平成 27 年 9 月 25 日

国際宇宙ステーションを使った脊髄損傷の再生医療研究が NASA 宇宙実験に採択

【ポイント】

1. 広島大学大学院医歯薬保健学研究院・基礎生命科学部門　保健学分野　生体環境適応科学研究室　弓削 類 教授が代表を務める研究グループによる、国際宇宙ステーションを使った世界初の脊髄損傷の再生医療研究が NASA の宇宙実験に採択されました。

2. 弓削教授が NASA ケネディー宇宙センターの微小重力シミュレーターセンター諮問委員会委員に就任しました。

3. NASA ケネディー宇宙センターに新設される微小重力シミュレーターセンターに広島大学発のバイオベンチャーである株式会社スペース・バイオ・ラボラトリーズが開発した重力制御装置「Gravite®」が設置されます。

【概要１】

広島大学大学院医歯薬保健学研究院・基礎生命科学部門　保健学分野　生体環境適応科学研究室　弓削 類 教授が研究代表を務める国際宇宙ステーションを使った再生医療研究が NASA に採択されました。

本研究は、広島大学とハーバード大学の共同研究チームにより実施します。

NASA は、2013 年に宇宙環境を利用した再生医療の研究へ取り組むことを表明しています。その一環の宇宙実験として、世界初の脊髄損傷の治療を目指した研究を行う計画です。

弓削教授らは、幹細胞（間葉系幹細胞）を微小重力環境で培養すると幹細胞の未分化性が維持されて、脊髄損傷モデルラットに細胞移植を行うと運動機能が回復するという研究成果を既に発表しています（Mitsuhara *et al.* Stem Cell Research & Therapy 4(35):2013）。

今回の宇宙実験は、この成果を元に計画され、今後、NASA と直接に打合せをしながら 2 年以内の実施を目指します。

実験では、宇宙の（真の）微小重力環境と、地上の重力制御装置「Gravite®」を使った模擬微小重力環境で、それぞれ幹細胞（頭蓋由来ヒト間葉系幹細胞）を培養し、その細胞を地上で脊髄損傷モデル動物へ細胞移植して、細胞の特性や運動機能の改善効果にどのような違いがあるかを検証する世界初の研究です（資料１）。

微小重力環境でみられる幹細胞の未分化維持の効用を期待したもので、その成果は最終的に幹細胞バンクに利用することを目指します。

【概要２】

弓削教授は、NASA ケネディー宇宙センターの微小重力シミュレーターセンタ

ー諮問委員会委員に就任しました（資料２）。諮問委員会委員は、世界で 6 名が選出され、任期は 2020 年までの５年間です。

弓削教授は、微小重力環境での幹細胞研究の専門家として、宇宙実験で行う再生医療の評価及び筋萎縮、骨萎縮、循環器系低下等の長期臥床による廃用性症候群などの医科学研究に対する評価、助言を行います。

今回の諮問委員就任には、2014 年３月に弓削教授らが主催した「広島大学研究力強化事業公開シンポジウムー宇宙環境を利用した再生医療への試みー」の支援（資料３）が大きな起点となりました。

また、NASA の 2013 年 CASIS（The Center for the Advancement of Science in Space）の報告書には、微小重力環境を使った再生医療研究の世界初の成果（Kawahara *et al.* PLoS ONE 4(7); 2009）として記載されています（資料４）。

【概要３】

NASA ケネディー宇宙センターに新設される微小重力シミュレーターセンターには、弓削教授が取締役を務める株式会社スペース・バイオ・ラボラトリーズが開発した重力制御装置「Gravite®」が設置されます。

微小重力シミュレーターセンターでは、動・植物を使ったライフサイエンス及び物理学研究の中から、パラボリック（放物線）飛行や落下実験、模擬微小重力装置等を使い、国際宇宙ステーションで行う候補実験への評価、助言を行います。宇宙の真の微小重力と地上の模擬微小重力環境とを比較し、どのような研究が宇宙実験で有用なのか、またその成果を人類の科学とイノベーションにどのように活用できるかを探索する研究と開発を行います。

【開発の経緯】

重力制御装置「Gravite®」について

弓削教授らの研究から、微小重力環境（宇宙ステーション内と同等の 10^{-3} G の環境）では、細胞の分化が抑制されることが分かってきました。地上で疑似的な微小重力環境を発生させる方法として、回転により重力の方向を変える「クリノスタット」と呼ばれる装置が知られており、幾つかの回転装置が開発されてきました。

今回、微小重力シミュレーターセンターに設置される装置は、直行二軸のまわりに試料を回転させ、重力ベクトルを全方位に分散させることにより、10^{-3}G の模擬微小重力環境を実現するだけでなく、単軸回転による遠心力を利用して 2～3G の過重力環境も作ることも可能となりました。理論的な重力環境の変化を可視化するため、加速度センサによってリアルタイムにモニタリングする機構も装備しています。また、細胞培養を行う CO_2 インキュベータ内の気温 37℃、湿度 95%という環境下でも設置できる仕様を実現しました。

株式会社スペース・バイオ・ラボラトリーズと株式会社イクシスリサーチが、ちゅうごく産業創造センター「平成 24 年度新産業創出研究会」にて開発した制御システム（特許出願済）の一部を活用し、その後、国立研究開発法人新エネルギー・産業技術総合開発機構（NEDO）プロジェクトの支援も受けながら、独自に製品化を目指してハード面の開発改良を行ってきました。2015 年 10 月から製品名「Gravite®」として、主に研究用途として株式会社スペース・バイオ・ラボラトリーズより世界で販売を開始する予定です。

【研究内容に関するお問い合わせ先】
広島大学大学院医歯薬保健学研究院　基礎生命科学部門
保健学分野　生体環境適応科学研究室　教授　弓削 類（ゆげ　るい）
TEL：082-257-5425
FAX：082-257-5425
E-mail：ryuge@hiroshima-u.ac.jp

株式会社スペース・バイオ・ラボラトリーズ
代表取締役　河原　裕美（かわはら　ゆみ）
TEL：082-257-１５０１
FAX：082-257-１５０１
E-mail：yumi@spacebio-lab.com

（別紙）

株式会社スペース・バイオ・ラボラトリーズについて

株式会社スペース・バイオ・ラボラトリーズは、2005 年に起業した広島大学発のバイオベンチャー企業です。35 億年の生命の進化の過程においてすぐ側にあった物理的環境に注目し、これまで微小重力、磁場、電気、超音波等の物理的環境下で細胞培養する研究を行い、細胞分化を人為的に促進・制御する手法を研究開発してきました。

この技術を、再生医療に応用したいと考えています。広島信用金庫と日本政策金融公庫広島支店国民生活事業から支援を頂き、重力制御装置「Gravite®」および歩行支援ロボットの事業化を進めています。重力制御装置「Gravite®」は、国立研究開発法人新エネルギー・産業技術総合開発機構（NEDO）やちゅうごく産業創造センターのご支援を頂きながら開発を続けて参りました。

詳細は、株式会社スペース・バイオ・ラボラトリーズのホームページ（http://www.spacebio-lab.com/）をご覧下さい。

【会社概要】

名称：株式会社スペース・バイオ・ラボラトリーズ

英語名称：Space Bio-Laboratories Co., Ltd.

代表取締役：河原　裕美

設立日：2005 年 12 月 14 日

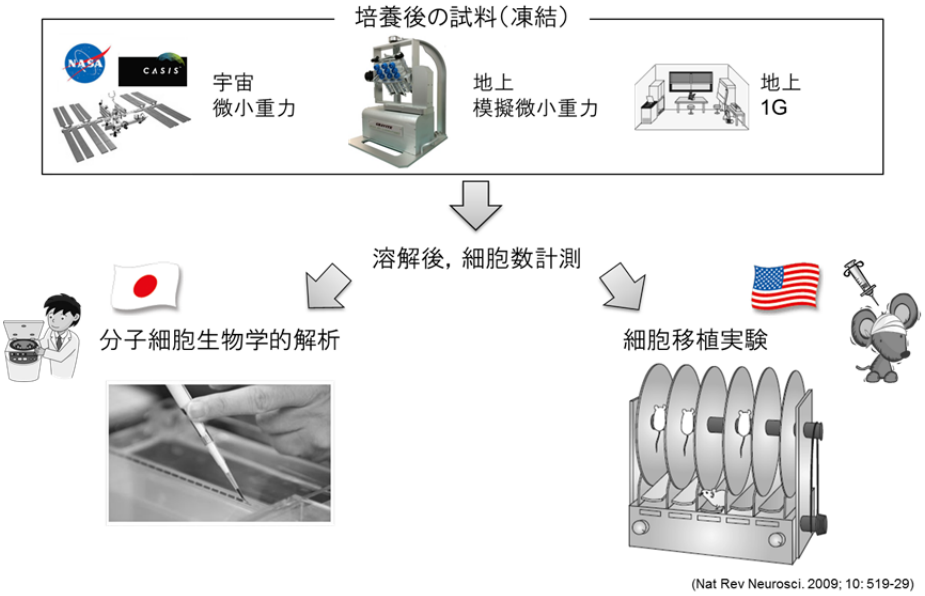
資本金：310 万円（2015 年3月現在）

事業内容：

1. 医療用，研究用の遺伝子と細胞，医薬品，診断薬，試薬，医療材料の研究開発，製造及び販売並びに輸出入
2. 医療機器，医療用具の研究開発，製造，販売及び輸出入
3. 遺伝子と細胞の診断法，治療法，培養法に関する研究開発，その装置の製造，販売及び輸出入
4. 再生医療，リハビリテーション，医薬品に関する研究開発，研究受託，技術コンサルティング
5. 再生医療、リハビリテーション，医薬品に関する装置，機器の研究開発，製造，販売，輸出入及びレンタル

Fig 2. 宇宙実験デザイン

Flow of post-flight sample analyses



【構成メンバー】

Principal Investigator：責任研究者

弓削　類	広島大学大学院医歯薬保健学研究院　生体環境適応科学･教授

Co-investigator：共同研究者

粂井　康宏	東京医科歯科大学･講師
栗栖　薫	広島大学大学院医歯薬保健学研究院　脳神経外科学･教授
岩月　幸一	大阪大学大学院医学系研究科　脳神経外科学･講師
末田　泰二郎	広島大学大学院医歯薬保健学研究院　外科学･教授
谷本　圭司	広島大学原爆放射線医科学研究所･助教
河原　裕美	株式会社スペース･バイオ･ラボラトリーズ･代表取締役
Yang (Ted) D. Teng	Laboratory of SCI & Stem Cell Biology Research, Neurosurgery and PM&R, HMS/BWH/SRH Harvard University･Director

（資料２）

National Aeronautics and Space Administration
Kennedy Space Center
Kennedy Space Center, FL 32899

July 1, 2015

Reply to Attn of:

Dr. Louis Yuge
Professor
Hiroshima University,
Graduate School of Biomedical & Health Sciences
Division of Bio-Environmental Adaptation Sciences
2-3 1-chome Kasumi Minami-ku Hiroshima, Japan 734-8551

Dear Dr. Yuge,

Thank you for accepting my request to become a member of the Micro-g Simulator Advisory Committee at the NASA Kennedy Space Center, Florida. I am looking forward to our fruitful collaboration for establishment of a NASA-sponsored Micro-g Simulator Center.

Sincerely,

Howard G. Levine, PhD
Chief Scientist & IACUC Chair
KSC Utilization and Life Sciences Office
Mail Code UB-A
Kennedy Space Center, FL 32899
321-861-3502
Howard.G.Levine@nasa.gov

（資料３）

平成 25 年度　広島大学研究力強化事業公開シンポジウム
ー宇宙環境を利用した再生医療への試み—

Stem cell culture in space

Using the space environment to investigate new approaches to collaboration

日時：平成 26 年 3 月 25 日（火）　15:00－18:00

場所：広島大学　広仁会館 2 階　大会議室

Welcome to our Symposium
"Stem Cell Culture in Space"

Thank you very much for coming this symposium. We will be talking about Space…and about how exploring this final frontier can help us realize our dreams.

It is a great honor and pleasure, to have three of my very dear American colleagues here as keynote speakers. They are all world-leading scientists, highly respected in their respective fields as Space Biology and Stem Cell research, involved in work related to NASA and CASIS.

As you are well aware, discovery of stem cells is a very novel and powerful finding for humankind, much like space discovery. As such, this symposium will address Stem Cell Culture in Space, and also explore the possibility of using the space environment to investigate new approaches for collaboration.

I hope we will have an enjoyable time and fruitful discussions.

We would like to give special thanks for all the assistance that we received from the Academic and Social Industry-University Cooperation, Hiroshima University Laboratory Planning Office, We are grateful to Professor Taijiro Sueda, Professor Kaoru Kurisu, and Tokyo Medical and Dental University, Associate Professor Yasuhiro Kumei as Chair. And we are also grateful to Hiroshima University for their outstanding support of this symposium.

Louis Yuge
Professor
Graduate School of Biomedical & Health Sciences,
Hiroshima University

平成25年度　広島大学研究力強化事業公開シンポジューム

−宇宙環境を利用した再生医療への試み—

この度, 人類にとって最後のフロンティアである宇宙環境が私たちの生活にどのように役立つかについてシンポジュームを行うことになりました.

本シンポジュームに，親愛なる3名のアメリカ人の研究者を講演者としてお呼びできたことは，大変光栄です．彼らは，世界をリードする科学者であり，宇宙生物学や幹細胞研究のそれぞれの分野に関わる極めて重要な仕事をNASA，CASISで行っている方々です.

他方，皆さまがご存じのように幹細胞は，宇宙開発と同じように現代科学にとって新しくパワフルな発見であります．本シンポジュームの目的は，宇宙環境を利用した幹細胞研究の新しいアプローチの探求とその為の新しいコラボレーションを話し合うことです.

ご参加の皆さまとともに, 楽しい時間と実りある討論が行えることを心より願っています.

本シンポジュームは，平成25年度広島大学研究力強化事業として実現しました．開催に際し，国立大学法人広島大学，学術・社会連携室，研究企画室，総務支援グループ，座長を担当して頂く大学院医歯薬保健学研究院・心臓血管外科学・末田泰二郎 教授，脳神経外科学・栗栖 薫 教授，東京医科歯科大学　粂井康宏講師，その他多くの方々にお力添えを賜りました．この場をお借りして御礼と感謝の意を表します.

広島大学大学院　医歯薬保健学研究院
教授　弓削　類

PROGRAM

Stem cell culture in space

Using the space environment to investigate new approaches to collaboration

Place: Koujin-Kaikan at Hiroshima University
Date: MARCH 25, 2014

15:00-15:10 Opening Remarks

【Chair】
Dr. Kaoru Kurisu (Professor, Graduate School of Biomedical & Health Sciences, Hiroshima University)
Dr. Yasuhiro Kumei (Associate Professor, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University)

15:10-15:40 **Dr. Kenneth A. Souza** (Sr. Scientist, NASA Ames Research Center)
Highlights of Animal Research in Space: Foundations for the Future

15:40-16:10 **Dr. Michael S. Roberts** (Sr. Research Pathway Manager, CASIS-Center for the Advancement of Science in Space)
CASIS - Pathways for Research and Technology Development with Earth Benefit on the ISS National Lab

16:10-16:20 Break

【Chair】
Dr. Taijiro Sueda (Professor, Graduate School of Biomedical & Health Sciences, Hiroshima University)
Dr. Yasuhiro Kumei (Associate Professor, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University)

16:20-16:50 **Dr. Louis Yuge** (Professor, Graduate School of Biomedical & Health Sciences, Hiroshima University)
Cellular Responses to Simulated Microgravity

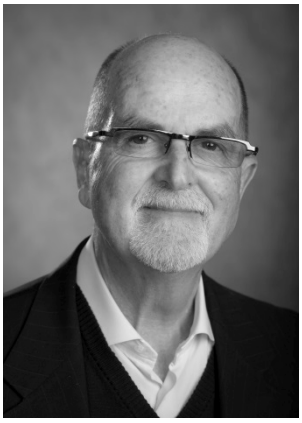
16:50-17:20 **Dr. Mary Kearns-Jonker** (Associate Professor, Department of Pathology and Human Anatomy Loma Linda University School of Medicine)
The Impact of Aging and the Environment on Isl-1+ Endogenous Cardiovascular Progenitor Cells in Human Neonates and Adults

17:20-17:30 Closing Speech

Title: Highlights of Animal Research in Space: Foundations for the Future

Kenneth A. Souza

Abstract



Before humans ventured into space, animals were used to assess the risks associated with rocket flights and the risk of leaving our planet of origin. Many diverse opinions were expressed as to what would happen to living systems subjected to sudden and severe accelerations as well as how they would react to the virtual absence of gravity. Some thought that normal cell division, metabolism, and reproduction and development would be adversely affected by spaceflight. Others thought that spaceflight would have little effect on basic processes, particularly at the cell and molecular levels since the natural intermolecular forces are many orders of magnitude greater than the force of gravity. The suborbital flights of the 1940's and 1950's with various small animals, the orbital flights of the Russian dogs, the American monkeys and chimps, and the menagerie of species flown on biosatellites in the 1960's, proved that life was not seriously debilitated by the stresses of launch and reentry or by the microgravity and radiation experienced during flight in low earth orbit. This presentation will briefly highlight a few examples of animal research in space, what was learned from them, the kinds of questions that animals are currently being used to address, and the foundation that animal research has provided in support of expanding human space exploration.

Biography

KENNETH A. SOUZA, AB, MS. He received his bachelor's degree in bacteriology from the University of California, Berkeley in 1966 and his Masters degree in Microbiology from San Jose State University in 1970. He joined NASA's Ames Research Center in 1966 and has spent over 40 years with NASA pioneering the fields of space biology and biomedicine. He retired from NASA in 2002 as the Director of Astrobiology and Space Research. He continues to support NASA's life sciences programs and projects as a Senior Scientist with Logyx, LLC. Under his leadership a suite of unique science equipment was built to support over 400 biological experiments that were flown on a variety of spacecraft including US and Russian biosatellites, the Space Shuttle, Mir, and the International Space Station. Those experiments greatly expanded our understanding of the role and influence of gravity on living systems and also contributed to the identification and mitigation of some of the risks associated with human spaceflight. He was instrumental in the negotiation and development of several international spaceflight projects and experiments with the Russian Space Agency, e.g., Bion Biosatellites and Mir; with the Japanese Space Agency, e.g., Shuttle/Spacelab-J, and the European Space Agency, e.g., Shuttle missions: IML-1, IML-2 and Neurolab. As a research scientist he conducted research in exobiology and space biology. His flight experiment aboard the Space Shuttle/Spacelab-J in 1992 demonstrated, for the first time, that a vertebrate species, an amphibian, could complete ovulation, fertilization, and early development normally in the virtual absence of gravity. He has published over 50 scientific articles in fields of exobiology, space biology and biomedicine, and received both national and international honors and awards for his management and scientific achievements, most recently the 2010 AIAA/ICES Jeffries Award for Contributions to Space Life Sciences and Medicine.

Kenneth A. Souza,
Senior Scientist,
Logyx, LLC
NASA Ames Research Center
Email: kenneth.a.souza@nasa.gov

Title: CASIS - Pathways for Research and Technology Development with Earth Benefit

Michael S. Roberts

Abstract

In 2005, the United States Congress designated the U.S. operating segment of the International Space Station as a national laboratory in order to maximize its use as a unique research environment for academic, commercial, and private institutions and other U.S. government agencies. In 2011 NASA selected CASIS, the Center for the Advancement of Science in Space, to manage the ISS National Lab and to define new research pathways for ISS to improve life on Earth. While NASA continues to support ISS research to advance space exploration goals, the ISS National Lab space managed by CASIS is focused on research and development with terrestrial benefits: exploiting the space environment to advance basic science, technology development, and translational research with commercial application. CASIS facilitates use of the ISS National Lab by other U.S. government agencies and by academic and private institutions, providing access to the laboratory's permanent microgravity setting and vantage point in low Earth orbit as well as the varied environments of space. This presentation will highlight the mission of CASIS and our approach to increase utilization of the ISS National Lab.

Biography

MICHAEL S. ROBERTS, B.A., Ph.D. He received a bachelor of arts in biology from Maryville College in 1985 and a doctorate in microbiology in 1993 with Dr. Frederick Cohan at Wesleyan University. He conducted post-doctoral research in the ecology of xenobiotic degrading bacteria at the RIKEN Institute in Wako-shi, Japan from 1994-1996 and at the Center for Microbial Ecology at Michigan State University from 1997-1999. In 1999, he joined the Dynamac Corporation to work in the NASA Advanced Life Support program at the John F. Kennedy Space Center (KSC) to direct research on bioregenerative technologies and closed-system biological approaches to human life support in space. This work took him from the Biomass Production Chamber in Hangar L at Cape Canaveral Air Force Station to the Space Life Sciences Lab at KSC in 2003 with brief visits to the Merritt Island National Wildlife Refuge and several parabolas in microgravity on a Zero Gravity flight. In addition to his ground-based research, he has served as Chief Scientist for CSS-Dynamac, Group Lead for QinetiQ North America, and as an investigator on multiple Shuttle and ISS flight experiments focused on the role of microgravity on bacterial gene exchange, plant-microbe interactions, and the performance of forward osmosis membranes for water recovery in space. He joined CASIS in 2013 as the Senior Research Pathway Manager.

Michael Roberts,
Senior Research Pathway Manager,
CASIS - Center for the Advancement of Science in Space
Space Life Sciences Lab, NASA Kennedy Space Center
E-mail: mroberts@iss-casis.org ; nichael.s.roberts@nasa.gov
CASIS Website: http://www.iss-casis.org

Title: Cellular Responses to Simulated Microgravity

Louis Yuge

Abstract

Microgravity is known to control cell cycle, cell proliferation, and differentiation. A 3D-clinostat is a multi-directional gravity device for simulated microgravity. By controlling rotation of two axes, a 3D-clinostat minimizes the cumulative gravity vector in cells cultured at the center of the device and makes 10-3G average over time velocity. This is accomplished by rotation of a chamber at the center of the device to disperse the gravity vector uniformly within a spherical volume, at a constant angular velocity. Our previous studies demonstrated simulated microgravity inhibited myoblasts and osteoblasts differentiation supporting data as gravitational space biology. In our study, we developed the application of microgravity to stem cells culture using a 3D-clinostat and newly developed GRAVITE. We reported microgravity potentiated stem cell proliferation such as human mesenchymal stem cells and mouse embryonic stem (ES) cells. Recently, regenerative medicine with bone marrow stromal cells (BMSCs) has gained significant attention for the treatment of central nervous system diseases. Here, we investigated the activity of BMSCs under simulated microgravity conditions. Neural induced mouse BMSCs (mBMSCs) cultured under 1G conditions exhibited neural differentiation, whereas those cultured under microgravity did not. Moreover, under microgravity conditions, mBMSCs could be cultured in an undifferentiated state. Next, we intravenously injected cells into a model of cerebral contusion and spinal cord injury. Graft mBMSCs cultured under microgravity exhibited greater survival in the both neurological disorder models damaged region, and the motor function of the grafted mice improved significantly.

We demonstrated that culturing cells under microgravity enhances their survival rate by maintaining an undifferentiated state of cells, making this a potentially attractive method for culturing donor cells to be used in grafting by GRAVITE. This method has significant potential for regenerative medicine and development biology. We attend human stem cell project supported by New Energy and Industrial Technology Development Organization (NEDO), and human iPS project supported by Japan Science and Technology Agency (JST).

Biography

LOUIS YUGE, B.A, M.Sc., Dr.Med.Sc., Ph.D., He received Dr.Med.Sc., PhD in Histology and Cell Biology from the Graduate School of Biomedical Sciences at Hiroshima University (Japan) in 2000. He is currently a Professor & Main director in the Division of Bio-Environment Adaptation Sciences, Graduate School of Biomedical & Health Sciences at Hiroshima University. He has published over 50 research papers, reviews and book chapters mostly in the area of cellular response in physical environments, space medicine, and rehabilitation medicine. He was a member of the working group of the International Space Station Program and the Lunar Survey Science in the Aerospace Exploration Agency (JAXA), and is Director of a cell therapy venture company, SBL (Space Bio-Laboratories Co., Ltd.: http://www.spacebio-lab.com/).

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Title: The Impact of Aging and the Environment on Isl-1+ Endogenous Cardiovascular Progenitor Cells in Human Neonates and Adults

Mary Kearns-Jonker

Abstract

Heart disease is the leading cause of death worldwide. Current advancements in stem cell research and reports from recent clinical trials indicate that c-kit+ or cardiosphere-derived endogenous cardiovascular progenitor cells improve cardiac function when administered as a cell-based treatment, however this effect is believed to be predominantly paracrine in nature. Our research team has isolated a promising new population of isl-1+ cardiovascular progenitor cells (CPC) that can be isolated as clonal populations from the heart of human neonatal and adult patients. Isl-1 expression is required for cardiac development during embryogenesis and we have shown that these isl-1+ clones are capable of regeneration when administered for stem-cell based repair. They can be differentiated into all cardiovascular lineages, including cardiac myocytes, endothelial cells and smooth muscle cells. Using a panel of cardiovascular progenitor cell clones isolated from human neonates and adults, we are studying the molecular basis for the enhanced regenerative capacity that is unique to neonatal CPC. In ground based studies, we have performed an extensive analysis of age-dependent changes in surface phenotype, microRNA expression, proliferative capacity, signaling and migration using matched, clonal neonatal and adult CPC. This allowed us to identify several functional and epigenetic differences that distinguish neonatal isl-1+ cardiovascular progenitor cells with extensive regenerative capacity, from adult clones with reduced regenerative capacity. We are interested in identifying the effects of the spaceflight environment on both neonatal and adult CPC and will utilize the International Space Station to determine the effects of microgravity on cell signaling, migration, proliferation, differentiation and senescence. An understanding of the impact of microgravity on endogenous cardiovascular progenitor cells has the potential to benefit patients on Earth who are candidates for treatment with cardiac stem cells as well as astronauts returning to Earth who may require cell-based treatment to repair lost heart muscle incurred during flight.

Biography

MARY KEARNS-JONKER, PhD. She completed her MSc and PhD graduate training at McGill University in Montreal, Quebec and her postdoctoral training at the National Institutes of Health. She was an Assistant Professor in the Dept of Cardiothoracic Surgery at the University of Southern California Keck School of Medicine until 2010 when she accepted her current position as an Associate Professor in the Dept of Pathology and Human Anatomy at Loma Linda University School of Medicine. She has over 40 publications in peer-reviewed journals, and maintains an active, externally-funded research laboratory focused on transplantation immunology and the use of cardiovascular stem cells for the repair of the heart.

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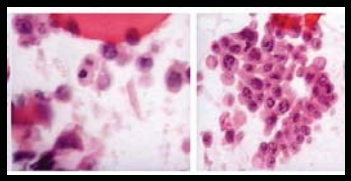
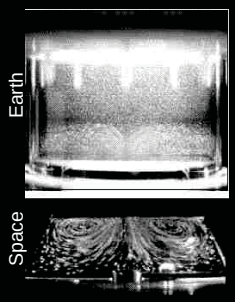
30 July 2013

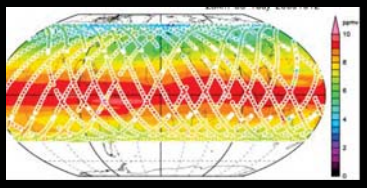
THE NATIONAL LAB RESEARCH ENVIRONMENT

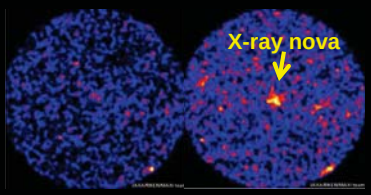
- Microgravity
- External Exposure
- LEO Observation Platform
- Technology Demonstration

Research for Earth Benefit









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Other images courtesy of NASA

RESEARCH SOLICITATIONS

August 2012

December 2012

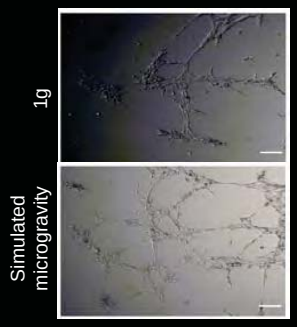
November 2012

March 2013

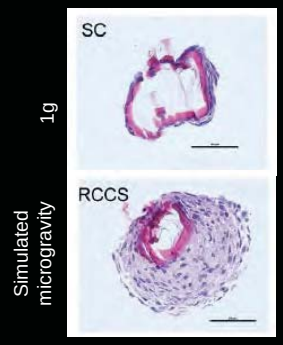
Closed July 26th 2013

STEM CELL PROPERTIES IN MICROGRAVITY

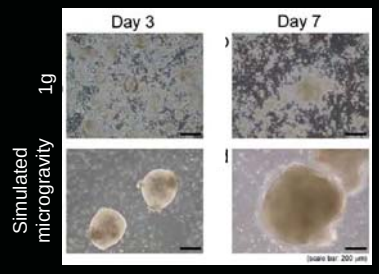
- Ability to either maintain pluripotency or improve differentiation



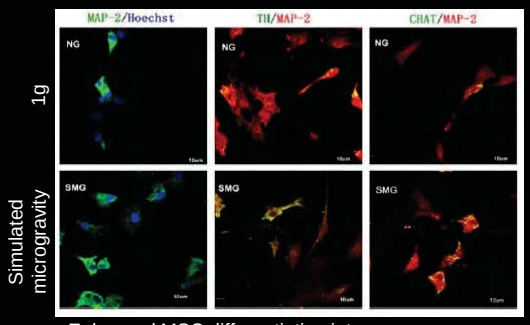
MSCs: Increased expression of endothelial markers, greater capillary formation



Epidermal stem cells: Multicellular structures maintain high proliferative capacity



Mouse embryonic stem cells: Large spheres remain undifferentiated and pluripotent



Enhanced MSC differentiation into neurons

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