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Challenges and Opportunities Opened by the Rising Biotechnology and Bioeconomy in the Context of Japan

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Japan formulated the Bioeconomy Strategy in 2019 and issued its new version in 2024. The document, resulting from the work of Integrated Innovation Strategy Promotion Council among the key areas of technoscientific innovation described: Biomanufacturing / bio-derived products, Industries related to biopharmaceuticals, regenerative medicine, cell and gene therapies. It is in line with the Grand Design and Action Plan for a New Form of Capitalism which forms Japan's solution for a variety of challenges Uniqueness of Japan's cultural and geographical features is seen as a strength aiding expansion of the market, which is locally valued at 100 trillion yen, while globally within 10 years potentially at $30 trillion (approx. 4,000 trillion yen), this ambitious goal will require inviting international and transcultural cooperation between researchers and forming biocommunities that will gather in Japan.

Bioeconomy as the Engine of Growth

It should be emphasized that under the umbrella term "bioeconomy" there lies a promise of solving current critical humanity's problems, like dependence on fossil fuels and associated carbon emissions (due to ability of carbon dioxide absorption by the engineered biomass), production of economically and environmentally friendly food thus enhancing sustainability, biomanufacturing - the ability to obtain critical biomaterials traditionally sourced from the environment through ineffective practices, which could be replaced by highly controlled and optimized industrial processes. It is also connected with new biomedical possibilities like replacing damaged body parts or injured organs without the need of donors or cellular therapies aimed at reversing tissue dysfunctions. The drug class called biologics, which are more advanced and have less side effects than small molecules can be one of the the results of bioeconomy focused development. Among important but less evident applications are bio- and nano- robotics able to interact and aid in more targeted surgical procedures, accompanied by biocompatible and biomimetic materials. These goals require development of new paradigms of industry and society functioning with large scale cultural changes connected with development of new funding routes.

Japan's Unique Potential in Becoming World's Bioeconomy Leader

Japan, being the world’s third largest economy is well equipped in terms of infrastructure and scientific resources that could aid in fostering bioeconomy development. The existence of

prominent areas designed for research, like Kawasaki Innovation Gateway (cancer treatment, regenerative medicine), AIST Kashiwa (Human Augmentation Research) are epitomizing the country's dedication to utilize technology in the mission of serving humanity's well being. Bioinformatics and the fusion of biotechnology and digital technology are the pillars of Japan's Bioeconomy Strategy. In this area, Japan's strong position is exemplified by the location of key information databases on its territory. The DDBJ (DNA Data Bank of Japan), established in 1987, serves as the location of deposition of genomic and nucleotide sequence data (the only one in Asia), and is the one of three such places in the world (European Molecular Biology Laboratory at the European Bioinformatics Institute and the GenBank at the National Center for Biotechnology Information, USA). Other critical resources for bioinformatics (structural bioinformatics and drug design) are the PDBJ (Protein Data Bank Japan) and KEGG (Kyoto Encyclopedia of Genes and Genomes). The leadership position of Japan in the field of regenerative biomedicine is connected with the research of Shinya Yamanaka, that allowed for the derivation of iPSC (Induced Pluripotent Stem Cells) in the process that does not involve human embryos in any way. The methods with utilization and destruction of human embryos for obtaining cells were earlier carried out by US - based researchers, which contributed to ethical problems connected with the field and permeated the public discussion on this topic. By solving ethical problems, Japan enabled the potential of commercialization and further development of regenerative medicine. The country also holds the first clinical application success: in 2014 experimental iPSC therapy was used to regenerate human retinal cells at the Foundation for Biomedical Research and Innovation (FBRI) facilities, located in Kobe. This institution also hosts the Fugaku supercomputer, used for an in silico drug discovery by RIKEN Center for Computational Science. There are also resources that allow for exploration of possibilities opened by quantum computing. The scale of research equipment used in structural biology is illustrated by the SPring-8 synchrotron radiation facility, used for protein X-ray crystallography (one of data sources for PDB). This vast research infrastructure is facilitating formation of biocommunities, of which most well known is Greater Tokyo Biocommunity (GTB) maintained by Japan Bioindustry Association (JBA). This organization (JBA), established in 1987 is responsible for the BioJapan, which is the world’s longest-running biotechnology industry exhibition.

Bioeconomy at the World's Stage: Opportunities for Asia - Europe Cooperation

The value of bioeconomy is recognized at the international scale: the World Economic Forum produced a themed report and issued a website. The European Commission in November 2025 published a report about its own new strategy for bioeconomy, already valued at €2.7 trillion, with the mission to replace fossil-based industries and become the source of critical raw materials. There is also awareness of Japan's Bioeconomy Strategy: EU-Japan Centre for Industrial Cooperation on its website acknowledges it, and promotes "bio-based society across the globe". The main problems connected with the European environment lies in the local culture, which makes application of biotechnology problematic. In Japan genetically modified organisms, like in the USA, are the subject of protective treatment by the law frameworks - there are no restrictions on introducing products of biotechnology to the market, gene edited crops do not require safety or environmental testing. This is in line with scientific consensus where the genetically modified organisms, being composed of the same biomaterials (proteins, nucleotides) are no different in terms of possible toxicity or adverse effects from the ones present in biological ecosystems or current agricultural practices. This area is the space of conflicts of interests between traditional food manufacturers and biotechnology industry, where the lack of scientific background and knowledge on behalf of consumers connected with the ability to influence perceptions by current established business entities plays a major role.

State of affairs in Europe creates favorable circumstances for Japan: highly qualified personnel trained in the European Union may find there opportunities for professional development, adding value to the local economic system. The main obstacle in this process is the language barrier, which could be overcome with the focus on acculturation and integration of European researchers into Japan's society. This is also a prime opportunity for Poland - country lacking ability to utilize research potential due to complete GMO exclusion, but with a highly developed scientific base, especially in the field of bioinformatics and computational biology. The other driving factor that may facilitate cooperation between Japan and Europe is the fact that traditionally, there was a close research and industrial relationship between Japan and the USA. This preference is explicitly stated in the interview from 2017 by Osamu Nagayama, president of JBA. It is also evident in recent cooperation between Meiji Holdings Co. and California Cultured Inc. where the subject is production of cocoa with so-called cellular agriculture practices. It illustrates the agility of the USA in protecting the development of its own biotechnology industry, the EU also started to express similar willingness, but these efforts seem inconsistent in implementation, leaving researchers and companies without an adequate level of support. This is in line with processes in Poland - scientists under pressure are more open to initiate transcultural exchanges with Asia, where the results of their work may bring fruits. The traditions of Japan - USA cooperation may be also a subject of revision, due to the newly observed trend of moving R&D to China. China developed technoscientific culture with the potential to surpass that of the USA and western countries. In a such highly competitive global environment some existing cultural bonds connecting Japan with Europe may serve as valuable reference points, initiating dialogue and fostering relationships: the term Rangaku (translated as Dutch learning) refers to the process of knowledge and technology transfer from western countries to Japan during the reign of Tokugawa shogunate. Thanks to this exchange taking place at the artificial island of Dejima, people in Japan were able to be introduced and take part in scientific and technological revolution and prepare the base for subsequent modernization. The importance of Dejima (located in Nagasaki), which was the only place for allowed presence of Europeans (Dutch traders) for 220 years, is reflected in recent and ongoing reconstruction of the site. Which may be interesting from a bioeconomy point of view, the Netherlands hosts the largest regenerative medicine community in Europe. The important issue that may bring polish researchers into an advantageous competitive position in this field, is that they express a more similar approach to Japan - with higher focus on bioethics than western countries.

Bioeconomy and the Opportunities for Poland

Poland, with a strong bioinformatics research community, has a chance to become a valuable contributor to the growth of bioeconomy in Asia. The independence of bioinformatics from physical laboratory constraints (computer simulations are computational experiments) allows for providing valuable insights that can be utilized in research and drive physical experimental investigations. This approach is called "in silico biology".

Constructing Technoscientific Culture, Enabling Bioeconomy

Agriculture can be considered the basic source of wealth for countries and individuals, this observation, reflected in Japan's traditional financial measure - Koku, is also present in biochemistry, where food - derived energy in the form of ATP is called universal currency. In this light bioeconomy plays a foundational role for humanity's progress. This, in turn contributes to its very delicate, and conflict - prone position within societies, due to social order changing abilities. Free market economies are characterized by uninterrupted decision making by economic agents. Providing rationale based on science for wide social processes of customer decision making can

facilitate creation of bioeconomy products and services, because of public acceptance being a critical barrier. Visual information presentation and processing plays a critical role in biological systems understanding. It ranges from molecular biostructures reconstruction by X-ray crystallography through microscopy, to larger scales.

Therefore the human visual culture itself can become a source of bioeconomy enabling processes. Japan is the country where visual culture achieved status uncommon in other countries. Narratives constructed with the tools derived from writing were transformed into pictorial storytelling devices, appealing to the mass market. The western culture have no comparable features: simplicity of writing system caused separation of images from text, traditionally closed elite-circles of movie making studios prevented mass participation of players from various social groups; association of comic books with low art by western audiences is the factor responsible for their marginalization. On the contrary, Japan treats visual storytelling in the same way as literature and attributes animation with equal status to that of film. This culture of participation also creates a favorable environment for the communication of science, because narratives concerning biotechnology can shape cognitive and value landscapes. It can also address the public perceptions beyond science, like cultural constructions about genetic engineering with mythology status. Perceived artificiality of genetic engineering products can be addressed with provision of narratives based on scientific reality that connects biotechnology and robotics. Japan is unique in terms of the social presence and roles attributed to robots in its culture.

The word "robot" as being of slavic origin opens another opportunity for intercultural exchange between Europe and Japan. Advances in molecular biology allowed for conceptualization of essential functional biological entities in terms of artifacts: proteins are conceptualized as robots. Biomolecular systems are described in terms of living machinery and computer animations are used to visualize and explore them. Introducing this understanding to popular culture would be beneficial for bioeconomy. It solves an important problem of bridging the gap between visions present within the scientific community and Japan's (and the world's) public, expressed in declarations of building a society based on nanotechnology. Japan recognized its own popular culture industry as an important part of the economy, under the umbrella of the "Cool Japan" governmental program. The importance of culture - related industries lies in the fact that the value in the form of intellectual property is created "out of thin air" not requiring capital investments or extensive physical resources. It requires ingenuity and creativity, which may be described in terms of human and cultural capital. It also contributes to the brand image of the country. This is the rationale behind strong support of Keidanren (Japan Business Federation) with the idea of making a separate governmental agency for this purpose. The further development of this kind of industry may also be facilitated by sourcing skilled personnel from abroad. It is the solution proposed by companies. It also represents another vein of opportunities for European scientists and all participants that possess necessary abilities to take part in culture creation.

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