Extremophiles and Space Exploration

Dr. Ivan Glaucio Paulino Lima

UNIVERSITIES SPACE RESEARCH ASSOCIATION
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USRA Was Founded in 1969

“I would like to propose that the Academy take initiative in convening the representatives of a number of appropriate universities to discuss the formation of such a consortium.”

James E. Webb, NASA Administrator, 1961 – 1968
In his 1965 letter to Frederick Seitz,
President of the National Academy of Sciences

“To constitute an entity by means of which universities and other research organizations may cooperate with one another, with the governments of the United States and other nations, and with other organizations toward the development and application of space-related science, technology, and engineering.”

From the USRA Articles of Incorporation

Written and Edited TO MERIT YOUR Confidence

THE HOUSTON POST

On The Move

HOUSTON, TEXAS 77001, SATURDAY, MARCH 2, 1968

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LBJ Visits MSC, Tells Of Lunar Institute Aims

By JIM MALONEY

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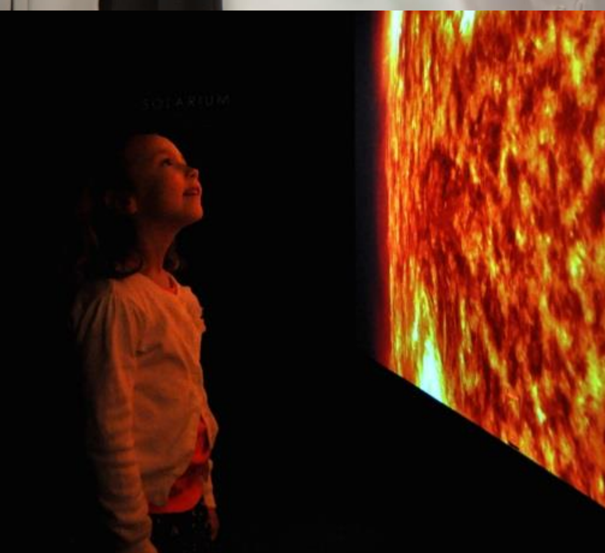
ROBERT JAMES LOPEZ RECEIVES PRESIDENT'S PEN
Impromptu Presentation Unfolds At Ellington Air Force Base

PRESIDENT AND PET, YUKI, LISTEN INTENTLY
NASA Administrator James E. Webb Briefs LBJ

USRA Is Driven by Its Mission and Values

OUR MISSION

- Advance the space- and aeronautics-related sciences and exploration through innovative research, technology, and education programs;
- Promote space and aeronautics policy; and
- Develop and operate premier facilities and programs by involving universities, governments, and the private sector for the benefit of humanity.



OUR VALUES

- **Passion**—for science, technology, and education.
- **Partnerships**—with universities, governments, and the private sector.
- **Professionalism**—through excellence, accountability, and respect for others.

Today, USRA's Core Competencies Span a Broad Range of Space- and Aeronautics-Related Disciplines

What We Do:

- Astronomy and Astrophysics
- Planetary Science
- Earth Sciences
- Space Life Sciences
- Materials Science
- Fluid Physics
- Space Nuclear Power and Propulsion
- Computational Sciences
- Advanced Technology Development
- Facility Management and Operation
- Education and STEM Workforce Development

...From California to Puerto Rico

USRA

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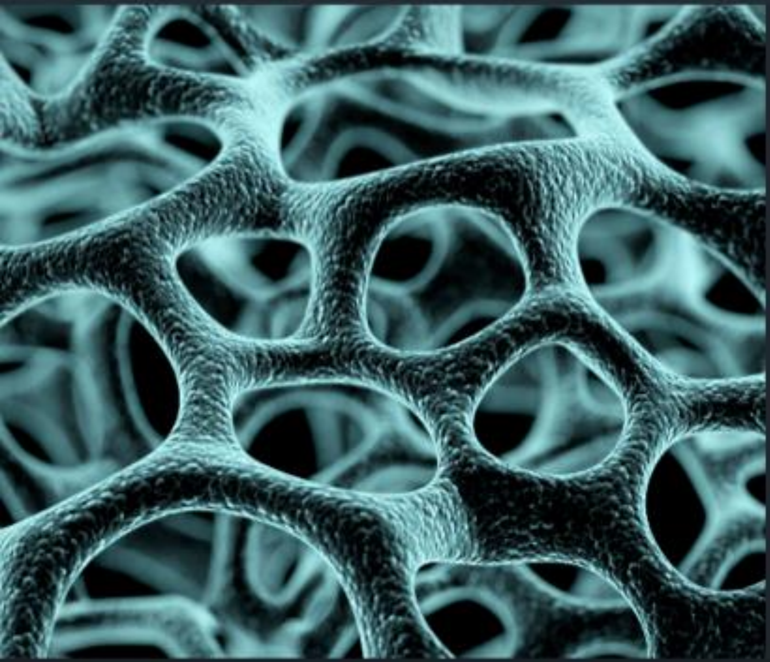
MENU

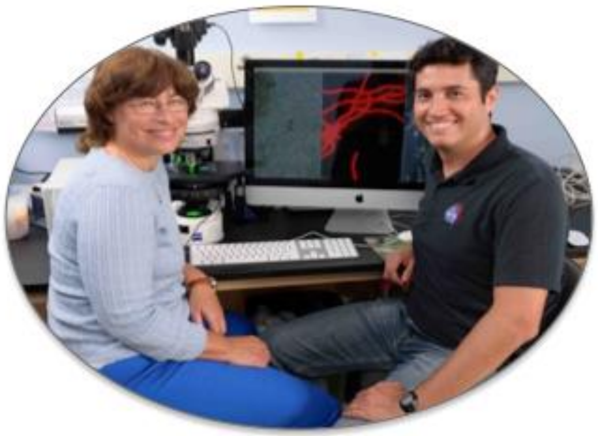


SYNTHETIC BIOLOGY

USRA has partnered with the Synthetic Biology Lab at NASA's Ames Research Center, to conduct collaborative research in synthetic biology focusing on application for human space exploration and astrobiology. The goal is to harness engineered biological systems to further space exploration and science, to search for life beyond Earth, and to improve life on Earth.

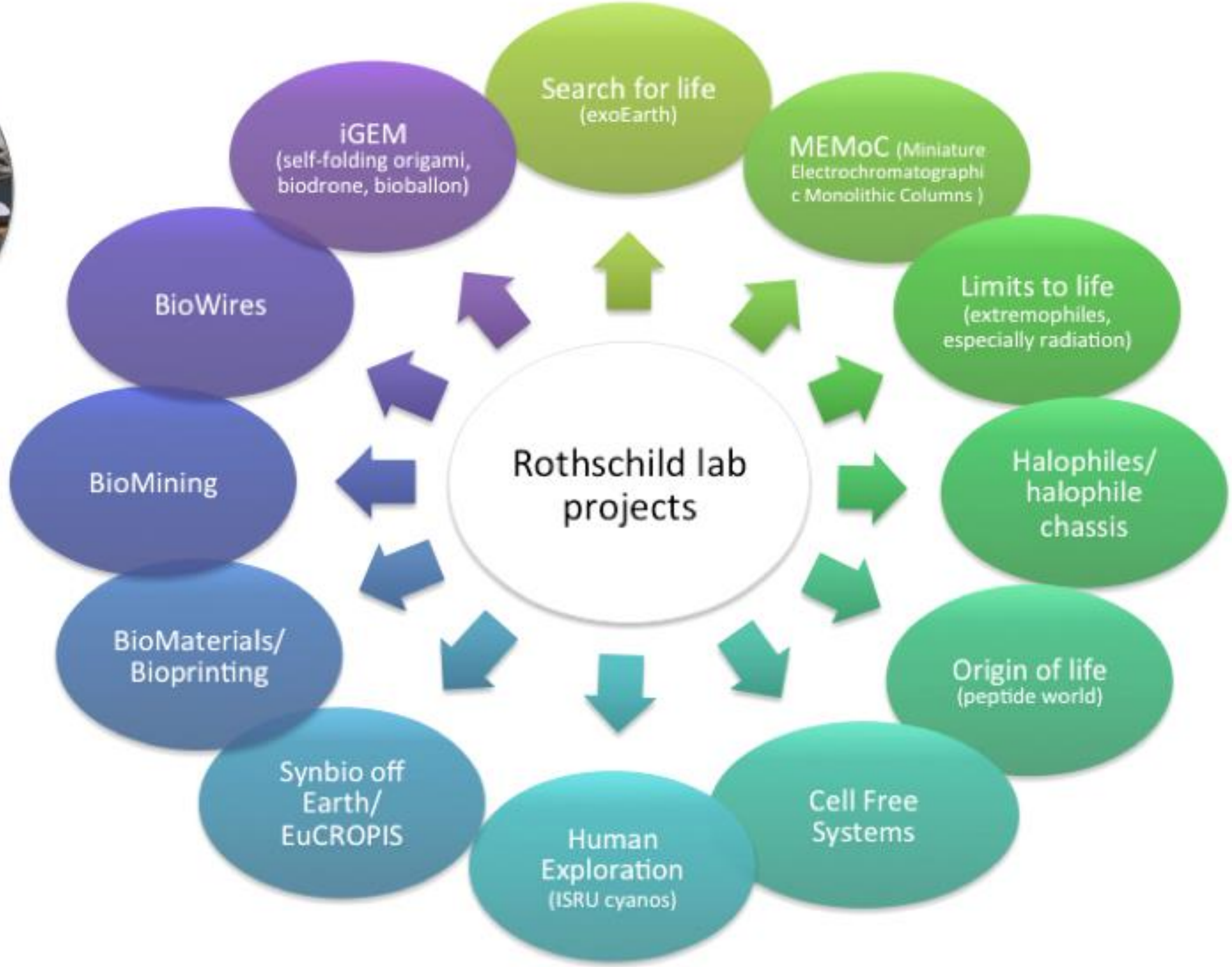
Research is accomplished through lab and field work including instrument development, as well as missions such as the Eu:CROPIS mission which is planned to demonstrate synthetic biology technology in space.

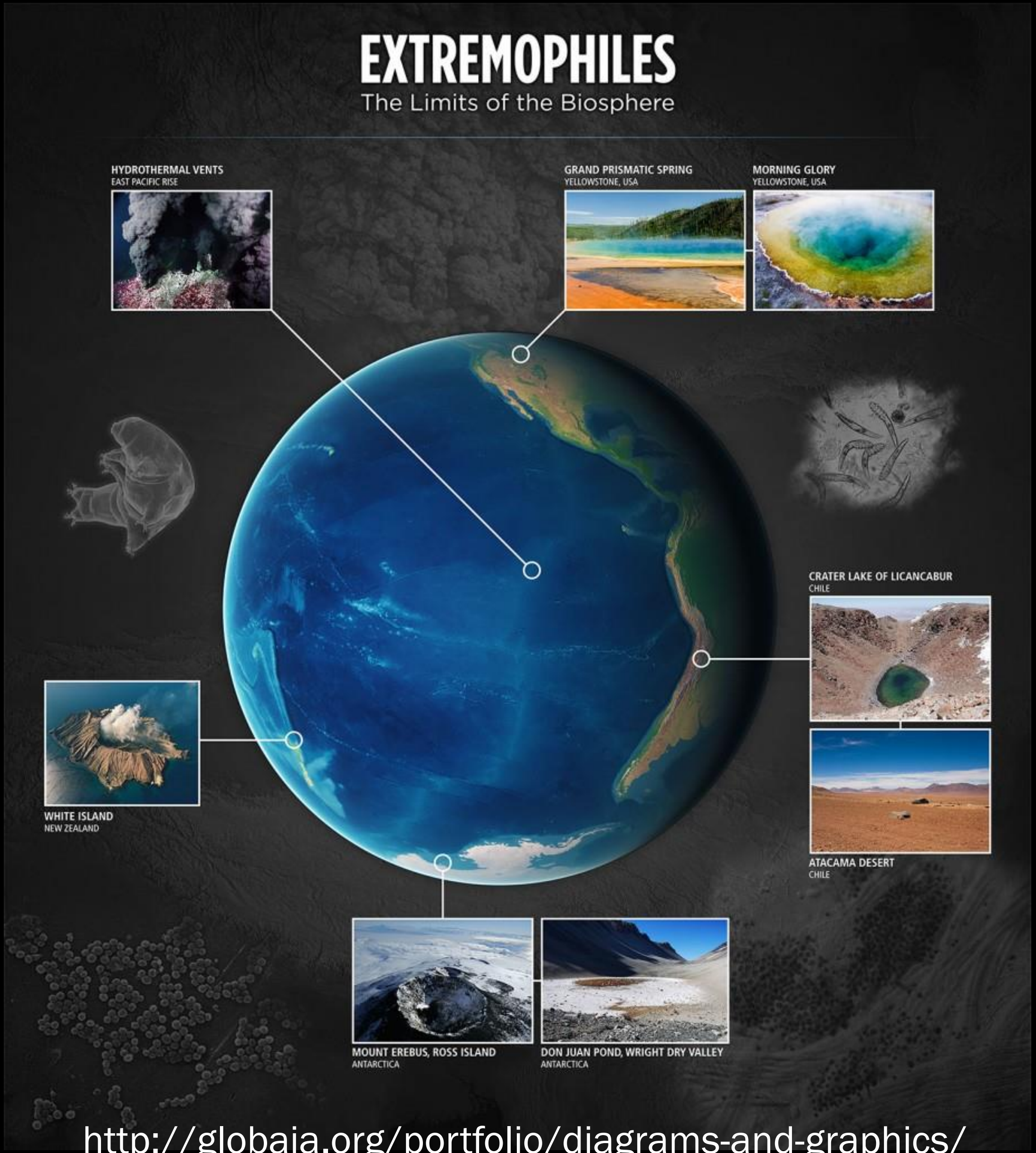
http://www.riacs.edu/



Dr. Ivan Paulino-Lima

- Development, delivery and ground controls for the PowerCell payload on the DLR Eu:CROPIS mission
- Continuation of my NPP work on extremophiles and radiation





http://globaia.org/portfolio/diagrams-and-graphics/

https://astrobiology.nasa.gov

Extremophiles**			
Factor	**Class**	**Defining Growth Condition**	**Example Organisms**
High Temperature	Hyperthermophile Thermophile	> 80°C 60 to 80°C	*Pyrolobus fumarii*
Low Temperature	Psychrophile	< 15°C	*Synechococcus lividis*
High pH	Alkaliphile	pH > 9	*Psychrobacter, Vibrio, Anthrobacter*
Low pH	Acidophile	pH < 5 (typically much less)	*Natronobacterium, Bacillus, Clostridium paradoxum*
Radiation	–	High ionizing and UV radiation	*Deinococcus radiodurans, Rubrobacter, Pyrococcus furiosus*
High Pressure	Barophile Piezophile	High weight High pressure	Unknown *Pyrococcus* sp.
Salinity	Halophile	2 to 5 M NaC1	*Halobacteriaceae, Dunaliella salina*
Low Nutrients	Oligotroph	e.g., <1 mg L^{-1} dissolved organic carbon	*Sphingomonas alaskensis, Caulobacter* spp.
Oxygen Tension	Anaerobe Microaerophile	Cannot tolerate O_2 Tolerates some O_2	*Methanococcus jannaschii* *Clostridium*
Chemical Extremes	–	Tolerates high concentrations of metal (e.g., Cu, As, Cd, Zn)	*Ferroplasma acidarmanus* *Ralstonia* sp. CH34

* Table adapted from Marion et al. 2003. Reprinted with permission from Elsevier.

** Table adapted from Mancinelli and Rothschild 2001. Reprinted with permission from Macmillan Publishers Ltd.

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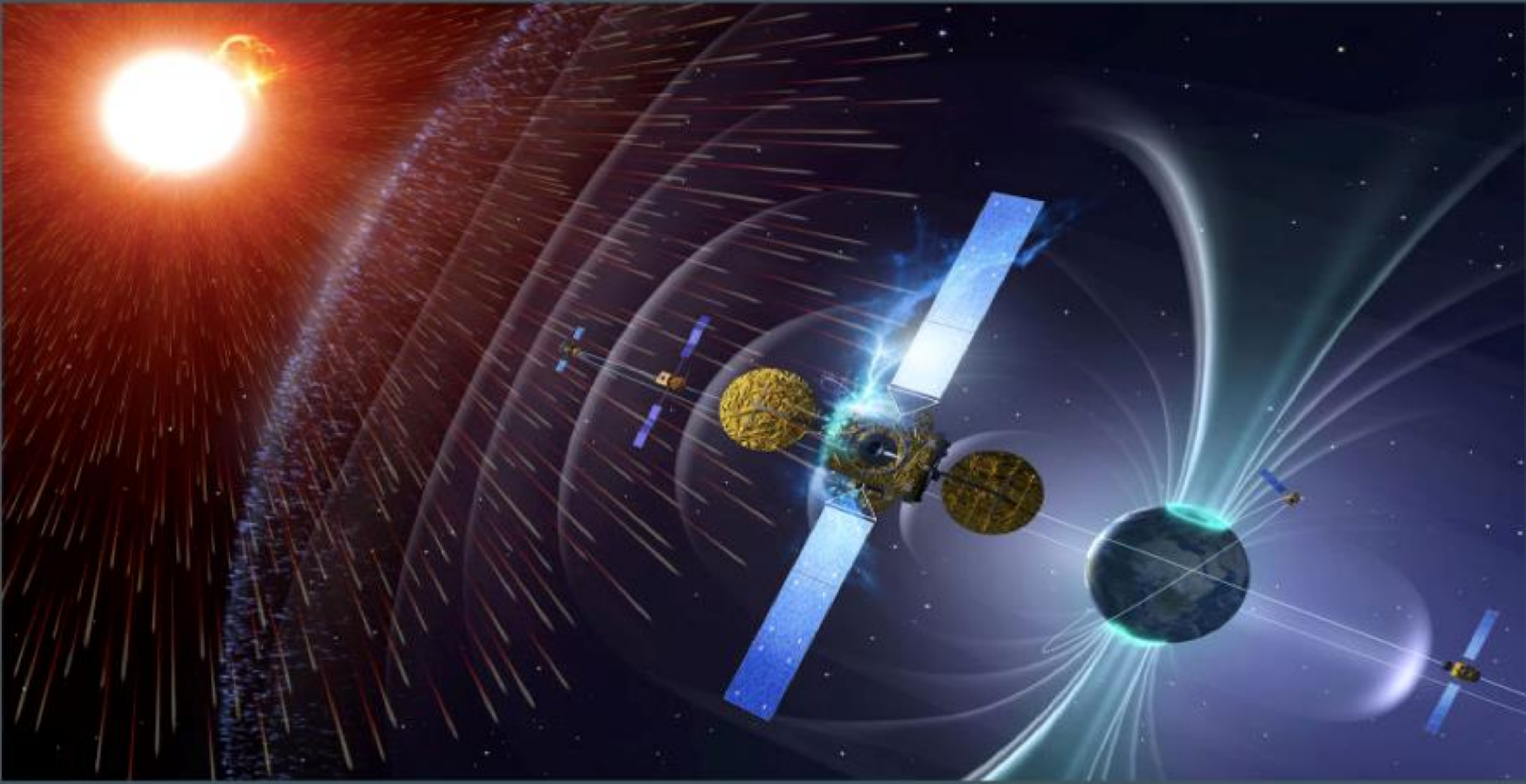
Why the study of radiation and its effects on materials and biology is important?



http://www.esa.int/Our_Activities/Space_Engineering_Technology/Proba_Missions/Detecting_radiation

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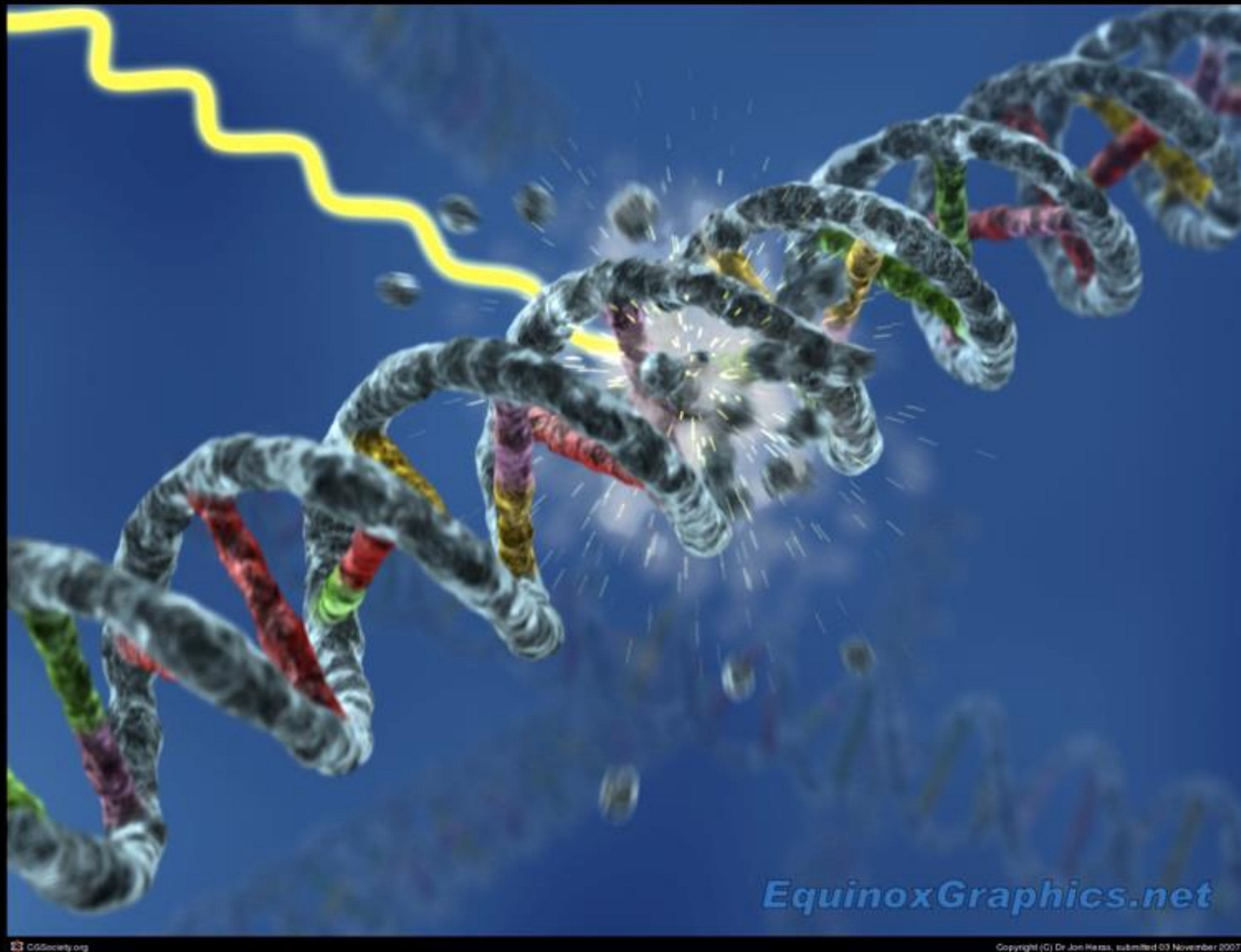
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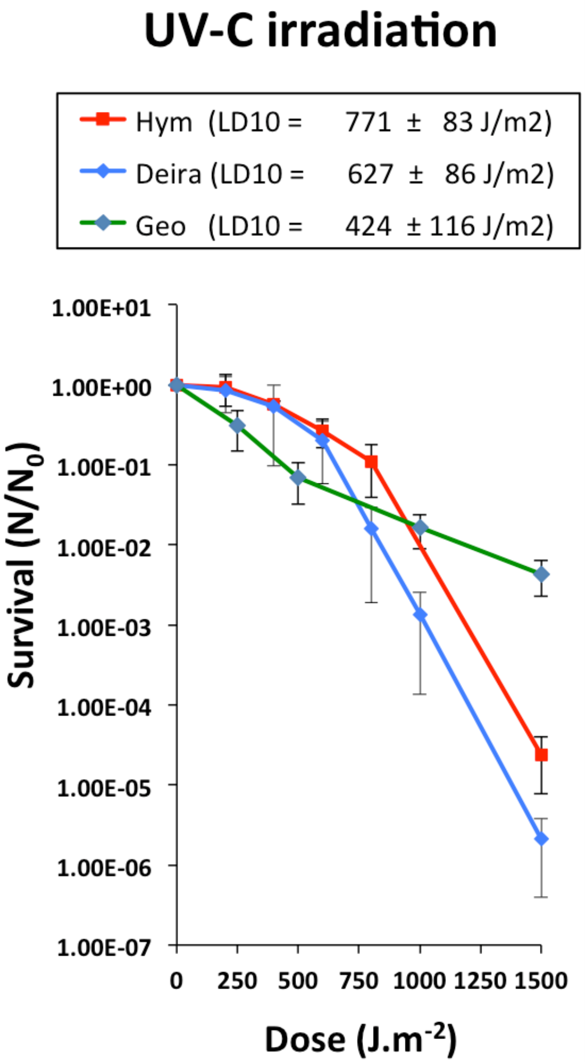

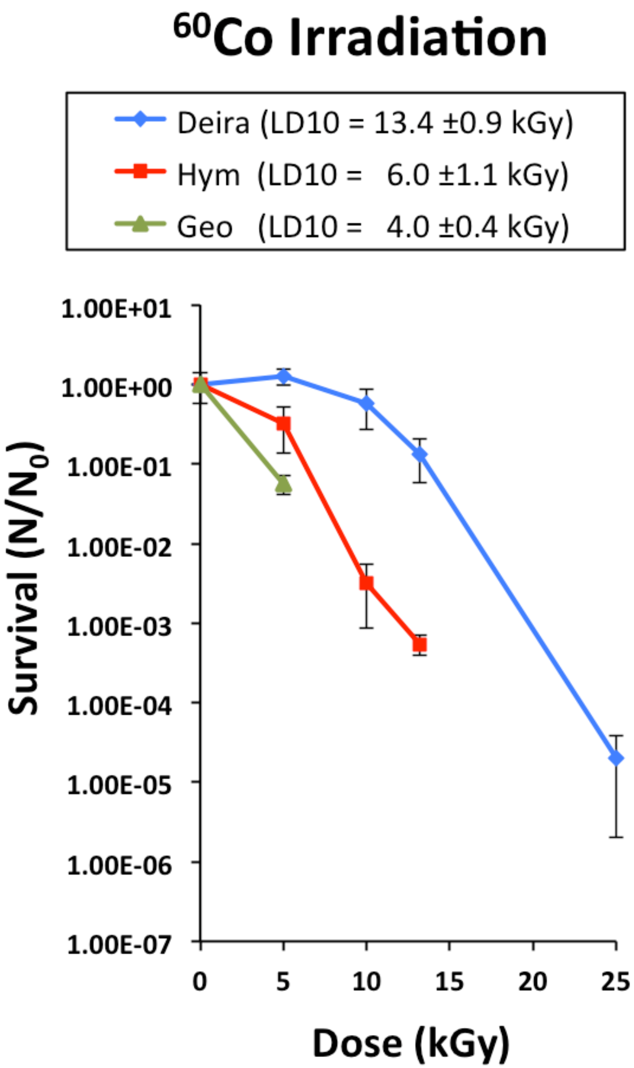

Paulino-Lima et al. (2016) *J. Photochem. Photobiol. B*, 163-, 327-336.

Journal of Photochemistry & Photobiology, B: Biology 163 (2016) 327–336

Contents lists available at ScienceDirect

Journal of Photochemistry & Photobiology, B: Biology

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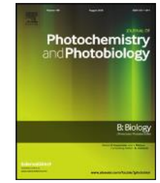

Extremely high UV-C radiation resistant microorganisms from desert environments with different manganese concentrations

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ARTICLE INFO

Article history:
Received 10 December 2015
Accepted 10 August 2016
Available online 29 August 2016

Keywords:
Desiccation
Ultraviolet radiation resistance
Extremophile
Manganese
Microbial diversity

ABSTRACT

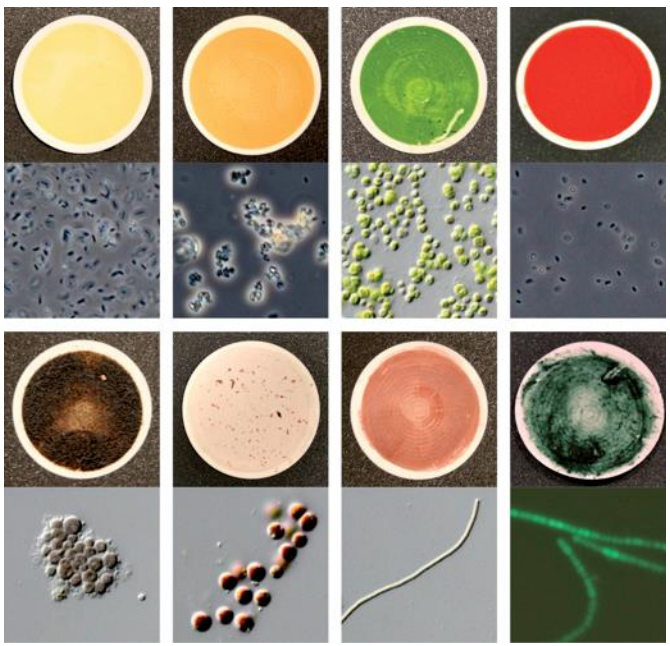
Desiccation resistance and a high intracellular Mn/Fe ratio contribute to ionizing radiation resistance of *Deinococcus radiodurans*. We hypothesized that this was a general phenomenon and thus developed a strategy to search for highly radiation-resistant organisms based on their natural environment. While desiccation is a typical feature of deserts, the correlation between radiation resistance and the intracellular Mn/Fe ratio of indigenous microorganisms or the Mn/Fe ratio of the environment, has not yet been described. UV-C radiation is highly damaging to biomolecules including DNA. It was used in this study as a selective tool because of its relevance to early life on earth, high altitude aerobiology and the search for life beyond Earth. Surface soil samples were collected from the Sonoran Desert, Arizona (USA), from the Atacama Desert in Chile and from a manganese mine in northern Argentina. Microbial isolates were selected after exposure to UV-C irradiation and growth. The isolates comprised 28 genera grouped within six phyla, which we ranked according to their resistance to UV-C irradiation. Survival curves were performed for the most resistant isolates and correlated with their intracellular Mn/Fe ratio, which was determined by ICP-MS. Five percent of the isolates were highly resistant, including one more resistant than *D. radiodurans*, a bacterium generally considered the most radiation-resistant organism, thus used as a model for radiation resistance studies. No correlation was observed between the occurrence of resistant microorganisms and the Mn/Fe ratio in the soil samples. However, all resistant isolates showed an intracellular Mn/Fe ratio much higher than the sensitive isolates. Our findings could represent a new front in efforts to harness mechanisms of UV-C radiation resistance from extreme environments.

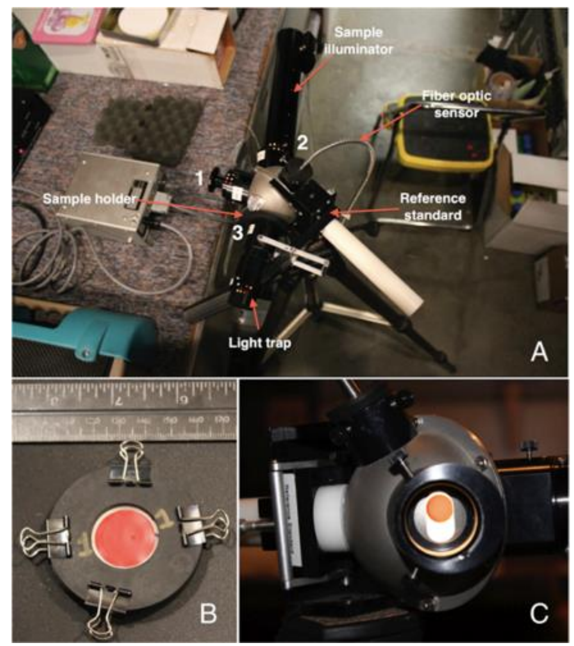
Surface biosignatures of exo-Earths: Remote detection of extraterrestrial life

Siddharth Hegde[a,1], Ivan G. Paulino-Lima[b], Ryan Kent[c], Lisa Kaltenegger[a,d], and Lynn Rothschild[e]

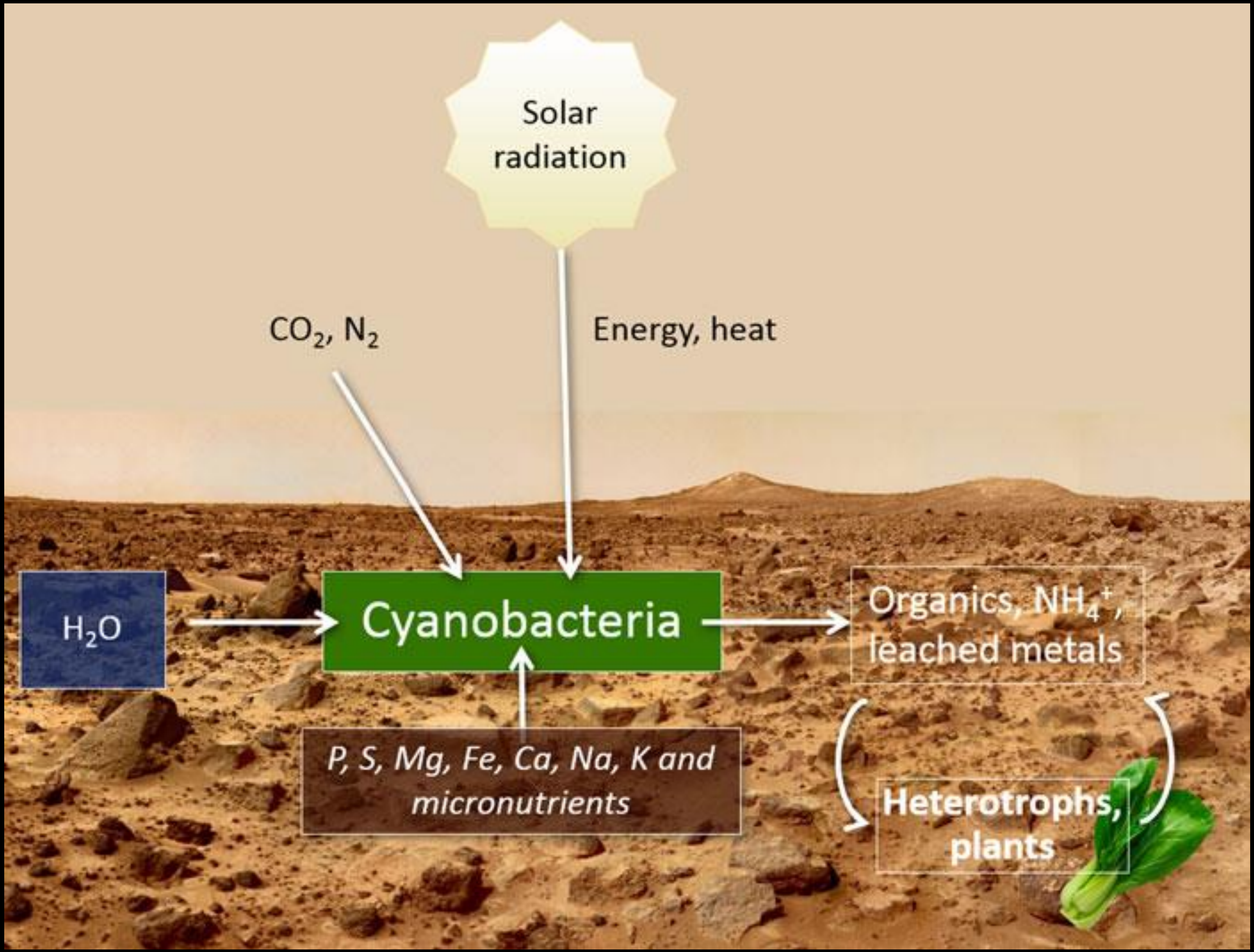
[a]Max Planck Institute for Astronomy, Heidelberg 69117, Germany; [b]National Aeronautics and Space Administration Postdoctoral Program Fellow, National Aeronautics and Space Administration Ames Research Center, Moffett Field, CA 94035; [c]University of California, Santa Cruz University Affiliated Research Center, National Aeronautics and Space Administration Ames Research Center, Moffett Field, CA 94035; [d]Institute for Pale Blue Dots, Department of Astronomy, Cornell University, Ithaca, NY 14853; and [e]National Aeronautics and Space Administration Ames Research Center, Moffett Field, CA 94035

Edited by Neta A. Bahcall, Princeton University, Princeton, NJ, and approved February 2, 2015 (received for review November 5, 2014)





Hegde et al. (2015) *PNAS*, 112(13), 3886-3891.



Cyprien et al. *Int. J. Astrobiology* (2016)

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20130011371.pdf

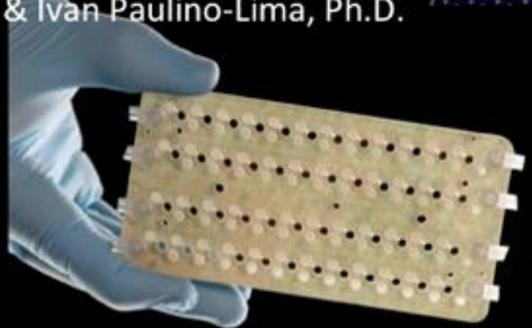
PowerCells on Eu:CROPIS: A demonstration of synthetic biology technology and biology in space

Eu:CROPIS: A DLR satellite mission scheduled to launch in March 2017

Euglena Combined Regenerative Organic Food Production In Space

PI: Lynn J. Rothschild, Ph.D.

Biology: Ryan Kent, Griffin McCutcheon, Evie Pless & Ivan Paulino-Lima, Ph.D.



How does variable gravity impact synthetic biology?

PowerCell:
- Co-culture
- Transformation


"The Earth is the cradle
of humanity, but one can not
live in a cradle forever"
Konstantin E. Tsiolkovsky


Thank you !