applied sciences

MDPI

Editorial

Advances in Space Biology: Cell Behavior in Microgravity

Maria A. Mariggiò [1,*] and Giulia Ricci [2]

[1] Department of Neuroscience, Imaging and Clinical Sciences, University "G. d'Annunzio" of Chieti-Pescara, 66100 Chieti, Italy
[2] Department of Experimental Medicine, University of Campania "Luigi Vanvitelli", 80138 Naples, Italy
* Correspondence: maria.mariggio@unich.it

check for updates

Citation: Mariggiò, M.A.; Ricci, G. Advances in Space Biology: Cell Behavior in Microgravity. *Appl. Sci.* **2022**, *12*, 11575. https://doi.org/10.3390/app122211575

Received: 1 November 2022
Accepted: 10 November 2022
Published: 15 November 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

The intrinsic nature of human beings always pushes them to search for knowledge of everything that surrounds them, from the depths of the sea to the peaks of the mountains up to the space expanses. At first, scientists developed instruments, which allowed deep space to be observed, and this has since developed into a massive exploration campaign, unveiling space as a fascinating extreme environment.

Recent decades have seen an increasing number of space missions that, with the ambitious goal of colonizing the Moon and reaching Mars and other distant planets, have opened new areas of scientific research, which intend to build a better understanding of how the space environment affects living systems [1–3]. Nowadays, space biology has become a highly topical scientific field that has increasingly earned the interest of the scientific community. This area of research, even if established for space exploration, has offered new fundamental pieces of information on how cells perceive the gravitational force, and more generally the "physic" microenvironment in which they are embedded. It is now well documented that gravitational force change, experienced by living organisms during spaceflights, significantly impacts several biological processes, such as metabolism, adhesion, cytoskeleton re-modelling, replication, and gene expression control. The cellular mechanisms triggered by microgravity have been disclosed only partially and are still under investigation. However, it is clear that all cell types, from prokaryotes to eukaryotes, react to microgravity, in an attempt to adapt to it. However, much more is yet to be discovered and defined. This research topic even opens to the development of new devices that facilitate the study and exploitation of the microgravity effects on living systems, giving new perspectives to industrial research purposes. This Special Issue, "Advances in space biology: cell behaviour in microgravity", set out to describe how space biology has modified our perception of "Cell Biology", from a scientific and technological point of view. We collected 10 manuscripts including 5 full original articles, 1 brief communication, and 4 reviews. All of them, though lending different perspectives, sharpened the focus on the cell response to microgravity conditions and on the difficulties peculiar to this kind of investigation.

In this short editorial, we wish to highlight the most relevant "take-home-messages" of the articles and reviews that contributed to the success of this project. It should be noted that most of the manuscripts examined the effects of microgravity on mammalian cells, suggesting that one of the most consistent research interests is centered around the effects of space flight on complex organisms. Notably, research articles focused on the cell adaptation potential and differentiation processes under microgravity conditions, as well as on the possible countermeasures applicable to minimize microgravity-dependent cell alterations. Some articles regarded results obtained in a real space environment, but most of the proposed papers reported results obtained in simulated microgravity systems. To this regard, it is worth mentioning that one review and one of the research articles have explored the microgravity simulators, including their strengths, limits, and defects, as well as how to implement their performances [4,5]. This highlights how space biology research has had a robust impact at the bio-engineering level, encouraging new technologies which fulfil the needs of the scientific community. Some articles used stem cells as models and investigated potential practical challenges [6], demonstrating microgravity-induced effects on cell proliferation and/or differentiation processes [7,8]. One of the main tissues affected by microgravity conditions is the bone, and Dr Smith had reviewed how exposure to real or simulated microgravity affects the structure and function of osteoblasts, osteocytes, osteoclasts, and their mesenchymal and hematologic stem cell precursors. In addition, the author highlighted the critical roles that insulin-like growth factor-1 and its receptors play in maintaining bone homeostasis [9]. On this topic, Fava et al. collected and discussed evidences on lipid signaling in bone remodeling, as well as the immune response after microgravity exposure [10]. These authors underlined the role played by endogenous bioactive lipids that control immune and bone homeostasis, and whose signaling are altered in microgravity conditions.

One of the remaining open issues on space biology regards the possible cellular transduction system triggered by microgravity, which can be considered as a redistribution of reduced extracellular forces. It is widely accepted that microgravity-induced effects on bone and muscle cells can be attributed to the activation of mechanosensing and signaling transduction. Aventaggiato et al. reviewed and discussed the most important mechanosensors involved in normogravity and microgravity, also describing new promising molecules which act as mechanosensors [11]. The cell adhesion molecules and cytoskeletons are strictly connected to the mechano-transduction system, and this can explain changes in cell shape, cell–cell and matrix interactions, and cytoskeletal dynamics in cells exposed to microgravity [12,13].

To conclude, we wish to personally thank all the authors who contributed to this issue and made the whole thing possible.

Author Contributions: M.A.M. and G.R. equally contributed to the conceptualization and writing—original draft preparation, review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Adamopoulos, K.; Koutsouris, D.; Zaravinos, A.; Lambrou, G.I. Gravitational Influence on Human Living Systems and the Evolution of Species on Earth. *Molecules* **2021**, *26*, 2784. [CrossRef] [PubMed]
2. Baba, A.I.; Mir, M.Y.; Riyazuddin, R.; Cseplo, A.; Rigo, G.; Feher, A. Plants in Microgravity: Molecular and Technological Perspectives. *Int. J. Mol. Sci.* **2022**, *23*, 10548. [CrossRef] [PubMed]
3. Sharma, G.; Curtis, P.D. The Impacts of Microgravity on Bacterial Metabolism. *Life* **2022**, *12*, 774. [CrossRef] [PubMed]
4. Neelam, S.; Lee, A.; Lane, M.A.; Udave, C.; Levine, H.G.; Zhang, Y. Module to Support Real-Time Microscopic Imaging of Living Organisms on Ground-Based Microgravity Analogs. *Appl. Sci.* **2021**, *11*, 3122. [CrossRef]
5. Ferranti, F.; Del Bianco, M.; Pacelli, C. Advantages and Limitations of Current Microgravity Platforms for Space Biology Research. *Appl. Sci.* **2021**, *11*, 68. [CrossRef]
6. Di Filippo, E.S.; Chiappalupi, S.; Balsamo, M.; Vukich, M.; Sorci, G.; Fulle, S. Preparation of Human Muscle Precursor Cells for the MyoGravity Project's Study of Cell Cultures in Experiment Units for Space Flight Purposes. *Appl. Sci.* **2022**, *12*, 7013. [CrossRef]
7. Shaka, S.; Carpo, N.; Tran, V.; Espinosa-Jeffrey, A. Behavior of Astrocytes Derived from Human Neural Stem Cells Flown onto Space and Their Progenies. *Appl. Sci.* **2021**, *11*, 41. [CrossRef]
8. Cepeda, C.; Vergnes, L.; Carpo, N.; Schibler, M.J.; Bentolila, L.A.; Karouia, F.; Espinosa-Jeffrey, A. Human Neural Stem Cells Flown into Space Proliferate and Generate Young Neurons. *Appl. Sci.* **2019**, *9*, 4042. [CrossRef] [PubMed]
9. Smith, J.K. Microgravity, Bone Homeostasis, and Insulin-Like Growth Factor-1. *Appl. Sci.* **2020**, *10*, 4433. [CrossRef]
10. Fava, M.; Leuti, A.; Maccarrone, M. Lipid Signalling in Human Immune Response and Bone Remodelling under Microgravity. *Appl. Sci.* **2020**, *10*, 4309. [CrossRef]
11. Aventaggiato, M.; Barreca, F.; Vernucci, E.; Bizzarri, M.; Ferretti, E.; Russo, M.A.; Tafani, M. Putative Receptors for Gravity Sensing in Mammalian Cells: The Effects of Microgravity. *Appl. Sci.* **2020**, *10*, 2028. [CrossRef]

12. Catizone, A.; Morabito, C.; Cammarota, M.; Schiraldi, C.; Corano Scheri, K.; Ferranti, F.; Mariggiò, M.A.; Ricci, G. Microgravity-Induced Cell-to-Cell Junctional Contacts Are Counteracted by Antioxidant Compounds in TCam-2 Seminoma Cells. *Appl. Sci.* **2020**, *10*, 8289. [CrossRef]
13. Ricci, G.; Cucina, A.; Proietti, S.; Dinicola, S.; Ferranti, F.; Cammarota, M.; Filippini, A.; Bizzarri, M.; Catizone, A. Microgravity Induces Transient EMT in Human Keratinocytes by Early Down-Regulation of E-Cadherin and Cell-Adhesion Remodeling. *Appl. Sci.* **2021**, *11*, 110. [CrossRef]