Cell Therapy & Engineering Connect
2024, Article ID. 2024.0001, Cite as: www.doi.org/10.69709/CellEngC.2024.121735

SCIFINITI

Editorial

OPEN ACCESS

Exploring a New Era in Cell Engineering

Ken-ichiro Kamei[✉,1,2,3,*]

[1] Programs of Biology and Bioengineering, Divisions of Science and Engineering, New York University Abu Dhabi, Abu Dhabi, UAE
[2] Institute for Integrated Cell-Material Sciences (WPI-iCeMS), Institute for Advanced Study, Kyoto University, Kyoto 606-8501, Japan
[3] Department of Pharmaceutics, Wuya College of Innovation, Shenyang Pharmaceutical University; Shenyang 110016, China

Article History
Submitted: October 10, 2024 Accepted: October 10, 2024 Published: October 11, 2024

1. Introduction

As the Editor-in-Chief of *Cell Engineering Connect*, it is both an honor and a privilege to introduce this inaugural issue. Our journal is dedicated to exploring the latest advancements in the rapidly evolving field of cell engineering, an interdisciplinary domain that holds the key to transformative innovations in healthcare, biotechnology, and synthetic biology. The convergence of cell biology, bioengineering, and data science is enabling researchers to manipulate cellular systems in unprecedented ways, opening new pathways for disease treatment, tissue regeneration, and biomanufacturing.

2. Rapid Growth of Cell Engineering

Over the past decade, the pace of innovation in cell engineering has accelerated dramatically. Groundbreaking techniques such as CRISPR-Cas gene editing [1], synthetic biology circuits [2], and induced pluripotent stem cell (iPSC) technology [3] have moved from theoretical research into practical applications. These developments have shifted the paradigm from merely understanding cellular mechanisms to actively controlling and designing them for specific functions, such as disease modeling. With the launch of *Cell Engineering Connect*, we aim to provide a dedicated platform for researchers and practitioners to share cutting-edge discoveries and innovations, ultimately driving the next wave of breakthroughs.

3. Therapeutic Advancements in Cell Engineering

One of the most exciting areas of cell engineering is its application to therapeutic development. The ability to precisely edit genes and engineer cells has revolutionized the approach to treating genetic disorders, cancer, and autoimmune diseases. Advances in CRISPR-based genome editing are paving the way for novel treatments for refractory cancer [4] and sickle cell anemia [5], and the others. These early successes highlight the potential of engineered cells as living drugs, capable of precise, targeted action within the human body.

4. Regenerative Medicine and Tissue Engineering

In the realm of regenerative medicine, the development of bioengineered tissues and organs is another groundbreaking frontier [6]. Researchers have made significant strides in creating functional tissues, such as heart muscle patches and pancreatic islets, using 3D bioprinting and stem cell-derived materials. These innovations are bringing the field closer to the long-sought goal of generating fully functional, lab-grown organs for transplantation, potentially alleviating the global shortage of donor organs. Moreover, the integration of biomaterials with living cells is enabling the creation of tissue scaffolds that can guide tissue regeneration and repair *in vivo*, offering new hope for patients with degenerative diseases and traumatic injuries.

5. Organs-on-a-Chip

Organs-on-a-chip technology presents groundbreaking potential by replicating human organs at the cellular level using microfluidic devices. [7]. These chips recreate the physical and biochemical environments of organs like the liver, lungs, and heart, enabling researchers to study disease mechanisms and drug responses more accurately than traditional methods like animal testing. By integrat-

* **Corresponding Author(s):**
Ken-ichiro Kamei; Programs of Biology and Bioengineering, Divisions of Science and Engineering, New York University Abu Dhabi, Abu Dhabi, UAE; Institute for Integrated Cell-Material Sciences (WPI-iCeMS), Institute for Advanced Study, Kyoto University, Kyoto 606-8501, Japan; Department of Pharmaceutics, Wuya College of Innovation, Shenyang Pharmaceutical University; Shenyang 110016, China; kk4801@nyu.edu

ing stem cells into these systems, scientists can generate organ-specific tissues on a chip, allowing for the study of complex diseases and personalized medicine applications. Stem cell-derived models can simulate patient-specific conditions, offering tailored drug testing and reducing reliance on animal models. Additionally, the use of stem cells allows for more dynamic research on organ regeneration and development. Looking forward, combining multiple organ chips with stem cell-derived tissues into a "human-on-a-chip" system could revolutionize drug development and accelerate the discovery of safe and effective therapies [8,9].

6. Neuroengineering

A particularly promising and rapidly evolving field is neuroengineering. The ability to manipulate and interface with the nervous system at the cellular level is driving advancements in both medical treatment and brain-computer interfaces. Cell-based therapies are being developed to repair damaged neural circuits, offering new approaches to treating neurodegenerative diseases like Parkinson's [10] and Alzheimer's [11]. Similarly, engineered neural tissue is being explored for spinal cord injury repair, with the goal of restoring lost function [12]. Furthermore, bioengineered brain interfaces are making strides toward advanced prosthetics and human-machine symbiosis, offering unprecedented control and precision for patients with disabilities.

7. Immune Engineering

Immune engineering, an emerging frontier, holds remarkable potential to revolutionize the treatment landscape for diseases characterized by immune dysregulation, such as cancer., autoimmune diseases, and chronic infections. Beyond CAR-T therapies, researchers are working on the next generation of immune-modifying treatments, which include creating synthetic immune cells capable of adapting in real time to a patient's immune environment [13]. Techniques such as engineering macrophages and natural killer cells are being explored for their ability to target tumors, providing new tools in the fight against cancer. Immune engineering also holds promise in the development of vaccines, offering the potential to create highly targeted and effective immune responses against a wide range of pathogens.

8. Cell Engineering for Environmental Sustainability

The impact of cell engineering extends beyond human health. In the field of synthetic biology, engineered cells are being designed to perform industrial and environmental tasks, such as producing biofuels, breaking down plastic waste, and detecting environmental toxins. These applications demonstrate the versatility of engineered cells as not only therapeutic agents but also powerful tools for addressing global challenges [14]. Looking at the future, the ability to design and program cells with specific functions will undoubtedly play a critical role in sustainable development and environmental stewardship.

9. AI and Machine Learning in Cell Engineering

Artificial intelligence (AI) and machine learning (ML) are revolutionizing cell engineering by enabling the analysis of vast biological data, optimizing experiments, and accelerating discoveries. AI-driven models can predict gene expression, simulate cellular behaviors, and enhance drug discovery by screening compounds and predicting their interactions with cells [15]. This speeds up the development of therapies and personalized medicine. AI also plays a key role in areas like stem cell differentiation and organs-on-a-chip, simulating complex systems for more accurate predictions and outcomes. As AI continues to evolve, it will drive significant advances in cell engineering, leading to faster, more personalized treatments.

10. Ethical and Regulatory Challenges

However, these advancements also bring significant ethical and regulatory challenges. The ability to modify human cells raises important questions and concerns about the boundaries of genetic manipulation and the potential for unintended consequences. The recent advent of germline genome editing, where changes to DNA can be inherited by future generations, has sparked a global debate about the ethical implications of such technologies. While the therapeutic potential is immense, the possibility of off-target effects and unintended consequences highlights the need for stringent oversight and careful consideration of the long-term impacts of these technologies on both individuals and society.

11. Global Collaboration and Networking from UAE to the World

As a journal originating from the UAE, *Cell Engineering Connect* is uniquely positioned to foster networking and collaboration, not only within the UAE but also across the MENA region and globally. The UAE has rapidly emerged as a center for scientific and technological innovation, and the establishment of this journal reflects the nation's commitment to advancing research and knowledge. There is substantial potential for collaboration between researchers in the MENA region and their global counterparts, and we aim to serve as a bridge that facilitates the exchange of ideas, expertise, and resources. By establishing a global network of scientists, engineers, and industry leaders, they aim to accelerate the development of cell-based technologies that can significantly impact healthcare, industry, and the environment.

12. Conclusions

At *Cell Engineering Connect*, the commitment is to fostering a responsible and inclusive dialogue about the future of cell engineering. It is believed that ethical considerations must be at the forefront of scientific discourse and that researchers, policymakers, and the public must work together to establish frameworks that ensure the safe and equitable development of these technologies. The journal will serve not only as a platform for sharing scientific breakthroughs but also as a forum for discussing the broader implications of this work.

In conclusion, the field of cell engineering stands at the threshold of a new era, one in which cells are not merely passive entities to be studied but dynamic systems to be engineered and harnessed for specific purposes. *Cell Engineering Connect* aims to be at the forefront of this revolution, serving as a nexus for collaboration, innovation, and discovery, particularly fostering partnerships within the UAE, across the MENA region, and globally. As we look to the future, I invite you, our readers, to join us in shaping the direction of this exciting field. Together, we can push the boundaries of what is possible in cell engineering and make meaningful contributions to science and society.

Conflicts of Interest

The authors declare no conflicts of interest regarding this article.

Acknowledgments

I thank my lab members and collaborators for their invaluable support. I also acknowledge ChatGPT for assistance with English editing.

References

[1] Bai, X.; Huang, Z.; Duraj-Thatte, A.M.; Ebert, M.P.; Zhang, F.; Burgermeister, E.; Liu, X.; Scott, B.M.; Li, G.; Zuo, T. Engineering the gut microbiome. *Nat. Rev. Bioeng.* **2023**, *1*, 665–679. [CrossRef]

[2] Cubillos-Ruiz, A.; Guo, T.; Sokolovska, A.; Miller, P.F.; Collins, J.J.; Lu, T.K.; Lora, J.M. Engineering living therapeutics with synthetic biology. *Nat. Rev. Drug Discov.* **2021**, *20*, 941–960. [CrossRef] [PubMed]

[3] Takahashi, K.; Tanabe, K.; Ohnuki, M.; Narita, M.; Ichisaka, T.; Tomoda, K.; Yamanaka, S. Induction of Pluripotent Stem Cells from Adult Human Fibroblasts by Defined Factors. *Cell* **2007**, *131*, 861–872. [CrossRef]

[4] Stadtmauer, E.A.; Fraietta, J.A.; Davis, M.M.; Cohen, A.D.; Weber, K.L.; Lancaster, E.; Mangan, P.A.; Kulikovskaya, I.; Gupta, M.; Chen, F.; et al. CRISPR-engineered T cells in patients with refractory cancer. *Science* **2020**, *367*, eaba7365. [CrossRef]

[5] Alayoubi, A.M.; Khawaji, Z.Y.; Mohammed, M.A.; Mercier, F.E. CRISPR-Cas9 system: a novel and promising era of genotherapy for beta-hemoglobinopathies, hematological malignancy, and hemophilia. *Ann. Hematol.* **2024**, *103*, 1805–1817. [CrossRef] [PubMed]

[6] Li, L.; Zhang, X.; Zhou, J.; Zhang, L.; Xue, J.; Tao, W. Non-Invasive Thermal Therapy for Tissue Engineering and Regenerative Medicine. *Small* **2022**, *18*, 2107705. [CrossRef]

[7] Vunjak-Novakovic, G.; Ronaldson-Bouchard, K.; Radisic, M. Organs-on-a-chip models for biological research. *Cell* **2021**, *184*, 4597–4611. [CrossRef] [PubMed]

[8] Jalili-Firoozinezhad, S.; Miranda, C.C.; Cabral, J.M.S. Modeling the Human Body on Microfluidic Chips. *Trends Biotechnol.* **2021**, *39*, 838–852. [CrossRef]

[9] Yang, J.; Hirai, Y.; Iida, K.; Ito, S.; Trumm, M.; Terada, S.; Sakai, R.; Tsuchiya, T.; Tabata, O.; Kamei, K. Integrated-gut-liver-on-a-chip platform as an in vitro human model of non-alcoholic fatty liver disease. *Commun. Biol.* **2023**, *6*, 310. [CrossRef] [PubMed]

[10] Takahashi, J. iPS cell-based therapy for Parkinson's disease: A Kyoto trial. *Regen. Ther.* **2020**, *13*, 18–22. [CrossRef] [PubMed]

[11] Han, F.; Lu, (Paul) P. (Eds.) *Stem Cell-Based Therapy for Neurodegenerative Diseases*; Advances in Experimental Medicine and Biology; Springer Singapore: Singapore, 2020; Volume 1266, ISBN 9789811543692. Available online: http://link.springer.com/10.1007/978-981-15-4370-8 (accessed on 10 October 2024).

[12] Kawai, M.; Imaizumi, K.; Ishikawa, M.; Shibata, S.; Shinozaki, M.; Shibata, T.; Hashimoto, S.; Kitagawa, T.; Ago, K.; Kajikawa, K.; et al. Long-term selective stimulation of transplanted neural stem/progenitor cells for spinal cord injury improves locomotor function. *Cell Rep.* **2021**, *37*, 110019. [CrossRef] [PubMed]

[13] Park, J.H.; Rivière, I.; Gonen, M.; Wang, X.; Sénéchal, B.; Curran, K.J.; Sauter, C.; Wang, Y.; Santomasso, B.; Mead, E.; et al. Long-Term Follow-up of CD19 CAR Therapy in Acute Lymphoblastic Leukemia. *N. Engl. J. Med.* **2018**, *378*, 449–459. [CrossRef]

[14] Hassard, F.; Curtis, T.P.; Dotro, G.C.; Golyshin, P.; Gutierrez, T.; Heaven, S.; Horsfall, L.; Jefferson, B.; Jones, D.L.; Krasnogor, N.; et al. Scaling-up Engineering Biology for Enhanced Environmental Solutions. *ACS Synth. Biol.* **2024**, *13*, 1586–1588. [CrossRef]

[15] Capponi, S.; Wang, S. AI in cellular engineering and reprogramming. *Biophys. J.* **2024**, *123*, 2658–2670. [CrossRef] [PubMed]