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Exploring
a better tomorrow

Space:
The next frontier in tissue engineering

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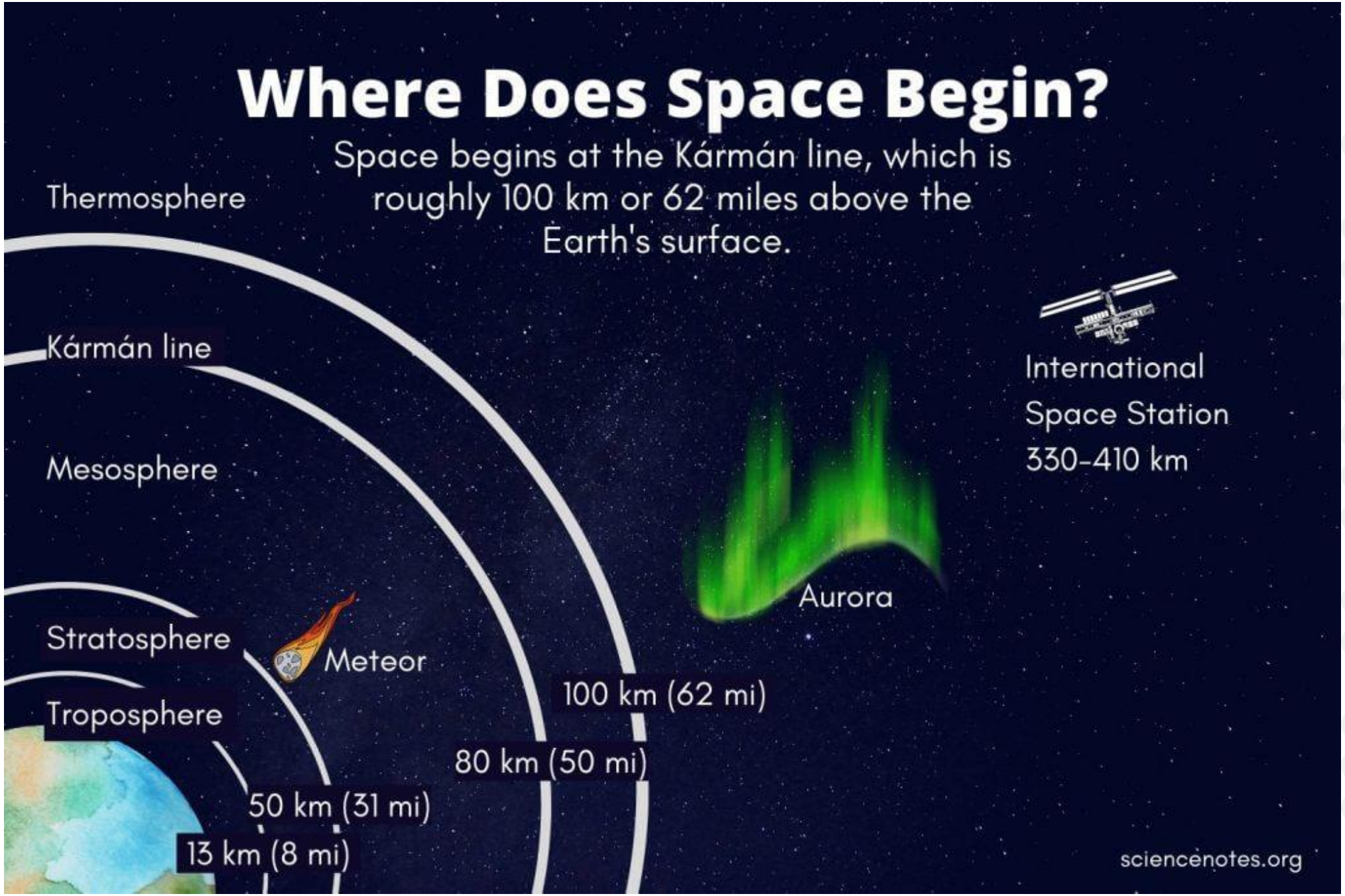
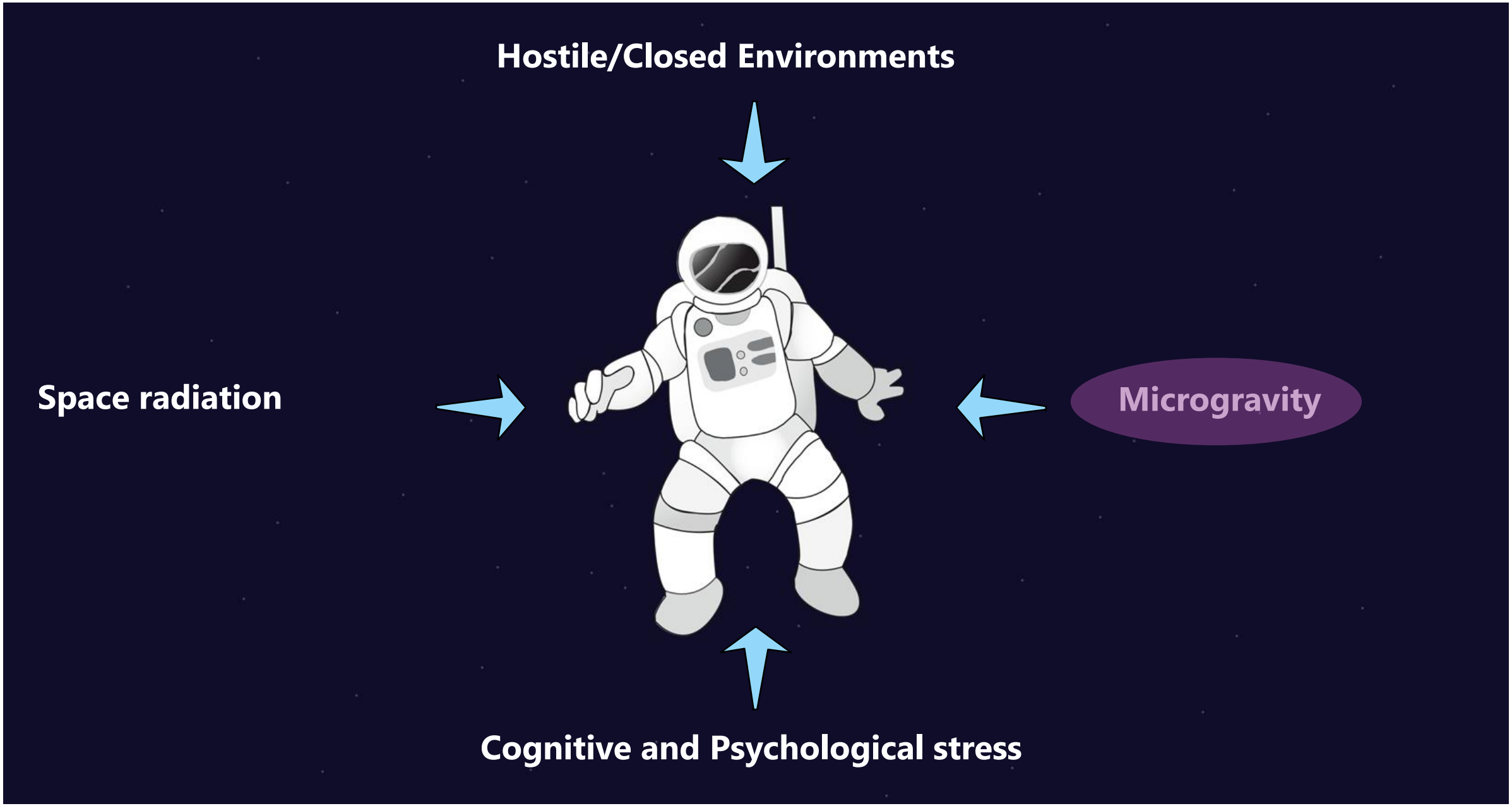
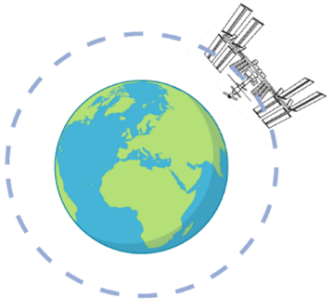
Astronaut 2.0 session: 21st century Explorers to Mars – 19/10/2022


Where Does Space Begin?
Space begins at the Kármán line, which is roughly 100 km or 62 miles above the Earth's surface.
Thermosphere
Kármán line
Mesosphere
Stratosphere
Troposphere
Meteor
Aurora
International Space Station 330-410 km
100 km (62 mi)
80 km (50 mi)
50 km (31 mi)
13 km (8 mi)
sciencenotes.org

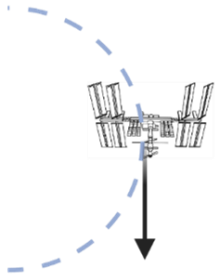

Hostile/Closed Environments
Space radiation
Microgravity
Cognitive and Psychological stress

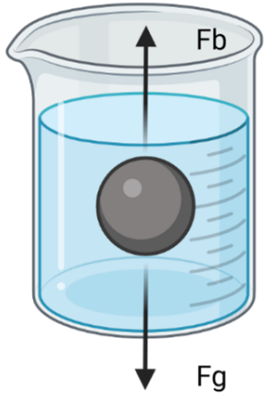
Microgravity for tissue engineering?

Gravity ⟷ Free fall ⟷ Buoyancy



~ 88.6% of Earths' gravitational field on ISS





Buoyancy force = Gravitational force

Up to week ~21

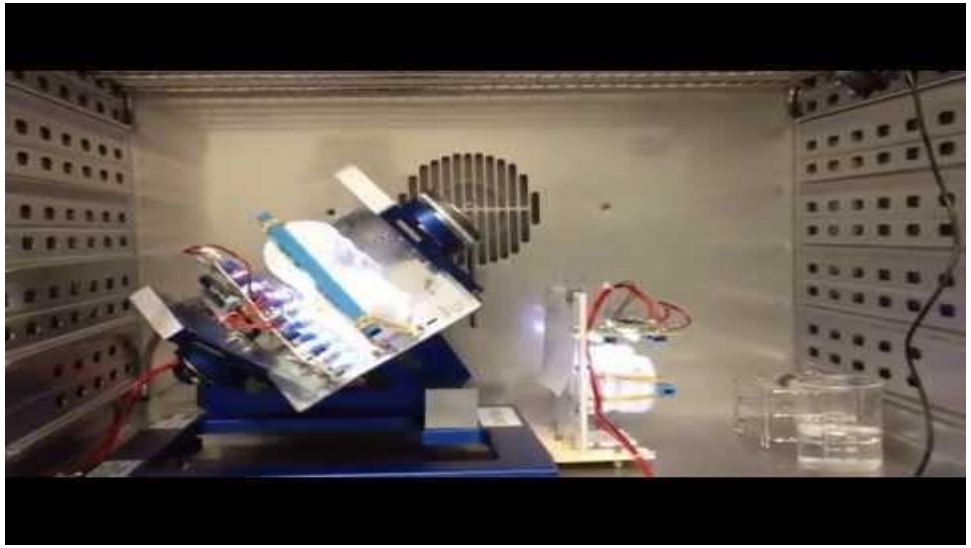
Sekulića et al 2005

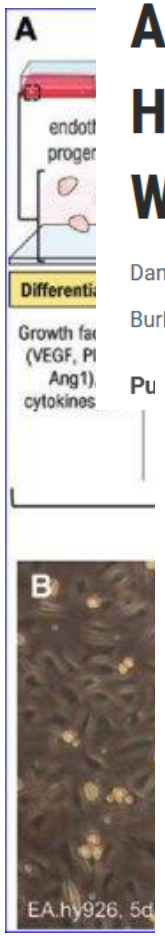
Designed by Freepik

Tissue engineering under microgravity

Effects of simulated microgravit

- Prof. Daniela Grimm





Tissue Engineering Part A > Vol. 15, No. 8 > Original Articles

A Delayed Type of Three-Dimensional Growth of Human Endothelial Cells Under Simulated Weightlessness

Daniela Grimm, Manfred Infanger, Kriss Westphal, Claudia Ulbrich, Jessica Pietsch, Peter Kossmehl, Sonia Vadrucci, Sarah Baatout, Burkhard Flick, Martin Paul, and Johann Bauer

ELSEVIER

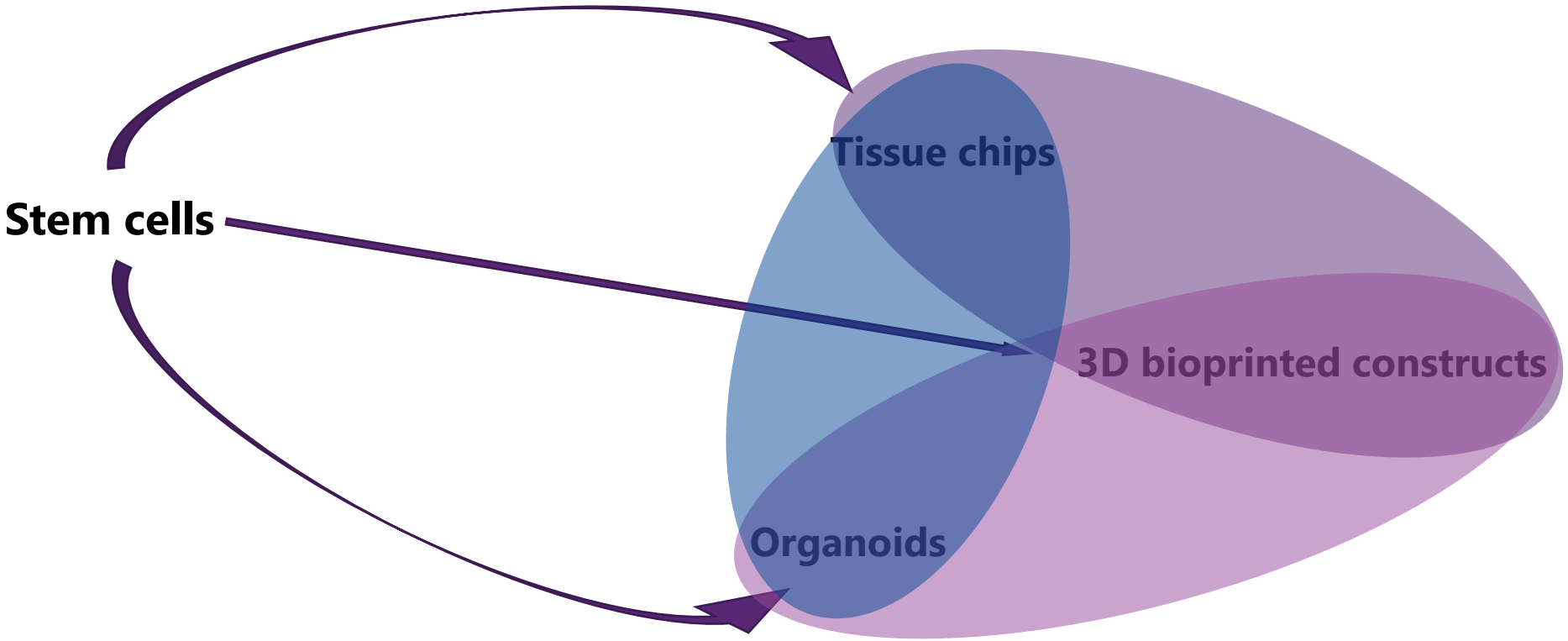
Biomaterials

Volume 124, April 2017, Pages 126-156

Three-dimensional growth of human endothelial cells in an automated cell culture experiment container during the SpaceX CRS-8 ISS space mission – The SPHEROIDS project

Jessica Pietsch [a], Samuel Gass [b], Stefano Nebuloni [b], David Echegoyen [a], Stefan Riwaldt [a, e], Christin Baake [a], Johann Bauer [c], Thomas J. Corydon [e], Marcel Egli [d], Manfred Infanger [a], Daniela Grimm [a, e]

Tissue engineering in space: where are we?



Stem cells in space

- **Increased potency and expansion**
- **Improved stem cell differentiation**

Article | Open Access | Published: 01 June 2020

Feasibility, potency, and safety of growing human mesenchymal stem cells in space for clinical application

Peng Huang, Athena L. Russell, Rebecca Lefavor, Nisha C. Durand, Elle James, Larry Harvey, Cuiping Zhang, Stefanie Countryman, Louis Stodieck & Abba C. Zubair

Stem Cell Reports ISSCR

Article

OPEN ACCESS

Space microgravity improves proliferation of human iPSC-derived cardiomyocytes

Antonio Rampoldi,[1] Parvin Forghani,[1] Dong Li,[1] Hyun Hwang,[1] Lawrence Christian Armand,[1] Jordan Fite,[2] Gene Boland,[2] Joshua Maxwell,[1] Kevin Maher,[1] and Chunhui Xu[1,3,*]

Stem Cell Reports ISS

Report

OPEN

Effects of Spaceflight on Human Induced Pluripotent Stem Cell-Derived Cardiomyocyte Structure and Function

Alexa Wnorowski,[1,2,11] Arun Sharma,[1,3,4,5,11] Haodong Chen,[1,3] Haodi Wu,[1,3] Ning-Yi Shao,[1,3] Nazish Sayed,[1,3] Chun Liu,[1,3] Stefanie Countryman,[6] Louis S. Stodieck,[6] Kathleen H. Rubins,[7] Sean M. Wu,[1,3,8] Peter H.U. Lee,[9,10] and Joseph C. Wu[1,3,8,*]

Article | Open Access | Published: 26 July 2018

Cardiovascular progenitor cells cultured aboard the International Space Station exhibit altered developmental and functional properties

Jonathan Baio, Aida F. Martinez, Ivan Silva, Carla V. Hoehn, Stephanie Countryman, Leonard Bailey, Nahidh Hasaniya, Michael J. Pecaut & Mary Kearns-Jonker

Original Article | Open Access | Published: 19 September 2018

SCD – Stem Cell Differentiation Toward Osteoblast Onboard the International Space Station

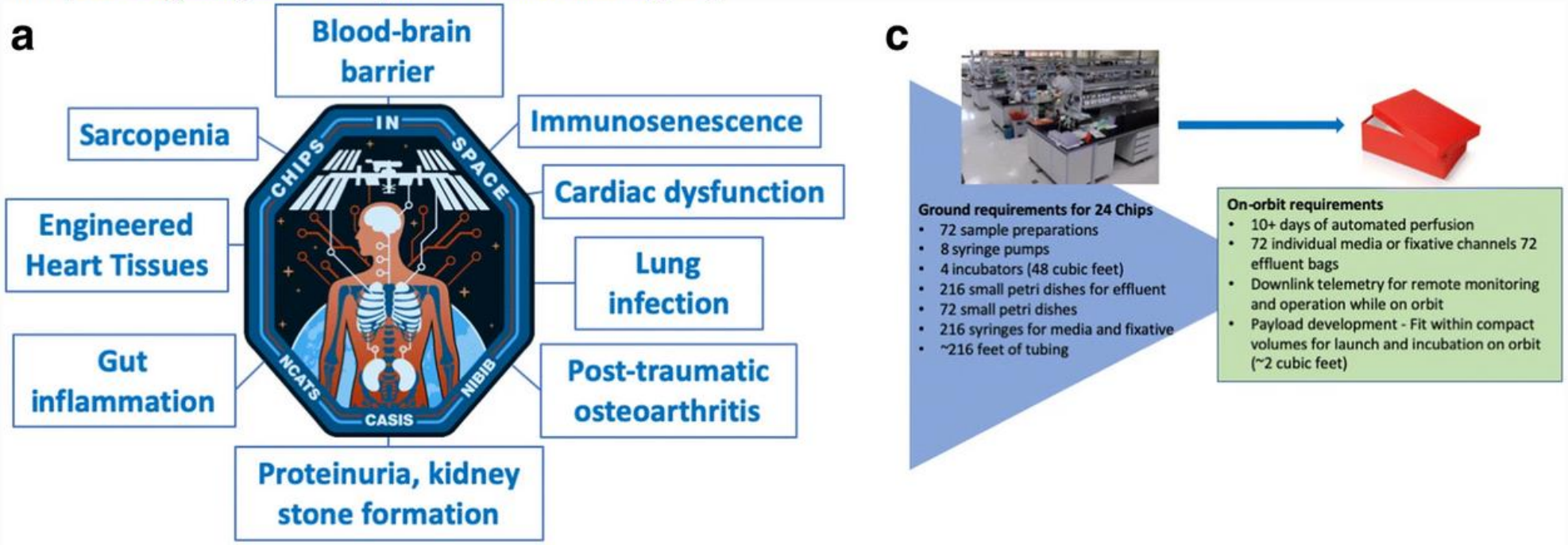
Silvia Bradamante, Damariz Rivero, Livia Barenghi, Michele Balsamo, Simone Paolo Minardi, Francesco Vitali & Duccio Cavalieri

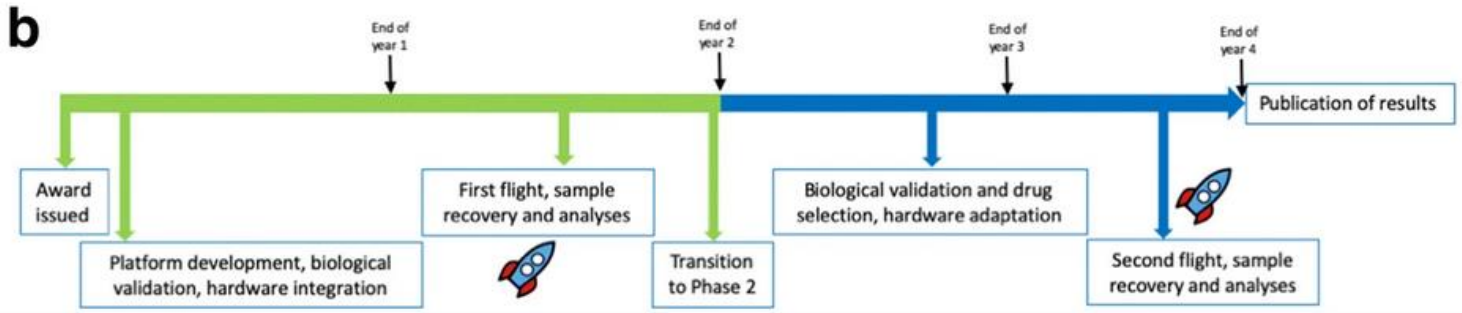
Effects of Microgravity on Early Embryonic Development and Embryonic Stem Cell Differentiation: Phenotypic Characterization and Potential Mechanisms

Feng Li[1†], Ying Ye[2†], Xiaohua Lei[3*] and Wensheng Zhang[2,4*]

Tissue chips in space

From: Tissue Chips in Space: Modeling Human Diseases in Microgravity





Bioprinting in space

SCIENCE ADVANCES | RESEARCH ARTICLE

BIOENGINEERING

Magnetic levitational bioassembly of 3D tissue construct in space

Vladislav A. Parfenov[1,2*†], Yusef D. Khesuani[1†], Stanislav V. Petrov[1], Pavel A. Karalkin[1,3], Elizaveta V. Koudan[1], Elizaveta K. Nezhurina[3], Frederico DAS Pereira[1], Alisa A. Krokhmal[1‡], Anna A. Gryadunova[1], Elena A. Bulanova[1], Igor V. Vakhrushev[1], Igor I. Babichenko[4], Vladimir Kasyanov[5§], Oleg F. Petrov[6], Mikhail M. Vasiliev[6], Kenn Brakke[7], Sergei I. Belousov[8], Timofei E. Grigoriev[8], Egor O. Osidak[9], Ekaterina I. Rossiyskaya[10], Ludmila B. Buravkova[11], Oleg D. Kononenko[12], Utkan Demirci[13*], Vladimir A. Mironov[1,14*]

Organ.Aut - Roscosmos

3D BioFabrication Facility – NASA

3D Bioprinting Aboard the International Space Station Using the Techshot BioFabrication Facility

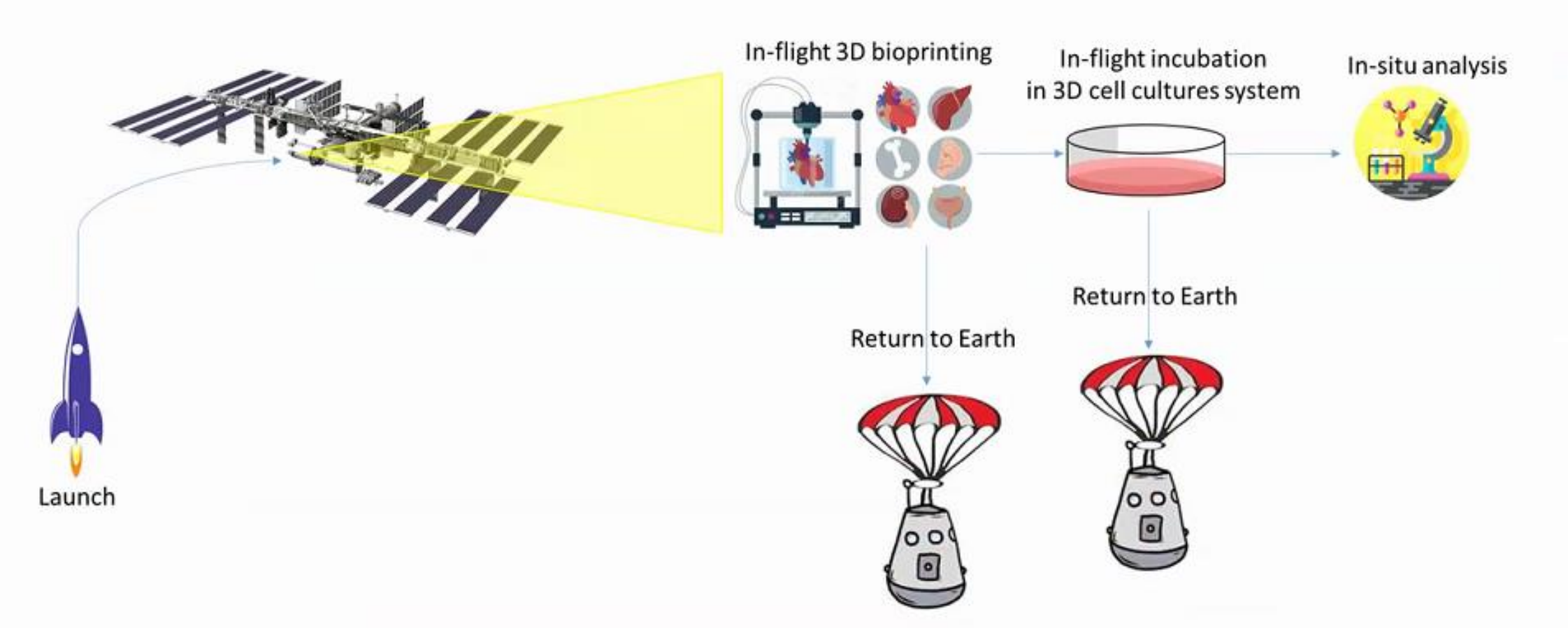
Carlos C. Chang, Eugene D. Boland

Book Editor(s):Volker Hessel, Jana Stoudemire, Hideaki Miyamoto, Ian D. Fisk

First published: 01 July 2022 | https://doi.org/10.1002/9783527830909.ch16

Bioprinting in space

ESA Task force for implementing a bioprinter on the ISS



Current state of healthcare

Current Challenges

- Aging, unique & vulnerable populations
- Focus on outcomes
- New healthcare challenges
- Scrutiny on cost of care
- Need for patient specific care
- Reimbursement Challenges

Technological Opportunities

- Robotic/Digital Surgery and Diagnostics
- Predictive Modeling
- Bioprinting to regenerate rather than repair
- Diagnostic Tools
- Ultra personalization

Bioprinting opportunities

Product Supportive Technologies

Improved in vitro test methodologies (disease, patient and anatomical specificity)

Reduced reliance on animal testing

Improved in vivo modeling capabilities (expanded testing, R&D, planning, training)

Accelerated Product Development

Transformational Product Technologies

Technologies that regenerate and repair rather than replace

New Treatment Paradigms

Acknowledgements

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Space Application Services

Hilde Stenuit

Otto-von-Guericke-Universität

Daniela Grimm

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Belgian Nuclear Research Centre

European Commission

Belgian Science Policy Office
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Thank you for your attention!