平成 27 年 8 月 26 日

NASA ケネディ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就任と重力制御装置「Gravite®」の設置

【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 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。
2. 弓削 類 教授は、微小重力環境での幹細胞培養の専門家として、宇宙実験で行う再生医療の研究及び医科学研究領域に対する評価、助言を行います。
3. 高齢社会や長期臥床での筋萎縮、骨萎縮等の廃用性症候群の治療法の開発も進めて行く予定です。
4. 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、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】

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、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１）。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。

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公表しており、弓削 類 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。

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 類 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。同社は今後、NASA が公認した模擬微小重力装置として「Gravite®」を世界販売する計画です。

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。真の宇宙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。弓削 類 教授らのグループも国際宇宙ステーションを使った再生医療の宇宙実験を計画中です。

【開発の経緯】

重力制御装置「Gravite®」について

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 教授らの研究から、微小重力環境（宇宙ステーション内 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）の国プロジェクト事業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展開で販売を開始する予定です。

今回の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の就任には、2014 年３月に弓削 類 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 2）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 3）。これらの活動を含め 15 年来

行って来た研究の成果が認められ今回の就任に至ったものと思われます。

【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

（資料１）

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２）

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

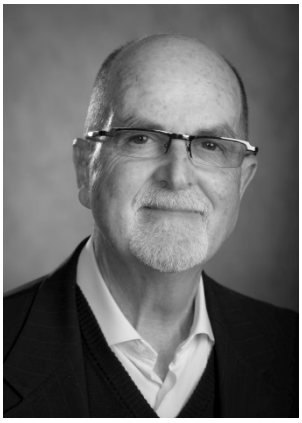
16:50-17:20 **Dr. Mary Kearns-Jonker** (Associate Professor, Department of Pathology and Human Anatomy Loma Linda University School of Medicine)
The Impact of Aging and the Environment on Isl-1+ Endogenous Cardiovascular Progenitor Cells in Human Neonates and Adults

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/).

Louis Yuge,
Professor & Main director, Graduate School of Biomedical & Health Sciences
Division of Bio-Environmental Adaptation Sciences Hiroshima University, Japan Space Bio-Laboratories Co., Ltd.
E-mail: ryuge@hiroshima-u.ac.jp
Yuge lab: http://home.hiroshima-u.ac.jp/yugelab/

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.

Mary Kearns-Jonker,
Associate Professor
Department of Pathology and Human Anatomy
Loma Linda University School of Medicine
E-mail: mkearnsjonker@llu.edu

【連絡先】

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CASIS™

The Center for the Advancement of Science in Space

Manager of the International Space Station U.S. National Laboratory

NASA Advisory Council Commercial Space Opportunities

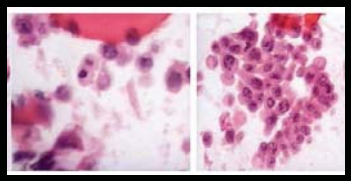
Duane Ratliff, Chief Operating Officer

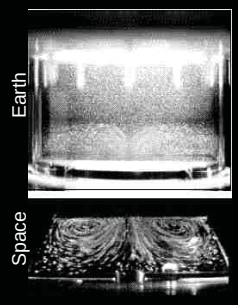
30 July 2013

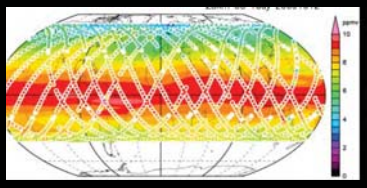
THE NATIONAL LAB RESEARCH ENVIRONMENT

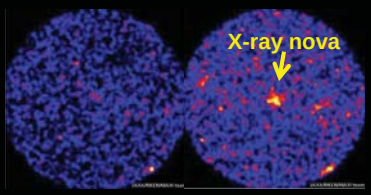
- Microgravity
- External Exposure
- LEO Observation Platform
- Technology Demonstration

Research for Earth Benefit



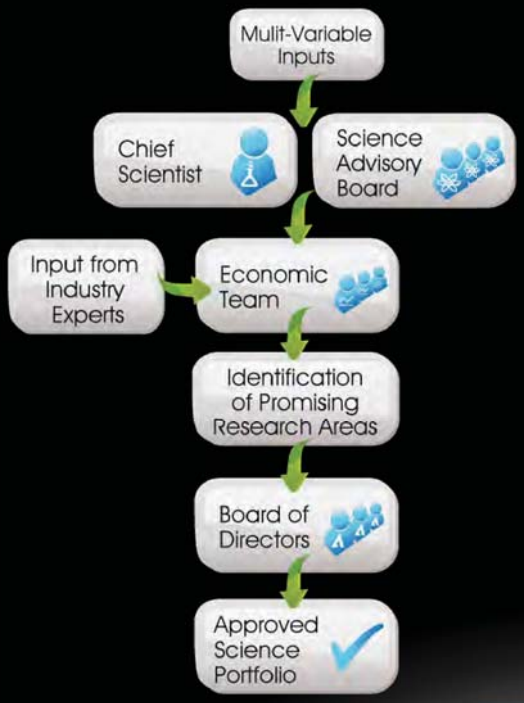






Wilson et al. PNAS 104(41); 2007
Swan et al. PNAS 109(40); 2012
Kikuchi et al., Journal of Geophysical Research 115(D23306); 2010
Other images courtesy of NASA

CREATING OPPORTUNITY



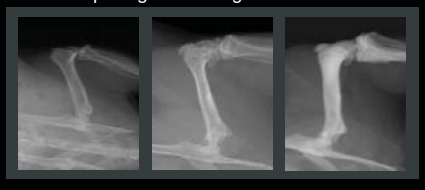
CASIS seeks to develop a robust and diverse research portfolio by:

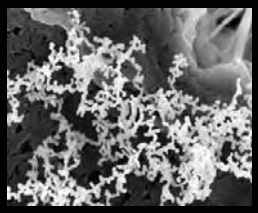
- Identifying unique and promising capabilities of the National Lab
- Assessing market size, market interest and time to translate research benefits to National stakeholders
- Approve and execute research portfolios

INITIAL RESEARCH PRIORITIES

- Biosciences
- Materials Science
- Earth and Space Observation
- Technology Demonstration

Osteoprotegerin testing in mice on Shuttle

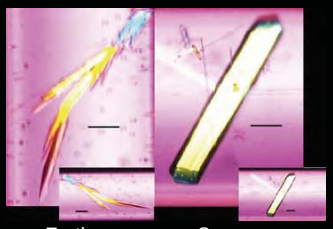




Metal nanoparticles produced in microgravity

Sarychev Peak Eruption, Kuril Islands

H-PGDS crystallized with novel inhibitors



Earth Space

Acta Cryst. (2010). F66, 846–850

Other images courtesy of NASA, ESA

RESEARCH SOLICITATIONS

August 2012

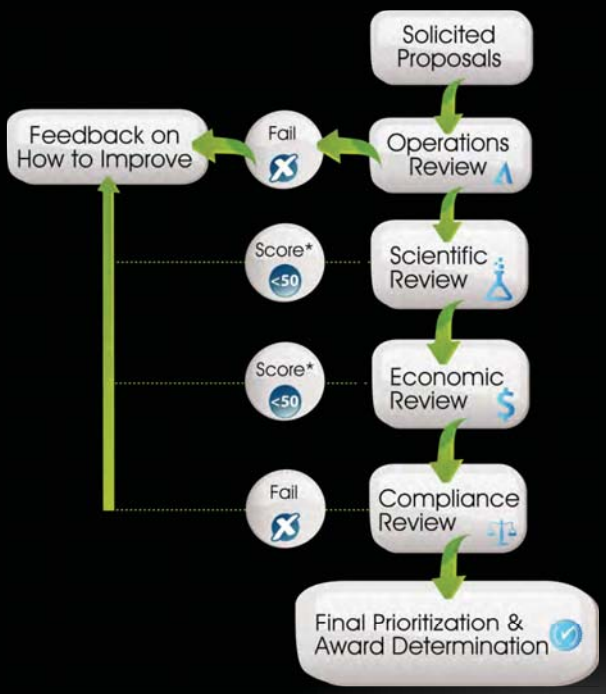
December 2012

November 2012

March 2013

Closed July 26th 2013

EVALUATION & SELECTION PROCESS



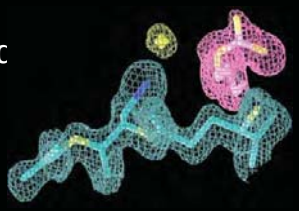
1. Operations team determines technical feasibility
2. Review for scientific merit by external panel of subject matter experts
3. Economic valuation to assess tangible and intangible value to U.S. taxpayer
4. Legal and Compliance team review of regulatory, compliance, IP and other potential legal issues
5. Final award and prioritization determinations by Executive Director, Chief Scientist and Chief Economist

EXAMPLE PROJECTS

Grant Awardees from Formal Solicitations and Selected Unsolicited Projects

PROTEIN CRYSTALLIZATION

- *Dr. Joseph Ng, iXpressGenes Inc.:* The location of IPPase-associated hydrogen atoms potentially involvec in catalysis (using neutron diffraction)
- *Dr. Sergey Korolev, Saint Louis University School of Medicine:* Human calcium-independent phospholipase PLA2g6 and prothrombin
- *Dr. Edward Snell, Hauptman-Woodward Medical Research Institute at SUNY Buffalo:* Four medically-relevant proteins, two of which have large disordered regions: OXR1, ECHDC1, Srcasm and HSPA13
- *Dr. Pamela Bjorkman, California Institute of Technology:* Exon 1 polyglutamine repeat in huntingtin protein



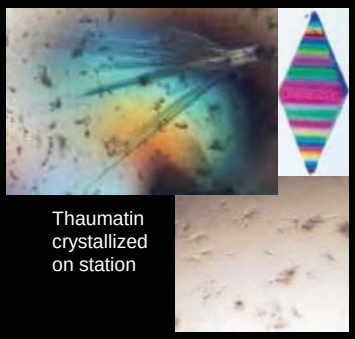
HQL-79 crystallized on station

Cell aggresomes
Credit: Yury Chernoff

Images courtesy of NASA and NIGMS

PROTEIN CRYSTALLIZATION

- *Dr. Stephen Aller, University of Alabama-Birmingham:* High-impact human membrane proteins, specifically ABC proteins, including multi-drug resistance transporters
- *Dr. Constance Schall, The University of Toledo:* Three medically important enzymes involved in amino acid and nucleotide biosynthesis and metabolism: MTAN, TS, and AAT



Thaumatin crystallized on station

Additional CASIS-sponsored PCG projects in preparation for flight include a Merck investigation into the structure of a medically relevant monoclonal antibody (PI Paul Reichert).

Images courtesy of NASA

MATERIALS SCIENCE

- *Dr. Kathleen Morse, Advanced Materials Applications, LLC:* Use of the Gumstix™ Computer On Module in radiation studies to examine fault-tolerant computers
- *Dr. W. Jud Ready, Georgia Institute of Technology:* Development of cost-effective, energy-efficient photovoltaic cells made of lightweight carbon nanotubes

CASIS released an RFP broad in scope to promote use of the NanoRacks external platform for research with Earth applications

Images courtesy of NanoRacks

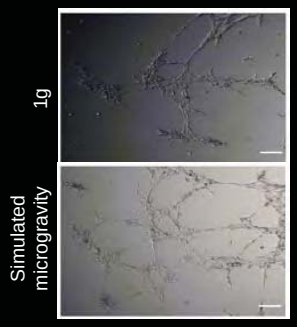
EARTH OBSERVATION

- CASIS issued an RFI to gauge commercial interest in using the Hyperspectral Imager for the Coastal Ocean (HICO)
- Of the many responses received, two were converted into formal proposals:
  - *Naval Research Laboratory:* Development of harmful algal bloom early detection, quantification, and classification algorithms
  - *HySpeed Computing:* Development of a prototype enterprise architecture for rapidly implementing new remote sensing algorithms and applications

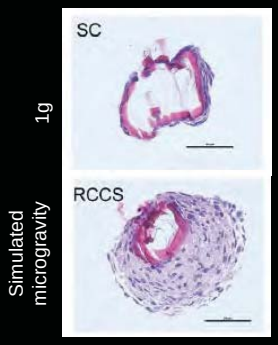
Image courtesy of NASA

STEM CELL PROPERTIES IN MICROGRAVITY

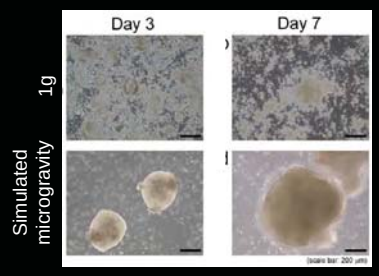
- Ability to either maintain pluripotency or improve differentiation



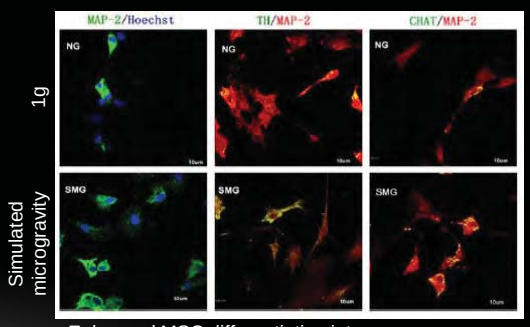
MSCs: Increased expression of endothelial markers, greater capillary formation



Epidermal stem cells: Multicellular structures maintain high proliferative capacity



Mouse embryonic stem cells: Large spheres remain undifferentiated and pluripotent



Enhanced MSC differentiation into neurons

Chen et al. Nueroscience Letters 505; 2011
Zhang et al. Naturwissenschaften 100; 2013
Lei et al. PLoS ONE 6(11); 2011
Kawahara et al. PLoS ONE 4(7); 2009

UNSOLICITED PROPOSALS

- Microgravity research has been NASA-focused, discovery in nature, not targeted to commercial application. As a result, research opportunities may not be understood or structured

- Unsolicited proposals provide an opportunity for research that may not fit within the requirements of a formal grant
- To date, the majority of CASIS' flight opportunities have been derived from this process

Images courtesy of NASA

UNSOLICITED AWARDS

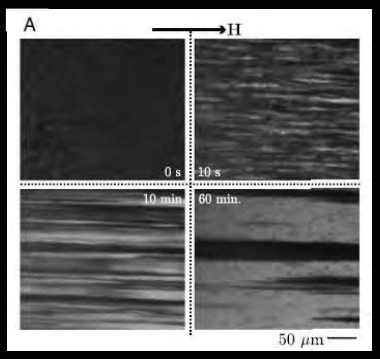
- *Dr. Anna-Lisa Paul, University of Florida:* Identification of genes involved in Arabidopsis root morphology/adaptive physiology

- *Methodist Hospital Research Institute:* Hardware development for the study of nanoscopic diffusive transport, toward healthcare applications
- *Southwest Research Institute:* Study of meteors that impact Earth's atmosphere, using the Window Observational Research Facility

Images courtesy of NASA

UNSOLICITED AWARDS

- *Proctor and Gamble/Zin Technologies:* Colloid phase transition and separation kinetics, toward improvement of product formulations and stability
- *Department of Veterans Affairs:* Evaluation of known and novel anti-cancer drug therapies using yeast chemical genomics



Particle aggregation in a magnetic field

- *COBRA PUMA GOLF:* Bonding of dissimilar materials by electroplating, toward the improvement of alloys for commercial use

Swan et al. PNAS 109(40); 2012

EDUCATION OPPORTUNITIES

- Windows On Earth: A suite of integrated software tools to help students, scientists and astronauts identify targets for photography from ISS *(CASIS collaboration with TERC and the Association of Space Explorers)*

- Story Time From Space: An astronaut on the station will read from a children's book and perform simple related science demonstrations

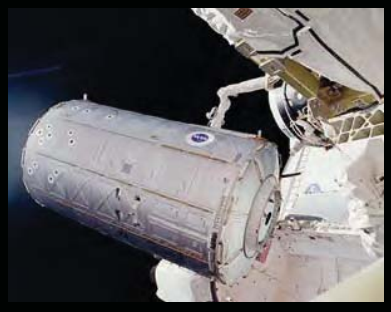
Images courtesy of NASA and the University of Colorado

FUNDING

Seeding Opportunity, Generating Funds, Partnering Financial Benefits

ENTRY POINTS AND FUNDING MECHANISMS

- Formal Grant Call
  - CASIS awards grant funding
- Unsolicited Proposals
  - Result of BD, Outreach
  - Options for seed funding from CASIS
  - Support through institutional partnerships: venture capital, matching, philanthropic funding, in-kind resources



Moving money within the CASIS Marketplace

LOOKING FORWARD

Incentivizing Further Commercial Development

UPCOMING OPPORTUNITIES

- Unsolicited proposal opportunities continue
- Science Advisory Board to evaluate research outcomes for future grant consideration
- Partnership maturation will create fund leverage & research streams
- Technology demo, validation and development
- Crowdsourcing: Generate ideas geared to identify out-of-the-box research that may be realized through partnering with expertise

Image courtesy of NASA

NATIONAL LAB UTILIZATION TO DATE

- To date >$15M obligated for ISS NL research across 40 projects
- >$2M non-NASA funds committed to targeted flight opportunities
- Commercial Partnerships with Boston Museum of Science, MD Anderson, Baylor College of Medicine, MIT, MassChallenge, Boeing, NSTA, The Broad Institute, etc.
- Flight Project Agreements with P&G, Merck, Cobra Puma, numerous universities
- MOAs in place and/or in development with NIH, NOAA, USDA, VA, DoD, NRL (Navy)

HOW CAN COMMERCIAL UTILIZATION BE ACHIEVED

- Demonstrate that the fundamental questions re: microgravity can be answered
- Create opportunities to address these questions – seed funding, partnerships, grant challenges, outreach
- Familiarize the research community at large with the CASIS business model and utility of ISS
- Streamline process while preserving safety and integrity of crew and vehicle
- Achieve repeatability, reduce time to flight, and lower cost


CASIS™
www.iss-casis.org
Twitter: @iss_casis

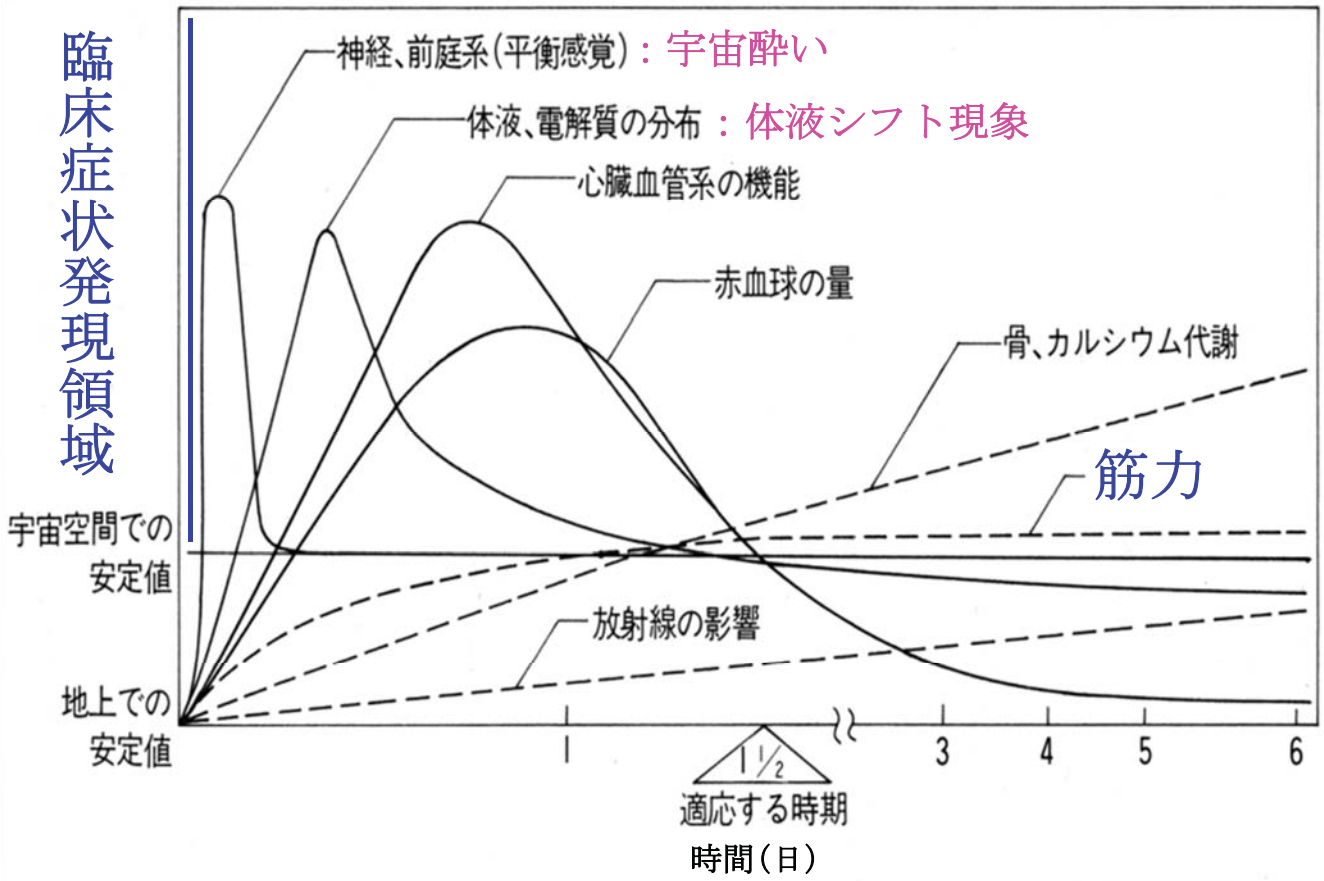
NASAケネディー宇宙センターの
微小重力シュミレーターセンター諮問委員会委員就任
重力制御装置「Gravite®」の設置の説明

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室　教授

（株）スペース・バイオ・ラボラトリーズ　取締役

弓削　類

Space Adaptation Syndrome (SAS)：宇宙適応症候群



Developed new gravity controller

SPACE BIO LABORATORIES
since2005 www.spacebio-lab.com

Gravite：重力制御装置

重力ベクトルを時間軸で分散して10^{-3}Gの模擬微小重力環境をつくり出す．
同時に，遠心で2～3Gの過重力環境もつくれる重力装置

地上での模擬宇宙環境の実現

微小重力（10^{-3}G）：細胞分化抑制
過重力（2-3G）　：細胞分化促進

特許出願 (Patent)

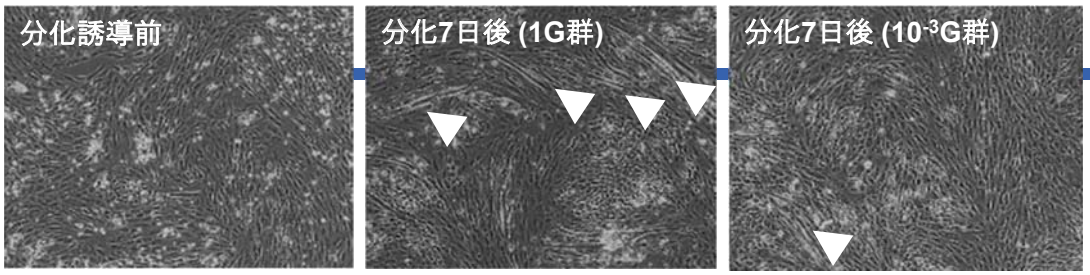
名　　称	重力制御装置
出願番号	2013-124777
出 願 日	2013年6月13日
出 願 人	㈱スペース・バイオ・ラボラトリーズ ㈱イクシスリサーチ

特許出願 (Patent)

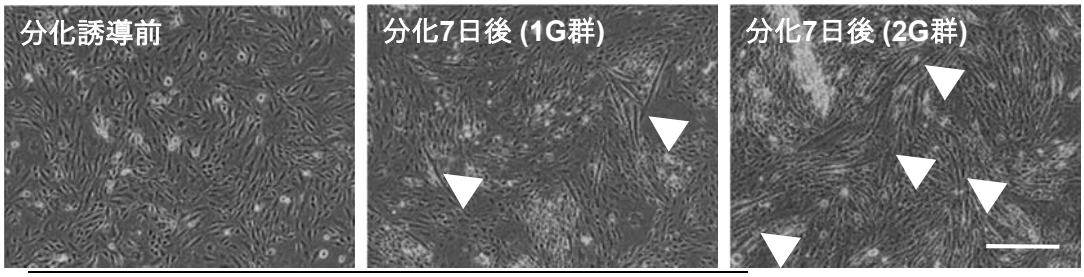
名　　称	細胞培養用重力変動装置
出願番号	2013-132109
出 願 日	2013年6月24日
出 願 人	㈱スペース・バイオ・ラボラトリーズ ㈱イクシスリサーチ

【GRAVITEの性能試験　筋芽細胞(L6)での実施例】

微小重力モード



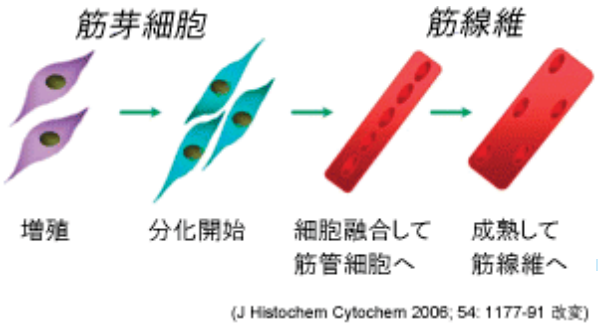
過重力モード



重力環境を変化させると筋細胞分化に影響を与えることが分かった

重力依存性に細胞の分化誘導が出来る

形態学的解析	筋管細胞発生数	細胞の最大横径
10^{-3}G環境	↘	↘
2G環境	↗	↗



(J Histochem Cytochem 2006; 54: 1177-91 改変)

模擬微小重力装置を使った研究

宇宙飛行や長期臥床による骨・筋萎縮等の廃用性症候群

1）骨芽細胞（ヒト由来）→ 骨萎縮

Yuge L., Hide I., Kumagai T., Kumei Y., Takeda S., Kanno M., Sugiyama M., Kataoka K. Cell differentiation and p38MAPK cascade are inhibited in human osteoblasts cultured in a 3D-Clinostat. *In Vitro Cell Dev Biol-Animal*, 39: 89-97 (2003)

2）筋芽細胞（ラット由来）→ 筋萎縮

Hirasaka K., Nikawa T., Yuge L., Ishihara I., Higashibata A., Ishioka N, Okubo A., Miyashita T., Suzue N., Ogawa T., Oarada M., Kishi K. Clinorotation prevents differentiation of rat myoblastic L6 cells in association with reduced NF-<kappa>B-signaling. *BBA-Molecular Cell Research*, 173: 130-140 (2004)

細胞の分化が抑制されるという知見が得られた → 幹細胞研究

RESEARCH SOLICITATIONS

REQUEST FOR PROPOSALS

Advancing Protein Crystallization Using Microgravity

August 2012

REQUEST FOR PROPOSALS

Materials Testing in the Extreme Environment of Space

December 2012

REQUEST FOR INFORMATION

Utilization of Existing ISS Hyperspectral Imaging for Commercial Product Development

November 2012

REQUEST FOR INFORMATION

Development of Strategies for Support of Stem Cell Research on the International Space Station U.S. National Laboratory (ISS NL)

March 2013

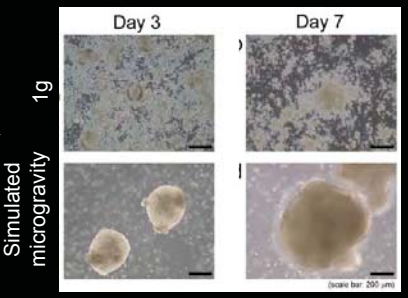
REQUEST FOR PROPOSALS

Funded Opportunity for Stem Cell Research Onboard the International Space Station

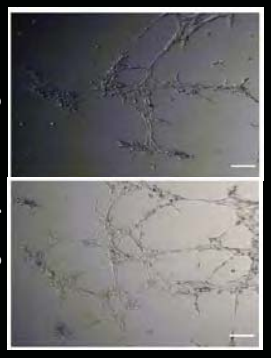
Closed July 26th 2013

STEM CELL PROPERTIES IN MICROGRAVITY

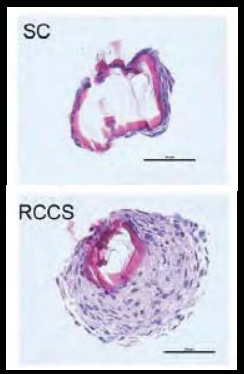
- Ability to either maintain pluripotency or improve differentiation



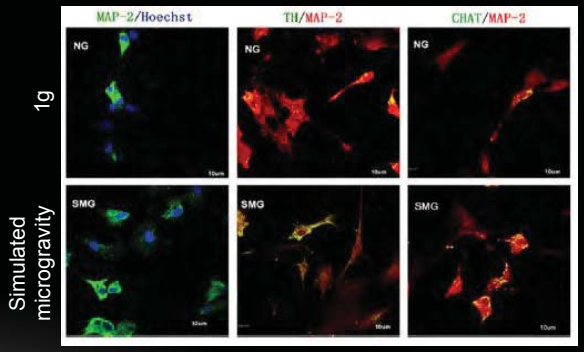
Mouse embryonic stem cells: Large spheres remain undifferentiated and pluripotent



MSCs: Increased expression of endothelial markers, greater capillary formation



Epidermal stem cells: Multicellular structures maintain high proliferative capacity



Enhanced MSC differentiation into neurons

Chen et al. Nuerosciece Letters 505; 2011
Zhang et al. Naturwissenschaften 100; 2013
Lei et al. PLoS ONE 6(11); 2011
Kawahara et al. PLoS ONE 4(7); 2009

http://www.nasa.gov/sites/default/files/files/CSC_CASIS_NACMk2_July2013_TAGGED.pdf

HIROSHIMA UNIVERSITY

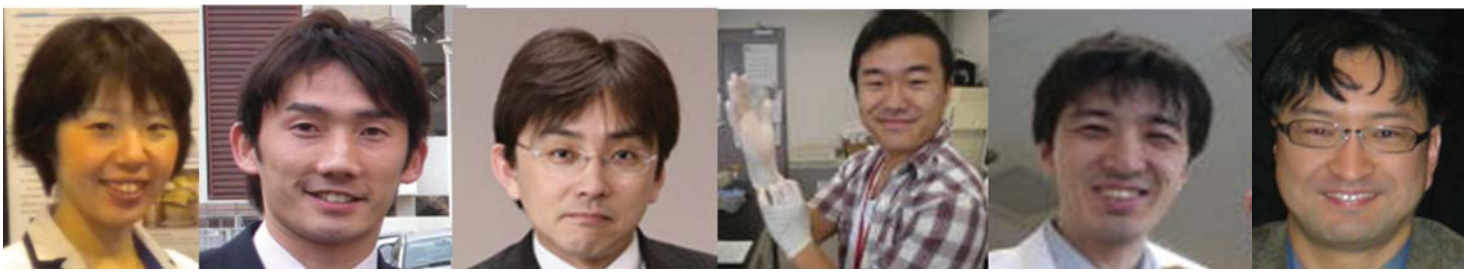
SBL SPACE BIO LABORATORIES since2005 www.spacebio-lab.com

Simulated Microgravity Enables LIF-free Culture in Mouse Embryonic Stem Cells

Yumi Kawahara[1,2], Tomotaka Manabe[3], Masaya Matsumoto[3], Kazuyuki Ogawa[3], Teruyuki Kajiume[1], Masaaki Takeda[1], Takuro Magaki[1], Hiroshi Yamashita[1], Tetsuya Takahashi[1], Shiro Aoki[1], Yoshimasa Sueda[1], Masayasu Matsumoto[1], Louis Yuge[2,3]

[1] Graduate School of Biomedical Sciences,
[2] Space Bio-Laboratories Y. K.,
[3] Graduate School of Health Sciences, Hiroshima University

(Kawahara Y., Kajiume T., *et al.*,PLoS ONE, 2009)



Leukemia inhibitory factor (LIF) は，ES細胞の未分化性を保つには不可欠なファクターである.
幹細胞の臨床応用には動物由来のマテリアルは使用しない方が望ましい.

Pre-culture

Mouse ES cells (BRC6, derived from C57BL/6 mice) (RIKEN BRC CELL BANK, Tsukuba, Japan) were cultured with MEFs according to a standard protocol.

Experiment

1.0 x 10^6 mouse ES cells were seeded on OptiCell™ (Thermo Fisher Scientific Nunc brand, Rochester, NY, USA), and cultured for seven days.

Culture conditions

- feeder-free and serum-free ESF-C medium
  (Cell Science and Technology Institute Inc., Sendai, Japan)
- Non-addition of LIF
- Non-coated culture vessels

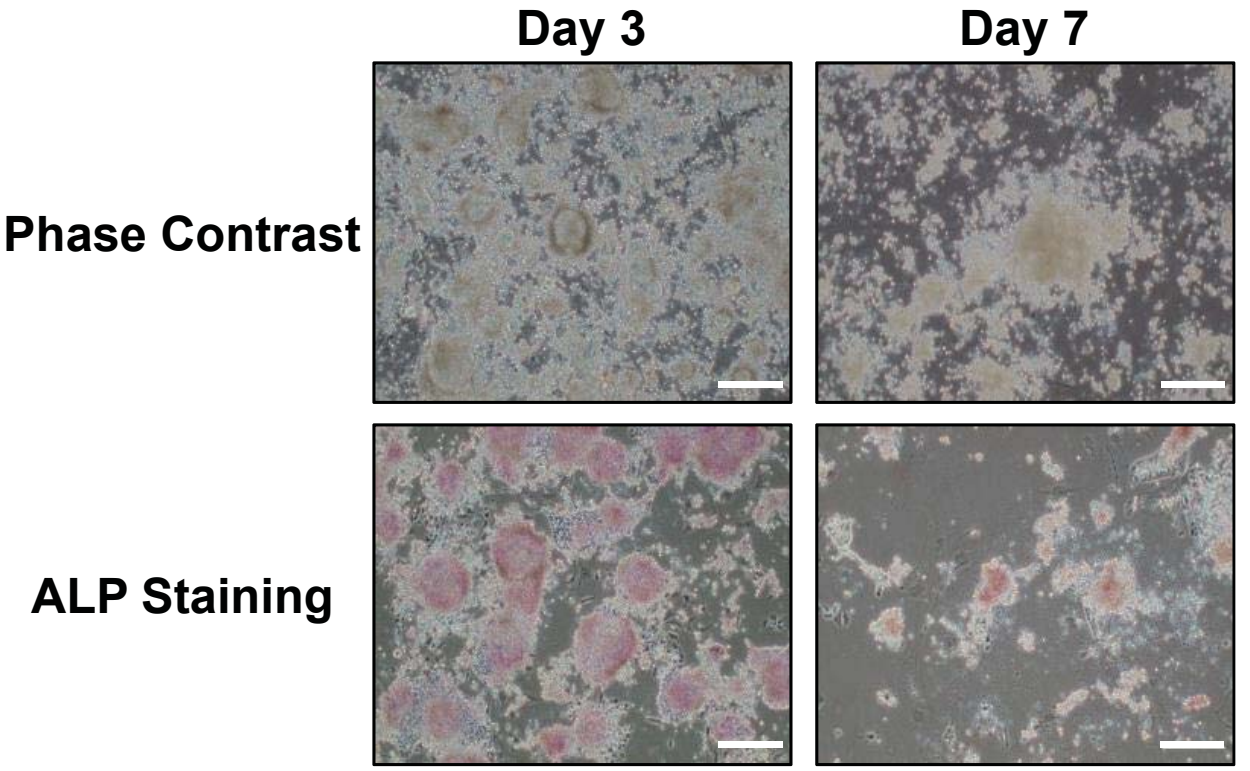
Experimental groups

Group 1G: cells cultured in normal 1G environment
Group MG: cells cultured in 10^{-3}G environment

(Kawahara Y., Kajiume T., *et al.*, PLoS ONE, 2009)

Results 1

Morphological Change and ALP Staining of Group 1G

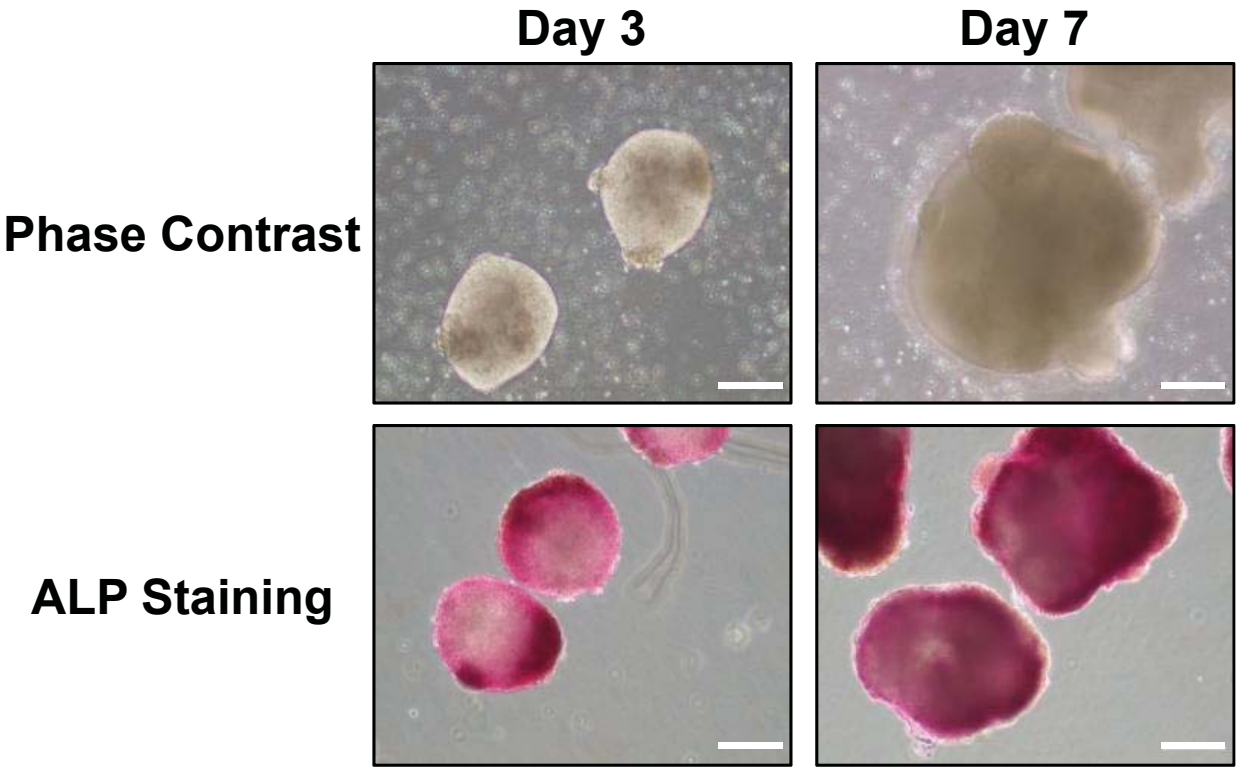


(scale bar: 200 μm)

(Kawahara Y., Kajiume T., *et al*., PLoS ONE, 2009)

Results 2

Morphological Change and ALP Staining of Group MG

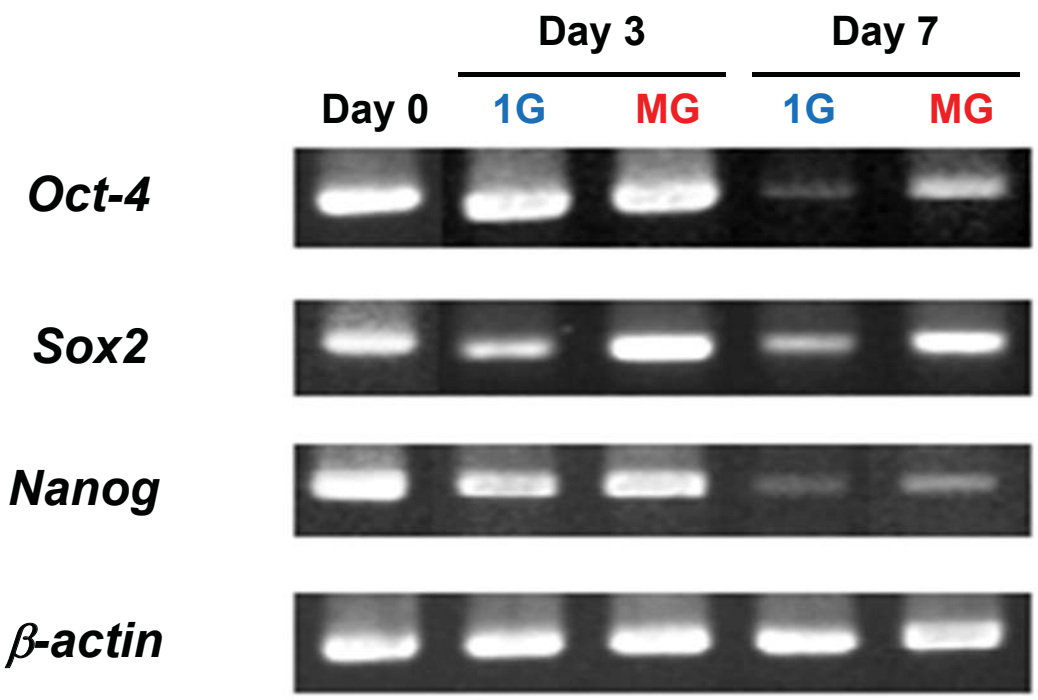


(scale bar: 200 μm)

(Kawahara Y., Kajiume T., *et al*., PLoS ONE, 2009)

Results 3

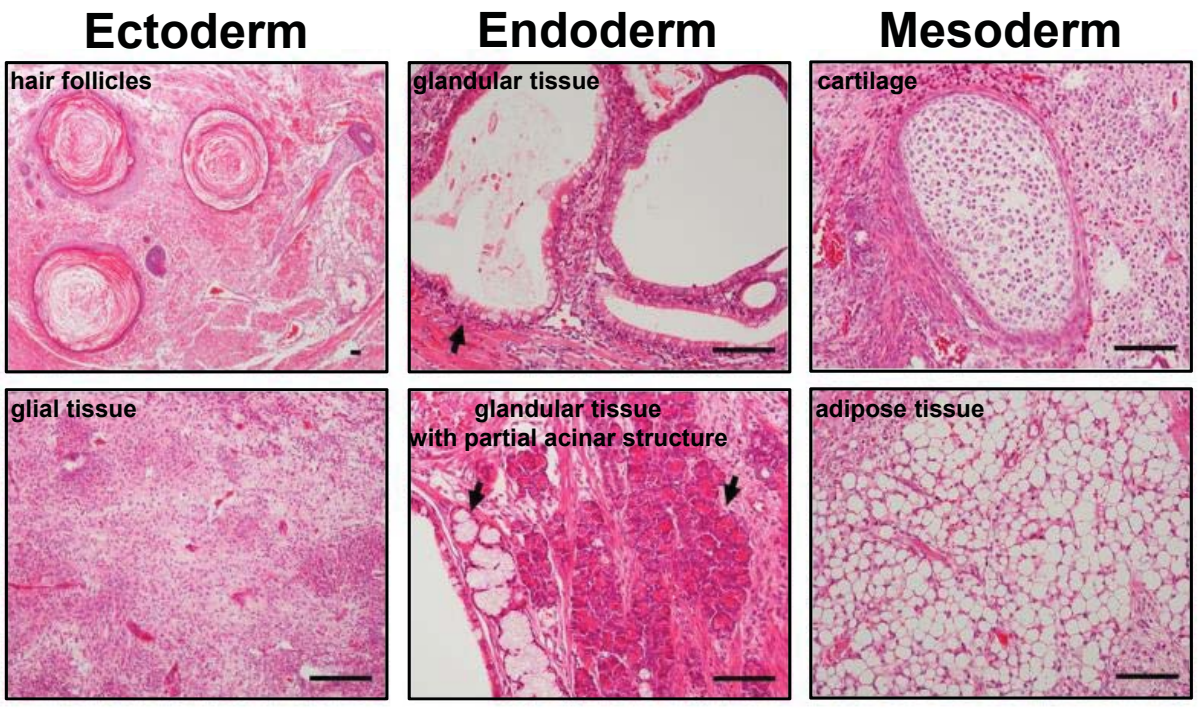
mRNA expression of undifferentiation markers



(Kawahara Y., Kajiume T., *et al*., PLoS ONE, 2009)

Results 4

Generation of teratomas (only) in Group MG



(scale bar: 100 μm)

(Kawahara Y., Kajiume T., *et al*., PLoS ONE, 2009)

1. **Feeder-free**
2. **Coating-free**
3. **LIF-free**
4. **Serum-free**
5. **Trypsin-free**

Our previous studies

Osteoblasts, myoblasts, and human mesenchymal stem cells, cultured in a 3D-clinostat Gravite show suppression of cell differentiation.

(Yuge L., *et al.,* In Vitro Cell Dev Biol-Animal 39: 89-97, 2003)
(Hirasaka K., *et al.*, BBA-Mol Cell Res 1743: 130-140, 2005)
(Yuge L., *et al.*, Stem Cells Dev 15: 921-929, 2006)

Present study

Mouse ES cells could be maintained in feeder-free and serum-free culture conditions without LIF in simulated microgravity.

We successfully developed a novel LIF-free simulated microgravity culture technique for mouse ES cells. In addition, our method does not require a feeder layer, serum, coating materials or trypsin to maintain the cells.

(Kawahara Y., Kajiume T., *et al.*, PLoS ONE, 2009)

これまでの微小重力環境を使った再生医療に関する論文業績

1. Imura T., *et.al.*: Interactive effects of cell therapy and rehabilitation realize the full potential of neurogenesis in brain injury model. Neurosci Lett, 555: 73-78, 2013
2. Kawahara Y., Yuge L.: Simulated microgravity based stem cell cultures enhance their utility for cell-based therapy. Current Biotech, 2: 257-261, 2013
3. Mitsuhara T., *et.al.*: Simulated microgravity facilitate cell migration and neuroprotection after bone marrow stromal cell transplantation in spinal cord injury. Stem Cell Res Ther, 4: 35, 2013
4. Yuge L., *et.al.*: Simulated microgravity maintains the undifferentiated state and enhances the neural repair potential of bone marrow stromal cells. Stem Cells Dev,20: 893-900, 2011
5. Takeda M., *et.al.*: Effects of simulated microgravity on proliferation and chemosensitivity in malignant glioma cells. Neurosci Lett. 463: 54-59, 2009
6. Kawahara Y., *et.al.*: LIF-free embryonic stem cell culture in simulated microgravity. PLoS ONE 4: e6343, 2009
7. Makihira S., *et.al.*:Impact of the microgravity environment in a three-dimensional clinostat on osteoblast- and osteoclast-like cells. Cell Biol Int, 32: 1176-1181, 2008
8. Yuge L., *et.al.*: Microgravity potentiates stem cell proliferation while sustaining the capability of differentiation. Stem Cells Dev, 15: 921-929, 2006

National Aeronautics and Space Administration

Kennedy Space Center
Kennedy Space Center, FL 32899

July 1, 2015

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, PhD
Chief Scientist KSC ISS Research Office
at NASA Kennedy Space Center

【ポイント】

- 広島大学大学院の弓削 類が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.
- 弓削は，微小重力環境での幹細胞培養の専門家として，宇宙実験で行う再生医療の研究及び医科学研究領域に対する評価，助言を行います.
- 高齢社会や長期臥床での筋萎縮，骨萎縮等の廃用性症候群の治療法の開発も進めて行く予定です.
- 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，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，同社は今後，NASAが公認した模擬微小重力装置として，世界販売する計画です.

（参考資料）

NewsReleas

日本政策金融公庫

平成 27 年8月 26 日
日 本 政 策 金 融 公 庫
国民生活事業　中国創業支援センター

広島大学発ベンチャー企業へ資本性ローンによる融資を実行

日本政策金融公庫（略称：日本公庫） 広島支店 国民生活事業は、株式会社スペース・バイオ・ラボラトリーズ（本社：広島県広島市、社長：河原裕美）に「資本性ローン（挑戦支援資本強化特例制度）」を適用し、７月 27 日に運転資金４０百万円の融資を実施しました。

「資本性ローン（挑戦支援資本強化特例制度）」は、平成 24 年度１次補正予算により、日本公庫 国民生活事業において創設された制度で、金融検査マニュアルにいう「十分な資本的性質が認められる借入金」の定義（※）を満たしているため、融資でありながら金融機関の査定業務においては借主の資本金として看做すことが可能な制度です。顧客の財務体質強化、キャッシュフローの改善による成長支援とともに、民間金融機関の追加支援の呼び水となることが期待されている制度です。

（※）１　償還条件：契約時における償還期限が５年を超え、期限一括償還であること。
　　２　金利設定：配当可能利益に応じた実績連動型であること。
　　３　劣 後 性：法的破綻時の劣後性が確保されていること。

日本公庫では、今後とも本融資制度を活用し、新たな事業を推進する成長企業を積極的に支援します。

＜融資先企業の概要＞

企 業 名 代 表 者	株式会社スペース・バイオ・ラボラトリーズ かわはら　ゆみ 河 原　裕美	創業年月	平成 17 年 12 月
事業所	広島県広島市南区霞一丁目２番３号 広島大学霞総合研究棟 210 号室		
事業内容	①幹細胞大量培養技術開発及び関連装置「Gravite®」の販売 ②リハビリテーション及び歩行支援ロボットの研究技術開発		
事業概要	①再生医療及び宇宙開発に携わる大学などの研究機関や医療機関等に、重力制御装置（Gravite®）と関連機器の直販 ②埼玉大学田中英一郎准教授と共に歩行障害のリハビリを支援する装置の共同開発。株式会社オリジンへ製造・販売を委託。販売台数に対して、ロイヤリティを受ける予定。		

【本件に関するお問合わせ先】（平日 9:00～17:00）
日本政策金融公庫 国民生活事業　中国創業支援センター（担当：前田）
〒730-0031　広島市中区紙屋町１-２-22 広島トランヴェールビルディング５階
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