1.3. General Assessment of the Policy

- Effectiveness and Efficiency of National and Local Government Policies
- Changes after the COVID-19 Pandemic

Table 9. Recent Biohealth Policies of Korean Government including AI/Big Data driven Convergence

Third Basic Plan for Fostering Biotechnology (September 2017) and 2025 Science and Technology-based Bioeconomy Innovation Strategy	<ul style="list-style-type: none"> — Related agencies: Ministry of Education, Ministry of Agriculture, Food and Rural Affairs, Ministry of Trade, Industry and Energy, Ministry of Welfare, Ministry of Environment, Ministry of Oceans and Fisheries, Ministry of Food and Drug Safety — This was the highest statutory plan for R&D in the field of biotechnology, jointly established by eight ministries, including the Ministry of Science and ICT, in accordance with the Biotechnology Support Act. It presented a national vision and policy guidelines to foster and develop the field of biotechnology by synthesizing and systematizing detailed plans for the related ministries. Under the supervision of the Ministry of Science and ICT, a basic plan was established through cooperation with the related ministries, and additional annual implementation plans were established based on the basic plan. — Main content: Three key strategies were presented (bio R&D innovation, bio-economy creation, and national ecosystem foundation), and implementation plans and roadmaps for red, green, and white biotechnology were established.
Fourth Science and Technology Master Plan (2018–2022) (February 2018)	<ul style="list-style-type: none"> — Related agencies and organizations: Ministry of Science and ICT (department in charge), field committees (private experts from the industries, universities, and institutes), researchers, the general public, and related ministries — This was a mid-to-long-term development strategy that presented the vision, goal, and direction of the domestic science and technology innovation policy over five years (2018-2022), putting forth the future vision of science and technology from a long-term perspective. — Main content: To strengthen package-type support for the industrialization of growth engines, regulatory improvement for nurturing the bio/healthcare sector was recommended, while recognizing bioconvergence as the key field of science and technology.
Bio-health Industry Innovation Strategy (May 2019)	<ul style="list-style-type: none"> — Related agencies: Ministry of Welfare, Ministry of Economy and Finance, Ministry of Science and ICT, Ministry of Trade, Industry and Energy, Ministry of SMEs and Startups, Ministry of Food and Drug Safety, Financial Services Commission, and Korean Intellectual Property Office — Main content: Various plans were presented, including the plan to build five big data platforms (national bio big data for up to one million people, hospital-based big data, new drug candidate big data, bio patent big data, and public institution big data), the R&D project plan for the “development of AI drug development platforms,” the plan to expand government R&D investment for the development of innovative new drugs and medical devices, the plan to shorten the approval period for drugs and medical devices, the plan to prepare a roadmap for regulatory improvement, the plan to establish an open innovation cooperation system with leading companies as well as startups and venture companies, and the human resource development plan to meet the needs of industrial sites, such as AI drug development and biopharmaceutical production.
Expansion of priority review for fields related to fourth industrial revolution technology (June 2019)	<ul style="list-style-type: none"> — Related agencies: Korean Intellectual Property Office — Main content: The expansion of the priority review for fields related to the fourth industrial revolution technology was implemented on June 10, 2019. The new patent classification system of the fourth industrial revolution, which was previously limited to seven technology fields, was expanded to 16 technology fields through reorganization. The priority review was also expanded to these additional nine fields, including “breakthrough therapy” and “personalized healthcare.”

Establishment of the Bio-health R&D Investment Strategy I (December 2019)	<ul style="list-style-type: none"> – Related agencies: Ministry of Science and ICT – Main contents: The biohealth R&D field was reorganized in the 10 areas linked to policies, and customized investment strategies (intensive short-term support or mid-to-long-term support) were presented, considering the characteristics of each field. Specifically, government R&D investment strategies in four fields, including source and infrastructure, pharmaceuticals, healthcare services, and industrial innovation and regulatory science, were presented first in December 2019. <p>* The “Bio-Health R&D Investment Strategy II” for the remaining six fields (bioconvergence, medical devices, regenerative medicine, clinical and healthcare research, human resource development, and life resources and information infrastructure) will be announced in 2021.</p>
Improvement of 15 key bio-health regulations in four areas (January 2020)	<ul style="list-style-type: none"> – Related agencies: Ministry of Welfare, Ministry of Food and Drug Safety, Ministry of Environment, Ministry of Trade, Industry and Energy, and Ministry of Employment and Labor – Main content: In accordance with the revision of the Personal Information Protection Act, the “Medical Data Usage Guidelines” were established for the use of medical data, and the medical technology review system was improved to expand the recognition of innovative technologies using innovative VR- and AR-based medical devices. The plan to enact a lower statute was presented to designate medical devices with new convergence technologies, such as AI imaging devices, as innovative medical devices and devices eligible for priority review and approval by the Ministry of Food and Drug Safety. Establishment of a regular discovery and improvement system centered around the industry and research sites was proposed through the Bio-health Industry Innovation Strategy Promotion Committee.
Biotech industry innovation policy direction and core tasks (January 2020)	<ul style="list-style-type: none"> – Related agencies: Cross-ministerial bio-industry innovation TF (including ministries, Korea Development Institute, KRIBB, Korea Insurance Research Institute, Korea Health Industry Development Institute, Agricultural Biotechnology Research Institute, and Korea Institute for Industrial Economics and Trade) – Main content: Five key strategies included R&D innovation to strengthen global competitiveness, focused human resource development in new fields, advancement of regulations and systems to promote market growth, support for bio-ecosystem creation and overseas expansion, and support for the commercialization of bioconvergence technology.
Strategies for promoting the commercialization of the biotech industry and regional advancement (November 2020)	<ul style="list-style-type: none"> – Related agencies: Ministry of Trade, Industry and Energy, Ministry of Welfare, Ministry of Economy and Finance, Ministry of Science and ICT, Ministry of SMEs and Startups, and Office for Government Policy Coordination – Main content: These included strategies for promoting effective investments in pharmaceuticals, medical devices, digital healthcare, and regional infrastructure, as well as advancing the biotech industry. Specifically, detailed advancement strategies related to pharmaceuticals (enhancement of the production and distribution structure, support for fostering human resources at each stage of the value chain, and alleviation of development risks), medical devices (securing the domestic market based on field demand, supporting integrated market entry, and strengthening the competitiveness of new medical devices), and regional demands (strengthening strategic nurturing of clusters, expansion of cluster enterprise support functions, strengthening cluster linkage and cooperation) were presented.
Innovative Growth BIG3 Industry Intensive Promotion Plan (December 2020)	<ul style="list-style-type: none"> – Related agencies: Ministry of Economy and Finance, Ministry of Welfare, Ministry of Trade, Industry and Energy, Ministry of Science and ICT, Ministry of SMEs and Startups, and Financial Services Commission – Main content: Through the “Innovative Growth BIG3 Promotion Conference,” in which the public and private sectors participate, field-oriented core tasks for the relevant BIG3 industries, such as system semiconductors, future vehicles, and biohealth, were selected and extensively promoted.
Funding to foster ventures and start-ups in the BIG3 industries (January 1, 2021)	<ul style="list-style-type: none"> – Main content: This plan was aimed at creating an additional KRW 500 billion government venture fund to foster ventures and startups in the BIG3 industries, such as future cars, biohealth, and system semiconductors. According to this plan, a preliminary feasibility study to build a “Korean Lab Central,” including not only ventures and startups, but also large pharmaceutical companies, hospitals, and research institutes, would be conducted in the first half of the year. Through this, a research environment would be created based on big data and AI, which are the core technologies in biotech, and research at ventures and startups would be promoted until entry into the clinical stage.
Establishment of the Bio-health R&D Investment Strategy II	<ul style="list-style-type: none"> – Related agencies and organizations: Special Committee on Biotechnology (as a cross-ministerial coordinating body under the National Science and Technology Advisory Council, it involves government officials heading the relevant ministries and private members from industries, universities, and institutes, with a total of 30 members) – Main content: In addition to Bio-health R&D Investment Strategy I established in December 2019, 10 areas of biohealth R&D investment strategy were presented.
Human resource development plan for AI specialists in the BIG3 industries (April 2021)	<ul style="list-style-type: none"> – Related agencies: Ministry of Education, Personal Information Protection Commission, and Statistics Korea – Main contents: This plan was aimed at nurturing human resources in the BIG3 industries, including future vehicles, biohealth, and system semiconductors. This plan fostered over 36,000 people in AI-related fields, including industrial AI and AI integration industrial field specialists and biohealth specialists; over 22,000 regulatory science and bio-processing workforce members; and over 22,000 clinical trial and regenerative medicine specialists.

Source: Summarized based on press and policy materials.

Table 10. Recent Biohealth Policies of Daejeon City

2021 Regional Industry Promotion Plan for Daejeon (November 2020)	<ul style="list-style-type: none"> – Related agencies and organizations: Ministry of SMEs and Startups, Korea Institute for Advancement of Technology, and Daejeon Metropolitan City – Main contents: This was a local industry promotion plan led by the local governments to build a self-sustaining industrial and corporate ecosystem. With the aim of becoming the “core city of South Korea, leading the Korean version of the New Deal by accelerating digital transformation and creating a low-carbon society,” this plan fostered next-generation wireless communication convergence, AI, and biomedical technologies
2030 Bio-health Innovative Growth Master Plan (January 2021)	<ul style="list-style-type: none"> – Related agencies: Daejeon Metropolitan City – Main content: The goal of this plan was to create a global biohealth startup hub cluster in Daejeon to establish a “technology-based biotech venture hub in Daejeon.” This plan included strategies such as establishing advanced infrastructure for a virtuous cycle of bio startup and growth with a 5+2 promotion strategy; nurturing bioprofessionals and attracting an excellent workforce; creating an environment to promote investment in biotechnology; establishing the foundation for Born2Global promotion; establishing industry–university–institute–hospital governance and networks; promoting the designation of a free economic zone; and presenting biohealth initiatives suitable for Daejeon.

Source: Summarized based on press and policy materials.

Table 11. The Basic Plan of 2030 Biohealth Innovative Growth of Daejeon City

Promotion strategies	Establishing advanced infrastructure for a virtuous cycle of biotech startup and growth	<ul style="list-style-type: none"> – Establishment of a Korean-style Bio Lab Central – Establishment of a global growth support center for gene-based medicine – Establishment of shared research facilities for pathogen resources in response to emerging infectious diseases
	Nurturing bio-professionals and attracting an excellent workforce	<ul style="list-style-type: none"> – Establishment of a training center for GMP production experts – Cultivation of human resources suitable for each company through the establishment of a bio contract department – Provision of support for local settlement and attraction of excellent workforce – Operation of the Daejeon Bio Job platform
	Creating an environment to promote investment in biotechnology	<ul style="list-style-type: none"> – Creation of a fund dedicated to bio-health in Daejeon – Holding a Bio-health Demo Day – Hosting an international bio-health conference
	Establishing a foundation for Born2Global promotion	<ul style="list-style-type: none"> – Establishment of an overseas core in the biotech industry – Establishment of a global clinical support platform linked to overseas hospitals – Provision of support for global biomedical IP creation – Technical marketing and global licensing support – Provision of support for manufacturing prototypes for global technology commercialization
	Establishing industry–university–institute–hospital governance and networks	<ul style="list-style-type: none"> – Reorganization of the bioindustry fostering system (system and dedicated institution) – Composition and operation of the Biotech Industry Development Council – Establishment of a fast-track support system for preclinical and clinical trials – Activation of the joint operation of the Daejeon Human Material Bank
Additional strategies	Promoting the designation of a free economic zone	<ul style="list-style-type: none"> – Attracting investments by domestic and foreign biohealth companies and attracting domestic and foreign talent to start businesses in Daejeon
	Presenting biohealth initiatives suitable for Daejeon	<ul style="list-style-type: none"> – Strategic development of six major biohealth technologies suitable for Daejeon (including big data analysis and utilization support)

Source: Daejeon Metropolitan City (2021).

2.2. Resource Mobilization

2.2.1. Biohealth R&D Investment Strategies I and II

— In 2019, the Ministry of Science and ICT established the Biohealth R&D Investment Strategy I by forming a working group involving industry, academia, research, and private investment industry experts to design and implement a system classifying and reviewing biohealth R&D investments into 10 fields: source/basic research, bioconvergence, pharmaceuticals, medical devices, regenerative medicine, healthcare services, clinical/health research, industrial innovation/regulatory science, human resource development, and life resource/information infrastructure. In 2021, through the Biohealth R&D Investment Strategy II at the government level, an investment strategy was established in conjunction with a biohealth research and industry support policy across 10 fields (Ministry of Science and ICT, January 28, 2021). As part of these biohealth R&D investment strategies, the main content related to AI and big data included bioconvergence (new drug development), pharmaceuticals (establishment of related platforms), healthcare services (big data standardization and security), and human resource development (Table 12).



Table 12. AI and Big Data related Biohealth R&D Investment Strategies

Field	Main contents
Bioconvergence (linking of medicines, medical devices, and healthcare services)	Expansion of R&D investment in next-generation drug development through the efficient discovery of drugs and improvement of drug delivery technologies via integration with advanced technologies, such as AI
Pharmaceuticals [derivation of candidate substances and drug development, provision of support for the development of evaluation technology for emerging therapeutic fields, and establishment of a common (e.g., AI) platform to promote new drug development]	Provision of support for the development of evaluation technology for emerging therapeutic fields and establishment of a common platform (e.g., AI) for facilitating the development of new drugs
Healthcare services (healthcare big data construction, utilization, and service)	Provision of support for the development of a common platform, such as standardization and security technology, for healthcare big data, which can lead to social consensus within the scope of the related regulations.
Human resource development (industrialization specialists, research specialists, and strengthening the basis of workforce nurturing policies)	Technology integration with promising fields (e.g., BT + AI) and strengthening of new investment in healthcare human resource development projects (basic medical scientists and medical specialists)

Source: Ministry of Science and ICT (2021.01.28.).

2.2.2. Status of R&D Investment in South Korea and Daejeon

— According to the Korea Bio-Economy Research Center (KBERC), which is affiliated to the Korea Biotechnology Industry Organization, domestic bioindustry²⁾ R&D expenditure increased by approximately 10%, from KRW 768.6 billion in 2010 to KRW 1.83 trillion in 2019. During the same period, R&D expenditures on medical devices and pharmaceuticals within the biohealth industry increased by 11.8% and 13.8 %, respectively, showing high increases compared with those in other subfields (Table 13).

— Table 14 summarizes changes in biotech industry R&D trends by province, with a focus on areas where the major domestic bio clusters are located in Daegu-Gyeongbuk Advanced Medical Complex, Osong Advanced Medical Complex, Daejeon Biotech Complex, Wonju Medical Device Techno Valley, Pangyo/Gwanggyo Techno Valley, Songdo Biotech Complex, and Seoul Hongneung Bio Hub. In 2018, the bioindustry R&D expenditure was highest in Gyeonggi, followed by Chungbuk, Incheon, Seoul, Daejeon, Gangwon, and Daegu. Notably, the compound annual growth rate (CAGR) of R&D expenditure from 2010 to 2018 was close to 10% in all regions except Daegu, but there was no significant increase (0.0%) in Daejeon. Over time, bioindustry R&D in Daejeon steadily increased from 2010 to 2014, but showed an overall decrease from 2014 to 2017.

— However, based on criteria other than the absolute scale of R&D or the trend of change by year, R&D investment in Daejeon is comparable to that in other regions. According to Hwang Hye-ran (2020), the average R&D expenditure related to the biotech industry per company by region from 2016 to 2017 was the highest in Gyeonggi (KRW 1.927 billion), followed by Seoul (KRW 1.846 billion), Chungbuk (KRW 14.64 billion), and Daejeon (KRW 1.4 billion), and in 2017, the regional ratio of R&D expenditure to sales was the highest in Daejeon (10.0%), boasting a potent R&D intensity.

2) This includes the sub-fields of medicine, chemical/energy, food, environment, medical devices, equipment and appliances, resources, and services.

Table 13. Biohealth R&D expenditure in each field from 2010 to 2019 (Unit: KRW hundred million, %)

Field	2010		2011		2012		2013		2014		2015	
	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio
Medicine	4,811	62.6	6,247	67.2	6,495	64.4	8,295	71.8	9,263	74.2	9,748	74.5
Medical devices	318	4.1	406	4.4	556	5.5	515	4.5	559	4.5	561	4.3
Chemistry and energy	833	10.8	934	10	1,017	10.1	883	7.7	899	7.2	1,142	8.7
Food	942	12.3	1,055	11.3	1,231	12.2	1,099	9.5	958	7.7	867	6.6
Environment	119	1.6	116	1.3	122	1.2	100	0.9	96	0.8	93	0.7
Equipment and appliances	97	1.3	134	1.4	130	1.3	113	1	115	0.9	116	0.9
Resource	154	2	141	1.5	145	1.4	160	1.4	158	1.3	165	1.3
Services	412	5.4	271	2.9	383	3.8	381	3.3	436	3.5	394	3
Total	7,686	100	9,302	100	10,079	100	11,547	100	12,486	100	13,086	100

2016		2017		2018		2019	
Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio
10,455	74.1	11,114	74.2	12,174	71.7	13,116	71.30%
561	4	618	4.1	891	5.3	1,019	5.50%
1,137	8.1	1,166	7.8	1,495	8.8	1,473	8.00%
1,043	7.4	1,114	7.4	1,269	7.5	1,291	7.00%
92	0.6	97	0.6	118	0.7	132	0.70%
120	0.8	129	0.9	87	0.5	131	0.70%
223	1.6	226	1.5	102	0.6	111	0.60%
489	3.5	508	3.4	837	4.9	1,123	6.10%
14,118	100	14,973	100	16,974	100	18,397	100.00%

*Results after 2016 should be interpreted with caution with respect to the time series for some industries, considering the changes in the classification system.

Source: Korea Biotech Industry Survey [Reproduced from the Korea Bio-Economy Research Center affiliated with the Korea Biotechnology Industry Organization (2020, 2021)].

Table 14. Trends in Biohealth R&D Investment of Main Regions from 2010 to 2018 in South Korea (Unit: KRW hundred million, %)

Region	2010		2011		2012		2013		2014		2015	
	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio
Daejeon	698	9.1	1,033	11.1	968	9.6	1,132	9.8	1,246	10	1,068	8.2
Seoul	851	11.1	827	8.9	1,062	10.5	1,140	9.9	922	7.4	1,138	8.7
Incheon	1,117	14.5	1,507	16.2	1,747	17.3	2,810	24.3	3,642	29.2	3,595	27.5
Daegu	178	2.3	45	0.5	40	0.4	32	0.3	34	0.3	30	0.2
Gyeonggi	2,320	30.2	3,102	33.3	3,393	33.7	3,097	26.8	3,505	28.1	3,576	27.3
Gangwon	252	3.3	194	2.1	214	2.1	253	2.2	282	2.3	316	2.4
Chungbuk	889	11.6	1,092	11.7	1,274	12.6	1,250	10.8	1,444	11.6	1,750	13.4
Total	7,686	100	9,302	100	10,079	100	11,547	100	12,486	100	13,086	100

2016		2017		2018		CACR (20110-2018)
Expenditure	Ratio	Expenditure	Ratio	Expenditure	Ratio	
947	6.7	464	3.1	698	4.3	0
1,441	10.2	1,393	9.3	1,860	11.3	10.3
4,231	30	3,898	26	2,481	15.1	10.5
27	0.2	28	0.2	49	0.3	-15
3,902	27.6	4,878	32.6	6,181	37.7	13
365	2.6	479	3.2	578	3.5	10.9
1,498	10.6	2,147	14.3	2,883	17.6	15.8
14,118	100	14,973	100	16,406	100	9.9

*Based on the business sites (factory > research center > headquarters), one site was selected per city and province to identify its location.

Source: Reproduced from the Korea Bio-Economy Research Center affiliated with the Korea Biotechnology Industry Organization (2020, 2021).

2.2.3. Status of Human Resources in Daejeon City

Although the biohealth industry has recently attracted interest due to the COVID-19 pandemic, the number of related professionals in South Korea is smaller than in other countries. According to the Korea Biotechnology Industry Organization (2020), the number of domestic bioindustry professionals increased by 7.057% in the pharmaceutical sector from 13,837 in 2010 to 20,894 in 2019, and by 3.413% in the medical device sector, from 1,969 in 2010 to 5,382 in 2019. The analysis of the biohealth workforce growth trend for the next five years (2020–2024) based on the 10-year average annual growth rate revealed that the workforce is expected to increase most in the medicine (6.8%) sector, followed by the medical devices (6.2%) sector.

Universities and colleges in Daejeon city seeking to nurture experts in the biohealth industry include KAIST, Chungnam National University, University of Science and Technology (UST), Hannam University, Hanbat University, Mokwon University, Daejeon University, Pai Chai University, Woosong University, and Daejeon Health Sciences College. The average number of students graduating from 2010 to 2019 was approximately 1,500 per year, of which nearly 200 graduated with masters, and 190 with a doctorate (Hwang Hye-ran, 2020).

To nurture experts with practical competencies suitable for the biohealth industry, several related public institutions, in addition to industries, universities, and institutes, are operating and supporting programs to foster a professional workforce in Daejeon. Moreover, Daejeon TechnoPark is in charge of leading scientific and technological innovations, as well as the innovative growth of small-to-medium-sized venture companies in Daejeon. Daejeon TechnoPark conducts a joint industry–university cooperation project and fosters experts in the bio-healthcare industry through an MOU with Konyang University (Lee Young-min, 2020). Daejeon and Woosong Universities were selected as participating universities in the biohealth field for the 2021 Digital New Technology Talent Nurturing Innovation Sharing University Project, a project hosted by the Ministry of Education as part of the Korean version of the New Deal project to develop high-quality human resources suitable for the medical, health, and healthcare fields by 2026. In particular, AI- and big data-based biohealthcare projects are under way (Yoo Soon-sang, 2021). In addition, Startup KAIST, K-School, and the KRIBB Future Strategy Research Department and Technology Transfer Center are cluster-based institutions (Science & Technology Policy Institute, 2021).

In an interview, an official from the biohealth industry in Daejeon stated that although the relevant universities are distributed across Daejeon, providing a supply of human resources, the influx of a high-quality workforce is not sufficient to meet the needs of the industry in general. In other words, there is a gap between the workforce required by companies and the available workforce. In addition, a highly skilled workforce faces problems finding employment in Daejeon in contrast to Seoul and other metropolitan areas following graduation. The problems of nurturing and securing the workforce are well known, particularly for the most difficult processes that require the most support for the operation of a company. For instance, a biohealth company based on AI and big data convergence in Daejeon is planning to recruit senior personnel among students who can operate AI-based drug development platforms in Korea and the United States by opening regional offices to solve difficulties in recruiting the research workforce. To fill this gap, there is a need for policies supporting industry- or company-specific education and the creation of educational content through discussions among specialized human resource training institutes and biotech companies, enabling students to be directly deployed into the industry after graduation.



2.3. Production

2.3.1. Medicines and Medical Devices

Business Status via Venture Generation

The biohealth industry in Daejeon has grown autonomously and is centered on several venture companies. Currently, there are 311 biohealth related venture companies in Daejeon (Cho Han-pil, 2021), which can broadly be divided into first- and second-generation companies according to the establishment period and industry characteristics (Table 15). According to the Bio-Healthcare Association, the number of companies increased significantly in 2000, 2005, 2010, 2015, and 2021. First-generation companies are mainly those established from the mid-late 1990s to the 2000s, primarily dealing with conventional biohealth R&D (medicines and medical devices, among others). Representative first-generation companies include Bioneer Corporation, ALTEOGEN, LegoChem Biosciences, and Y-Biologics (HelloDD, 2021).

As briefly noted above, first-generation venture companies were formed by gradually expanding companies spun off from Bioneer Corporation, Inbionet, LG Life Sciences (currently LG Chem Life Science Innovation Center), and KRIBB. Since the early days of their establishment, these companies have developed through cooperation and the organic formation of communities, such as the Daedeok Biocommunity (established in 2000), Breakthrough Therapy Salon (established in 2012), and Bio-Healthcare Association (established in 2015). The second generation of ventures refers to companies established after 2010, which

implement and develop technologies by integrating emerging tools, such as AI and big data, with existing conventional biohealth technologies. Representative companies include Sugentech (diagnostics), Innovotherapeutics (new synthetic drugs), SyntekaBio (anti-cancer drugs), and EnsolBio Sciences (animal arthritis treatment).

Technology Export Status

Biohealth companies in Daejeon city mainly focus on new drug development and export development results in the form of technology. Owing to the nature of biohealth technology, its implementation and performance are somewhat delayed compared to those of other technologies. The biohealth industry in Daejeon started achieving concrete results in the 2010s in the form of technology exports and the attraction of investment (Hwang Hye-ran, 2020). According to the Korea Health Industry Development Institute (2020), there were 14 and 13 technology exports from local pharmaceutical and biotech companies in 2019 and 2020, respectively. Regarding the status of key technology exports by major biohealth companies in Daejeon, LegoChem Biosciences and ALTEOGEN signed milestone contracts for ADC source technology, human hyaluronidase, and subretinal fibrosis and wet macular degeneration treatments in the United States and France, among other countries, in 2019 and 2020 (Korea Health Industry Development Institute, 2020).

Table 15. Characteristics of Bio-Venture by Generation in Daejeon City

Type	First generation	Second generation
Research and development field	Based on pharmaceuticals, medical devices, and convergence technology (AI and big data)	
Establishment period	1990 to 2010	2010 to present
Characteristics	Conventional biohealth industry research and spin-off companies	Convergence technology (AI and big data) research companies and conventional biohealth industry research companies
Representative companies	Bioneer Corporation, LegoChem Biosciences, ALTEOGEN, Y-Biologics, GenoTech	SugenTech, Innovotherapeutics, SyntekaBio, EnsolBio Sciences
Opportunities and limitations	<ul style="list-style-type: none"> - Strong self-sustaining cooperative culture by forming a community - Business succession problems due to aging of the first generation of ventures - Communication with other generations is not as efficient as collaboration and communication within the first generation - Doubtful and skeptical of non-conventional biohealth companies based on convergence technology (AI and big data) 	<ul style="list-style-type: none"> - Broadening research horizons in the biohealth industry based on convergence technology - There are only a few laboratories and factories that can conduct and develop convergence technology (AI and big data)-based research, due to the lack of relevant infrastructure, particularly in Daejeon. - Compared to other areas, there are relatively more opportunities to gather expertise in business operations, technology development, and exports through a number of first-generation cooperative organizations. - Efforts are required to improve the somewhat negative perception that the first-generation ventures have of convergence technology (AI, big data)-based non-conventional biohealth companies and share expertise through collaboration.



Production Status by District

While Daejeon has no large biohealth companies, its strategic location as the “Silicon Valley” of Korea favors cooperation between various venture companies, universities, and government agencies. Since it is very important to obtain advice on various processes such as clinical trials, hospital cooperation, and CROs³⁾ when initiating a venture or startup, entrepreneurs tend to prefer places with many mentor companies, and related infrastructure. An official from an organization related to the biohealth industry in Daejeon stated in an interview that there are many such tutor companies in Daejeon, and the tutoring culture is well developed. In addition, because of the nature of this industry, bio-companies do not need to compete with one another, with numerous overseas partners and products. Overall, these advantages and its unique culture make Daejeon an attractive location for biotech ventures.

In 2019, Daejeon was designated a regulation-free special zone⁴⁾ in the biomedical sector to create jobs and revitalize the local economy by fostering bioindustry. Organizations in the regulation-free special zone include Daejeon Techno Park, Chungnam National University Hospital, Daejeon Eulji Hospital, and Konyang University Hospital, in addition to nearly 20 companies, with three major expected effects. In terms of policy, this would promote innovative growth and new business activities for the biomedical companies in Daejeon. From an economic point of view, the designation of a regulation-free special zone targeting the biomedical industry in the region would lead to the growth of the sector and target industry. In addition, the expected social effects include reduced regulatory costs, and contribution to public health.

Furthermore, in July 2020, based on the recommendations of the Minister of SMEs and Startups at the time, Daejeon was selected as the “Infectious Disease Treatment Regulation-Free Special Zone” among the three regulation-free special zones, and selected as a “business destination” for the early commercialization demonstration of vaccines and therapeutics⁵⁾ through the establishment and operation of a shared research facility for pathogen resources, allowing joint use of research facilities and encouraging more bio ventures and startups to participate in the development of infectious disease treatments (Hong Da-young, 2020).

The International Science Business Belt (ISBB) aims to foster a world-class science-based innovation cluster by establishing an outstanding basic research environment and a global settlement environment based on Article 12 of the Science Belt Act and Science Belt Basic Plan. There are three base districts: Sindong (heavy-ion accelerator and related research facilities), Dungok (Advanced Research Industrial Complex), and Doryong (Institute for Basic Science and Patent Information Service). Nearly 20 biohealth companies, including LegoChem Biosciences, are scheduled to move into the Sindong–Dungok district by 2022 (Korea Innovation Foundation, 2021; Kim In-han, 2020). ALTEOGEN, a representative company in Daejeon, autonomously established a GMP factory in the Sindong–Dungok district. This factory plans to produce Eylea biosimilars and human hyaluronidase at the scales of European Good Manufacturing Practice (GMP) and US cGMP. Since the GMP process deals with drugs used in clinical trials (human studies), the related procedures are relatively strict and demanding. Currently, there are very few GMP factories in Daejeon, and the establishment of a GMP factory by ALTEOGEN is significant to meet the goals of the company (reducing concerns regarding technology expertise leakage during phase-3 clinical trials and the CMO processes), as well as to improve the technology and expand the biohealth industry and cluster in Daejeon. With the operation of the factory, it will now be easier for other biohealth companies in Daejeon to perform clinical trials extending

3) Contact Research Organizations.

4) In accordance with the Act on Special Cases Concerning the Regulation of Regulation-Free Special Zones and Special Economic Zones for Specialized Regional Development, this is a zone to which special regulatory exceptions are applied to foster innovative businesses or strategic industries in metropolitan areas, excluding the metropolitan area. The designation period for Daejeon Biomedical Regulation-Free Special Zone is from December 6, 2019, to December 5, 2023 (4 years) (Daejeon Biomedical Regulation-Free Special Zone, 2021)

5) This refers to providing the pathogen resource common research facility (BL3*), which is the greatest challenge for bio startups in the development of vaccines and therapeutics, eliminating the initial barriers to entry and establishing a one-stop support system for the entire biotech industry, from the rapid diagnosis of infectious diseases to the development of vaccines and treatments in conjugation with the existing regulation-free special zone projects focusing on diagnostics**. (Shin Y, 2020)

*Biosafety level (BL) 3: A research facility with complete containment, corridor access restrictions, and high-performance filters.

**Joint operation of a human material bank (Chungnam, Eulji, Konyang University Hospitals), simplifying the procedure for entering the in vitro diagnostic device market.

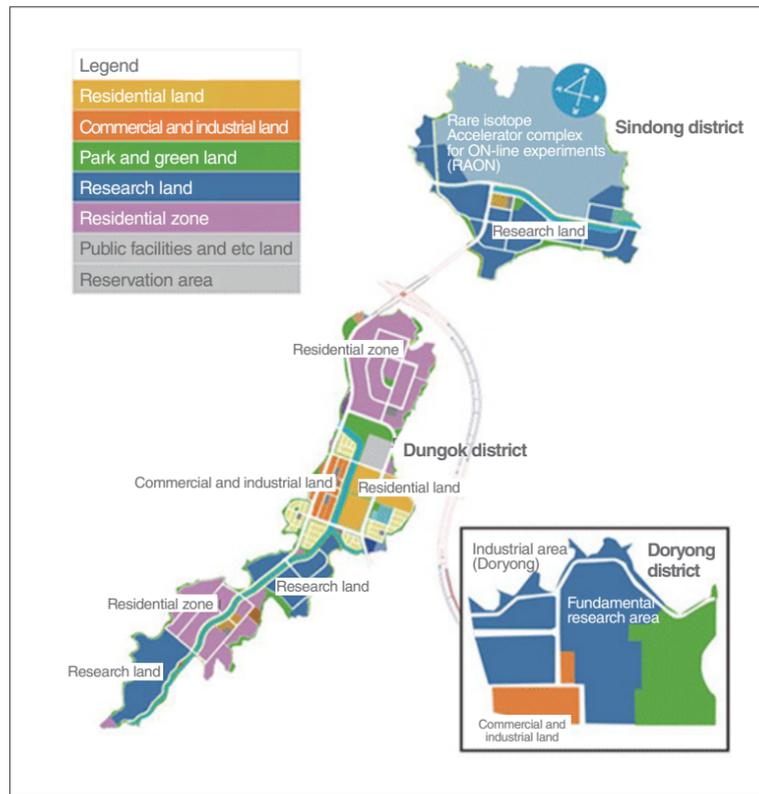


Figure 3. Map of the International Science&Business Belt (ISBB) in Daejeon City

Source: Korea Innovation Foundation (2021)

beyond phase-3. Since conventional companies in Daejeon have never conducted phase-3 clinical trials, a more advanced biohealth industry and cluster can be envisioned in the future.

Meanwhile, the GMP factory of the Daejeon TechnoPark BIO Convergence Center passed due diligence in the quality control step of the European Medicines Agency (EMA) in June 2020 (Hit News, 2020); however, whether to close the facility or establish a new utilization plan considering its aging and deficits around August 2021 remained under discussion (Lee Jeong-hoon, 2021). Regarding the status of other companies in the production district, Kyuloseel, which develops CAR-T cell therapy, is planning to build a KRW 30 billion GMP factory for the production of CAR-T treatments in Dungok, which is currently in its design stage (Kim Chan-hyuk, 2021). According to an official from a biohealth company in Daejeon, KRICT and Chungnam National University laboratories in Daejeon were used to validate the experiments.

Changes after the COVID-19 Pandemic

While the biohealth field is gaining increasing attention owing to COVID-19, Daejeon has witnessed substantial growth and profits in the field of in vitro diagnostics. For instance, Sugentech registered the COVID-19 antigen self-test diagnostic kit “SGTi-flex COVID-19 Ag (Self-testing)” in the UK, obtained the Certificate of Conformity (CE CoC) approval—the first European approval in South Korea—and signed a contract to supply a rapid diagnosis kit for COVID-19 antigen worth KRW 13 billion to “Medaz Vietnam General Service Company Ltd.” in Vietnam, recording the sales of KRW 41.35 billion in 2020 (975.4% increase from the previous year) (NICE Evaluation Information, 2021). Similarly, Seasun Biomaterials, another company in Daejeon, has received official local approval for COVID-19 diagnostic products (NICE Assessment Information, 2021). Another diagnostic company established in 2000, SolGent, was supported by Samsung, and its automation facilities were selected as a model case for supporting small-to-medium-sized enterprises by the Ministry of SMEs and Startups at the time. SolGent developed the DiaRapid™ COVID-19 Ag Test Kit in 2021, and obtained a CE certification (Park Sun-ha, 2021).

2.3.2. AI and Big Data based Convergence Technology

As members of the Bio-Healthcare Association (2021), SyntekaBio, GHBio, and Healinnols conduct R&D on AI-based new drug development materials for convergence (AI/big data-based) biohealth companies in Daejeon. Table 16 lists other biohealth companies based on convergence technology in Daejeon, including Tomocube, which uses technology for diagnosing diseases with a stereoscopic microscope (HelloDD, 2021).

Table 16. Convergence Biohealth Companies in Daejeon City

Division	Company name
Medicines (New Drug)	(1) Innovo Therapeutics (synthetic new drugs for immune disorders, cancers, and metabolic diseases) <ul style="list-style-type: none"> - Innovo Therapeutics established corporations in Seoul and Daejeon in 2019, received technology introduction contract and funding, and venture business certification in 2020. - It was established by researchers with experience in developing new drugs successfully at LG Life Sciences (currently, LG Chem Life Science Innovation Center). - It developed a web-based drug research platform, DeepZema. - The headquarters are located in Seoul, and the corporate research institute is located in Daejeon.
	(2) SyntekaBio (AI-based drug platform, genome big data, and anticancer drug) <ul style="list-style-type: none"> - SyntekaBio was established in 2009, starting as a research institute company in 2014 by investing in the “Supercomputing for Genome Big Data” technology of the Electronics and Telecommunications Research Institute of Korea. - It was listed on KOSDAQ in December 2019. - It is located in Daejeon, Seoul, and Cheongju, with headquarters as well as the genomic data integration and AI big data centers in Daejeon. - In South Korea, it is the only company to publish four bioinformatics algorithms in SCI journals (two ADIScan, one HLAScan, and one CDRscan) and three global consortium journals (Science and Nature) in the genomics domain. - It signed a contract with overseas CROs to conduct overseas clinical trials of “STB-R011,” a therapeutic agent for COVID-19, in 2021.
	(3) EnsolBio Sciences (degenerative arthritis treatment) <ul style="list-style-type: none"> - EnsolBio Sciences has its headquarters in Daejeon. - It was established and certified as a venture company in 2001 and was listed on KONEX in 2018. - It developed “KISDD,” a bio-big data-based new drug candidate discovery platform, and signed a technology transfer contract for the treatment of animal osteoarthritis (EAD100) with the top 10 global veterinary pharmaceutical companies in 2020.
	(4) GHBio (customized animal production service using genetic scissors technology) <ul style="list-style-type: none"> - Since its establishment in 2014, it has developed and applied a biotechnology platform equivalent to a clinical evaluation system to verify the efficacy of biopharmaceuticals in preclinical evaluations. - In-house research facilities and animal breeding clean room facilities were established in Daedeok Techno Valley in 2020. - It developed a humanized PD-1 mouse model.
	(5) Healinnols (chronic inflammatory diseases) <ul style="list-style-type: none"> - Established in 2021, it aimed to overcome the limitations of technology and graft innovative technologies through unique technology and expertise.
Medical devices	(1) Tomocube (three-dimensional holographic microscopy and AI-integrated diagnostics) <ul style="list-style-type: none"> - It was established in 2015. Since the development of a three-dimensional holographic microscope, it has been pursuing bio-diagnostics by incorporating AI.

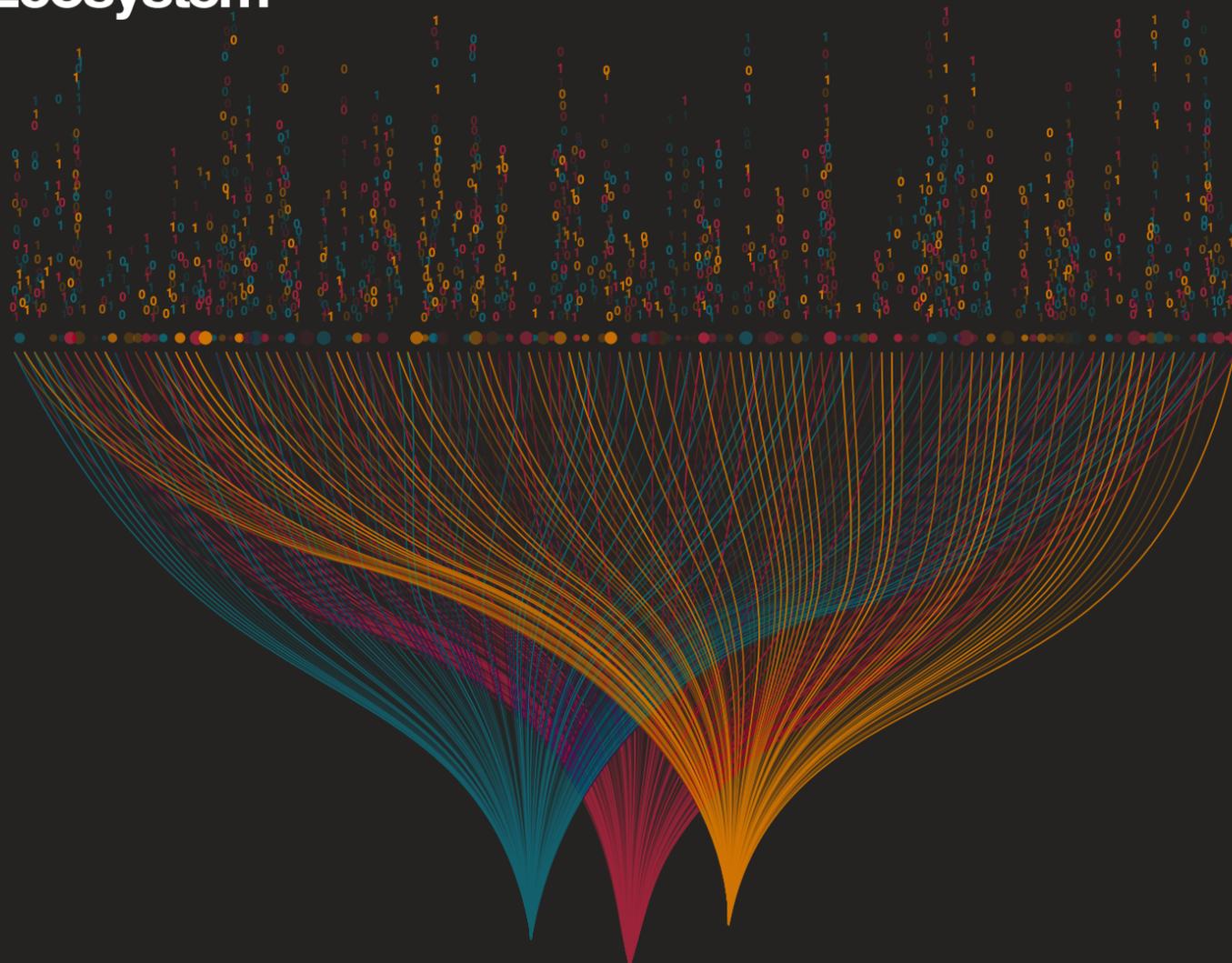
Source: Company Websites, 2021; SyntekaBio Introduction Material, 2021; Kim Chan-hyuk, 2021; Hong Sook, 2021.

Changes in Production Processes and Difficulties in Conversion

According to an official from a biohealth company in Daejeon, convergence technology-based biohealth companies face more difficulties than conventional biohealth companies in linking experimental and verification institutions and production facilities, as the production method based on AI and big data convergence is different from existing production methods. Biohealth companies in Daejeon have the advantage of being able to negotiate better prices when conducting experiments and verification in Daejeon, and it is easier to make the necessary modifications in the manufacturing process. However, although it is advantageous to perform testing and verification in Daejeon, of approximately 600 target proteins, only 20 can be actually tested. Currently, only a few companies in Korea perform testing at the level of AI-based drug development (analysis of approximately 600 target proteins by this company). Therefore, it is crucial to support the growth of the company at the government level, which is the standard for AI-based drug development in South Korea, including Daejeon. This will increase the number of companies aiming to become CROs, further contributing to the establishment and growth of related convergence technology companies.

03

The Desired State of the Innovation Ecosystem



3.1. The Main Characteristics and Elements



3.1.1. Main Characteristics of the Target Biohealth Industry

Characteristics of the biohealth industry, such as new drugs and medical devices.

- Among the biohealth industries, new drugs and medical devices can be sold after successful non-clinical and clinical experiments and obtaining approval from national regulators such as the Ministry of Food and Drug Safety (KFDA), or the U.S. Food and Drug Administration (FDA). While the process of developing new drugs to treat diseases is long and costly, the rewards of success, particularly in terms of sales revenues, can be very significant.
- In the medical device industry, new products are rapidly developed and released into the market, with a combination of advanced technologies of the 4th Industrial Revolution, such as AI, big data, 3D printing, robots, and ICT.

The appearance of new cutting-edge medical technology and its advanced medical products

- Advanced technologies such as AI and big data are being combined, leading to major changes in the healthcare industry, such as the development of new drugs and medical devices.
- In the R&D sector, heterogeneous technologies are being fused to develop cutting-edge medical technologies, and applied research is also vigorously under way to commercialize them.
- In 2018, medical devices applying artificial intelligence were released, obtaining approval for the first time from regulators in both Korea and abroad (VUNO med-BoneAge by domestic vuno companies, IDX-DR of US IDX companies, etc.).

Improvement and establishment of departments related to regulatory systems, and licensing

- There is a significant need to use medical big data held by hospitals or institutions (the Health Insurance Service, etc.) for the development of new drugs and medical devices.
- However, due to legal restrictions, such as the Personal Information Protection Act, the use of public medical big data is very limited, and there is a serious need to improve the legal system to solve these problems.

High-tech convergence professionals.

- Professionals are needed to drive the transition to the biohealth industry by combining advanced technologies such as AI medical devices, new AI drugs, and medical big data platforms.
- In the existing bioindustry, experts in a single field, such as biology, chemistry, and machinery, conduct research, development, and product production. However, the biohealth industry, which combines advanced technologies, requires experts who can promote heterogeneous convergence research and development, such as AI and biohealth convergence.

3.1.2. The Growth Process of the Bioindustry Ecosystem in Daejeon

Daejeon city classifies the stages of the growth process of the local bioindustry into three different periods as follows:

"Daejeon Bio 1.0" era (initial period, 1990-1999)

- The first bio-venture (Bioneer) company was created based on the government creation of the Daedeok R&D Special Zone.

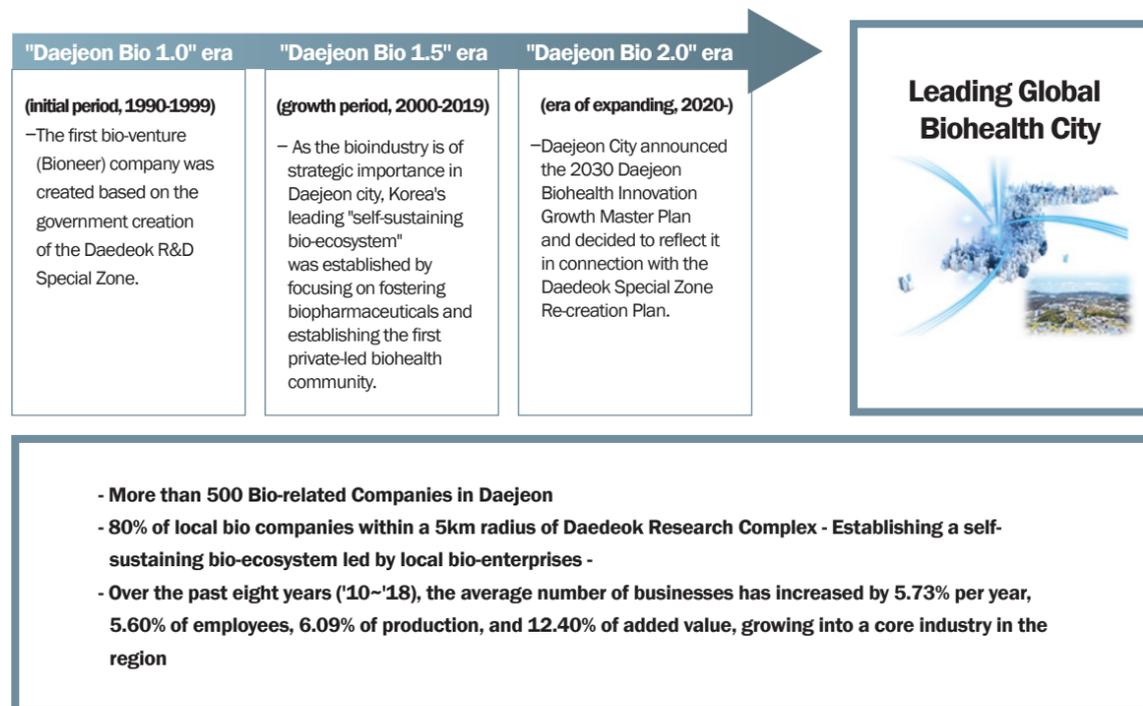
"Daejeon Bio 1.5" era (growth period, 2000-2019)

- As the bioindustry is of strategic importance in Daejeon city, Korea's leading "self-sustaining bio-ecosystem" was established by focusing on fostering biopharmaceuticals and establishing the first private-led biohealth community.

"Daejeon Bio 2.0" era (era of expanding, 2020-)

- Daejeon City announced the 2030 Daejeon Biohealth Innovation Growth Master Plan and decided to reflect it in connection with the Daedeok Special Zone Re-creation Plan.

Figure 4. The Growth Process of Bio-Industry in Daejeon
Source: Daejeon City Government



3.1.3. Major Elements of the Biohealth Industry Ecosystem in the Entire Product Development Cycle

Importance of one-stop support for the entire cycle

- Bio-venture product development is carried out as a process of generating ideas, research and development (R&D), prototype development, non-clinical testing (animal experiments), clinical trials (Phases 1-3), trial tests and licensing, product production, sales, etc.
- Not only is it difficult for bio-companies, including startups, to build the facilities, equipment, and infrastructure necessary for all of these product development processes, but it is also difficult to proceed with non-clinical and clinical trials, and licensing processes.
- Therefore, companies may require consulting and support throughout the product development cycle from the stage of idea generation through to licensing and eventual product sales. It is important to provide continuous one-stop support for this.

Providing shared laboratories and support for convenient use

- Companies can accomplish efficient research results through the provision of consultancy and the ability to rent research laboratories appropriate to the nature and scale of companies activities, particularly capital and work force and the key development field. Support can also be provided for additional factors such as rental costs and service guidance during their stay.
- Beyond support for startups to rent and use laboratory space, the full range of complementary services required in the conduct of new experiments for product development in the laboratory can be provided. This can create an optimal ecosystem environment enabling startup researchers to focus on and develop products in a short time period.

Offers a platform for open innovation connections

- Provide an open space for interactive networking with startups, hospitals, universities, and pharmaceutical companies.

- Provides various programs and information as well as facility infrastructure space for free and active exchange.

High-tech and high-end infrastructure is available in government-funded research institutes such as Daedeok Innopolis (KRIBB, KRICT, ETRI, etc.), and can be used to provide R&D support, and patented technologies to bio-ventures to commercialize and scale

- Creation of a favorable environment and supports linkage to enable the research institutes in the Daedeok Innopolis provide support or advise on advanced science and technology and heterogeneous convergence technologies needed in the process of developing new bio-venture products.

Support for linking non-clinical/clinical tests

- Stability and efficacy tests through non-clinical tests (animal testing) of products or new drug candidates are supported in connection with non-clinical testing institutions.
- By conducting a dedicated test or joint study from Phase 1 to Phase 3 clinical trials through one to one matching between companies and hospitals in the central region, the approval period of a product is shortened.

Support for test evaluation and licensing linkages

- Supports cooperation with certified testing laboratories so that the safety, toxicity, and performance evaluation of the prototypes developed by bio companies can be carried out quickly.
- Consulting and test evaluation services are provided in accordance with test inspection guidelines in Korea and major overseas countries according to the product line of bio companies.
- If any of the new products developed by bio companies require permission from national licensing agencies (KFDA, FDA, etc.), consulting for the licensing process, technical document preparation, and licensing is supported.
- Provides licensing support suitable for each country's licensing process in major overseas countries (the United States, Europe, Japan, China, etc.).

Operation and support of a joint GMP production center

- Open lab sharing to manufacture a trial product GMP Smart Factory was installed and operated to support the manufacture of startups.

- In the case of bio-startups and venture companies, many products must be manufactured within GMP facilities, but in reality, it is difficult for individual small startups to build GMP facilities, obtain GMP certification, and manufacture the products.

- Therefore, a GMP facility that can be jointly used by multiple startups was established to support the manufacture and production of startup products in a publicly open manner.

- Installation of a small open GMP smart factory that can be used by many companies simultaneously to help them manufacture prototypes.

Support for global expansion

- It provides online meeting spaces and interpretation services that allow companies to perform global innovative networking both online and on-site.

- Preparation and provision of programs for international exchanges of startups with overseas hospitals, universities, and pharmaceutical companies. This assists in securing the latest information, identifying global market needs, and pioneering new markets.

- Supporting startups to participate in overseas exhibitions and linking online and offline meetings with overseas buyers so that they can enter the global market.

- Establishing and supporting marketing strategies for overseas expansion based on local market demand in individual countries.

3.1.4. Major Stakeholders of Biohealth Ecosystem

Analyzing the current status of biohealth industries in Korea and Daejeon, and identifying major stakeholders to derive core leverage strategies with the aim of achieving desired industrial transformation.

- Through analysis of major technologies and market trends in the domestic and foreign bioindustry, major bio-clusters in Korea were created by the government, and Daejeon's strengths lie in medical devices used for diagnosis, rather than new drug fields.

- The biohealth industry in Daejeon focuses on attempting digital transformation centered on new drugs and medical devices, and conducts interview with major actors related to this.

Onsite interviews with biohealth companies and written advice from stakeholders to derive leverage strategies for industrial transformation.

- While the 4th Industrial Revolution technologies are attracting attention as a growth engine according to the digital new deal and AI national strategy, the role of the central government and Daejeon City is to discover corporate demand and innovative growth desired by companies and stakeholders.

- From July to November 2021, Daejeon's representative biohealth companies were selected based on the recommendations of related organizations, such as the Biohealth Care Association and Daejeon TP.

- Interviews with representative companies enable the identification of the current status of regulations at central and local government levels, policy support, and opportunities and difficulties in corporate activities.

- Interviews and written advice from hospitals, academia, and related public institutions are used to grasp the diverse perspectives of stakeholders in Daejeon's biohealth industry.

Table 17. Progress of Interviews with Biohealth Stakeholders

Fields	No.	Institute	Date	Interview Method
Industry	1	Bio-Healthcare Association	21.7.16.	onsite
	2	Syntekabio Co., Ltd	21.7.23.	video confer.
	3	Levosketch Co., Ltd.	21.9.9.	video confer.
	4	E&S Healthcare Co., Ltd.	21.9.15.	onsite
	5	LegoChem Bioscience Co., Ltd	21.10.26.	onsite
	6	YBiologics Co., Ltd.	21.10.26.	onsite
	7	VUNO Co., Ltd.	21.11.15.	video confer.
	8	Bugang Tech Co., Ltd.	-	onsite
	9	Jinon Bio Co., Ltd.	-	onsite
Academia	10	Dept. of Med. & Biology at Konyang University	21.11.19.	video confer.
	11	KAIST Dept. of Bio and Brain Engineering	21.11.24.	video confer.
	12	KAIST Graduate School of AI	21.11.26.	video confer.
	13	Dept. of Bio AI Convergence at Chungnam National Univ.	21.12.7.	video confer.
Supporting Organization	14	Osong Medical Innovation Foundation, Medical Device Center	21.12.8.	onsite
	15	Osong Medical Innovation Foundation, New Drug Development Center	21.12.8.	onsite
	16	Korea Institute of Toxicology (KIT)	-	online
	17	Daejeon TechnoPark, Biocenter	21.7.19.	onsite
Research Institute	18	Korea Research Institute of Bioscience and Biotechnology	-	online
	19	Korea Institute of Science and Technology Information, Data Analysis Dept.	-	online
	20	Korea Research Institute of Standards and Science, Bio-analysis Standard Group	-	online
	21	Korea Research Institute of Standards and Science, Bio-analysis Standard Group	-	online
Hospitals	22	Asan Medical Center, Dept. of Radiology	21.12.23.	video confer.
	23	Chungnam National University Hospital, Medical Research Institute	-	online
	24	Chungnam National University Hospital, Dept. of Diagnostic Laboratory	-	online

3.2. Resource Mobilization

The following are excerpts from expert interviews that were conducted for this report.

3.2.1. The Development of Convergence Strategies between Industries and Subjects

Problems with Convergence Strategy

An industry-academic integration strategy is essential in preparing a convergence strategy.

- Traditionally, it was difficult for companies to survive in Daejeon's biofield, due to difficulty in procuring qualified staff, given insufficient university capacity and a bias towards theoretical learning.
- It is necessary to prepare a convergence strategy based on the linkage between related universities and research institutes so that it can be fused with big data, AI, and equipment fields.
- Academia should cooperate in technology convergence. However, companies work closely with universities and research institutes because it is not easy to collaborate with them based on tight collaboration, rather than only in the private sector, whose main purpose is to pursue profits.
- The importance of collecting high-quality field data requires AI companies to connect and collaborate with bio companies to secure the data.

It is necessary to develop a specific industry classification system and global standards for convergence industries.

- Data and guidelines are required to train AI models and system that can be used in the bio-industry.
- Given that the fundamental and industrial paradigms are different, it seems problematic to evaluate and judge them based on the same standards. The Bio industry is not included in the industry classification system of the Ministry of Industry. Since the current system is an old classification system, it is classified as a chemical or precision machine. With all countries selecting the biohealth industry as a growth engine, Korea believes that the industrial classification system is insufficient and requires improvement.

It is necessary to continuously build a nationwide database, expand infrastructure, and change awareness of data sharing.



— In fact, a lot of data are widely scattered, and the conditions for data sharing are unfavorable with data recognized as property.

— Infrastructure is the reason for this difference in developed countries. This is because when the technology level is the same, the more databases there are in the development of new drugs based on AI or big data, the more dominant they are. Building and sharing databases is thus very important.

— Currently, there is a large lack of organic linkages in infrastructure, which are necessary to establish, to ensure a link from the original technology development to product development for the biohealth industry in the region.

— As the biohealth R&D paradigm is changing to symptom-based (experience-based medical) statistics-based (evidence-based medical) → algorithm-based (precision medical), data is actually a very important industrial resource, and data infrastructure needs to be expanded through a shift in viewing medical care as an industry.

Direction of Convergence Strategy Development

Establishment of an Industry-Academic Cooperation Network to accelerate convergence

- It is necessary to draw specific opinions by discussing various topics through a research group in which industry, academia, and research institutes all participate. The research group should include investors so that positive opinions can lead to immediate business decisions. When mobilizing a research group, officials from hospitals, research institutes, companies, investors, and schools should all be involved.
- It is necessary to support the connection of traditional bio-companies with AI companies that promote convergence at the national level.
- There is a need for policy support to expand technical training and presentations by invited subject-matter experts from industries, academia, and hospitals. Such trainings and presentations can be conducted by KAIST AI Graduate School as well as other departments and universities.

Deriving a roadmap for convergence strategies for the biohealth industry based on artificial intelligence

— Deriving a biohealth industry strategy based on artificial intelligence as a future growth strategy in Daejeon: Phase 1 (operation of research associations-organization of business groups), Phase 2 (commercialization), and Phase 3 (globalization: it is also important to conduct joint research with San Francisco).

Improving the system to secure flexibility of related innovation support organizations.

- While government-funded research institutes have grown in size over the years, their system remains the same as 30 years earlier. As a preemptive requirement for the digital transformation of biohealth, systemic changes in government-funded research institutes should be prioritized to facilitate convergence.
- Above all, it is necessary to establish a driver for the commercialization of science by developing a compensation system that works for individual scientists.

Expansion of the Biohealth Data Infrastructure

- 1) Sharing regional corporate information, support infrastructure, and performance by establishing a comprehensive information network for corporate support in Daejeon. 2) Expanding cooperation between local companies by sharing the demand for technology, products, and discovery of supply and demand companies. It is necessary to share biohealth R&D budget execution plans and performance in Daejeon, carry out large national tasks, and link and coordinate regional R&D specialized fields.
- It is necessary to implement a project that supports long-term data platforms. In the United States, papers are still being published using data from the 1980s. Thus, data quality control must be performed by generating and sharing data from a long-term perspective.

Operating the convergence support program

- The program should be able to raise research funds only when creating a research group, assigning it, creating a symposium, and networking. There is a need to create an assignment that induces institutions to proceed autonomously with this process.

3.2.2. The Requirement for Supply and Demand and Training of Professionals in Related Fields

Obstacles to the supply and demand of professionals

In addition to fostering talent in each industry, it is necessary to develop educational programs that cultivate various competences beyond bio/AI that

are required by consumers, such as companies and donor research institutes.

- Usually, companies provide various education streams for their new recruits, yet ventures cannot afford training for incumbent employees.
- It is difficult to hire professionals in the convergence field. It is a struggle to introduce algorithms related to new drug development to AI centers and to improve the completeness of AI-based new drug development platforms. However, there is an urgent need to cultivate and recruit high-quality human resources.
- Educational lecture content is a supplier-centered professor's perspective. The Bio industry has to compete with the world and high-tech companies to take the lead, but the application focus is wrong. In addition to basic knowledge, it is urgent to switch to practical education that can instill practical and problem-solving knowledge and skills in learners.
- To globalize the industry, it is necessary to have a workforce in the fields of business matching and marketing. Although marketing personnel are recruited, the industry finds it difficult to obtain individuals fluent in foreign languages who have majored in bio-related topics
- Although AI is exaggerated, this workforce must indeed be prepared for the future, as AI workforce is currently very scarce.
- In the clinical trial process, there is a lack of experts with overall knowledge of the basic data composition necessary for approval of the efficacy evaluation support system and Investigational New Drug Application (IND) to expand indications.

It is necessary to establish an industry-academic networking system to foster talent.

- Cooperation and linkage between the corporate support system and the university support system are necessary so that supply and demand can be properly matched by narrowing the gap between the perspective of universities and companies looking at the workforce.

It is necessary to expand infrastructure and establish settlement requirements to allow talented people to remain in the region.

- In the case of high-quality KAIST students, they tend to get many employment offers from companies located in Seoul or Pangyo.

- The wage gap is gradually narrowing, but in terms of living conditions, Daejeon is perceived as a boring city without infrastructure, and lacking the charm of Gangnam and Seoul.

Improvement in supply and demand for professional labor

Development of a customized education curriculum centered on practice.

- It is necessary to achieve field-based learning through production and customized educational content through discussions with faculty and bio-companies in related fields.
- In the case of applied subjects or capstone design subjects for graduation, it provides an opportunity to carry out projects to solve problems in the field by opening courses that are linked to internships and industrial practices.

Expanding the global network by attracting overseas personnel.

- Rather than limiting the industry to Korean human resources, it would be highly beneficial to invite foreign human resources who can present and lead future management in the right direction, making use of their overseas networks.
- Large-scale investments are needed to attract overseas personnel so that they can quickly enter the global market and the related knowledge can remain in the region.

Joint development and operation of field education programs centered on industry-academic research centers

- Daejeon City, universities, research institutes, hospitals, and bio associations gather to produce curricula and jointly operate educational programs by introducing credit exchange systems between universities in Daejeon and Chungnam.
- Since it is not easy to adapt directly to the field after graduating from university, a training program for prospective employees who can gain field experience is being jointly developed with universities and government-funded research institutes.

3.2.3. Attracting Public and Private Investment

Directions for Improving Public and Private Investments

While IT technology is important, bio-content is also important; balanced investment between infrastructure and bio-content is needed when allocating the budget.

The biohealth industry is expensive in terms of reagent materials and equipment. Therefore, policy support in this field is required.

- Maximizing synergy through organic linkage with the research industry (equipment for R&D, reagent, and service) and power generation projects on another axis

To develop new AI-based drugs, it is necessary to produce large amounts of candidate drugs and conduct tests to determine the toxicity of these candidate drugs so that they can become customized drugs for patient treatment. Therefore, the mass production of new drug candidates using AI and the search for customized drugs should be carried out.

3.2.4. Industry-academia-cooperation -center and Communication Consultative Organization

Obstacles facing the industry-academia cooperation.

There is a strong lack of centrality connecting the industry-academia perspectives.

- There are many science and technology institutions in Daejeon, and in order to play their role in the normal way, the proportion of laboratory and IT research institutes must match, and the AI/big data environment needs centrality.

- A central point is needed to establish voluntary and organic communication between innovation subjects in the field. Currently, more than 90% of the biohealth industry works by government intervention or through support policies, and approximately 50% of these biohealth startup have failed. The need to provide a supportive environment for the remaining 50% of researcher communities to network has increased. Furthermore, such support is needed to ensure that the ventures they start succeed as the failure rate is too high.

- Seamless communication between supply and demand to identify each other's needs and provide optimal services in a timely manner.

- It is necessary to establish a natural and active networking platform to identify needs and ensure optimal service.

- The government continues to suggest new topics, and wants to hear various opinions from the field; a platform is needed for all industries/medical/regulatory experts and policy experts to gather for discussion.

The absence of a dedicated organization for joint policy planning and communication enhancement program operation of the industry-academia-cooperation center.

- It is necessary to promote local industries by utilizing networks, technoparks, research institutes, local governments, and local universities. Owing to the lack of operational strategies and the project costs of local networks, continuous activities are difficult because of irregular network activities. It is necessary to establish and operate a head quota that can play a role in policy planning to establish an industrial development strategy suitable for regional conditions and characteristics.

- Due to individual support from each supporting organization, consistent and systematic support for regional specialization is insufficient, and it is necessary to prepare a scrum-methodology corporate support system.

- Several programs to strengthen communication between subjects are created in the form of specific tasks, but a stronger and more integrated cooperation platform requires a dedicated organization that encompasses existing cooperative networks and performs comprehensive and systematic coordination.

Establishing a policy communication consultative body between industry, academia, and the public.

Establishing a pan-ministerial cooperation system and operating an organization dedicated to open innovation.



- There is a need for a pan-ministerial cooperation system that can organically harmonize R&D (scientific donation), certification and standards (Ministry of Food and Drug Safety), market creation, and support for global expansion.

- National investment is directed towards various fields. However, it is necessary to establish and support dedicated organizations as platforms for open innovation.

- Establishing and operating a dedicated organization to promote open innovation by establishing a regional innovation network centered on technoparks, creative economy innovation centers, universities, and research institutes located in the region.

Platform-based industrial support and fostering policy development system Platform

- operation is required as a venue for a comprehensive discussion on technical matters, ethical issues, safety issues, product licensing and scope of use, and matters required for the development process.

- Public debate on conflict mediation is needed to revitalize the biohealth industry. As it is a matter of changing the paradigm of medical care, public debate is needed through the establishment of a multidisciplinary platform, including users (patients), industry officials, social science, humanities, and ethics officials.

- If competent people with expertise and vision communicate with various subjects in a value-neutral manner to lead cooperation, it will be possible to build a developed biohealth industry ecosystem drawn by local governments in the mid-to-long term.

3.3. Production

3.3.1. Fostering Technology-based Start-up Companies

Current Status of Technology-Based Start-ups and Support Issues

Current status of bio-companies in Daejeon

- More than 500 bio-related companies are concentrated in this region. In particular, around 80% of local bio companies are located within a 5 km radius of the Daedeok Innopolis, which is advantageous for cooperative networks between companies and related organizations.

- Local bio companies are continuously growing, and over the past eight years (2010-18), the annual average number of businesses has increased by 5.73%, the number of workers by 5.60%, production by 6.09%, and added value by 12.40%.

Lack of open innovation support infrastructure for technology-based startups

- Establish a customized system for consumers to prevent talent leakage, an administrative system to support corporate start-ups, and a start-up hub that combines investment network connection and communication.

- For example, open innovation is very well established in the case of the United States, where attitudes and administrative procedures are systematically established to converge with each other.

Lack of guidelines for profit allocation to revitalize open innovation for start-ups

- When Korea develops new technologies, it is difficult to achieve open innovation because of the distribution of patent shares and profits. It is therefore important to develop the necessary guidelines that can be mediated at the local government or national level.

Technology-based startup support improvement

Operate a demand-oriented start-up incubation program.

- It is necessary to break away from public-led start-up incubation in connection with the establishment of the "Daejeon Startup Center (a tentative name)." In the case of a successful overseas incubation model, large and existing companies in the biohealthcare field participate in practical childcare activities and conduct practical open cooperation.

- Establishing a support service model according to the company's growth model through expert mentoring in all fields, such as identifying the support demand of local companies, planning tasks, screening, performance management, and commercialization.

- Prior to this, a demand survey including the self-diagnosis of enterprises was conducted, and self-diagnosis and support based on corporate demand were presented through customized mentoring. This included support for technical and management advice and problem-solving, project planning support, project performance inspection and progress management, commercialization planning, performance management support.

Operate a program to support convergence and co-operation between startups.

- It is necessary to establish a system in which related research institutes located in Daejeon and Daejeon-based companies share information and cooperate on difficult technology. It is necessary to promote the development of bio-policy, information sharing, and collaboration models in Daejeon through various business exchange meetings such as the Knowledge Research Association.

Start-up Global Entry Support Program Operations

- It is necessary to establish an infrastructure or support system that can grow to the next level to the growth of companies and their global advancement.
- It is necessary to prepare aggressive promotional measures for global market development, such as a plan to jointly promote a brand by combining local companies.

3.3.2. Support for the Digital Transformation of Traditional Biohealth Companies

There are quite a few companies in Daejeon that have many AI materials (big data); however, AI-using companies usually face difficulties in designing BMs. As there is not much AI and big data support in the field of biohealth, companies need to develop such policies in the future.

Regulatory sandboxes must function properly.

Direction for Digital Transformation Support for Traditional Biohealth Companies

Providing practical education and consulting in utilizing AI/big data

- In addition to funding, it operates eye-level education and support programs by linking support from competent consulting institutions.

- Venture companies have little funding power and are vulnerable to hacking and information security; therefore, it is necessary to support and supplement these areas.

Support the establishment of a joint utilization infrastructure for technology that is difficult for individual companies to handle.

- It is necessary to build databases, access hardware, and utilize technology software organized by local governments or central governments to support companies in order to jointly utilize them well.

Appropriate compensation is required to motivate bio-healthcare developers

- In Korea, due to medical insurance issues, appropriate compensation has not been made for developers. Providing appropriate incentives to biohealth developers is necessary to foster related industries.

3.3.3. Establishment and Support of Demonstration Complexes

Problems in the demonstration complex

Lack of infrastructure for clinical trials

- Clinical trials require hospitals to have an environment in which tests can be conducted; however, only 5% of all university hospitals nationwide are properly equipped. Most of them are equipped with facilities for non-clinical testing.
- For experiments/tests, certain conditions must be met, professors must be present, and special environments such as related facilities must be established.

Lack of accessibility and inadequate living conditions in the demonstration complex

- It is an international science business belt. However, its internal infrastructure is not international. The bus runs every two hours, but the route is very poor.
- Human resources are crucial in building industrial complexes and infrastructure, yet there are many problems in recruiting the workforce due to the lack of convenience in the workplace.

Lack of geographic access to innovators

- When collaboration with other institutions began at the research stage, R&D and commercialization support were smooth; however, when a considerable number of other institutions progressed, it was difficult to match similar experts in this institution.

- This is caused by a sense of spatial distance and can become super large with many venture companies.

Direction of the Establishment and Support of the Demonstration Complex

Operating a regulatory-free testbed that enables practical empirical support

- This system eases regulations on new business-related chunks faced by regions and companies on a regional basis. It is also necessary to consider introducing regulatory innovation systems, such as deregulation and testbeds, to enter the market in new technologies and new fields that are created in special zones.
- It is necessary to accelerate the actual commercialization linkage by strengthening the test bed of the research results according to the designation of the biohealth industry regulatory free zone.

Establishment of an empirical complex based on regional characteristics and operation of an empirical project

- When constructing a regional cluster, it is important to establish settlement conditions that satisfy the desire to stay in the region.
- It is necessary to design and operate a large-scale demonstration program so that a virtuous cycle system between regional innovators can be established.

Creating a globally oriented demonstration cluster

- Since it is necessary to create a cluster for the globalization of local biohealth companies, it is necessary to invite experts from the private sector rather than bureaucrats, or especially to select and operate experts with global backgrounds as heads.
- It operates programs that can facilitate technology and information sharing and create synergy at the global level, such as by promoting local companies through the establishment of global networks.

3.4. Consumption/Use

3.4.1. Supporting Medical Data Use

Medical data problems

Lack of meaningful understanding of medical data

- A large amount of high-quality data is needed to obtain meaningful research results, together with proper guidance. However, there is no practical cooperation.
- There is a question of whether hospitals can produce results when doctors who create and manage data in the field need to be involved. It is necessary to consider whether the government or local authorities can supplement this.

Personal information protection issues exist according to the sensitivity of the medical data.

- Opening medical data is a very sensitive issue, and although there are three data laws to balance industry development and privacy, they do not act as a strong safety net.
- After releasing a large amount of data, the hospital has no choice but to take a passive attitude as the situation arises in which the hospital is responsible for a certification problem.
- Even if such risk is taken, the hospital does not benefit, so one needs to think about protective measures, benefits and incentives.

Ambiguous sovereignty and management methods for medical data

- In the case of medical data, many subjects are involved in the process of generating data, and the authority to own and manage this data is distributed.
- Medical data have the primary purpose of treating patients; however, the problem now is the secondary purpose of developing new technologies. In other words, the distribution of all matters and research results for secondary purposes is not clear at this time.

Directions to support the use of medical data

Guidance on possible issues when using research data

- IRB is designed with a focus on pure research, mainly on whether to protect patients' rights and manage the patients' potential harm.
- Patients providing data need to be notified of problems that will arise from the perspective of industrial utilization.

Medical data required for learning support.

- It is necessary to provide high-quality data for learning as well as to collect, generate, and manage learning data for this purpose.

Establishing a management system to clarify data sovereignty and encourage the use of research data

- When a hospital commercializes a technology based on certain data, it is necessary to establish a compensation system for patients who own that data.
- It is necessary to activate utilization by providing guidelines to data providers that they will not be held accountable under any conditions.
- Developing a data management system to clarify authority and boosting performance, such as defending disadvantages caused by data disclosure and recognizing rights to data created by individuals.



Clinical Trial Support Needed.

Ultimately, global pharmaceutical companies such as Pfizer should emerge in Korea; however, this is difficult to achieve in a short time period. First, it is necessary to consider ways to increase the added value by supporting non-clinical trials and phase 1 clinical trials in the clinical trial process, and then transferring the technology. By ensuring that clinical trials are established as a process skilled in public infrastructure, individual companies should overcome the difficulties of clinical trials, and reach success in commercialization. It is important to provide such public support in all directions, such as prototype production, empirical support, licensing, technical support, and start-up support under the direction of competent coordinating organizations. There is a need for policy support that can lead companies with AI technology to conduct clinical trials in a flexible manner. Pipelines are also required to help new drug developers conduct clinical trials easily and inexpensively.

To commercialize R&D results, a safety and validity evaluation system for licensing is required. Validity evaluation should use different systems according to the mechanism of action, such as drugs, and there are difficulties due to the different maturity of evaluation systems for each laboratory. It is also necessary to develop a system that supports regional efficacy evaluations.

It is necessary to cultivate regulatory experts with an understanding of medical regulations that can support various clinical trials and global-level contracts. Economic problems that may occur in the early stages of the development and provision of measurement standards can be overcome more easily by providing appropriate funding from local governments.

Recently, there has been a need for companies to use living human cells. However, some cells, such as blood cells, are regulated, making it difficult for companies to use them smoothly. It is necessary to establish an infrastructure for evaluating the efficacy and safety while using normal organoids and disease-specific organoids.

3.4.2. Regulatory Improvement

Problems with licensing

Lack of effectiveness of regulatory sandboxes

- The current regulatory sandbox is practically inapplicable. National laws, such as the Personal Information Protection Act and Medical Service Act, remain the same; however, it is very difficult to operate sandboxes only at the lower end at the regional level for example.

Complex Licensing Processes and Regulations

- The process for prototyping and licensing necessary for actual commercialization is complicated; therefore, a support system is required to facilitate this process.
- The remarkable application of bio-welding technology and the development of high-functional high-tech products are increasing the difficulty of proving the scientific efficacy and securing the safety of the product (technology), and relatively new market development items such as bio-chips, molecular diagnosis, and medical devices.
- In order for new technologies that meet technical convergence and social demands in the biohealth industry to lead to commercialization, it is urgent to secure technologies such as strict regulations, licensing, and preoccupation with standards.

The gap between the speed of change in the market and the licensing process

- In terms of medical devices, licensing is interlocked; however, no matter how good the technology and product are, no matter how late the licensing is, it is difficult to commercialize it.

Direction for improving the licensing stage

Reinforcement of biohealth regulations through operation of a special zone for regulation of biohealth cycles

- National and local governments need to designate high-tech medical industrial complexes as special zones for regulatory freedom so that sufficient medical data can be utilized in the development stage to develop innovative medical devices.

- To utilize data in the healthcare field, medical information data collection is often violated by the Medical Service Act and Pharmaceutical Affairs Act.

Platform operation of regulatory sandboxes

- It is judged as a new regulation to have each company receive a regulatory sandbox and seek a solution. In addition, companies with headquarters/research centers in the area (e.g., Dunsan-dong, Dungok-dong, Gwanpyeong-dong) need a specific or tailored policy with a grace period of the next three years under any regulation.
- Regulations and regulatory sandboxes seek to maximize administrative effects through a transition to a platform-level regulatory solution method rather than solving the difficulties of a single company.

Accelerate regulatory processes to enter the global market

- It is necessary to prepare for global expansion based on technology verification data actually tested in Korea; however, positive regulations are too slow.
- It must be changed to a negative method that regulates only important issues and leaves the rest to the market.
- From the perspective of the global value chain, minimizing regulations that exist only in Korea and maintaining regulations that do not meet global standards, such as positive → negative, pre-regulation → post-regulation, etc.

Secure expertise through data-based regulatory design and implementation

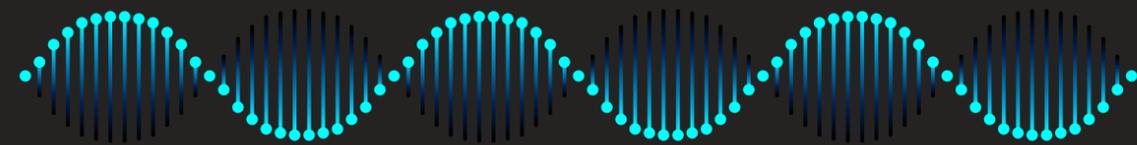
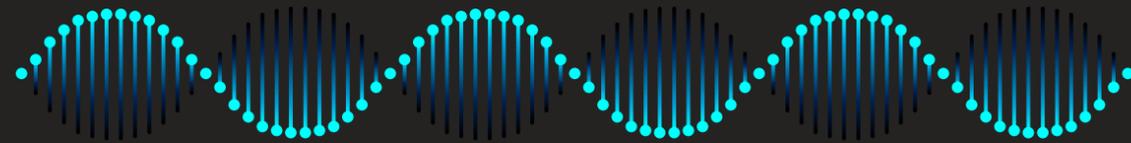
- It is necessary to secure regulatory expertise through data-based regulatory design and implementation, which require regulatory agencies to participate in the R&BD project every week to monitor and resolve regulations.

Innovative Supportive Medical Fees Methods

- Many technologies that use AI/big data are not medical practices" as technologies that prevent the occurrence of diseases; therefore, medical fees cannot be received under the current medical fee system.
- The conflict between the paradigm of the basic medical fee system and the paradigm of newly developed technologies will be identified, and medical fees for innovative products, as in the US case, will be provided to support companies.

04

How to Accelerate the Transition



4.1. Leverage Points

4.1.1. Transition of a Biohealth Industry with the Whole-cycle Perspective

Strategy to foster the bioindustry from a whole-cycle perspective

- In the process of developing major healthcare products such as new drugs and medical devices, local bio companies provide facilities and equipment infrastructure, support for research and development of new drug candidates/prototypes, and support for non-clinical testing.
- For the development and commercialization of biohealth technologies, such as new drugs and medical devices incorporating cutting-edge technologies, it is important to support each of the major development processes from a full-cycle perspective. For this, support through the creation of a biohealth industrial ecosystem and the establishment of a cooperative system is also needed.

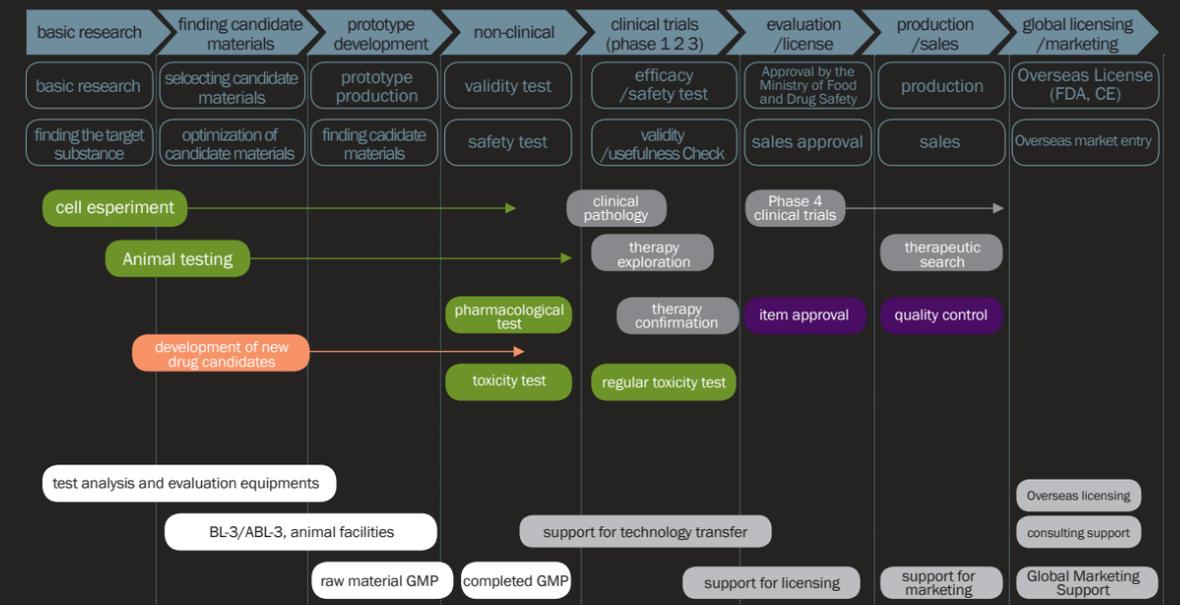


Figure 4. A General Development Process of a Biohealth Product

4.1.2. Competency to foster Biohealth Industry in Daejeon

Daejeon city has major infrastructure and capabilities to foster bio-industry in the region.

- The region has strengths as a global bio cluster because it has abundant R&D performance, bio-startup experience, active venture investment, and skilled bio-professionals in Daejeon.

Excellent R&D capabilities

- As the largest source of bio-source technology in Korea, it has 26 specialized research institutes, 45 research institutes, 295 research institute companies, and excellent R&D results.

A bio company with extensive experience

- There are about 500 Deep Tech bio companies in the region, and the Bio Healthcare Association is actively promoting unique information and mentoring between them.

Establishment of specialized facilities to support biohealth business ventures

- Regulatory free zones in the region are designated, and human-derived banks and public research facilities for pathogen resources are established.
- It has the highest level of bio-startup support facilities, such as the KRIBB's Startup Incubation Program and Daejeon TechnoPark's Bio-Convergence Center.

4.1.3. Main Factors to support the Transformation of the Whole-cycle Biohealth Industry

Open platform

- Establishing and supporting corporate support in the form of an open platform is necessary to support the biohealth industry's transformation.
- To do this, it is important to establish a whole-cycle one-stop support, shared laboratory provision, and ease of use, as well as an open innovation platform.

Human resources, Technology, and Equipment

- It is important to cultivate and support advanced convergence professionals and provide advanced technologies and high-end infrastructure for the transition to the biohealth industry.

Test evaluation and approval

- Depending on the characteristics of the biohealth industry, test evaluation and approval of prototypes/new drug candidates are important. To do this, it is important to strengthen support for a clinical constitution linked to non-clinical trials and clinical hospitals, as well as domestic and international licensing linkages.

Production and Marketing

- Since GMP facilities are needed to produce products after licensing new drugs and medical devices, it is important to support joint GMP manufacturing plants and global expansion.



4.2. Governance of Local Government

4.2.1. Direction of Fostering Biohealth Industry in Daejeon

Preparing a mid-to-longterm promotion plan for biohealth industry in Daejeon

- To foster local bio-industry, a plan to foster the 4th Industrial Revolution, a new deal plan, and a bio-health strategy for 2030 were established.
- Around 2000, Daejeon city prepared a plan for the development of the bio-industry and established the Bio-industry Promotion Council to foster the local bio-industry.
- The plan is as follows: 1) to grow into a global TOP5 bio cluster through various projects to maximize the growth potential of the local bio-industry, 2) to strengthen the bio-specific competitiveness, 3) to expand the investment value, and 4) to enhance sustainable growth value by preparing a master plan for the year 2030 in biohealth innovation growth.

4.3. Building Support Coalitions

4.3.1. Support for the Consultative Organization

It is effective to support local consultative bodies to promote the transformation of the biohealth industry by incorporating the advanced technologies of the 4th Industrial Revolution. Various communities related to science, technology, and business in the region have been created and operated. Therefore, it is necessary to support the consultative body in connection with this.

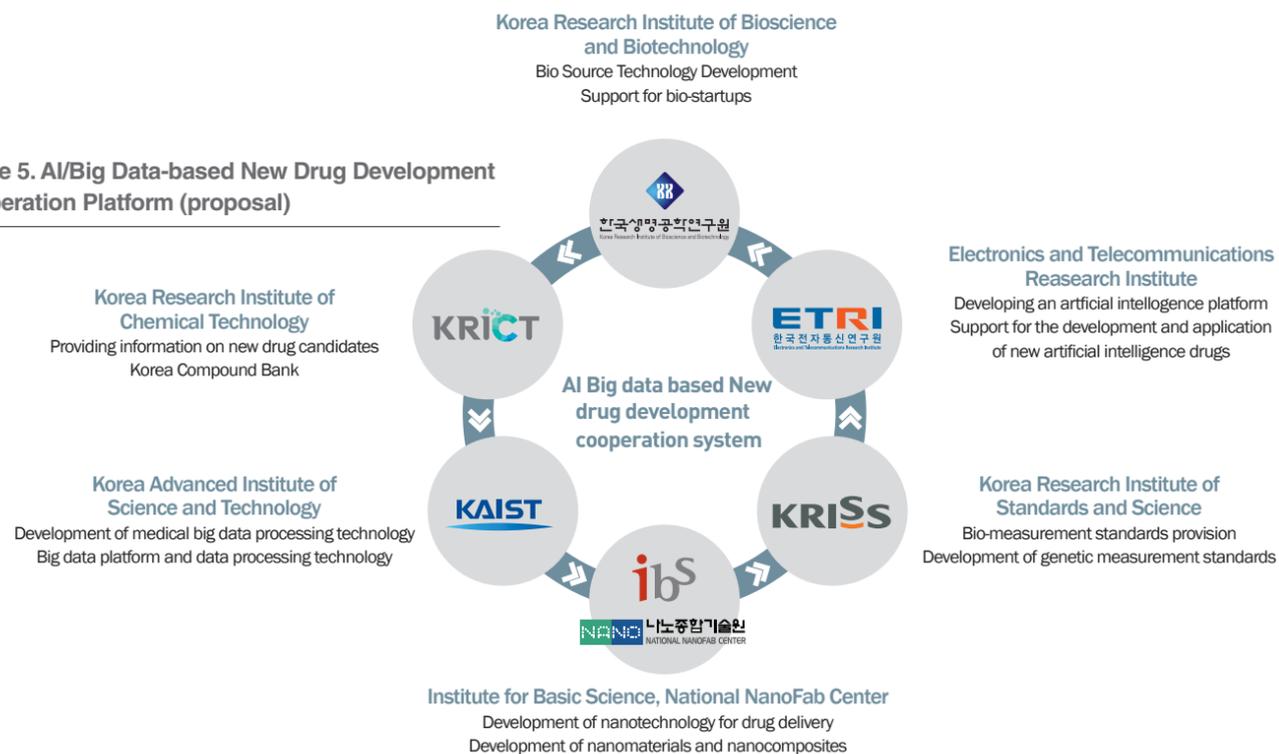
The Biohealthcare Association, based on a self-sustaining bioecosystem in Daejeon, has been organized. This association was established and operated based on a self-sustaining network. The Innovation New Drug Salon, created in Daejeon, is a purely private-led meeting that conducts information sharing and networks among experts under the theme of innovative new drugs and has spread nationwide.

Regional Bio-related Daedeok Innopolis BT Development Research Association, there is a medical forum in which researchers and entrepreneurs participate in communication and cooperation. Establishing and supporting a system to link and support related consultative bodies in the region is effective.

4.3.2. Preparation of Public Debate

It will promote biohealth forums and technology exchange meetings involving major officials, such as industry-academic research centers, which are major stakeholders in the biohealth field in the region. In Daejeon, the Bio Healthcare Forum has been held since 2019, centering on industries and hospitals, and it is necessary to further activate it.

Figure 5. AI/Big Data-based New Drug Development Cooperation Platform (proposal)



It is necessary to promote a technology exchange meeting for advanced biohealth technology which has been conducted since 2017 to support technology exchange and convergence research with the research institute in Daejeon.

It is necessary to establish an open policy platform in which all stakeholders related to fostering the biohealth industry participate, and to prepare a public debate forum to discuss major issues.

- To foster and develop a bio-industry ecosystem, it is necessary to establish and support operations based on open innovation. This supports the transition of bioenterprise start-ups and high-tech integration.

4.3.3. Establishing a Cooperative Platform for New Drug Development based on AI/Big Data

In the process of developing new drugs, such as vaccines and treatments, it is possible

to foster and support companies through the convergence and complex cooperation of heterogeneous technologies, induce researchers to start a business, and secure original technologies for new drugs.

It is necessary to discover and operate heterogeneous technology convergence and complex R&D programs in connection with the expertise and capabilities of contributing research institutes and universities in Daejeon.

- In connection with the KRIBB, research and development of bio-source technologies include genetic analysis of pathogens that cause infectious diseases, new drug development, and support for new drug start-ups.
- In connection with the Korea Advanced Institute of Science and Technology, professional research personnel specialize in the field of biohealth and convergence research and development.
- In connection with the Korea Research Institute of Chemical Technology, the Korea Compound Bank provides information on major compounds and cooperates in the research and development of target chemicals to discover new drug candidates.

- Development and provision of standardized measurement technologies tailored to the advanced measurement standards and technology-based bio-industry previously held in connection with the Korea Research Institute of Standards and Science.

- Develop an artificial intelligence platform for the development of new drugs to efficiently discover new drug candidates and conduct clinical trials in connection with the Korea Electronics and Telecommunications Research Institute and the Korea Advanced Institute of Science and Technology.

- In connection with the Korea Institute of Science and Technology Information, big data and big data platforms necessary in the process of developing new drugs are provided, together with joint research and development. Medical big data analysis technologies are also supported.

- Cooperation in the development of nanomaterials and nanocomposites, which are important in the development of new drug candidates and drug delivery technologies, nanotechnology development, and drug release control technologies, is in connection with the Institute for Basic Science.

4.3.4. Establishing Cooperation in Connection with Biohealth Companies utilizing Regional Infrastructure

Support for linkage cooperation among major corporate support organizations in Daejeon.

- There are various support organizations for corporate support during growth stages in the start-up of bio-companies, and corporate support programs are also prepared. Corporate support linked to this is also required.
- Government agencies include Daejeon Sejong Ministry of SMEs and Startups, Korean Intellectual Property Office, Korea Customs Service, Public Procurement Service, Statistics Korea, and Daejeon Regional Food and Drug Safety.
- Daejeon City agencies include Daejeon TechnoPark, Daejeon Institute of Science & Technology for Enterprise & People, Business and Employment Agency of Daejeon, Daejeon Center for Creative Economy & Innovation, Daejeon Information & Culture Industry Promotion Agency, Daejeon Credit Guarantee Foundation, Daejeon Sejong Research Institute, and Daejeon Institute of Design Promotion.

Infrastructure to support major startups in Daejeon

- It is important to establish a support organization and prepare a support program to support bio-startups in the region.

Institutions such as TIPs Town, Startup Park, Re-challenge and Innovation Campus, and Daejeon Startup growth campus were established to support start-ups in Daejeon. It is necessary to encourage cooperation and synergy among these institutions to promote the biohealth industry.

4.4. Managing Resistance to Change

4.4.1. Biohealth Major Stakeholder Resistance

Bio company

- Existing bio companies are developing and selling bio and medical products that belong to the classical industry classification system, and a backlash is expected against industrial transformation by combining advanced technologies, such as artificial intelligence and big data.
- From the standpoint of bio companies, it is necessary to promote the establishment of infrastructure for new technologies, professionals, and facility equipment to transform the industry by combining high-tech heterogeneous convergence technologies.
- Considering the reality of existing bio-companies, it is expected that small companies will have difficulty making bold investments and also changing directions to transform the bio-industry.
- It is necessary to supply and demand professionals to drive high-tech heterogeneous convergence technologies

for change; however, in reality, there is a lack of professionals with these capabilities.

Medical institutions, such as hospitals

- As end consumers of biohealth products, such as new drugs and medical devices, medical institutions, such as hospitals, adhere to a very conservative position.
- As they are conservative in minimizing the possibility of medical accidents in the introduction of new medical technologies or new products, even if a company develops cutting-edge medical technologies and products incorporating advanced technologies of the 4th Industrial Revolution, medical institutions are likely to be passive in using them on patients.
- If new technologies and new products that replace existing diagnosis and treatment, rather than the development of existing disease diagnosis or treatment technologies, are released, the hospital will not be likely to accept them.

Research Institute

- Biohealth R&D, which combines advanced technologies such as AI/big data, is characterized by a very different combination of heterogeneous technologies; therefore, there are realistic barriers to its realization in the research field.
- When researchers majoring in AI and bio-major researchers form a consortium to develop new AI drugs, they experience many difficulties in communication and collaboration when conducting research on common goals.
- Many problems need to be solved realistically, such as winning research projects to carry out biohealth research projects incorporating high-tech convergence and cooperation with other research institutes; therefore, resistance is expected.

The University

- Universities and graduate schools are subdivided by major departments; therefore, there is a limit to nurturing advanced convergence R&D talent. Recently, it has created departments and majors to cultivate advanced talent; however, it

lacks the number and expertise of professionals compared to the demand.

- Without the support of specialized and local governments to cultivate high-tech convergence professionals, it is difficult for universities to cultivate such professional talents themselves, and thus, resistance is expected.

The Citizens

- There is resistance to infringement of individual rights, such as AI/big data-based biohealth technology and medical big data-related personal information protection laws, necessary in the process of product development.
- Among the biohealth sectors, health-related products that can be used by the general public, in addition to new drugs and medical devices, are highly utilized because of the combination of advanced technologies; however, resistance due to limited scope and effectiveness is expected.

4.5. Policy Proposal

4.5.1. Creating an Ecosystem for Biohealth Industry Transformation based on AI/Big Data

Creating a biohealth industry transformation ecosystem led by local governments that can drive the transformation of the biohealth industry by incorporating advanced technology.

Owing to the nature of the biohealth industry, the establishment of an ecosystem for corporate support and a support system for fostering and developing from a full-cycle perspective from research and development to licensing and product launch are needed.

4.5.2. Government and Local governments' Legal System Maintenance and Policy Support

Establishing legal systems and policies to support, foster, and develop startups and companies that develop biohealth products by combining advanced technologies of the 4th Industrial Revolution, such as AI/Big Data.

Reorganization and establishment of a legal system to utilize big data on healthcare owned by government agencies, local governments, and hospitals to transform the biohealth industry.

4.5.3. To Support Human Resource Training to lead the Advanced Biohealth Industry

Government and local governments' policy establishment and support from various angles to cultivate professionals with advanced convergence expertise (such as R&D experts and domestic and foreign licensing experts) is a key element in the transition to the biohealth industry.

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**POINT Review
of Biohealth
Industrial
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Daejeon City,
South Korea**

Towards Advancing the Regional Biohealth
Industry by unlocking AI/Big Data, Digital
Technologies, and the Startup Ecosystem