Anna-Lisa Paul Director and Research Professor

# Education and training

University of South Florida, Tampa FL B.A. 1980 Botany

University of South Florida, Tampa FL M.S. 1984 Plant Physiology / Physiological Ecology

University of Florida, Gainesville FL Ph.D. 1989 Plant Molecular Genetics / Epigenetics

# Positions and Employment

2020 – Present Director, ICBR - [Interdisciplinary Center for Biotechnology Research](https://biotech.ufl.edu/dr-anna-lisa-paul-appointed-new-director-of-uf-icbr/)

2019 – 2020 Interim Director, Interdisciplinary Center for Biotechnology Research

2014 – Present Research Professor, University of Florida

2008 – 2014 Research Associate Professor, University of Florida

2005 – 2008 Associate Scientist (Research Faculty), University of Florida

1996 – 2005 Assistant in HOS (Research Faculty), University of Florida, Gainesville, FL

1990 – 1996 Postdoctoral work, UF and Northwestern University, Evanston, IL

Graduate Faculty in: the Department of Horticultural Sciences, the Program of Plant Molecular and Cellular Biology (PMCB), the UF Genetics Institute

# Honors and Special Professional Activities

## National and International (*selected activities annotated*)

* **Co-Chair, National Academies (NASEM) Panel: Strategy for Human Exploration of Mars** *The NASEM has convened a series of panels to help develop a consensus study on a science strategy for human exploration of Mars. I am the Co-Chair for one of the four panels (Panel on Biological and Physical Sciences and Human Factors) in support of the larger Mars Committee.* *Our contributions will guide and help prioritize the types of research that will be conducted by the first human missions to Mars.* 2024-present.
* **Fellow of the AAAS** (American Association for the Advancement of Science); honored for “*Distinguished contributions to the understanding of life's ability to move beyond planet Earth, as well as extraordinary service to the space biology science community*”. 2022.
* **The NASA ISS R&D Compelling Results Award** for *“Groundbreaking contributions to plant space biology”*, 2022.
* **National Academies (NASEM) Committee on Biological and Physical Sciences in Space**. *The CBPSS provides an independent, authoritative forum for identifying and discussing issues in space life and physical sciences between the research community, the federal government, and the interested public. The committee supports scientific progress in the field by providing advice to the federal government on the implementation of decadal survey recommendations. Our contributions help guide National research efforts in the field of space exploration and innovation.* 2023-present.
* **Advisory Committee for Plants for Space (P4S)** International Research, 2023-present
* **The American Astronautical Society Space Life Sciences Award** for “*Twenty years of seminal plant science research* *for 20 years of seminal plant science research on the ISS and exploration environments, culminating in the first growth of plants in Lunar regolith”*, 2023.
* **American Society for Gravitational and Space Research (ASGSR), Founders Award**.  *The highest honor given by ASGSR. It is made to a member of the Society for distinguished scientific contributions and leadership in the field of gravitational and space research*. 2021
* **Fellow of the ASGSR** (American Society for Gravitational and Space Research), 2019
* **The NASA Medal for Exceptional Scientific Achievement**. *The NASA Exceptional Scientific Achievement Medal (ESAM) is awarded for unusually significant scientific contribution toward achievement of aeronautical or space exploration goals. “… for individual efforts that have resulted in a contribution of fundamental importance in this field … whose accomplishments are far above others in quality or excellence.* 2019
* **ASGSR Science Technology Engineering Arts and Math (STEAM) Foundation** 2019-2022
* **Executive Board, American Society for Gravitational and Space Research (ASGSR)** *The ASGSR Executive Board is a three-year duty surrounding an individual’s election as President of the Society, comprising time as President-elect, President, and Past-President. Each post has distinct governing responsibilities to ASGSR, including representing ASGSR members to NASA, the Hill, and representing the scientific field of gravitational and space research as a whole.* 2016-2019
* **President, American Society for Gravitational and Space Research (ASGSR)** 2017-2018
* **University of Florida Rep. to Universities Space Research Association (USRA)** in 2017, 2018
* **Co-recipient of the NASA Award for Most Compelling Science on the ISS**, *Along with colleague Robert Ferl, we were recognized for our seminal work in how plant roots navigate in microgravity environments, which refuted a long-held tenet of plant biology.* 2015
* **Editor in Chief of Journal *Gravitational and Space Research***, 2009-2017
* **Governing Board, ASGSR** *The ASGSR Governing Board is responsible for managing and overseeing operations of the society, acts as a liaison between space researchers and NASA, and participates in presentations to Congressional representatives on topics of space research.* (2005-2008 and 2013-2016)
* **Element Science Lead, Kennedy Space Center, for NASA GeneLab**, 2013-2015
* **Member of NASA’s GeneLab Science Council**. *In 2013, NASA created “GeneLab” to serve as a repository for the growing field of biomolecular “omic” analyses in space research. The science council helped to define the parameters and policies of GeneLab. This initiative has now expanded into NASA’s new Open Science Data Repository (OSDR).* 2013-2017
* **Board Member, Suborbital Applications Researchers Group (SARG)**. *SARG is a component of the Commercial Spaceflight Federation. SARG comprises experts from the aerospace industry and academia who are committed to enhancing opportunities and research within suborbital vehicles. Our efforts had a direct and measurable impact on how NASA viewed suborbital vehicles as viable research platforms, and in enabling researchers to be allowed to conduct their own experiments in suborbital vehicles.* 2012-present
* **The ASGSR Orr Reynolds Distinguished Service Award**. *This award is made to an individual for distinguished service to the Society “above and beyond the call of duty.”*  2012
* **Member of International Space Station Standing Review Board (ISS-SRB).** *The ISS-SRB was convened to conduct a Program Implementation Review (PIR) to focus upon Sustainment and Utilization of the ISS. The ISS-SRB comprised representatives of NASA administration plus three representative ISS Principal Investigators. We worked on evaluating the needs, shortcomings and potential of the ISS. Through our efforts, actions and final report, the “life span” of the ISS was extended to 2024. (Although that lifespan assessment was recently updated).* 2011-2013
* **Member, Research Performance in Space Station Science Steering Group**. *The group worked on creating an “Atlas of ISS Science”, which could help display peer-reviewed science conducted on the ISS to convey the “return on investment” to the scientific community and the public*. 2012
* **Past Member, NSF grant panel: Biochemistry of Gene Expression**

## University of Florida

* **Chair, UF Astraeus Space Institute Administrators Council**. *Astraeus Administrator Council comprises leaders of Departments, Centers, and Institutes with connections to space-related research. The Council provides perspective as an advisory group to Astraeus Administration and helps represent space-related interests of their respective faculty and staff*. 2024 – present
* **Member, UF Research Senior Executive Committee**, 06/2023 – present
* **Co-Recipient of IFAS High Impact Research Publication Award** for: “*Plants grown in Apollo lunar regolith present stress-associated transcriptomes that inform prospects for lunar exploration*”, *Paul A-L, Elardo SM, Ferl R (2022) NPJ Commun Biol 5: 382 (*[*https://www.nature.com/articles/s42003-022-03334-8*](https://www.nature.com/articles/s42003-022-03334-8)*)* Awarded to A-L Paul and R.J. Ferl 2023
* **Chair, Search Committee for Assistant VP for Strategic Research Development,** 4/2023
* **Member, UF’s Science Journalist in Residence Program (SJR).** *The SJR brings leading science writers to the UF campus to interact with faculty and students*. 2022 – present
* **Member, UF Research Advisory Council**, April 2021 – 2023
* **Member, UF President Kent Fuchs’ UF Values Council,** October – December, 2020
* **Member, UF Research COVID Return to Work Taskforce**, April 2020 – June 2021
* **Chair, HOS Faculty Advisory Committee**, 2019 (Member, 2016-2018)
* **Member, ICBR Genomics Advisory Group**, 2015-2019
* **UF/HOS representative to National Association of Science Writers**, November 2013
* **Graduate Coordinator, Program in Plant Molecular and Cellular Biology**, 2013-2014
* **Lead IFAS Cohort Member.** *LEAD IFAS is a selective professional development program for IFAS (Institute for Food and Agricultural Sciences) faculty and staff focused on developing the leadership skills of current and future leaders.* March 2012 through March 2013
* **Co-Recipient of IFAS High Impact Research Publication Award**, “*Plant growth strategies are remodeled by spaceflight”*. Paul A-L, Amalfitan, CE, Ferl R.J. BMC Plant Biol 12, 232 (2012). (<https://doi.org/10.1186/1471-2229-12-232>) Awarded A-L Paul and R.J. Ferl 2013

# Professional Memberships

Lifetime Member American Society for Gravitational and Space Research (ASGSR) since 1998

Member American Society for Plant Biology (ASPB) since 1989

Member American Association of the Advancement of Science (AAAS) since 1989

Member American Institute of Aeronautics & Astronautics (AIAA) since 2015

# Publications (ORCID iD- [0000-0003-2211-2604](https://orcid.org/0000-0003-2211-2604))

## Publications – >100 Refereed.

1. Seo D, Strickland HF, Zhou M, Barker R, Ferl RJ, Paul A-L, Gilroy S (2024) GLARE: Discovering hidden patterns in spaceflight transcriptome using representation learning (in review: preprint with bioRxiv (bioRxiv:2024.2006.2004.597470).
2. Zhou M, Ferl RJ, Paul A-L (2024) Light has a principal role in the Arabidopsis transcriptomic response to the spaceflight environment. NPJ Microgravity 10 (1):82.
3. Zhou M, Riva A, Gauthier ML, Kladde MP, Ferl RJ, Paul A-L. (2024). Single-molecule long-read methylation profiling reveals regional DNA methylation regulated by Elongator Complex Subunit 2 in Arabidopsis roots experiencing spaceflight. Biol Direct, 19: 33.
4. Diao X, Haveman N, Califar B, Dong X, Prentice B, Paul A-L, Ferl RJ. (2024). Spaceflight impacts xyloglucan oligosaccharide abundance in Arabidopsis thaliana root cell walls. Life Sci Space Res (Amst), 41: 110-118.
5. Olanrewaju GO, Haveman NJ, Naldrett MJ, Paul A-L, Ferl RJ, Wyatt SE. (2023). Integrative transcriptomics and proteomics profiling of Arabidopsis thaliana elucidates novel mechanisms underlying spaceflight adaptation. Front Plant Sci, 14: 1260429.
6. Ferl RJ, Zhou M, Strickland HF, Haveman NJ, Callaham JB, Bandla S, Ambriz D, Paul A-L (2023) Transcriptomic dynamics in the transition from ground to space are revealed by Virgin Galactic human-tended suborbital spaceflight. NPJ Microgravity 9: 95
7. Haveman NJ, Schuerger AC, Yu PL, Brown M, Doebler R, Paul A-L, Ferl RJ (2023) Advancing the automation of plant nucleic acid extraction for rapid diagnosis of plant diseases in space. Front Plant Sci 14: 1194753
8. Paul A-L, Elardo SM, Ferl R (2022) Plants grown in Apollo lunar regolith present stress-associated transcriptomes that inform prospects for lunar exploration. NPJ Commun Biol 5: 382.
9. Haveman NJ, Zhou M, Callaham J, Strickland HF, Houze D, Manning-Roach S, Newsham G, Paul A-L, Ferl RJ (2022) Utilizing the KSC Fixation Tube to Conduct Human-Tended Plant Biology Experiments on a Suborbital Spaceflight. Life (Basel) 12
10. Liu D, Paul A-L, Morgan KT, Liu G (2022) Effects of oxygen fertilization on damage reduction in flooded snap bean (Phaseolus vulgaris L.). Sci Rep 12: 4282
11. Haveman N, Paul A-L, Ferl R (2022) Plant Biology and a New Approach to Space Farming. In: Space Manufacturing and Resources, pp 67-87.
12. Schuerger AC, Wheeler RM, Levine HG, Paul A-L, Ferl RJ (2022) Vegetable Health Challenges in Extraterrestrial Production. In Handbook of Vegetable and Herb Diseases, Elmer WH, McGrath M, McGovern RJ (eds), pp 1-49. Cham: Springer International Publishing
13. Paul, A-L, Haveman, N, Califar, B, and Ferl, RJ (2021). Epigenomic Regulators Elongator Complex Subunit 2 and Methyltransferase 1 differentially condition the spaceflight response in Arabidopsis. Frontiers in Plant Science 12.
14. Califar B, Zupanska A, Callaham J, Bamsey, M, Graham, T, Paul A-L, Ferl RJ (2021) Shared Metabolic Remodeling Processes Characterize the Transcriptome of Arabidopsis thaliana within Various Suborbital Flight Environments. Gravitational and Space Research 9, 13-29. doi:10.2478/gsr-2021-0002
15. Schuerger, A., Wheeler, R., Levine, H., Paul, A.-L., and Ferl, R.J. (2021). "Vegetable Health Challenges in Extraterrestrial Production," in Plant Disease Management. Handbook of Vegetable and Herb Diseases. Springer - (Accepted and in Production).
16. Tucker R, Callaham J, Zeidler C, Paul A-L, Ferl RJ (2020) NDVI imaging within exploration growth modules –study from EDEN ISS Antarctica. Life Sciences in Space Research 26 (https://doi.org/10.1016/j.lssr.2020.03.006)
17. Califar B, Sng NJ, Zupanska A, Paul A-L, Ferl RJ (2020) Root Skewing-Associated Genes Impact the Spaceflight Response of Arabidopsis thaliana. Frontiers in Plant Science 11:239
18. Zeidler C, Zabel P, Vrakking V, Dorn M, Bamsey M, Schubert D, Ceriello A, Fortezza R, De Simone D, Stanghellini C, Kempkes F, Meinen E, Mencarelli A, Swinkels GJ, Paul A-L, Ferl RJ (2019) The Plant Health Monitoring System of the EDEN ISS Space Greenhouse in Antarctica During the 2018 Experiment Phase. Front Plant Sci 10: 1457
19. Zhou M, Sng NJ, LeFrois CE, Paul A-L, Ferl RJ. (2019). Epigenomics in an extraterrestrial environment: organ-specific alteration of DNA methylation and gene expression elicited by spaceflight in Arabidopsis thaliana. BMC genomics, 20: 205.
20. Zupanska AK, LeFrois C, Ferl RJ, Paul A-L. (2019). HSFA2 Functions in the Physiological Adaptation of Undifferentiated Plant Cells to Spaceflight. International Journal of Molecular Sciences, 20
21. Beisel NS, Noble J, Barbazuk WB, Paul A-L, Ferl RJ. (2019). Spaceflight-induced alternative splicing during seedling development in Arabidopsis thaliana. Npj Microgravity, 5: 9.
22. Sng N, Kolaczkowski B, Ferl RJ, Paul A-L (2019) A New Member of the CONSTANS-Like Protein Family is a Regulator of ROS Homeostasis and Spaceflight Physiological Adaptation. AoB Plants, 11: ply075.
23. Krishnamurthy A, Ferl RJ, Paul A-L, (2018) Comparing RNA-Seq and microarray gene expression data in two zones of the Arabidopsis root apex relevant to spaceflight. Applications in Plant Sciences Applications in Plant Sciences, 6: e01197
24. Califar BM, Tucker R, Cromie J, Sng N, Schmitz RA, Callaham JA, Barbazuk B, Paul A-L, Ferl RJ. 2018. Approaches for Surveying Cosmic Radiation Damage in Large Populations of Arabidopsis thaliana Seeds – an Antarctic Example. Gravitational and Space Research, 6: 54-73
25. Beisel N, Callaham J, Sng N, Taylor DJ, Paul A-L, Ferl RJ (2018) Utilization of Single-Image Normalized Differential Vegetation Index (SI-NDVI) for Early Plant Stress Detection. Applications in Plant Sciences 6: e01186
26. Sng, N., A.-L. Paul, and R. J. Ferl. (2018). Phenotypic characterization of an Arabidopsis T-DNA insertion line SALK\_063500. Data in Brief 18: 913-919.
27. Paul A-L, Sng NJ, Zupanska AK, Krishnamurthy A, Schultz ER, Ferl RJ (2017) Genetic dissection of the Arabidopsis spaceflight transcriptome: Are some responses dispensable for the physiological adaptation of plants to spaceflight? PLoS One 12: e0180186
28. Zupanska AK, Schultz ER, Yao J, Sng NJ, Zhou M, Callaham JB, Ferl RJ, Paul A-L (2017) ARG1 Functions in the Physiological Adaptation of Undifferentiated Plant Cells to Spaceflight. Astrobiology 17: 1077-1111
29. Paul A-L, Zhou M, Callaham JB, Reyes M, Stasiak M, Riva A, Zupanska AK, Dixon MA, Ferl RJ (2017) Patterns of Arabidopsis gene expression in the face of hypobaric stress. AoB Plants 9: plx030
30. Zhou M, Callaham JB, Reyes M, Stasiak M, Riva A, Zupanska AK, Dixon MA, Paul A-L, Ferl RJ (2017) Dissecting Low Atmospheric Pressure Stress: Transcriptome Responses to the Components of Hypobaria in Arabidopsis. Front Plant Sci 8: 528
31. Zhou M, Paul A-L, Ferl RJ (2017) Data for characterization of SALK\_084889, a T-DNA insertion line of Arabidopsis thaliana. Data in Brief 13: 253-258
32. Schultz ER, Zupanska AK, Sng NJ, Paul A-L, Ferl RJ (2017) Skewing in Arabidopsis roots involves disparate environmental signaling pathways. BMC Plant Biol 17: 31
33. LeFrois CE, Zhou M, Amador DM, Sng N, Paul A-L, Ferl RJ (2016) Enabling the Spaceflight Methylome: DNA Isolated from Plant Tissues Preserved in RNAlater™ Is Suitable for Bisulfite PCR Assay of Genome Methylation. Gravitational and Space Research 4: 28-37
34. Schultz ER, Paul A-L, Ferl RJ (2016) Root Growth Patterns and Morphometric Change Based on the Growth Media. Microgravity Sci Technol: 1-11
35. Ferl RJ, Paul A-L (2016) The effect of spaceflight on the gravity-sensing auxin gradient of roots: GFP reporter gene microscopy on orbit. Npj Microgravity 2: 15023
36. Paul A-L, Ferl RJ (2015) Spaceflight exploration in plant gravitational biology. Methods in molecular biology 1309: 285-305
37. Ferl R.J., Koh J., Denison F., Paul A-L. (2015) Spaceflight Induces Specific Alterations in the Proteomes of Arabidopsis. Astrobiology 15: 32-56 (and cover article)
38. Gokirmak T, Denison FC, Laughner BJ, Paul A-L, Ferl RJ (2015) Phosphomimetic mutation of a conserved serine residue in Arabidopsis thaliana 14-3-3omega suggests a regulatory role of phosphorylation in dimerization and target interactions. Plant physiology and biochemistry : PPB / Societe francaise de physiologie vegetale 97: 296-303
39. Bamsey M.T., Paul A-L., Graham T., Ferl R.J. (2014) Flexible imaging payload for real-time fluorescent biological imaging in parabolic, suborbital and space analog environments. Life Sciences in Space Research 3: 32-44
40. Parsons-Wingerter P, Vickerman MB, Paul A-L, Ferl R.J. (2014) Mapping by VESGEN of Leaf Venation Patterning in Arabidopsis with Bioinformatic Dimensions of Gene Expression. Gravitational and Space Research 2: 68-81
41. Sng N., Callaham J., Ferl R.J., Paul A-L. (2014) Arabidopsis thaliana for spaceflight applications - preparing dormant biology for passive stowage and on orbit activation. Gravitational and Space Research 2: 81-89
42. Denison, F.C., T. Gokirmak, and R.J. Ferl, (2014) Phosphorylation-related modification at the dimer interface of 14-3-3omega dramatically alters monomer interaction dynamics. Archives of Biochemistry and Biophysics, 2014. 541: p. 1-12.
43. Schultz, E.R., K.L. Kelley, A.-L. Paul, and R.J. Ferl, (2013) A Method for Preparing Spaceflight RNAlater-Fixed Arabidopsis thaliana (Brassicaceae) Tissue for Scanning Electron Microscopy. Applications in Plant Sciences,. 1(8): p. 1300034
44. Paul A-L, AK Zupanskap, ER Schultz, Ferl RJ (2013) Organ-specific remodeling of the Arabidopsis transcriptome in response to spaceflight. BMC Plant Biology. 13:112.
45. Zupanska AK, RJ Ferl, FC Denisonp, A‐L Paul. (2013) Spaceflight engages heat shock protein and other molecular chaperone genes in Arabidopsis tissue culture cells American Journal of Botany. 100(1):235-248.
46. Paul A-L, R Wheeler, H Levine, RJ Ferl. (2013) Fundamental plant biology enabled by the space shuttle American Journal of Botany. 100(1):226-234.
47. Abboud T, A Berinstain, M Bamsey, RJ Ferl, A-L Paul, T Graham, MA Dixon, D Leonardos, M Stasiak, and R Noumeir. (2013) Multispectral Plant Health Imaging System for Space Biology and Hypobaric Plant Growth Studies. Insciences Journal 03:24-44.
48. Abboud T, M Bamsey, A-L Paul, T Graham, S Braham, R Noumeir, A Berinstain, and RJ Ferl (2013) Deployment of a fully-automated green fluorescent protein imaging system in a high arctic autonomous greenhouse. Sensors. 13:3530-3548.
49. Schultz ER, KL Kelley, A-L Paul, and RJ Ferl. (2013) A Method for Preparing Spaceflight RNAlater-Fixed Arabidopsis thaliana (Brassicaceae) Tissue for Scanning Electron Microscopy. Applications in Plant Sciences. 1(8):130003.
50. Paul A‐L, CE Amalfitano, RJ Ferl. (2012) Plant growth strategies are remodeled by spaceflight. BMC Plant Biology. 12:232.
51. Paul A-L, FC Denison, ER Schultz, AK Zupanska, RJ Ferl (2012) 14-3-3 phosphoprotein interaction networks - does isoform diversity present functional interaction specification? Frontiers in Plant Science 3: 190.
52. Schultz E, A Zupanska, S Manning-Roach, J Camacho, H Levine, A-L Paul and RJ Ferl (2012) Testing the Bio-compatibility of Aluminum PDFU BRIC Hardware. Gravitational and Space Biology 26(2): 48-63.
53. Paul A-L, A Zupanska, DT Ostrow, Y Zhang, Y Sun, J-L Li, S Shanker, WG Farmerie, CE Amalfitano, RJ Ferl. Spaceflight transcriptomes: unique responses to a novel environment (2012) Astrobiology 12(1): 40-56.
54. Mayfield J.D, A-L Paul, RJ Ferl (2012) The 14-3-3 proteins The 14-3-3 proteins of Arabidopsis regulate root growth and chloroplast development as components of the photosensory system. J. Experimental Botany (doi: 10.1093/jxb/ers022).
55. Denison F., A-L. Paul, AK Zupanska, RJ Ferl, (2011) 14-3-3 Proteins in Plant Physiology. Seminars in Cell and Developmental Biology 22(7): 720-727.
56. Paul A-L and Ferl RJ (2011) Using green fluorescent protein (GFP) reporter genes in RNAlater™ fixed tissue. Gravitational and Space Biology 25(1): 40-43.
57. Paul A-L, MS Manak, JD Mayfield, MF Reyes, WB Gurley, and RJ Ferl. (2011) Parabolic flight induces changes in gene expression patterns in Arabidopsis thaliana. Astrobiology 2011 Oct;11(8):743-58.
58. Ferl RJ, A Zupanska, A Spinale, D Reed, S Manning-Roach, G. Guerra , D. Cox, A-L Paul (2011) Performance of KSC Fixation Tubes with RNALater for orbital experiments: a case study in ISS operations for molecular biology. Advances in Space Research 48: 199-206.
59. Gokirmak T, A-L Paul, RJ Ferl (2010) Plant phosphopeptide-binding proteins as signaling mediators. Curr Opin Plant Biol 13: 527-532.
60. Visscher AM, A-L Paul, M Kirst, CL Guy, AC Schuerger, and RJ Ferl (2010) Responses of wildtype arabidopsis and ion transporter mutants to high levels of magnesium sulfate; consequences for (extra)terrestrial plant growth. PLoS One 5(8): e12348.
61. Ferl RJ, A-L Paul (2010) Lunar Plant Biology – A Review of the Apollo Era. Astrobiology 10: 261-74.
62. Bamsey M, A Berinstain, T Graham, P Neron, S Giroux, RJ Ferl, A-L Paul, Dixon MA (2009) Developing strategies for automated remote plant production systems: Environmental control and monitoring of the Arthur Clarke Mars Greenhouse in the Canadian High Arctic. Advances in Space Research 44: 1367-1381.
63. Visscher, AM, A-L Paul, M Kirst, AK Alling, S Silverstone, G Nechitailo, M Nelson, WF Dempster, M Van Thillo, JP Allen, RJ Ferl. (2009) Effects of a Spaceflight Environment on Heritable Changes in Wheat Gene Expression. Astrobiology 9: 359-67.
64. Paul, A-L, L Liu, S McClung, B Laughner, S Chen and RJ Ferl (2009) Comparative Interactomics: Analysis of Arabidopsis in vivo 14-3-3 complexes reveals highly conserved 14-3-3 interactions between humans and plants. J Proteome Res 8:1913-1924.
65. Paul, A-L, M Bamsey, A Berinstain, S Braham, P Neron, T Murdoch, T Graham. and RJ Ferl (2008). Deployment of a Prototype Plant GFP Imager at the Arthur Clarke Mars Greenhouse of the Haughton Mars Project. Sensors, 8: 2762-2773.
66. Folta KM, A-L Paul, JD Mayfield, RJ Ferl (2008) 14-3-3 isoforms participate in red light signaling and photoperiodic flowering. Plant Signaling and Behavior 3(5): 304 – 306.
67. Paul A-L, KM Folta, RJ Ferl (2008) 14-3-3 Proteins, red light, and photoperiodic flowering: A point of connection? Plant Signaling and Behavior 3(8) ISSN: 1559-2324.
68. Mayfield JD., KM Folta, A-L Paul, RJ Ferl (2007) The 14-3-3 proteins μ (mu) and υ (upsilon) influence transition to flowering and early phytochrome response. Plant Physiology 145(4): 1692–1702.
69. Sabina RL, A-L Paul, RJ Ferl, B Laber, SD Lindell (2007) Adenine Nucleotide Pool Perturbation Is a Metabolic Trigger for AMP Deaminase Inhibitor-Based Herbicide Toxicity. Plant Physiology. 143:1752.
70. Paul A-L and RJ Ferl, MW Meisel, (2006) High magnetic field induced changes of gene expression in arabidopsis. Biomagnetic Research and Technology Dec 22;4(1):7 doi:10.1186/1477-044X-4-7.
71. Richards, JT, KA Corey, A-L Paul, RJ Ferl, RM Wheeler, AC Schuerger (2006) Implications for Low-Pressure Bioregenerative Life Support Systems for Human Exploration Missions and Terraforming on Mars. Astrobiology 6:851-66.
72. Davis, JCh, A-L Paul, RJ Ferl, MW Meisel (2006) Topographical imaging technique for qualitative analysis of microarray data. BioTechniques 41: 554-558.
73. Stutte, GW, O Monje, RD Hatfield, A-L Paul, RJ Ferl, CG Simone (2006) Microgravity Effects on leaf morphology, cell structure, carbon metabolism and mRNA expression of dwarf wheat Planta 224:1038-1049.
74. Ferl, RJ, AC Schuerger, A-L Paul, MA Dixon, P Fulford and C McKay (2006) Mars plant biology: A workshop report and recommendations for plant biology in the exploration era. Habitation 11:1-4.
75. Paul A-L and Ferl R.J. (2006) The Biology Of Low Atmospheric Pressure- Implications For Exploration Mission Design And Advanced Life Support. Gravitational and Space Biology 19:3-17.
76. Paul, A-L, P Sehnke, RJ Ferl (2005) Isoform specific subcellular localization among 14-3-3 proteins in Arabidopsis appears to be driven by client interactions. Molecular Biology of the Cell 16: 1735-43.
77. Paul, A-L, MP Popp, WB Gurley, C Guy, KL Norwood and RJ Ferl (2005) Arabidopsis gene expression patterns are altered during spaceflight. Advances in Space Research 36:1175–1181.
78. Paul A-L, HG Levine, W McLamb, KL Norwood, D Reed, GW Stutte, HW Wells, RJ Ferl, (2005) Plant molecular biology in the space station era: Utilization of KSC Fixation Tubes with RNAlater. Acta Astronautica 56:623-8.
79. Paul, A-L, AC Schuerger, M Popp, JT Richards, M Manak, RJ Ferl (2004) Arabidopsis Gene Expression at Low Atmospheric Pressure. Plant Physiology 134:215-223.
80. Paul A-L, T Murdoch, E Ferl, HG Levine, RJ Ferl (2003). The TAGES Imaging System: Optimizing a Green Fluorescent Protein Imaging System for Plants. SAE Technical Paper 2003-01-2477 ICES Warrendale, PA: SAE International.
81. Paul, A-L, and RJ Ferl. (2002). Molecular aspects of stress gene regulation during spaceflight. J. Plant Growth Regulation 21:166-176.
82. Ferl, RJ, R Wheeler, HG Levine, A-L Paul. (2002) Plants in Space. Curr Opin Plant Biol 5:258-263.
83. Ferl, RJ, A Schuerger, A-L Paul, WB Gurley, K Corey, R Buckland (2002) Plant Adaptation to low atmospheric pressures. Life Support Biosph Sci 8:93-101.
84. Manak, MS., A-L Paul, PC Senhke, RJ Ferl (2002) Remote sensing in planta: transgenic plants as monitors of exogenous stress perception in real-time. Life Support Biosph Sci 8:83-91.
85. Paul, A-L, C Daugherty, E Bihn, D Chapman , K Norwood, RJ Ferl. (2001) Transgenic plant biomonitors: Stress gene biocompatibility evaluation of the Plant Growth Facility for PGIM-01. SAE Technical Paper 2001-01-2181 ICES Warrendale, PA: SAE International.
86. Paul, A-L, C Daugherty, E Bihn, D Chapman, K Norwood, RJ Ferl (2001) Transgene Expression Patterns Indicate that Spaceflight Affects Stress Signal Perception and Transduction in Arabidopsis. Plant Physiology 126:613-621.
87. Paul A-L, C Semer, T Kucharek, RJ Ferl (2001) The fungicidal and phytotoxic properties of benomyl and PPM™ in supplemented agar media supporting transgenic Arabidopsis plants for a Space Shuttle flight experiment. Journal of Applied Microbiology and Biotechnology 55:480-480.
88. Paul A-L, RJ Ferl (1999) Higher-order chromatin structure: looping long molecules. Plant Molecular Biology 41:713-720.
89. Paul A-L, RJ Ferl (1998) Higher order chromatin structures in maize and Arabidopsis: Direct measurement of chromatin domain loops. The Plant Cell 10:1349-1359.
90. Paul A-L, RJ Ferl (1998) Permeabilized Arabidopsis protoplasts provide new insight into the chromatin structure of three plant alcohol dehydrogenase genes. Developmental Genetics, 22:7-16.
91. Paul A-L, RJ Ferl (1997) In vivo footprinting in Arabidopsis. Methods in Molecular Biology, 82:417-429.
92. Bihn, EA, A-L Paul, SW Wang, GW Erdos, RJ Ferl (1997) Localization of 14-3-3 proteins in the nuclei of Arabidopsis and Maize. Plant Journal, 12:1439-1445.
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# Extramural Funding in last 12 years

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| --- | --- | --- | --- |
| **Role** | **Agency** | **Grant Title & Dates** | **Award** |
| **Co-PI** | NASA | NNH22ZDA001N - Leveraging the microbes of Earth's extreme environments for sustainable plant growth in lunar regolith. (**UF PI**; CoPI on Cornell U award / Chris Mason PI). 1/2024-1/2027 | $51,144 |
| **PI** | NASA | NASA-BPS – 80NSSC22K0214. Hypobaric Plant Biology in Space Exploration - Molecular Responses of Arabidopsis to Combined effects of Low Atmospheric Pressures and Microgravity of Spaceflight Vehicles. 10/25/2021 – 10/24/2024 (will NCE) | $550,000 |
| **CoPI** | NASA | 80NSSC22K0209 - Development of Plant Disease in Micro-g: Down-regulation of Host Resistance Implies Disease may be more Severe in Space-based Plant Growth Systems (Andy Schuerger PI)  | $220,570 |
| **Co-PI** | NASA | NRA NNH18ZTT001N-FG: Appendix B – Suborbital Biology The role of Ca2+ signaling during the early events of plant adaptation to spaceflight 10/20/2019 - 10/19/2022 (2024 in NCE) | $298,000 |
| **Co-PI** | NASA-FO | SpaceTech-REDDI-2019 - 80HQTR19NOA01-19FO-F1 – Biological Imaging in support of Suborbital and Exploration Science 10/20/2019-10/19/2021 | $461,949 |
| **PI**  | NASA | Epigenetic Adaptation to the Spaceflight Environment - Genomic Change Induced by Generations in Space. 9/2018 – 8/2021 (in EXT) | $511,983 |
| **Co-PI**  | NASA-FO | Human tended space biology: Enabling suborbital genomics and gene expression. R.J. Ferl (PI) and A-L. Paul (CoPI). 7/2018 – 6/2021 (in EXT).  | $299,838  |
| **Co-PI**  | NASA | Spectral imaging within the EDEN ISS project – an Antarctic analog for enhancing exploration life support. 2017-2019.  |  $286,690 |
| **PI** | NASA | Epigenetic change in *Arabidopsis thaliana* in response to spaceflight 2014-2018 | $449,176 |
| **Co-PI** | FSGC | UF in the Antarctic EDEN module in collaboration with the DLR 2016-2018 | $25,000 |
| **PI** | CASIS | Molecular Biology of Plant Development in the Spaceflight Environment II. 2015-2018.  | $182,929 |
| **PI** | NASA-ESC | Bioinformatics support for NASA’s GeneLAB 2014-2016 | $280,299 |
| **Co-PI** | NASA | Early stage plant adaptation to spaceflight - molecular responses of Arabidopsis to the transition from terrestrial environment to space. 2014-2017 | $149,619 |
| **Co-PI** | NASA | Molecular Responses of Arabidopsis to the Low Atmospheric Pressures of Spaceflight Vehicles and Planetary Habitats. 2014-2017.  | $522,611 |
| **PI** | CASIS | Molecular Biology of Plant Development in the Spaceflight Environment. 2013-2015  | $49,405 |
| **PI** | FSGC | Crew-Assisted and Crew-Autonomous Biological Imaging in Parabolic and Suborbital Vehicles. 2012-2013 | $10,000 |
| **PI** | NASA | Cell Signaling in Undifferentiated Cells - Perceiving the Spaceflight Environment without Specialized Tissues. 2012-2014 | $245,453 |
| **Co-PI** | NASA | Molecular Biology of Growth and Cell Remodeling within the Spaceflight Environment. 2012-2014 | $482,207 |
| **PI** | NASA | The impact of spaceflight on Arabidopsis: Deep sequencing and DNA arrays as collaborative readouts of the transcriptome of Arabidopsis seedlings and undifferentiated cells in space. 2010-2012  | $145,910 |
| **PI** | NASA | Gene Expression and Molecular Signaling in Spaceflight Environments. 2009-2013  | $283,608 |
| **Co-PI** | NASA | Transgenic plant biomonitors of spaceflight exposure – telemetric data collection. 2007-2012 | $712,025 |
|  |  |  |  |

# Invited Professional Presentations (selected, last 5 yrs)

**National Academies Space Week Public Lecture,** National Academy of Sciences Building, Washington DC, 3/19/2024 (<https://www.nationalacademies.org/event/03-18-2024/space-science-week-2024>)

**Presentation to NASEM Committee on Biological and Physical Sciences in Space:** Retrospective on Blue Origin Flight NS-26. Beckman Center, Irvine CA. 10/2024

**Public lecture for Women and Girls Science Day** (Gainesville, FL) 2/2023 (<https://calendar.ufl.edu/clas/event/27718-international-day-of-women-and-girls-in-science>)

**Panel Chair at the Next-Generation Suborbital Researchers Conference** (NSRC): The importance of Human-Tended Experiments, Boulder, CO. 2/28/2023

**Keynote Speaker at the Southern Section of the American Society of Plant Biology (ASPB)**. University of Arkansas, Fayetteville, AK. 3/26/2023

**Keynote Speaker the 10th Annual Meeting of the Southeastern Association of Shared Resources** (SEASR). Emory University, Atlanta, GA. 6/10/20223

**Invited speaker, Farm Foundation Roundtable** - Round Table Session Five: “Where Will We Farm in the Future”? Chicago, IL. 6/14/2023

**Keynote speaker at the annual meeting of the Georgia Academy of Sciences**. Valdosta, GA. 3/25/2022.

**Invited participant in Blue Origin’s “Orbital Reef” Payload User Workshop**, representing academic science interests and perspectives. Kent, WA. 4/17/2022.

**Keynote Speaker (along with colleague Rob Ferl) at the Hudson Alpha Crops conference on genomics and crop improvement.** I also served on a conference panel focused on diversity, equity and inclusion in plant science. Huntsville, AL. 6/15/2022.

**Invited speaker at the annual American Society for Plant Biology (ASPB) meeting** (Concurrent Symposium: Plants for Space). Portland, OR. 7/10/2022.

**Invited speaker at the 27th ELGRA (European Low Gravity Research Association) Symposium**. Lisbon, Portugal. 9/07/22.

**Invited speaker at the Corteva Agriscience Plant Sciences Symposium at the University of Illinois at Urbana-Champaign** - Innovations Connecting Complex Biosystems: From Cells to Ecosystems. Urbana-Champaign, IL. 9/16/22.

**Invited symposium speaker, annual meeting of the American Society for Gravitational and Space Research (ASGSR)**. I also served on a NASA Flight Opportunities panel at the meeting Houston, TX. 11/11/2022

**Invited presentation to Spring 2021 Meeting of the Committee on Biological and Physical Sciences in Space (CBPSS)**. Life Sciences Research on the Lunar Surface: “The Impact of the Chang’e-4 Mission on Lunar Exploration Biology Perspectives”. 3/23/2021.

**NASA Quantitative Genetics workshop – Co-organizer, and lead for Plant Science** **section**. (<https://genelab.nasa.gov/biological-and-physical-sciences-presents-quantitative-genomics-space-biology-workshop>) 5/26/2021.

**Invited seminar to Michigan State University**. “Exploration Science in Plant Space Biology – molecular tools and insights” 09/27/2021.

**NASA CUBES invited talk**: “Going Boldly - Exploration Science in Plant Biology”. 2/18/2020.

**Invited talk at the Next Generation Suborbital Research Conference**. Genomics Experiments in Human-Tended Suborbital Spaceflights: Using Shuttle and ISS Legacy Sample Handling. , Broomfield, CO. 3/1/2020.

**ASGSR “Plus 10” lecture**: “Plant Molecular Genetics in Space Exploration” 11/13/2020 (<https://www.youtube.com/playlist?list=PL2otGG0bPu59mK9uEEX6EtuThnt3XRHay>)

**Oregon State University, invited for a virtual day visit plus a seminar**. “Exploration science – going boldly in plant space biology” 11/19/2020

**Cornell University, invited to give the opening presentation at the 8th Annual Cornell Plant Breeding Symposium** (Common Plants for Uncommon Goals, April 12th, 2019)

**Invited Presentation at the Foundation for Food and Agriculture (FFAR)** / Precision Indoor Plants (PIP) Collaborative workshop on how space agricultural research can benefit our efforts on earth. New York City, NY. 6/18/2019).

**Invited speaker, ISS Research and Development meeting** –for Life Sciences Plenary Session. Presentation: Going Boldly – Plant Biology in Exploration Science. Atlanta, GA, 7/30/2019.

# Education and Public Outreach Activities (selected)

**Farmbits, Episode 121: Sowing the Seeds for Space.** Discussions on the topic of plant gene expression in response to spaceflight and exploration environments. (<https://x.com/UNLFarmBits/status/1770811703267115331>) 3/2024

**A series of presentations to groups of young girls from “A Girl's Place” summer camp**. The mission of A Girls Place is to empower girls to grow courageous, strong and self-sufficient. Our laboratory hosted several groups during the summer of 2024.

**Dutch national TV interview** for the Dutch family TV show "Klaas Kan Alles" ("Klaas Can Do Everything"). Filmed for the show at KSC, speaking with Klass on the topic of using microgravity to study plant behavior and adaptation. 7/2024.

**First Researcher-Tended Suborbital flight experiment** – multiple interviews and outreach events associated with our NASA funded researcher tended experiment to evaluate plant molecular responses to the transition to space launching on Blue Origin suborbital rocket (PIs A-L Paul and R.J. Ferl). My research colleague Rob Ferl served as the astronaut to conduct our experiment. Summer and fall, 2024 (e.g. [First NASA-Supported Researcher to Fly on Suborbital Rocket](https://www.nasa.gov/directorates/stmd/first-nasa-supported-researcher-to-fly-on-suborbital-rocket/) , [UF scientist Rob Ferl completes historic space mission](https://news.ufl.edu/2024/08/blue-origin-mission-completed/) , [UF/IFAS Plant Research on Blue Origin Flight](https://www.youtube.com/watch?v=hs94RtHkffY) , [UF’s Rob Ferl and Anna-Lisa Paul Talk About Blue Origin Spaceflight and Space Biology Experiments](https://www.wuft.org/podcast/tell-me-about-it/2024-09-22/ufs-rob-ferl-and-anna-lisa-paul-talk-about-blue-origin-spaceflight-and-space-biology-experiments)).

**Celebrating Women’s History Month: A UF researcher alters the future of space exploration.** (<https://news.ufl.edu/2023/03/anna-lisa-paul/>). 3/2023

**Star Talk – “Farming on the Moon” with Neil deGrasse Tyson,** (<https://www.youtube.com/watch?v=g3Jz2_KBUzs>)**.** 7/2022

**Plants grown in true lunar regolith for the first time** – there are multiple events, interviews and press releases that are associated with the publication of this this seminal work. A Google search of “[plants grown in lunar regolith](https://www.google.com/search?q=plants+grown+in+lunar+regolith&rlz=1C1GCEU_enUS819US819&oq=plants+grown+in+lunar+regolith&aqs=chrome..69i57j0i22i30l4j0i390j69i61l2.22118j1j7&sourceid=chrome&ie=UTF-8#ip=1)” will pull up many examples, and UF and IFAS communications put together several outstanding articles (e.g. [A tale of moondust at the University of Florida](https://www.youtube.com/watch?v=uw-zL0FfNJA) ,

[One small sprout… Lunar biology at UF](https://explore.research.ufl.edu/one-small-sprout.html) , [A First: Scientists grow plants in soil from the moon](https://blogs.ifas.ufl.edu/news/2022/05/12/a-first-scientists-grow-plants-in-soil-from-the-moon/)), and it was widely celebrated by NASA (e.g. [Scientists grow plants in Lunar soil](https://www.nasa.gov/humans-in-space/scientists-grow-plants-in-lunar-soil/), and [How to grow food on the Moon](https://www.nasa.gov/podcasts/gravity-assist/gravity-assist-how-to-grow-food-on-the-moon/)). The primary publication (Paul et al., 2022, Plants grown in Apollo lunar regolith present stress-associated transcriptomes that inform prospects for lunar exploration. [*Commun Biol* **5**, 382](https://www.nature.com/articles/s42003-022-03334-8)) has an Altmetric score of 5956, which places it in the 99th percentile (27th) of all 452,713 tracked articles of a similar age in all journals. 2022

**Public seminar for at the Planetarium for the Alachua Astronomy Club.** Gainesville, FL.2022

**Panel for discussion of the movie “Silent Running” and its relevance.** Florida Museum of Natural History. Hosted by Terry Harpold, Dept. of English, Director of Imagining Climate Change. 10/2022

**Presentation to PK Yonge STEM Journey event: “On Being a Space (*molecular*) Botanist”.** 5/2021

**Presentation for UF Workshop on Engaging NASA Research** (Science Mission Directorate section), organized by Assoc. Dean Forrest Masters. 5/2021

**Multiple interviews and outreach events associated with the event of the first “human tended” suborbital experiment** (PIs A-L Paul and R.J. Ferl). A Virgin Galactic employee served as the astronaut (e.g. [UF plant experiment flies on Virgin Galactic spaceship](https://news.ufl.edu/2021/07/uf-plant-experiment-virgin-galactic/) , [NASA-Supported Plant Experiment Flies to Suborbital Space with Virgin Galactic](https://www.nasa.gov/directorates/stmd/nasa-supported-plant-experiment-flies-to-suborbital-space-with-virgin-galactic/) , [Virgin Galactic just launched plants into space](https://theunconventionalgardener.com/blog/virgin-galactic-just-launched-plants-into-space/) ). 7/2021

**Biotech podcast discussion plant space research**. ( <https://www.talkingbiotechpodcast.com/321-the-challenges-of-growing-plants-in-space/> ). 12/03/2021

**Reddit AMA – Plants in Space**. Hosted by UF-Explore at annual AAAS meeting. 2/13/2020 <https://www.reddit.com/r/IAmA/comments/f3h9p0/we_are_university_of_florida_research_scientists/?ut>

**Organizing Board for the 2020 meeting of the Next Generation Suborbital Research Conference.** Broomfield, CO <https://www.boulder.swri.edu/NSRC2020/Site5/Program.html>). 3/1/2020,

**Plantae Webinar – “Plant Careers in Space Biology** " – Co-Organizer and presenter (<https://plantae.org/plantae-webinar-plant-science-careers-in-space-biology/>). 4/9/2020

**NASA Explorers Interview** – Season 4 of [NASA Explorers](https://www.facebook.com/NASAExplorersSeries/) , S4 Bonus: 20 Years of Science (<https://www.facebook.com/NASAExplorersSeries/videos/2952062194898764/>). 6/10/2020

**Educational and Public Outreach events: Future City Engineering Club** (rising 7th graders discussing space agriculture with A-L. Paul and R.J. Ferl). 7/23/2020

**Science Roundtable with NASA Administrator Bridenstine**; among the representatives from UF IFAS and the College of Engineering. 7/24/2020

**NASA Podcast: “Houston We Have a Podcast on plants in space**”. <https://www.nasa.gov/johnson/HWHAP/plants-in-space> 8/13/2020

**Presentation in NASA Web meeting Space Exploration Plant Sessions**: “Biotechnology tools for Earth and Space Science”. <http://www.spaceref.com/news/viewsr.html?pid=54125> 10/22/2020

**Conference Organizer for the 2019 annual meeting** of the American Society for Gravitational and Space Research., Denver, CO. 11/18/2019

**TEDxUF presentation: “Humans are Explorers - Go Boldly**” (04/06/2019, University of Florida) <https://www.youtube.com/watch?v=LwwDIP36eb8>)

**PBS NOVA interview** - plant growth in microgravity and the future of food in space <https://www.pbs.org/wgbh/nova/article/spuds-crops-in-space/> 8/19/2019

**Inner to Outer Space: Studying Biological Changes with Plants on Rockets** <https://www.nasa.gov/directorates/spacetech/flightopportunities/Inner_to_Outer_Space> 12/6/2019

**Women in Science Instagram story** for Friday, Feb. 9th, 2018, ahead of the UN’s Women and Girls in Science Day. : <https://twitter.com/ISS_Research/status/962796712241672192>

**Scientists on a mission to feed Mars** – University of Florida News 2/2017. A public outreach description and video set surrounding our most recent space biology launch to the ISS <https://social.shorthand.com/UFNews/uytChfNBEe/space-plants>

**The Conversation**. 8/2015 An independent source of news and views from the academic and research community, delivered direct to the public. This article focused on our space biology research <https://theconversation.com/taking-plants-off-planet-how-do-they-grow-in-zero-gravity-45032> .

**NPR Science Friday.** Our research featured on NPR Science Friday on the day of the premier of the movie “The Martian”. It was used to illustrate how real space plant biology is getting us closer to the goal of taking our biology to other planets <https://www.sciencefriday.com/videos/plants-in-space/>

**Scientific Thinking & Educational Partnership (STEP) program** A series of science videos for lesson plans related to the concept of researching and growing plants in spaceflight and novel planetary environments. These are posted on the UF Genetics web site (<http://www.youtube.com/user/UFGENETICS/videos>) and on YouTube, for instance:

Zero-G parabolic aircraft research - <http://www.youtube.com/watch?v=purGp-1juCE>

Reporter gene technology - <https://www.youtube.com/watch?v=IvmPc4j25ao>

# International Activities

## Canada

**Mars atmosphere analog studies at the University of Guelph CESRF (2002-present):**

Collaborations in the efficacy of using hypobaric environments in controlled agriculture, with a focus on planetary greenhouses. Publications: Paul et al. 2017, Zhou et al, 2017a; Zhou et al., 2017b; Abboud et al 2013a; Paul et al. 2008; Paul and Ferl 2006; Paul et al. 2004.

Guest lecture in a freshman agricultural science class taught by Professor Mike Dixon (10/2012). The class introduces students to the concepts of alternative agriculture, including concepts such as controlled, extraterrestrial greenhouses.

Collaborator on the Research Project: Innovative Technologies In Challenging Environments (InTICE), awarded to Mike Dixon, Professor and Director of Controlled Environment Systems Research Facility. InTICE is sponsored by the Canadian Space Agency as part of CSA’s Class Grant and Contribution Program to Support Research, Awareness and Learning in Space Science and Technology. The grant is a major component of a Collaborative Research and Development (CRD) project associated with the Natural Sciences and Engineering Research Council (NSERC) of Canada. The technology development and research activities are fundamental to the overall goals of the NSERC, and comprises an international collaboration among the CSA, the University of Guelph, the University of Florida and COM DEV Canada Ltd. My contribution involves the design of fluorescent reporter genes biology, and the imaging of these plants, for applications in protected agriculture.

**Arctic Research in the Canadian High Arctic (2006 - 2011 summer seasons)**

Research participant at the Haughton Mars Project, Devon Island, Nunavut, Canada. Summer research season 2006 – 2011. Conducted two areas of research: a survey of the ability to detect life signatures in impact breccia in the Martian and lunar analog regions of the Haughton Impact Crater, and the integration and characterization of telemetric imaging hardware in a Martian analog greenhouse (Arthur Clarke Mars Greenhouse; Publications Abboud et al 2013b; Bamsey et al. 2010; Paul et al. 2008).

## Germany

**German Space Agency (DLR), Bremen Germany (2016 - present)**

I am a team member on the EDEN-ISS project, a multi-national project supported by the German Space Agency (DLR) and the European Union (EU) Horizon 2020 Research and Innovation Program. I, and my colleague Rob Ferl, were the representatives for NASA and the United States among 16 other nations. The goal of the EDEN ISS project is to advance controlled environment agriculture technologies beyond the state-of-the-art. It focuses on ground demonstration of plant cultivation technologies and their application for spaceflight and planetary applications. We brought expertise and experience in plant growth in spaceflight environments, along with spaceflight experience in using specific informative imaging capabilities, to the EDEN-ISS project. In particular, to develop and supply to the project dual wavelength imagers and imaging procedures within the EDEN ISS facilities and provide image processing and analysis. The technology for specific dual wavelength Spectral Imaging builds on NASA ISS plant imaging technologies with the Advanced Biological Research System (ABRS) and Advanced Plant Habitat (APH) on the ISS as well as Earth-Imaging concepts such as NDVI and MODIS to produce a novel image-based plant health monitoring and plant science capability. Basically, image data from dual wavelength cameras will be downlinked from the Antarctic EDEN Mobile Test Facility (MTF) for community open science analyses with respect to plant health. (Publications: Beisel et al., 2018; Zeidler et al, 2019).

## Antarctica (summer seasons, 2017/18 and 2018/19)

The German-Based Alfred Wegener Institute supported expedition associated with the EDEN-ISS project (above). Paul and colleague Ferl were invited to join the EDEN-ISS Team on the ice at the Neumayer III (NMIII) research station in Antarctica. We were funded by NASA to participate and connect the two space agencies for the unified goal for the functionalization of plant growth in support of human exploration in spaceflight and future planetary habitats. Imaging technologies developed as part of ongoing ISS science by us were deployed within the Antarctic EDEN ISS plant production unit to provide tele-science support and plant science analytics to better understand the responses of plants, as well as production support to optimize plant performance.