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Presentation to
1ST JOINT AgroSpace-MELiSSA Workshop 2018
Rome, Italy
http://www.melissafoundation.org/#workshop-rome-2018

"Biosphere2 STEM Education Collaborative Opportunities"

by
Gene A. Giacomelli

with collaboration from
Joaquin Ruiz, John Adams, Murat Kacira, Kevin Bonine, Bruce Johnson, Jill Castek

The University of Arizona

May 18, 2018

RESEARCH, DISCOVERY & INNOVATION Biosphere2 | UA SCIENCE | College of Education

College of Agriculture & Life Sciences Controlled Environment Agriculture Center

COLLEGE OF AGRICULTURE & LIFE SCIENCES COLLEGE OF ENGINEERING Agricultural & Biosystems Engineering

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Title: Biosphere2 STEM Education Collaborative Opportunities

Authors: Gene Giacomelli, Joaquin Ruiz, John Adams, Murat Kacira, Kevin Bonine, Bruce Johnson, Jill Castek

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Biosphere2 is a 1.2 hectare glass-enclosed research and education center within a 16 hectare campus owned and operated by The University of Arizona (UA). STEM education (science, technology, engineering, and math) has been a major aspect of the activities and programs of Biosphere2. We will describe opportunities to combine the excitement of science and preparations for space travel with the desire to improve understanding of Earth's biosystems, with the need for life-support, food production, and challenges of extreme environments in Space.
The mission is to serve as a center for research, outreach, teaching, and lifelong learning about Earth, its living systems, and its place in the universe. This $200 million facility was built in the late-1980s, as a model Earth (Biosphere1) under glass that gives better understanding of the Earth. Biosphere2 is simultaneously a research facility for Earth system science (at scale and level of control unparalleled), a destination for visitors interested in science and global climate change, and a transformative venue for K-16 STEM education. With its five biomes (ocean, rainforest, wetlands, grassland, and desert) and three Landscape Evolution Observatory structures, Biosphere2, provides unique controlled experimentation and unprecedented systems-level and landscape-scale analyses. Examples of engagement and informal STEM learning at Biosphere2 include: (1) UA Arboretum indoor orchard; (2) aquaponics facility teaching ecosystems, nutrient cycling, and fluxes of carbon, water, and energy with large scaled hands-on problem solving opportunities; and, (3) in partnership with UA-Controlled Environment Agricultural Center, a Mars/lunar Greenhouse Outreach & Teaching module (MLGH-OTM) demonstrating principles of bio-regenerative life-support systems, that include components deployed at the National Science Foundation (NSF) Amundsen-Scott Station at the South Pole in Antarctica supporting scientists with fresh salads. Relevant collaborations in development or early stages include: the European Commission-funded 'STORIES of Tomorrow: Mission to Mars' program that, pending NSF support, will offer virtual field trips to Biosphere2, worldwide, and include digital learning assessment; partnership with the Buzz Aldrin Mars Exploration education program, including their well-developed curriculum support; and, other NASA resources such as lesson plan development for the MLGH-OTM and other controlled Food-Energy-Water integrated environments that can become effective urban horticulture solutions.

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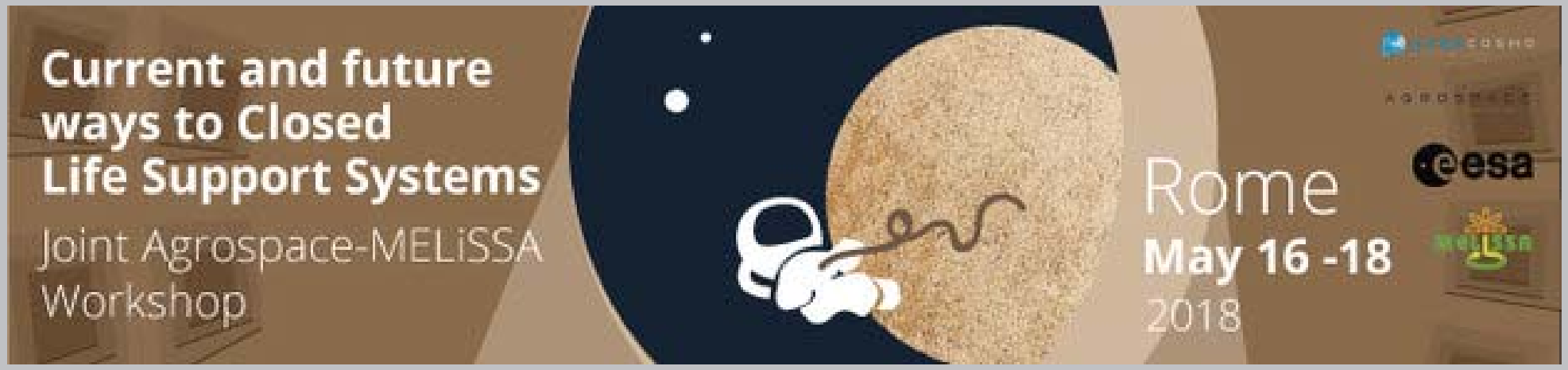

Biosphere2 STEM Education Collaborative Opportunities

Joaquin Ruiz, Vice President for Innovation, Executive Dean of the Colleges of Arts, Letters and Science, Dean of the College of Science, Thomas R. Brown Chair and Director of Biosphere 2, Professor of Geosciences, The University of Arizona

Kevin E. Bonine, Director of Education & Outreach, Biosphere 2, The University of Arizona

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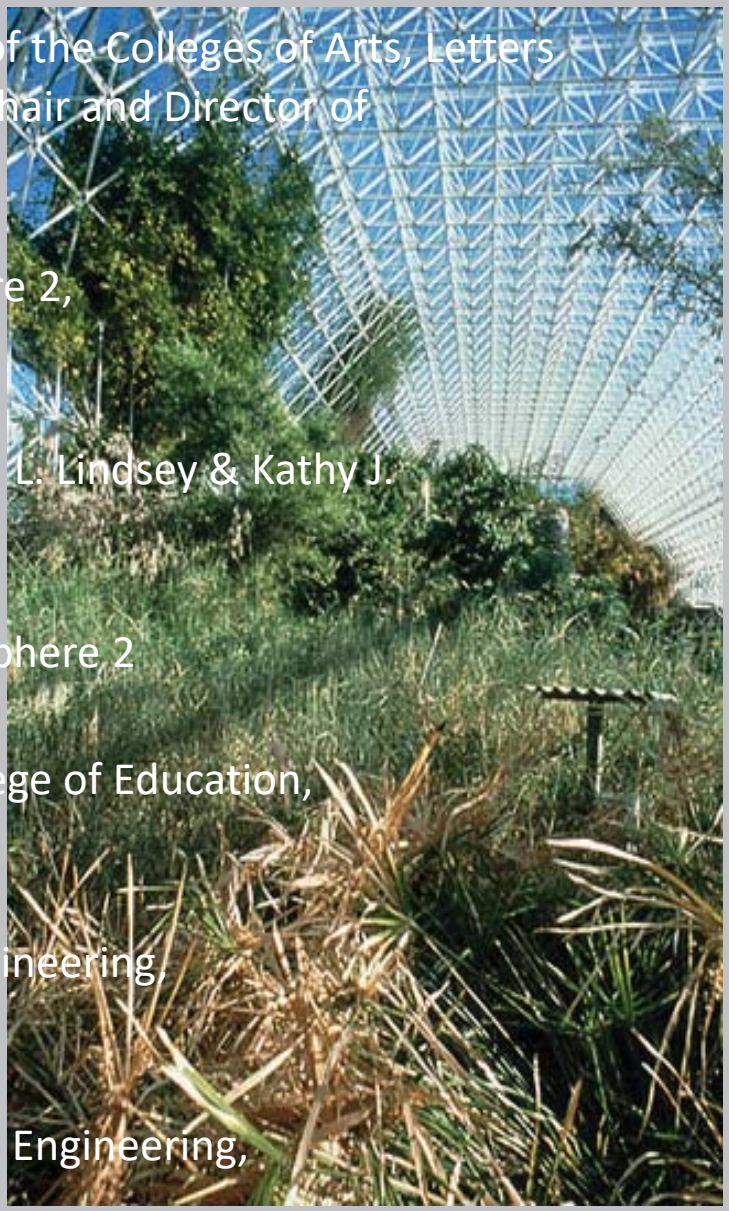
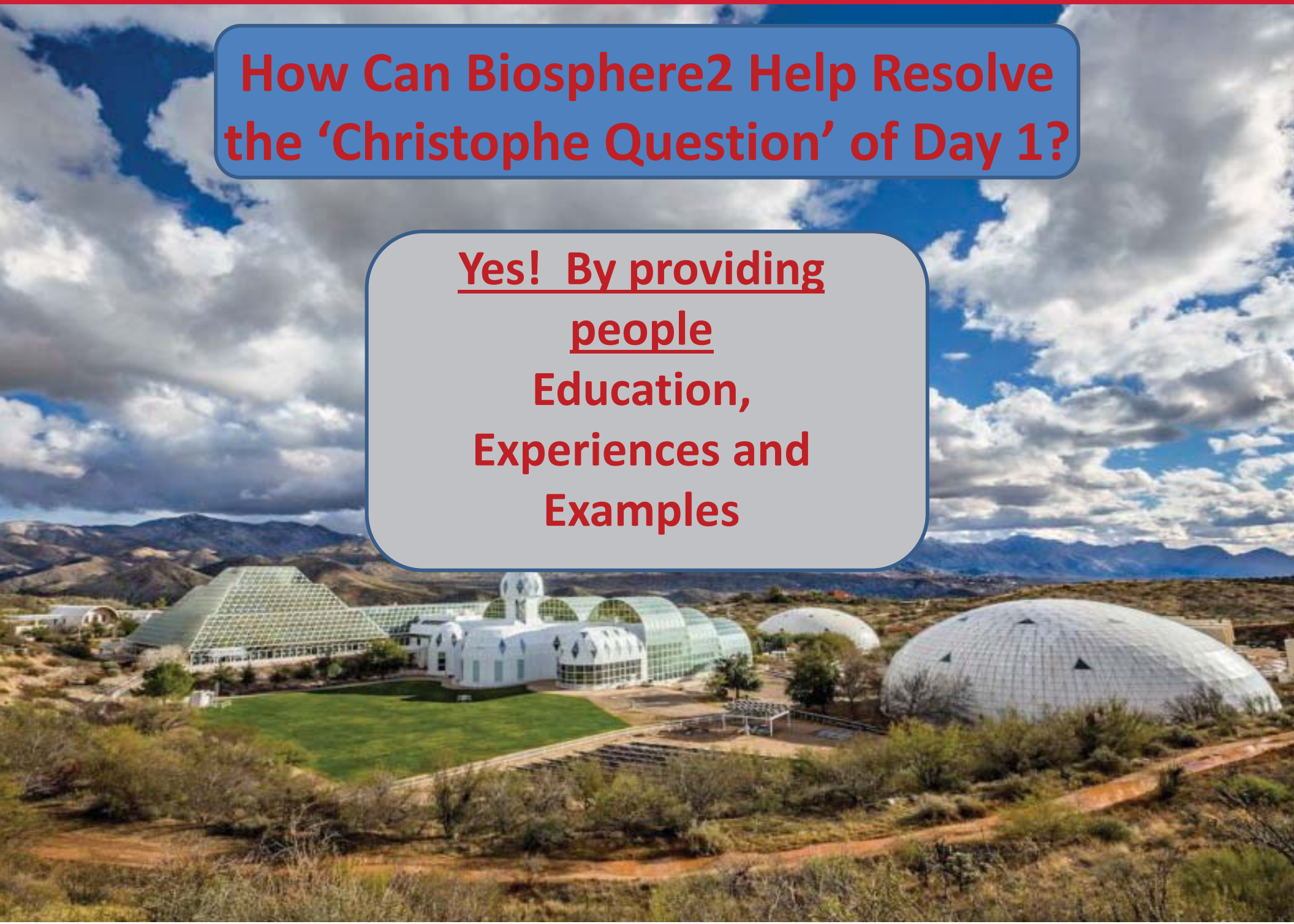


Dr. Joaquin Ruiz

Vice President for Innovation,
Executive Dean of the Colleges of Arts, Letters and Science,
Dean of the College of Science,
Thomas R. Brown Chair and Director of Biosphere 2,
Professor of Geosciences,
The University of Arizona,

How Can Biosphere2 Help Resolve the 'Christophe Question' of Day 1?



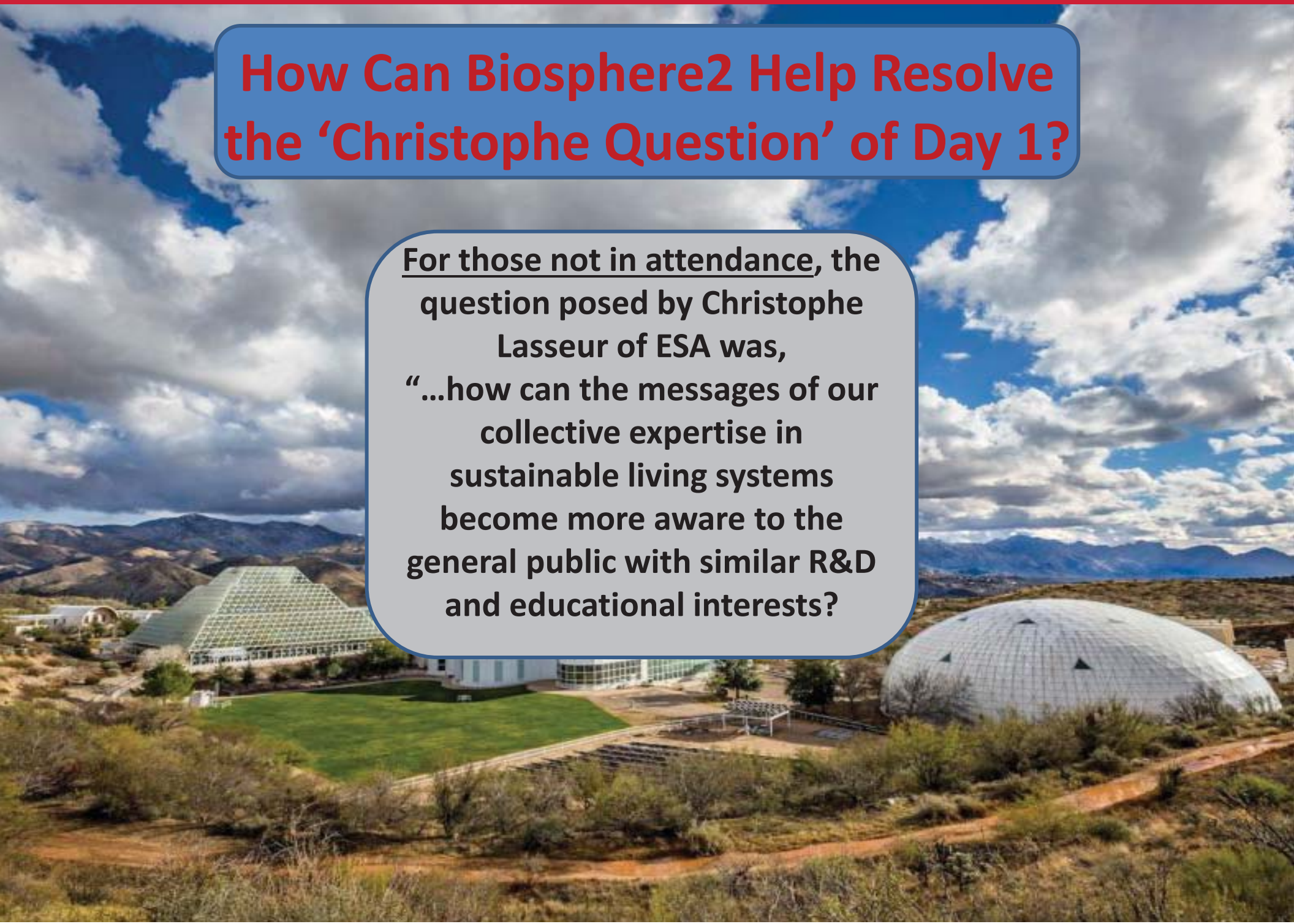
Yes! By providing people

Education,

Experiences and

Examples

How Can Biosphere2 Help Resolve the 'Christophe Question' of Day 1?

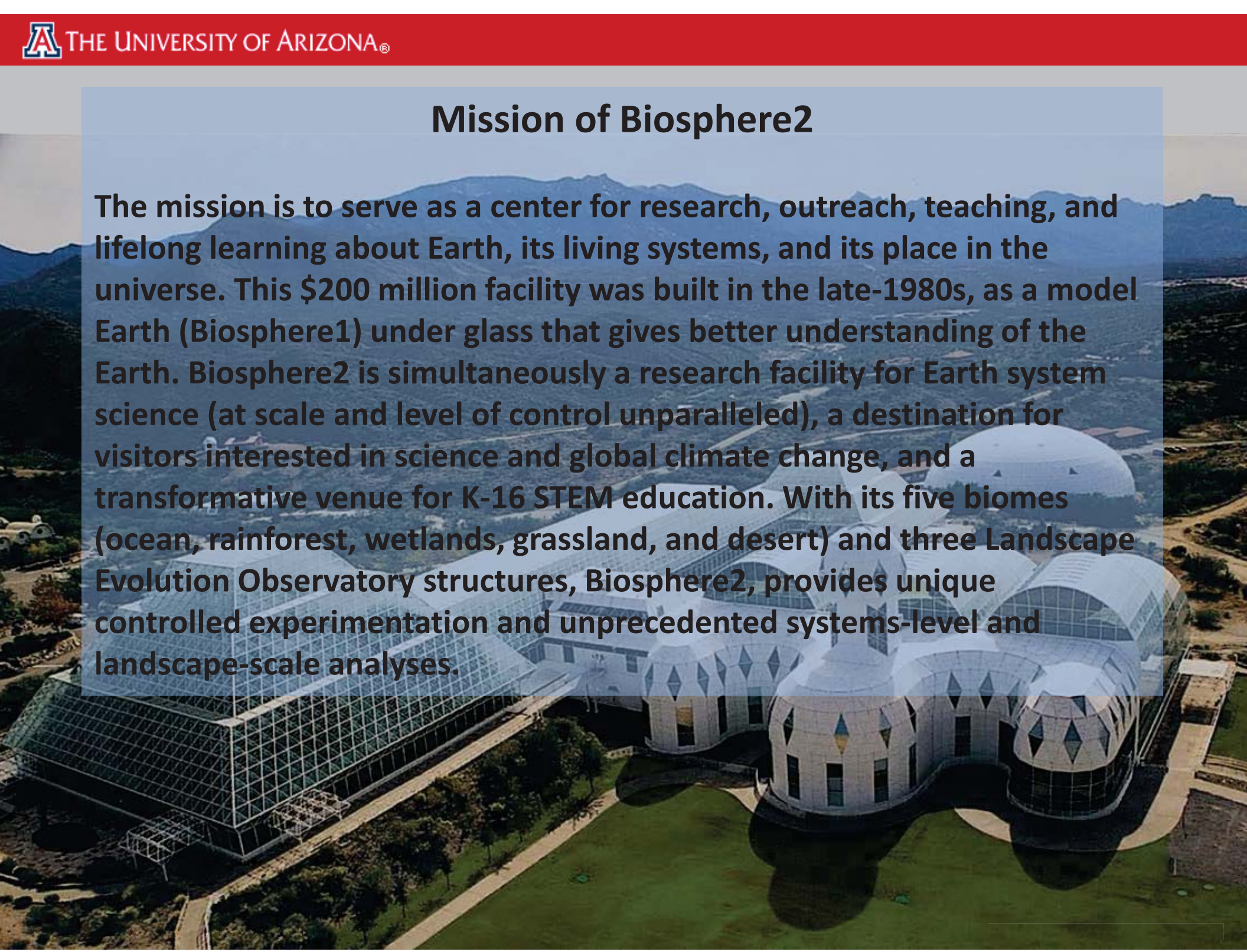


For those not in attendance, the question posed by Christophe Lasseur of ESA was, "…how can the messages of our collective expertise in sustainable living systems become more aware to the general public with similar R&D and educational interests?

What is Biosphere 2?

Biosphere2 is a 1.2 hectare glass-enclosed research and education center in a 16 hectare campus owned/operated by The University of Arizona

Mission of Biosphere2



The mission is to serve as a center for research, outreach, teaching, and lifelong learning about Earth, its living systems, and its place in the universe. This $200 million facility was built in the late-1980s, as a model Earth (Biosphere1) under glass that gives better understanding of the Earth. Biosphere2 is simultaneously a research facility for Earth system science (at scale and level of control unparalleled), a destination for visitors interested in science and global climate change, and a transformative venue for K-16 STEM education. With its five biomes (ocean, rainforest, wetlands, grassland, and desert) and three Landscape Evolution Observatory structures, Biosphere2, provides unique controlled experimentation and unprecedented systems-level and landscape-scale analyses.

Edward Bass

His financial support of a dream……

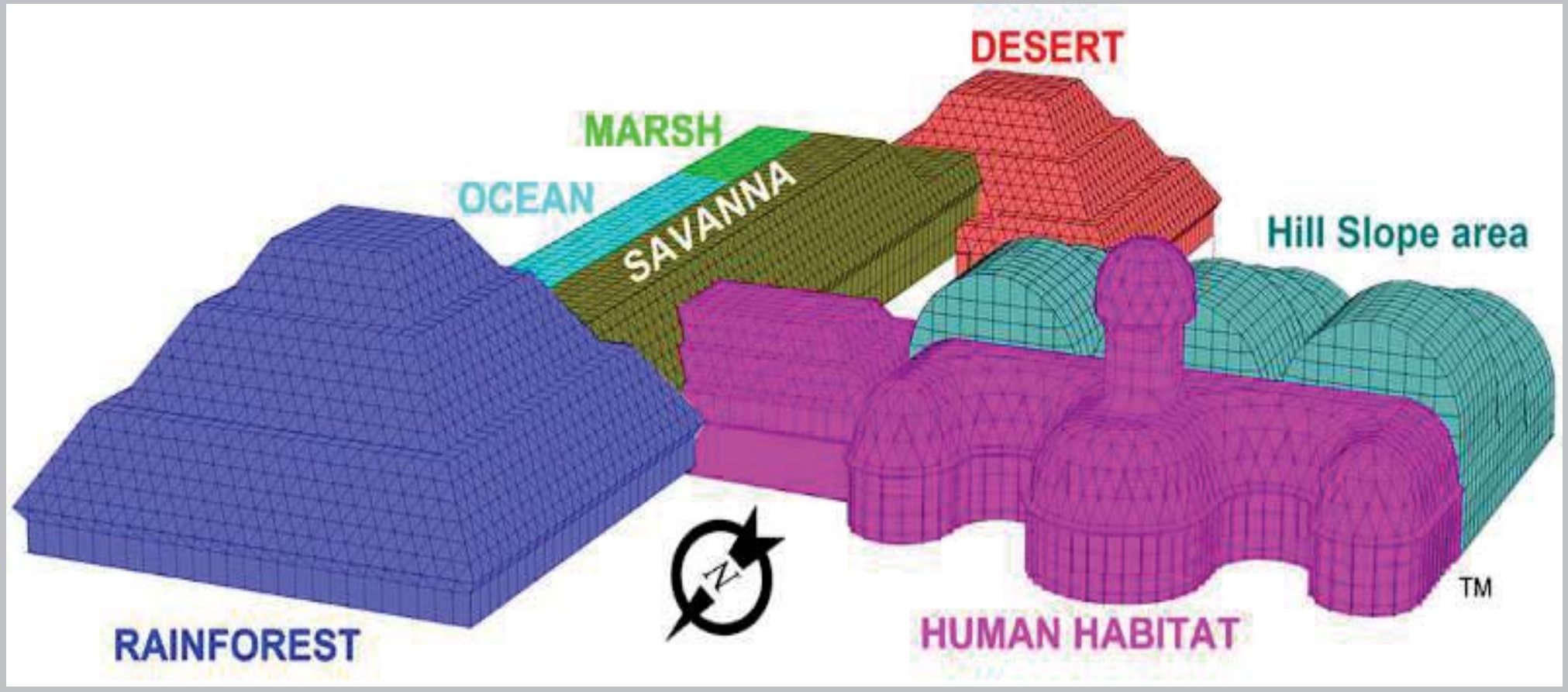
and $240M In 1980's……

Has become a value to the 21st Century Science and Agriculture on Earth and beyond

Edward Perry "Ed" Bass is an American businessman, financier, philanthropist, and environmentalist who lives in Fort Worth, Texas. He financed the Biosphere 2 project, an artificial closed ecological system, which was built between 1987 and 1991.

What is Biosphere 2?

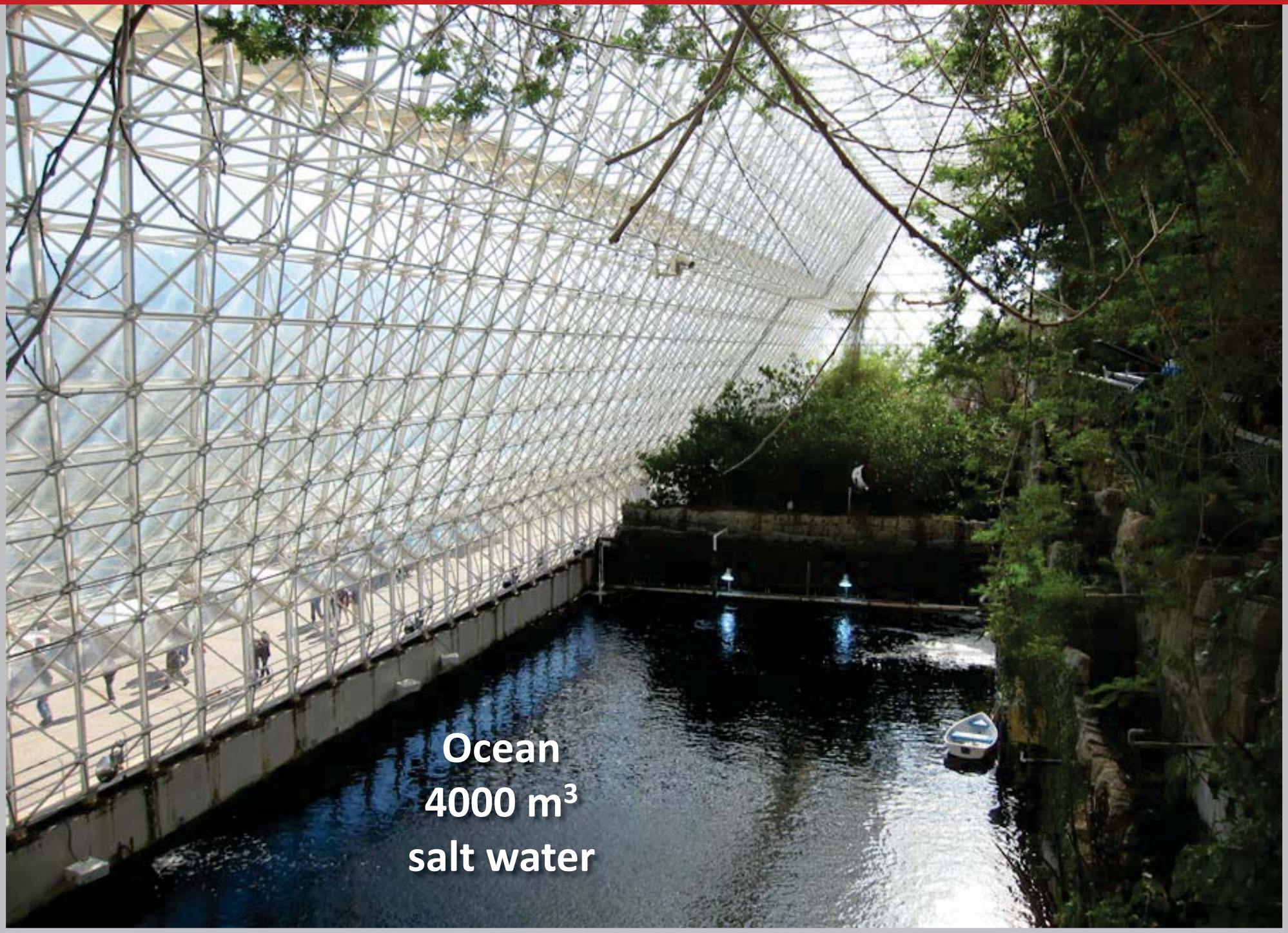
Five biomes: Ocean,
Rainforest,
Wetlands,
Grassland,
Desert, plus
Landscape Evolution Observatory structures



What is Biosphere 2?

Biosphere2, provides unique controlled experimentation and unprecedented systems-level and landscape-scale analytical laboratories

Rainforest
25 years in development


Ocean
4000 m³
salt water

CHASING CORAL

WHY WE NEED CORAL REEFS

Coral reefs are of the most important and diverse ecosystems on the planet. They are the rainforests of the sea.

FOOD SUPPLY

1 billion people rely on coral reefs for the food they provide.

ECONOMIC IMPACT

Reefs generate $36 billion dollars and create millions of jobs in the tourism sector alone.

NATURAL PROTECTION

Healthy corals protect our coastlines from tsunamis, hurricanes, and floods.

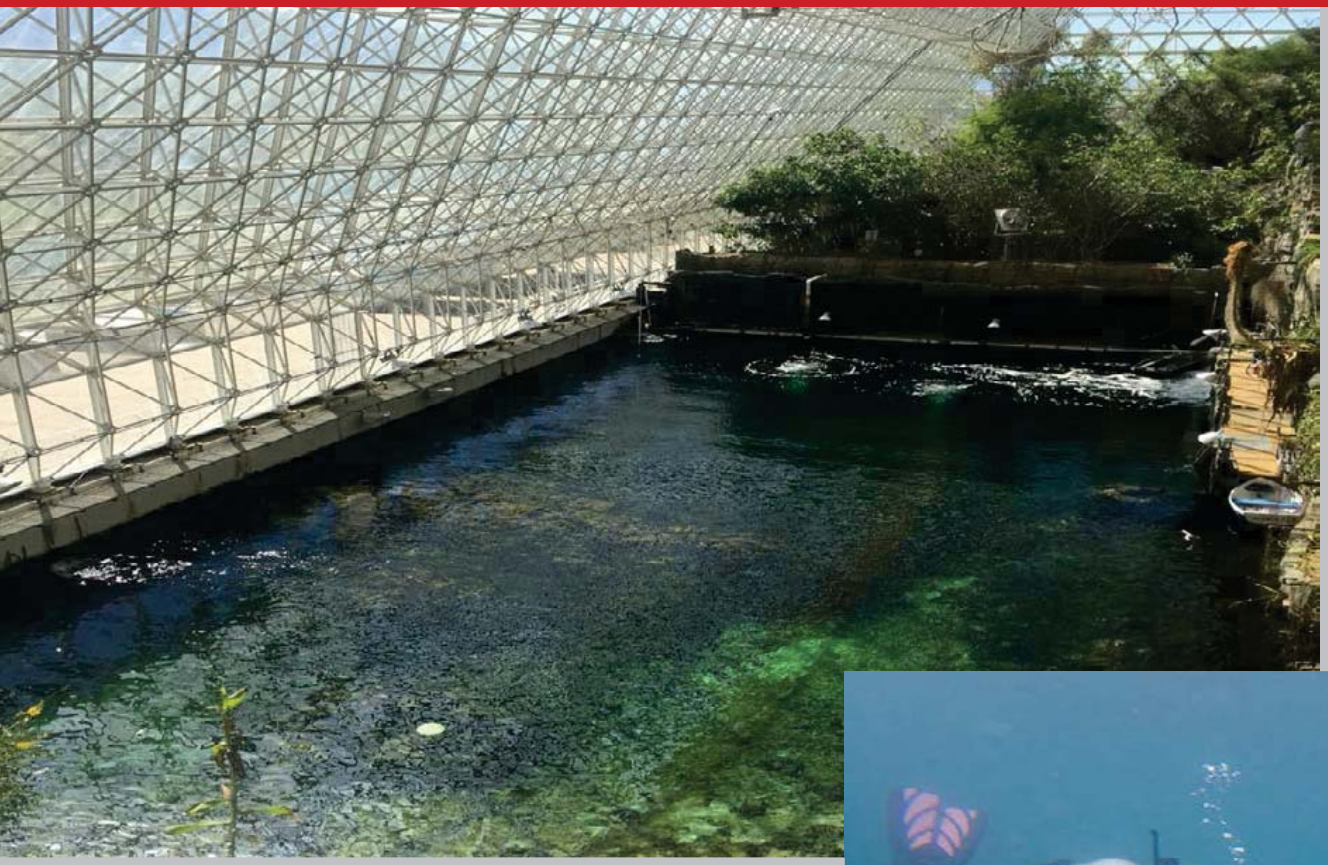
Join in at:
www.chasingcoral.com

CHASING CORAL

93% OF HEAT IN THE EARTH'S ATMOSPHERE IS ABSORBED BY THE OCEAN

Without our oceans the average air temperature would be 122° F.

Join in at:
www.chasingcoral.com



STEM education (science, technology, engineering, and math) has been a major aspect of the activities and programs of Biosphere2

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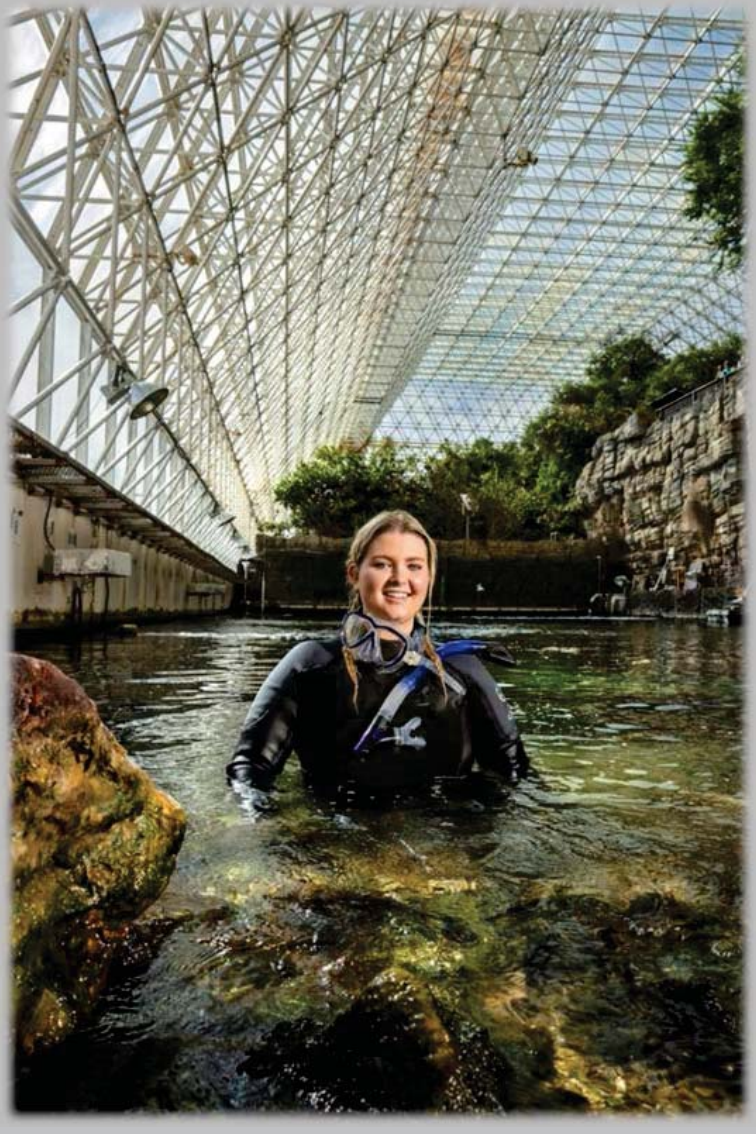
Luis Garcia-Ramirez, Engineering Student, hydroponic strawberry production success!

Opportunities to combine the excitement of science and preparations for space travel with the desire to improve understanding of Earth's biosystems, and life-support, food production, challenges of extreme environments in Space



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Biosphere 2, the world's largest controlled Earth science research facility

Hosts **100,000 visitors** each year, 10% of whom are **K-12 school children**.

The dual mission of research and outreach facilitates better scientific understanding of Earth systems and inspires appreciation of
STEM (science, technology, engineering, and math)
in many different audiences.

For more information and to discuss collaborations, please contact:
Kevin Bonine, Director of Education & Outreach
520-621-0232, kebonine@email.arizona.edu, biosphere2.org

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Biosphere2.org

Biosphere 2 K-12 Programs

Biosphere 2

Massive Open OnlineCourse (MOOC)
Biosphere 2, an Icon of Possibilities

Taught by: Kevin E. Bonine, PhD, Director of Education and Outreach

Module 1, get a virtual introduction to the engineering marvel that is Biosphere 2. Learn about the history of Biosphere 2 and how it is currently used as the world's best research instrument for earth systems science. Discover how the ocean, rainforest, and desert can be studied in one enclosed, 1.2 hectare structure in the Arizona desert.

Week 8 Feeding the Future

Can a Mars or Lunar greenhouse help feed people on Earth? Learn how space-farming models can be applied on Earth…..for a global population of 10 billion people. Discover innovative controlled agricultural systems, learn more about how plants grow, and get a chance to produce your own hydroponically grown vegetables at home!
With Dr. Gene Giacomelli, UA Controlled Environment Agriculture Center.

9 videos

https://www.coursera.org/learn/biosphere-science-future

Examples of engagement and informal STEM learning at Biosphere2

Aquaponics Facility -- teaching ecosystems, nutrient cycling, and fluxes of carbon, water, and energy within large-scaled hands-on problem solving opportunities for students

The NASA Steckler Space Grant Prototype Lunar Greenhouse program

- more than a decade of research at the UA-CEAC
- in collaboration with Sadler Machine Co
  beginning with the South Pole Food Growth Chamber
  through Raytheon Polar Services Company and
  the National Science Foundation (NSF), and
- with continued sponsorship by NASA, various aerospace
  companies including Italy's Aero-Sekur (Arescosmo)
  and the Franco-Italian Thales Alenia Space

Sadler Machine CO

ARIZONA SPACE GRANT CONSORTIUM

College of Agriculture & Life Sciences
Controlled Environment Agriculture Center

COLLEGE AND FELLOWSHIP PROGRAM
NATIONAL SPACE GRANT
NASA

Hungry Planets
Systems and Service, LLC

ThalesAlenia Space
A Thales / Finmeccanica Company

ARESCOSMO
DEFENCE AND SPACE

AERO SEKUR

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Development of an Outreach and Teaching Module (LGH-OTM) Based On Prototype Lunar Greenhouse

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Development of an Outreach and Teaching Module Based On Prototype Mars-Lunar Greenhouse (MLGH)

Development of an Outreach and Teaching Module Based On Prototype Lunar Greenhouse (LGH-OTM)

G. Giacomelli[1], M. Yanes[1], P. D. Sadler[2], R.L. Patterson[3], M.F. Munday[4]

[1]Agriculture and Biosystems Engineering, University of Arizona, Tucson, AZ, USA.
[2]Sadler Machine Company, Tempe, AZ, USA
[3]Lockheed-Martin Polar Services, Denver, CO, USA
[4]Hungry Planets Systems and Services, Tucson, AZ USA

The Lunar Greenhouse Outreach & Teaching Module (LGH-OTM) was developed with the Controlled Environment Agriculture Center at the University of Arizona, and its partners Hungry Planets Systems and Services, and Sadler Machine Company. It complements the activities of the Arizona-NASA Ralph Steckler Space Colonization grant program, whose outreach goal is to provide platforms presenting science, technology, education, food security and production, with educational demonstrations. The LGH-OTM, a portable version of the lab design Prototype Lunar Greenhouse, was designed to be exhibited around the USA to demonstrate and provide outreach and training for audiences of all ages. To date it has been displayed at San Diego County Fair June 8 to July 5, 2012, "Growing Out of this World food" exhibit area; and, at the Chicago Museum of Science & Industry July 25 - January 25, 2013 "Life In Space - The Lunar Greenhouse".

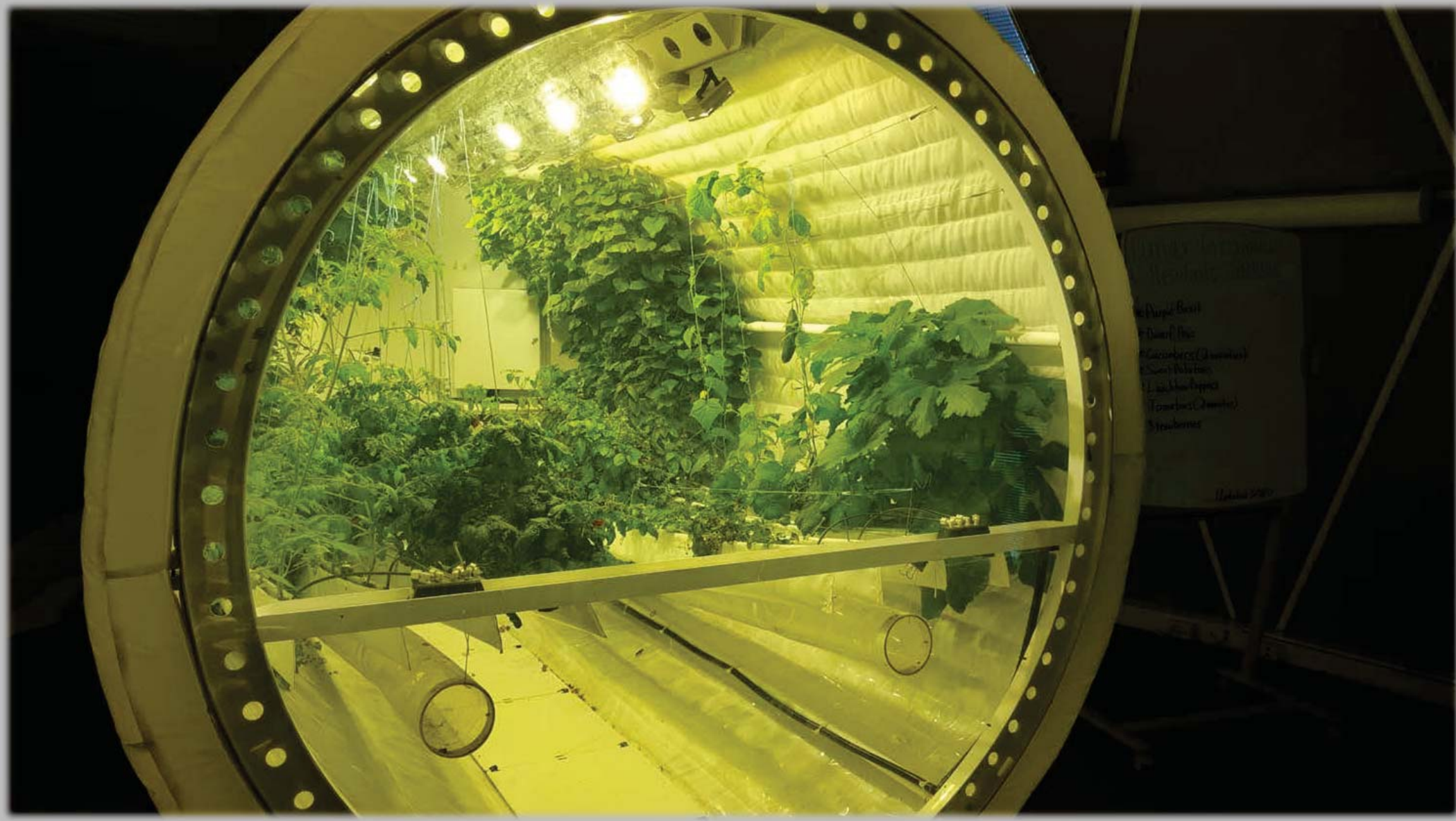
The Lunar Greenhouse program is based on more than a decade of research at the UA-CEAC in collaboration with Sadler Machine Co, beginning with the South Pole Food Growth Chamber through Raytheon Polar Services Company and the National Science Foundation (NSF), and with continued sponsorship by NASA, NSF and various aerospace companies including Italy's Aero-Sekur and the Franco-Italian Thales Alenia Space.

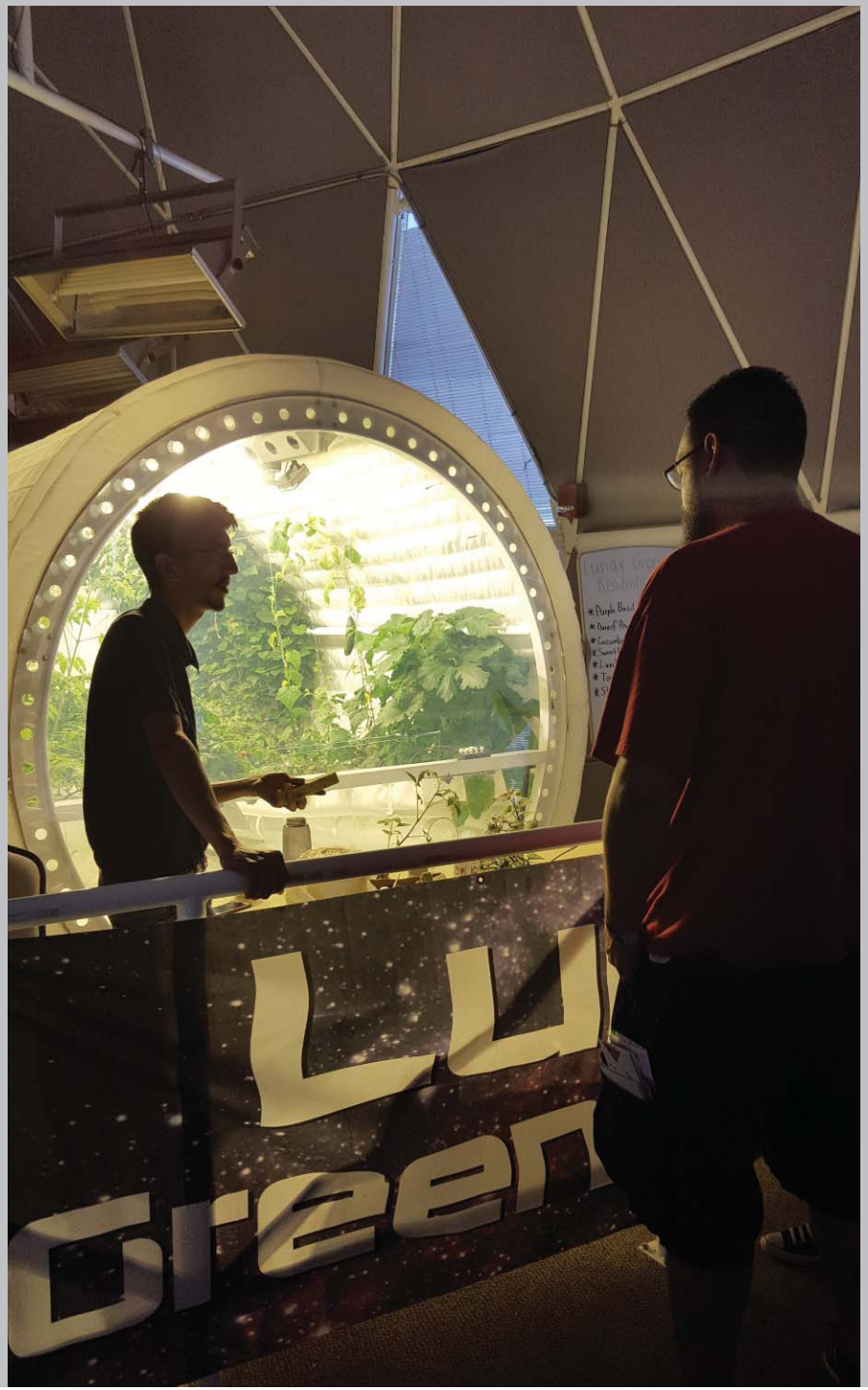
The lunar greenhouse (LGH) prototype project funded by NASA Steckler Phase 1 and 2 Space Grant supported collaboration from a multidisciplinary and multinational team of experts to study and evaluate the scientific and technical merit and feasibility of a lunar greenhouse prototype as a Bioregenerative Life Support System.

The LGH-OTM was constructed to demonstrate crop production within a BLSS-type physical environment with a hydroponic multi-cropping system that could produce crops (lettuce, strawberry, sweet potato, and tomato). It is a semi-autonomous food production device capable of automated climate control (air temperature, light, and hydroponic nutrient solution), and with labor for transplant and harvest can demonstrate controlled environment, hydroponic crop production within an educational setting. The presentation will focus on the design, operation and the educational experiences of the LGH-OTM.

The LGH-OTM

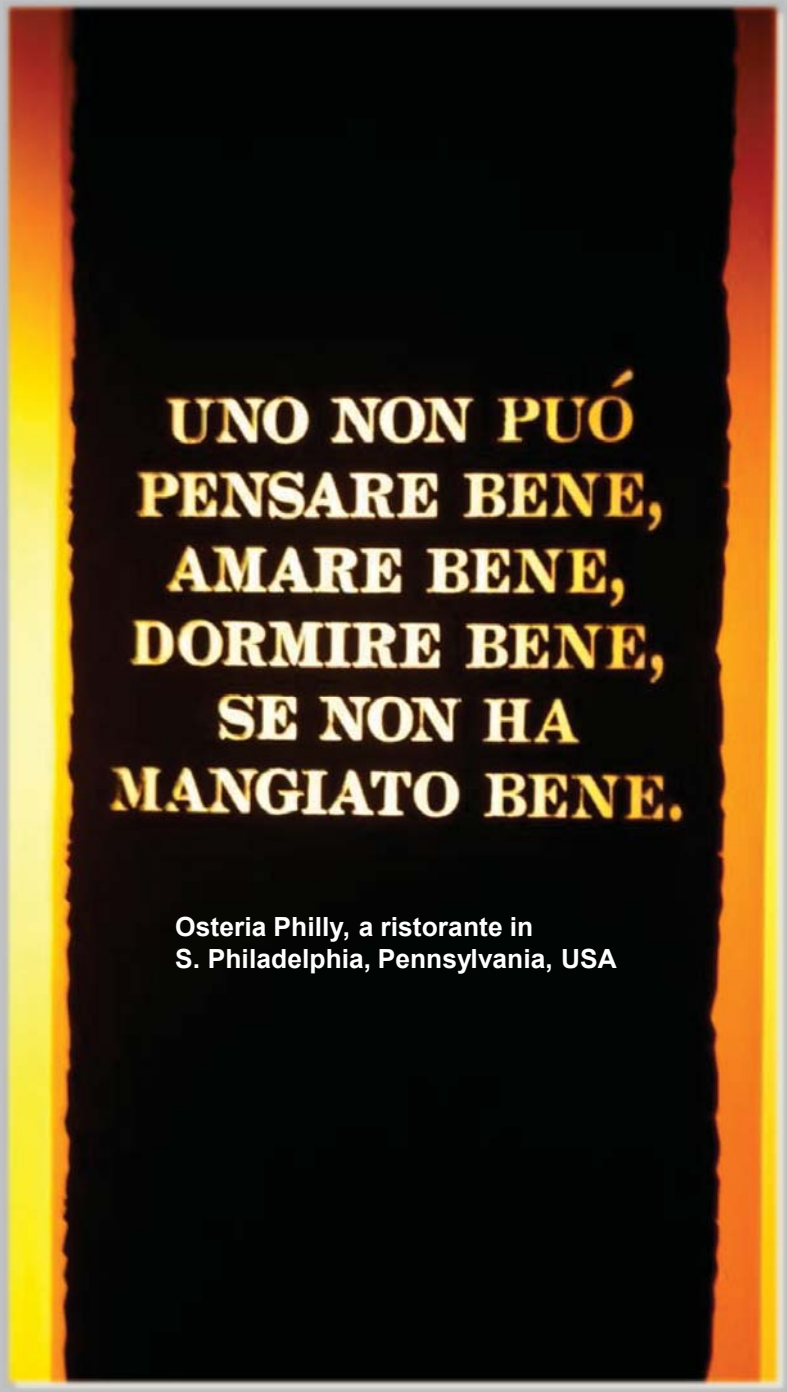
constructed to demonstrate crop production within a BLSS-type physical environment with a hydroponic multi-cropping system
lettuce, strawberry, sweet potato, and tomato
a semi-autonomous food production device capable of automated climate control (air temperature, light, and hydroponic nutrient solution), and with labor for transplant and harvest can demonstrate controlled environment, hydroponic crop production within an educational setting




Green


WANTED

One cannot
Think well,
Love well,
Sleep well,
if one has not
Eaten well.



Osteria Philly, a ristorante in
S. Philadelphia, Pennsylvania, USA

Final Words

Thank you

Education is Critical

Education is enhanced by hands-on opportunities

Successful JOINT AgroSpace-MELiSSA Workshop 2018

Table 1. Biopshere2 has LOTS of connections to food.

Landscape Evolution Observatory (LEO) research integrates Earth systems, hydrology, soil formation, and more – all relevant information for agriculture on Earth or elsewhere in the solar system. http://biosphere2.org/research/projects/landscape-evolution-observatory

Educational programming (some explicit food focus, others clear relevance):
http://biosphere2.org/education/our-most-popular-hands-on-science-experiences

Mars Lunar Greenhouse module on loan from CEAC:
https://cals.arizona.edu/lunargreenhouse/
https://www.youtube.com/watch?v=8V54UaUXqXg

Greg Barron-Gafford Agrivoltaics:
https://uanews.arizona.edu/story/ua-researchers-plant-seeds-make-renewable-energy-more-efficient
https://research.arizona.edu/stories/agrivoltaics

Aquaponics:
https://www.youtube.com/watch?v=mv_0V8ddwdQ

For Further Information

Dr. Gene Giacomelli
CEAC, giacomel@ag.arizona.edu +1 520 626 9566

Prof. Gene Giacomelli is a faculty member within the Department of Agricultural and Biosystems Engineering at The University of Arizona, and former Director of the Controlled Environment Agriculture Center. Giacomelli has gained international reputation through his pioneering work and expertise in the area of protected crops. Growing food on other planets is one of the collaborative international projects that he is leading, which is supported by the NASA Space Grant Consortium at the University of Arizona. The focus is efficient use of water, energy and other resources for implementation of a food and life support system for Moon/Mars. The results from this project will be applied to Earth protected agriculture food production systems."

For Further Information

The CEAC (Controlled Environment Agriculture Center) and The University of Arizona are dedicated to development of CE (Controlled Environment) technologies and worldwide applications, and for educating young people about the science and engineering of CE and hydroponic food support systems, and the other CE applications.

We will implement an interactive outreach and educational program to promote the benefits of CE for food production for modern agriculture, as well as, the new technologies of CE for enhancing, restoring, and maintaining critical earth life systems and human quality of life scenarios.

CE systems will be developed to help feed the world, while utilizing energy, labor and water resources effectively, and CE will become the platform for applications of new technologies using plant physiological processes [biomass fuels]; for space colonization life support [recycling all resources]; for remediation of air [carbon sequestration] and water [salts, heavy metals]; and for phytochemicals and plant-made pharmaceuticals [lycopene, vaccines].