Ferrari Farm®
Nature & Technology

G & A ENGINEERING Research Center

SPACE HYDROPONIC ALTERNATIVE

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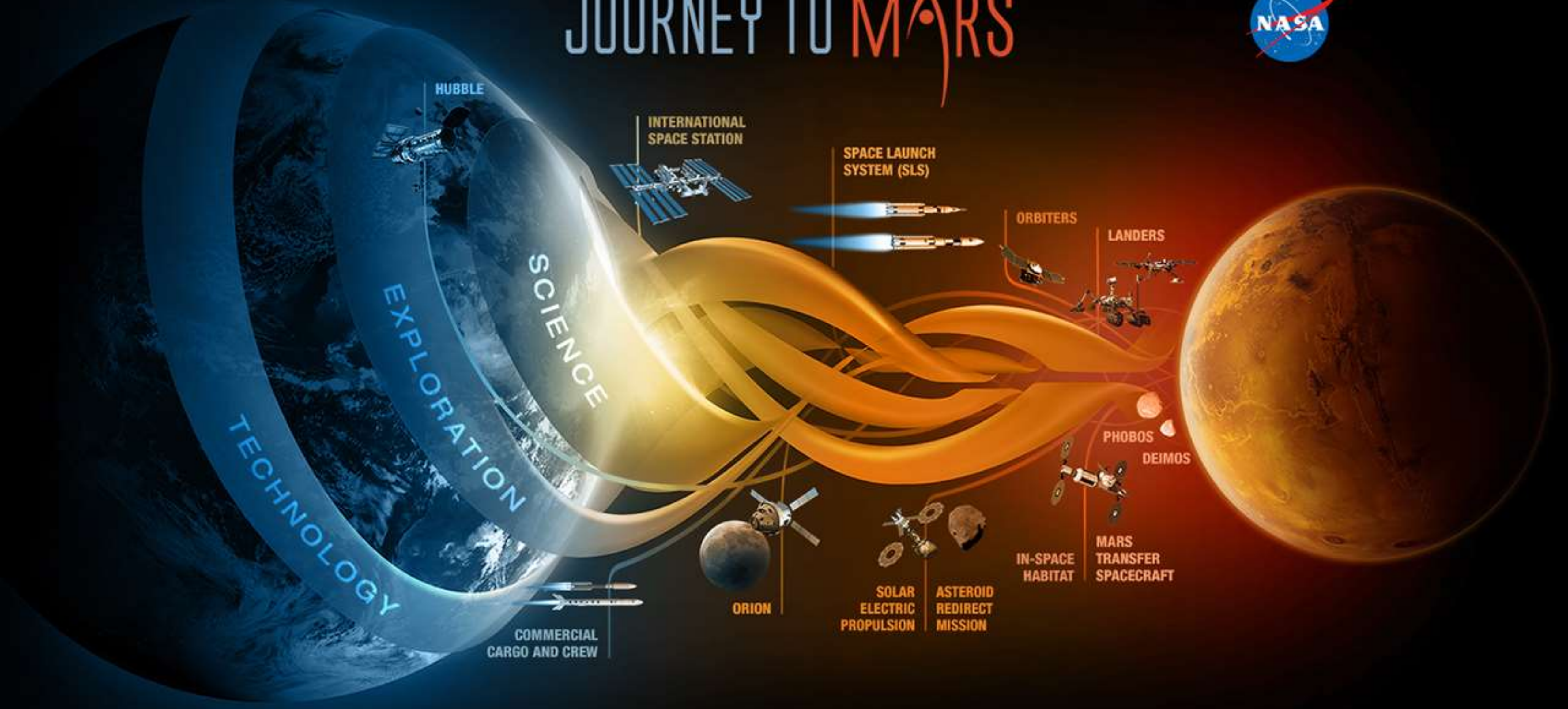
JOURNEY TO MARS



CURRENT SPACE FOOD SYSTEM

8 FOOD CATEGORIES:

- Rehydratable Food
- Thermostabilized Food
- Intermediate Moisture Food
- Natural Form Food
- Irradiated Food
- Frozen Food
- Fresh Food
- Refrigerated Food

Current ISS food system shelf life is 12 to 18 months.

MISSION TO MARS

- 2.5 year mission
  - ○ Earth-to-Mars Transit: ~ 6 months
  - ○ Mars Surface stay: ~ 18 months
  - ○ Mars-to-Earth Transit: ~ 6 months

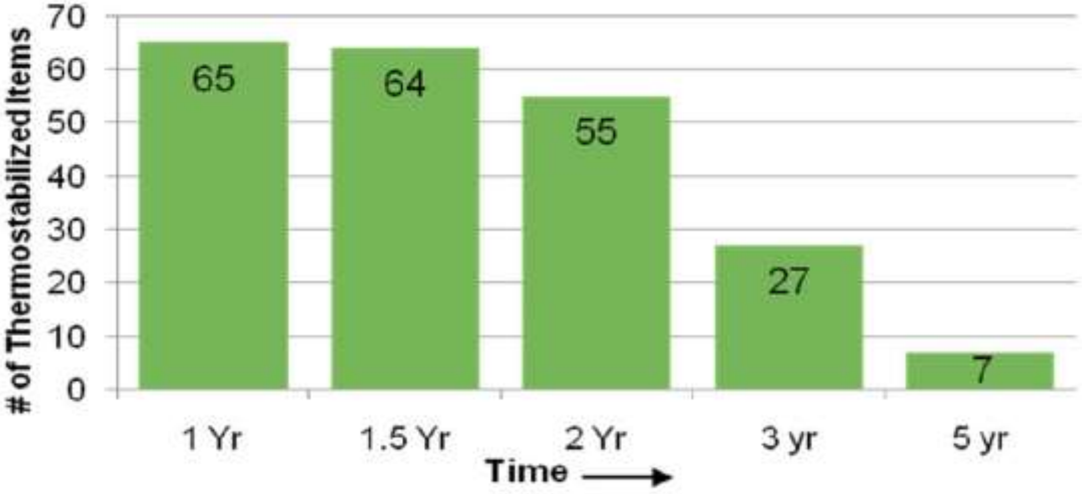
- A 5 year shelf-life is REQUIRED

  The current food system would become UNACCEPTABLE before the mission ended.

NASA RESULTS

Only 7 of 65 thermostabilized foods are expected to be ***palatable*** after 5 years of storage.

Limited data on *nutritional content* is available.



Catauro et al. JFS 2011

- Salmon in Pouch
- Tuna in Pouch
- Meatloaf
- Chicken Fajitas
- Grilled Pork Chop
- Chicken with Peanut Sauce
- Fiesta Chicken

5-YEAR SHELF-LIFE CHALLENGE

Processing

Pressure Assisted Thermal Sterilization (PATS) and Microwave Assisted Thermal Sterilization (MATS)

Packaging

Materials to improve clarity and barrier with less mass

Formulation

Increase stability of nutrients

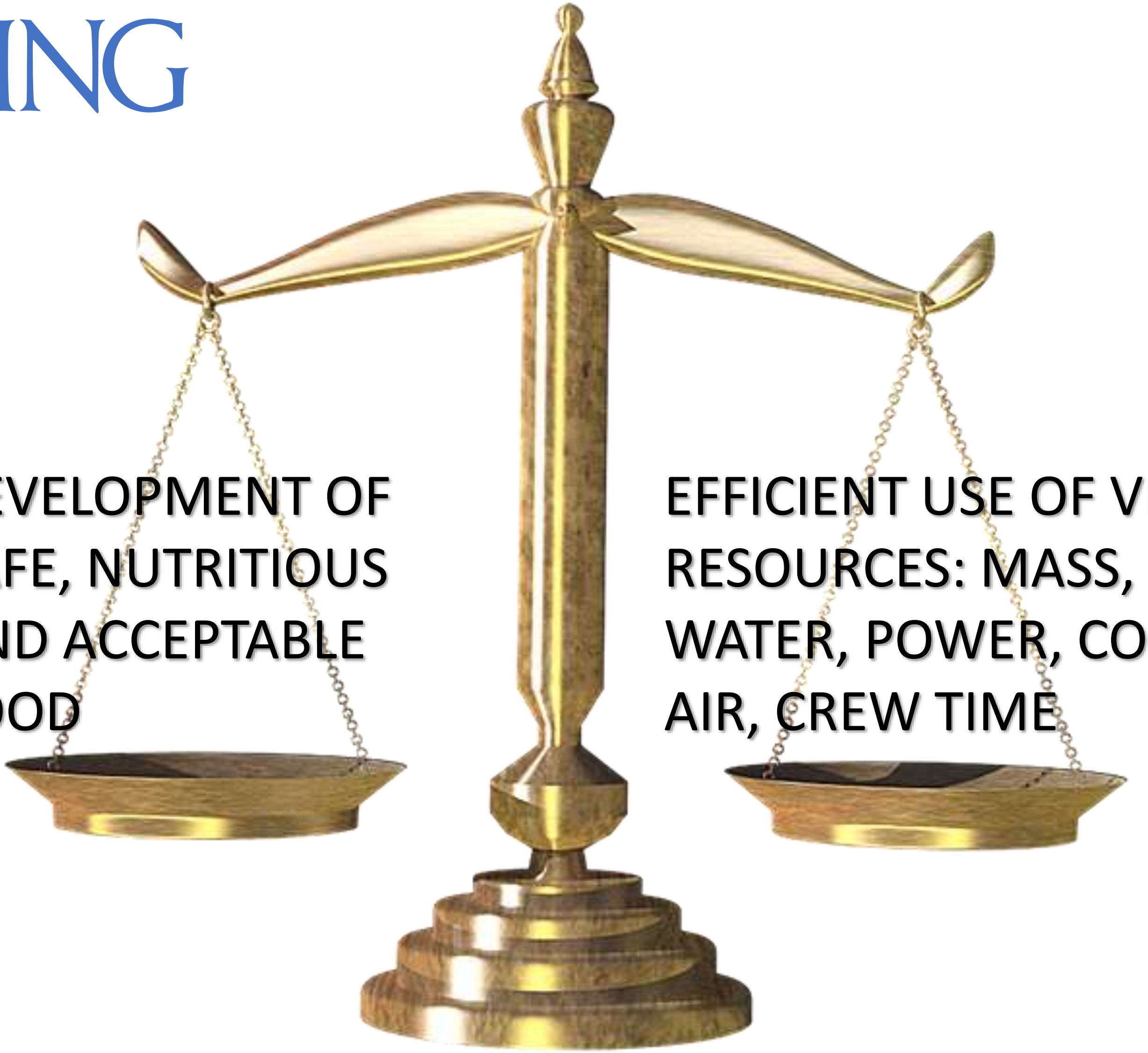
Environment

21°C storage

-80°C storage

Temperature
Radiation
Oxygen content (atmosphere)

IT'S A BALANCING ACT



DEVELOPMENT OF SAFE, NUTRITIOUS AND ACCEPTABLE FOOD

EFFICIENT USE OF VEHICLE RESOURCES: MASS, VOLUME, WATER, POWER, COOLING, AIR, CREW TIME

NEW CONCEPTS

Human deep space exploration & colonization of other celestial bodies requires the use of new generation space modules, capable of sustaining for long periods the lives of astronauts, without using supplies from earth.

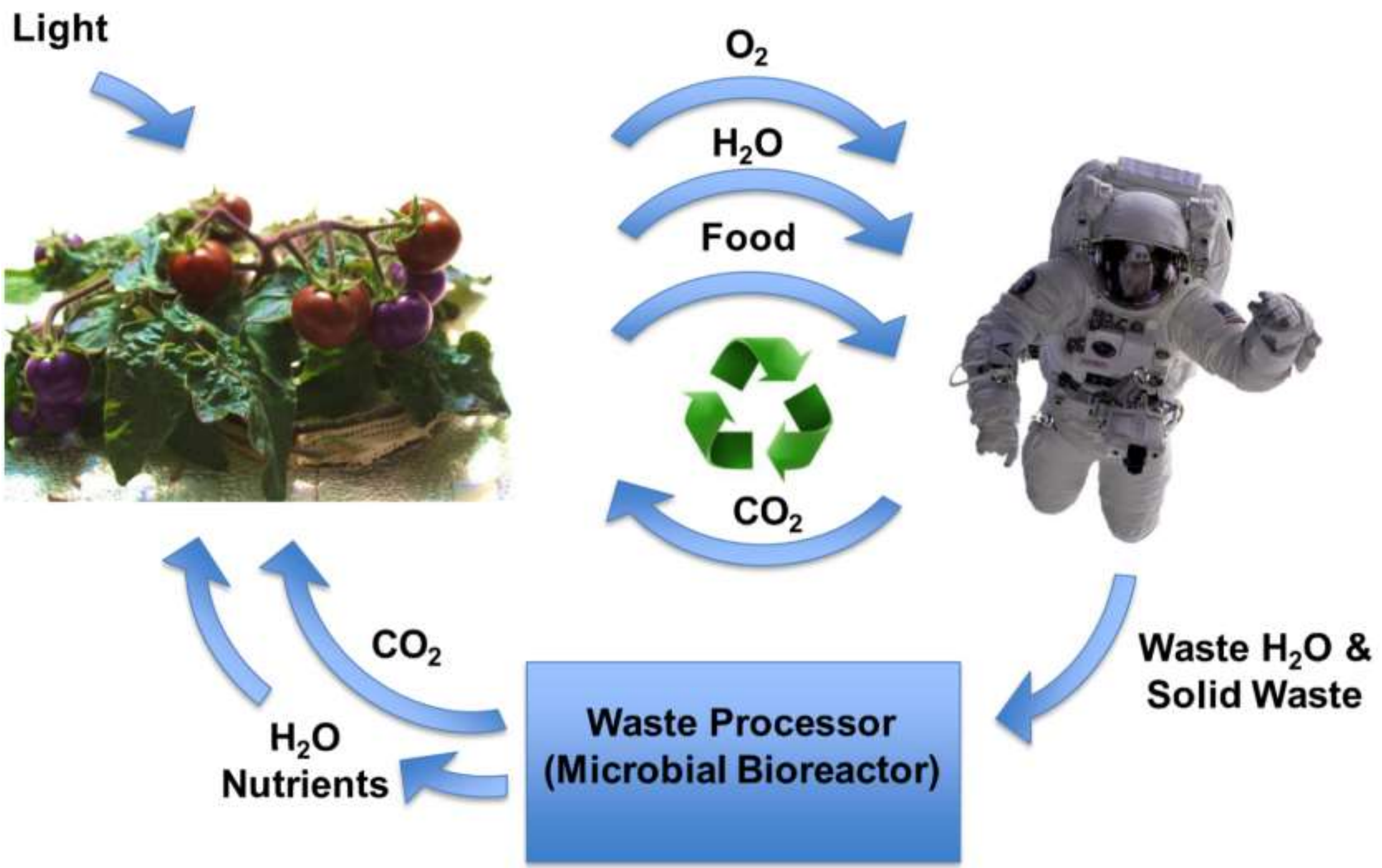
ON A MARS MISSION THERE WILL BE NO RESUPPLY MISSIONS.

LIFE SUPPORT SYSTEMS

The TRADITIONAL LIFE SUPPORT SYSTEMS are based on chemical-physical processes that guarantee the control of atmosphere and breathable air, water recycling, waste disposal, etc… requiring a constant supply of EXTERNAL RESOURCES

The principle is to recreate an ARTIFICIAL SPACE BIOSPHERE, just like the Natural Biosphere on the Earth's surface.

BIOREGENERATIVE SYSTEMS



BIOREGENERATIVE SYSTEMS

- On the agenda of the European Union Program Horizon 2020
- On the Global Exploration Roadmap
- A Working Group within Italian Space Agency (ASI)

SPACE GREENHOUSE

A "**Greenhouse Module**" is fundamental for any concept of independent and stable base for future space missions.

Inside a greenhouse it is possible to regenerate all the resources, through the closure of the life cycles of a habitat:

- Water Recycling
- Removal of CO_2
- Production of Oxygen and Food

SPACE GREENHOUSE

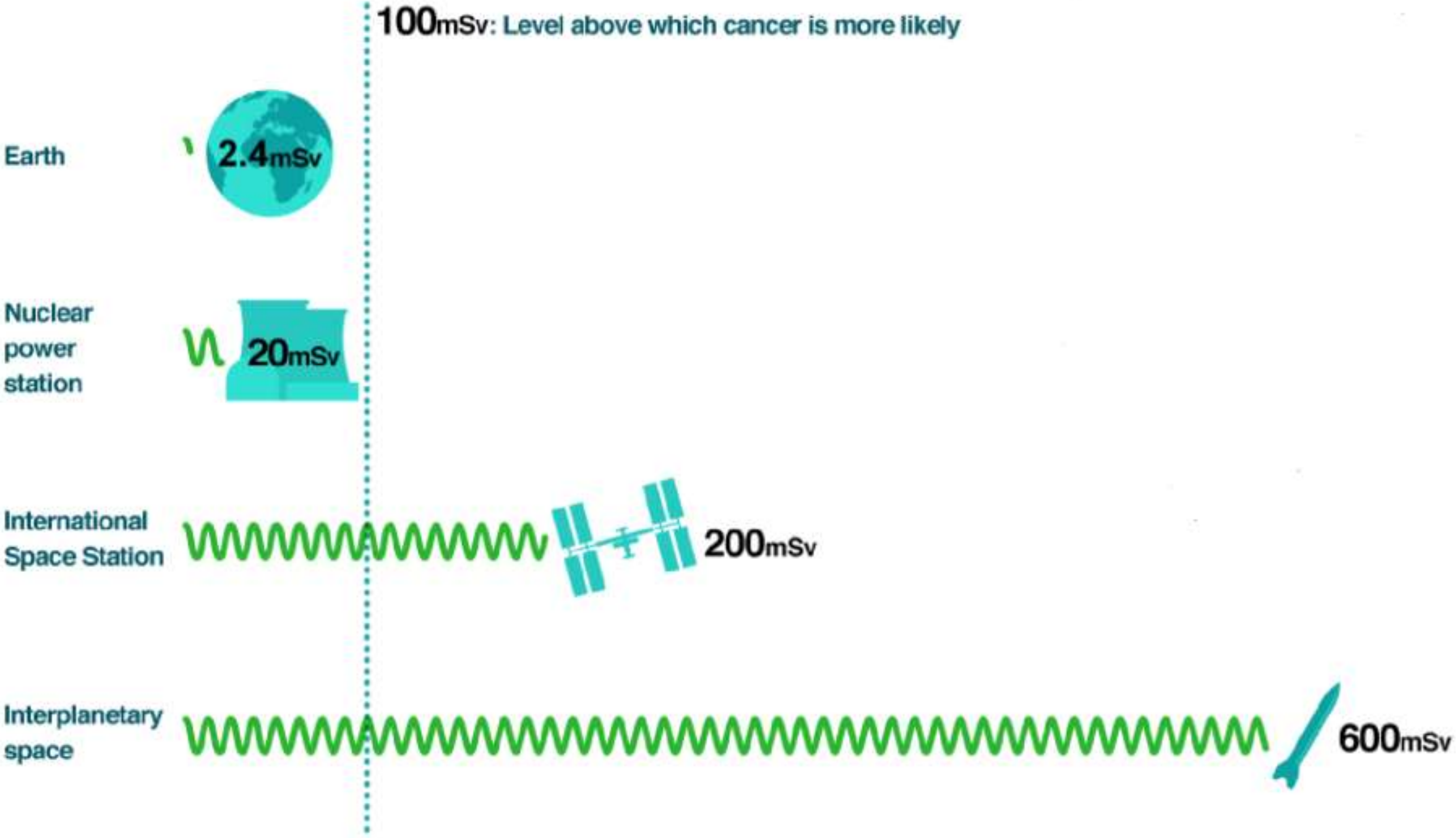
Could implement the astronauts diet, **BUT** Fresh Food have a positive role not only livelihoods, but also on the psychological wellbeing of astronauts, **improving morale** and **decreasing stress**.

RADIATIONS

- One of the major considerations for astronauts taking on deep space missions is radiation exposure, which can cause cell and tissue damage and increase astronauts' risk of cancer, neurogenerative diseases and premature aging

- The radiation risk increases beyond Low Earth Orbit

RADIATIONS



mSv = millisievert (a measure of the biological effects of radiation)

RADIATIONS

- **Foods** high in antioxidants can help mitigate that risk and astronauts can increase their uptake of **fresh-grown foods** high in antioxidants to protect themselves
- By increasing certain compounds such as lutein, beta carotene, zeaxanthin, lycopene in their diet, astronauts have a beneficial effect to protect themselves against radiative stress

SPACE GREENHOUSE

Growing plants with no Sunlight, without soil and with different gravity conditions from those on Earth is extremely complex.

In the biological field, studies currently focus on the choice of plant species better suited to be grown in EXTREME CONDITIONS

The GOAL is to identify the species most resistant to radiation and less sensitive to different conditions of gravity and light.

SPACE GREENHOUSE

When speaking or thinking of agricultural crops in space, it necessarily must refer to **HYDROPONICS.**

Made **without** the use of soil and using water as a **vehicle** for the nutrients transportation.

SPACE GREENHOUSE

Must take into consideration:

- Artificial Climate: T, RH, CO_2, O_2
- Artificial Lighting
- Water & Nutrient Supplying
- Pathogens Control
- Resistant Species

Must take into consideration the SPACE FARMING ENVIRONMENT

- Alterated Gravity
- Dangerous Radiations
- Hostile/Closed Environment
- Extreme Temperatures
- Alterated Light/Darck Cycles
- Isolation/Confinement
- Distance from Earth

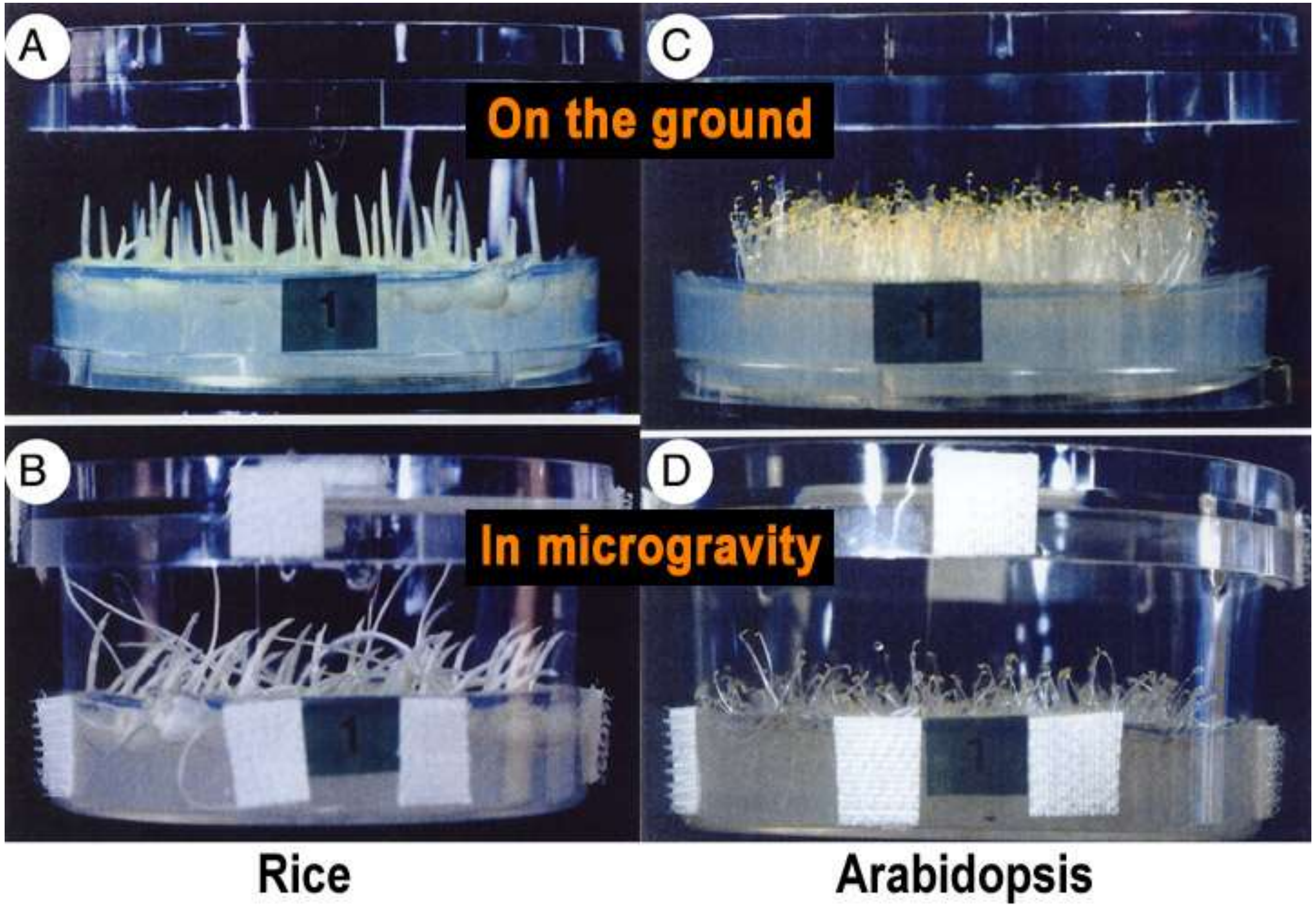
MICROGRAVITY

Microgravity or Reduced Gravity can be perceived as stressful by plants, but it doesn’t prevent the completion of the plants life cycle.

Even in microgravity plants can complete the life cycle "from seed to seed.“

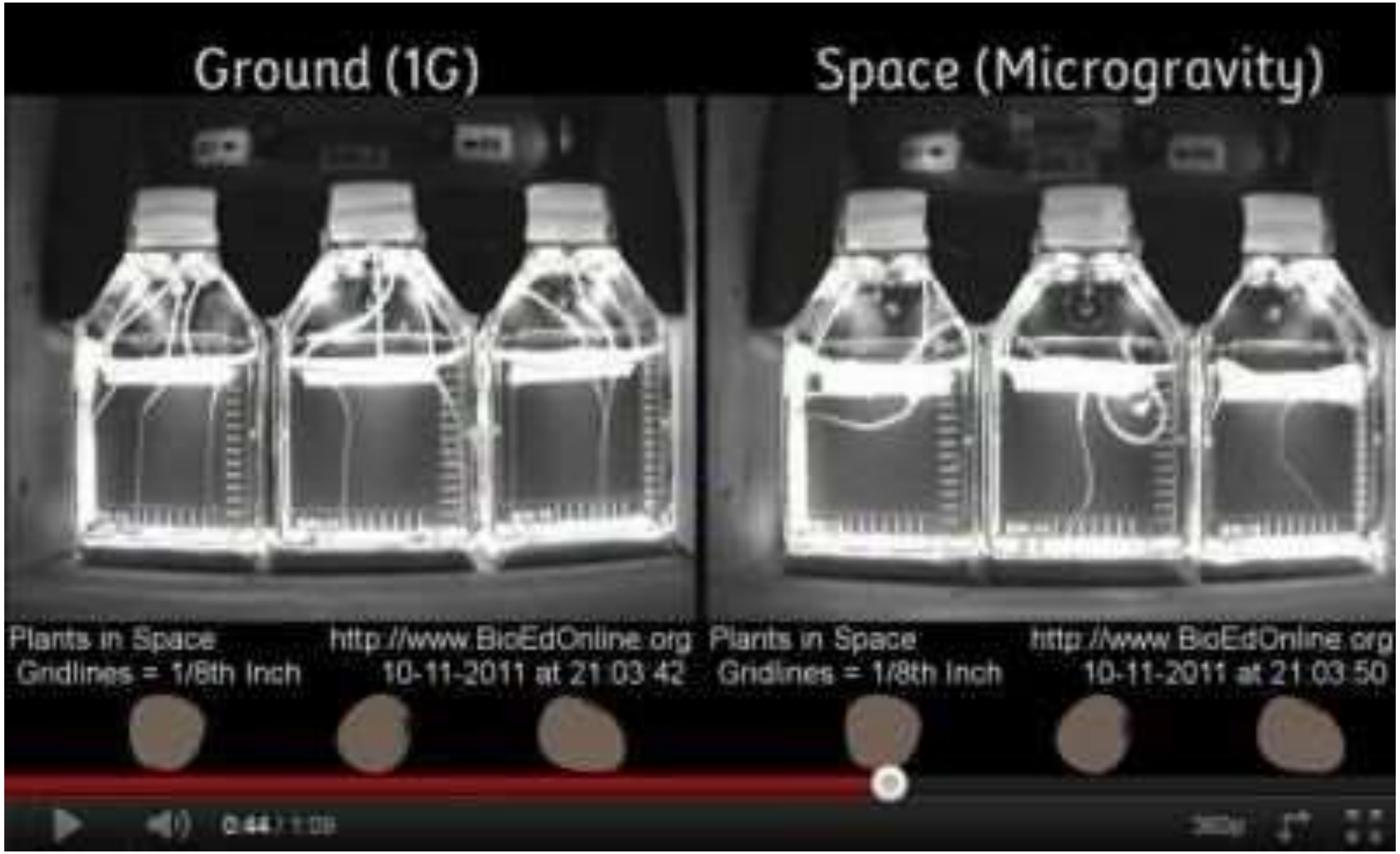
In space, roots grow in every direction, and water and other essential plant foods float.

MICROGRAVITY



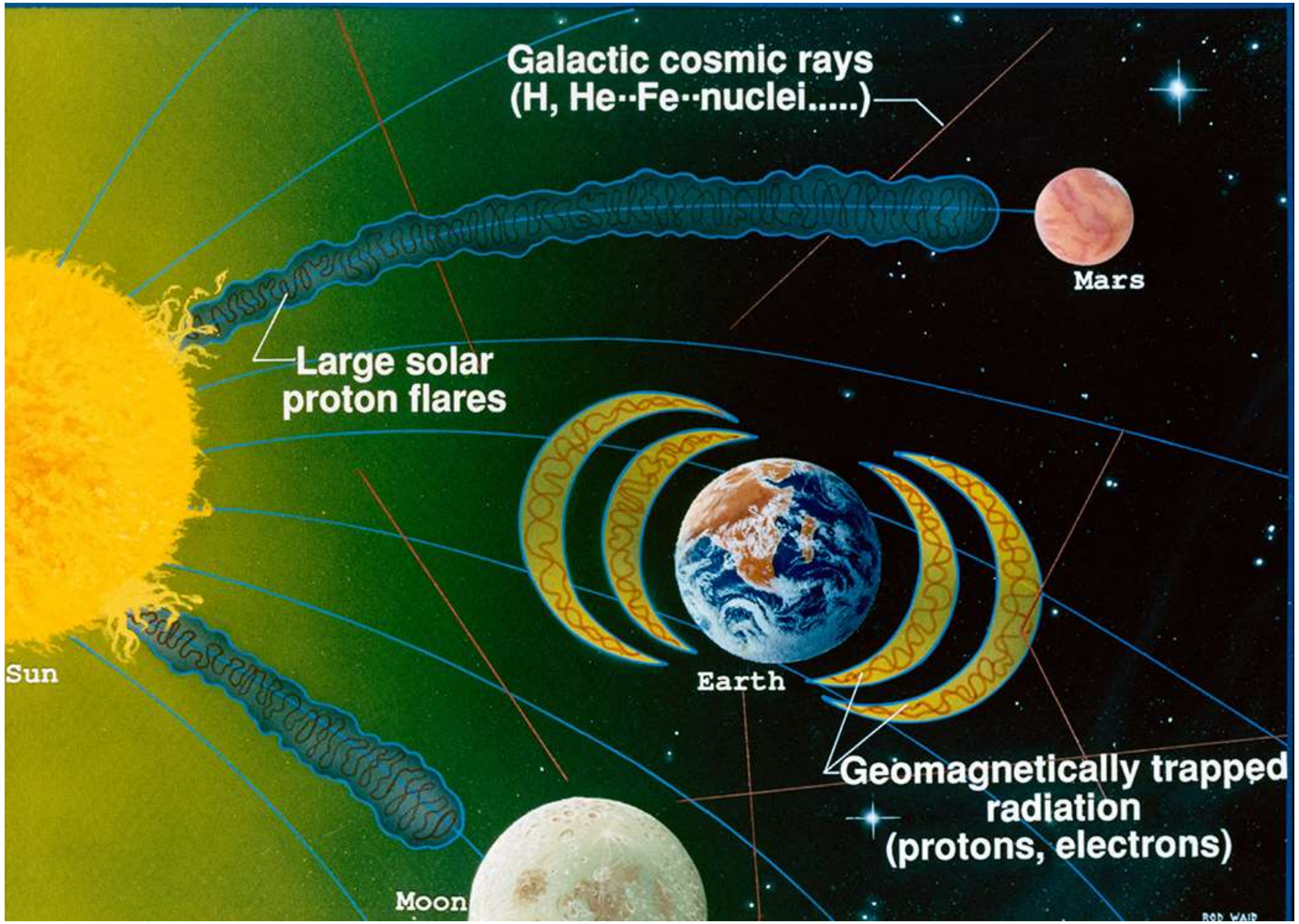
(courtesy of Professor Takayuki Hoson of Osaka City University)

MICROGRAVITY



RADIATIONS

- Galactic Cosmic Rays
- Extra-Galactic Cosmic Rays
- Jovian Electrons
- Trapped Particles
- Solar X-Rays
- Solar Flares: Neutrons, γRays, Protons, Heavy Ions



RADIATIONS

In general, the plants are more resistant to ionizing radiation, than animal organisms.

Lethal doses for animals can in fact have a positive or no effect on the plants.

Prolonged radiation exposure can completely destroy the fertility of plant and the plant gradually dies. Effects of Radiations in plants include Molecular Alterations, Morphological Alterations & Physiological Alterations.

SPATIAL PLANT SPECIES for Long Term Missions

The choice must combine many needs and constraints: high yield and high production of edible parts, fast production cycles, easy to reproduce, well growing without competition to coexist in multi-cropping systems, efficient photosynthesis and transpiration, able to acclimate to changes in light, temperature and humidity.

Main Characteristics: Reliable Germination, Low Native Microbial Level, Rich in Antioxidants.

Most suitable species under studies are Durum Wheat, Soft Wheat, Potatoes, Soy.

SPATIAL PLANT SPECIES for Dietary Intake

In order to better integrate the diet of astronauts with a fresh and highly nutritious food, we thought to use microgreens as they have a short cycle and high production yields, around 1000-1500 grams per square meter.

To meet the vitamin needs of an adult individual 50 grams of these are enough, while in the diet of an astronaut about 60-80 grams are needed thus integrating into the diet also powerful natural antioxidants such as anthocyanins.

SPATIAL PLANT SPECIES for Dietary Intake

EFSA's (European Food Security Authority) daily intake levels for an adult are:

- 90 mg for Vitamin C
- 13 mg for Vitamin E
- 70 µg for Vitamin K
- 0.57 mg for Vitamin A

SPATIAL PLANT SPECIES for Dietary Intake

Average values of concentration of Vitamin C, E, K and A

Nome	Specie	Produzione Kg/anno x mq	Peso Secco %	Contenuto Vitamina (mg/100 g PF)			
				C	E	K (µg/g)	A (mg RE/100g)
Amaranto g.	Amaranthus cruentus	17,5	9,3	131,6	17,1	4,1	1,48
Amaranto	Amaranthus hypocondriacus	17,5	9	114	15	3,6	1,43
Rucola	Eruca sativa	52,56	5,5	45,8	19,1	1,6	1,16
Basilico	Ocimum basilicum	13,4	7,3	90,8	24	3,2	1,02
Barbabietola	Chenopodiaceae	33,6	6,2	46,4	34,5	2	1,28
Sedano	Apium graveolens	14,6	6,8	45,8	18,7	2,2	0,93
Coriandolo	Coriandrum sativum	20,8	8,3	40,6	53	2,5	1,95

Nome	Specie	Produzione Kg/anno x mq	Peso Secco %	Contenuto Vitamina (mg/100 g PF)			
				C	E	K (µg/g)	A (mg RE/100g)
Crescione	Lepidium sativum	33,6	7,3	57,2	41,2	2,4	1,85
Senape rossa	Brassica juncea	37,5	5,7	62,2	22,1	1,9	1,06
Pisello	Pisum sativum	80	10,2	50	35	3,1	1,36
Ravanello	Raphanus sativus	72,9	8,1	70,7	87,4	1,9	1,05
Mizuna	Brassica rapa nipposinica	62,5	5,3	42	25	2	1,27
Cavolo rosso	Brassica oleracea v. capitata	40,4	7,7	147	24,1	2,8	1,92
Bietola rossa	Beta vulgaris	29,18	4,6	28,8	18,5	1,9	0,88

RE = Equivalent Retinol

1µg of RE = 1µg retinol = 6 µg β-carotene

THE MOON

Moon Village

Georgi I. Petrov, Daniel Inocente, Max Haney, Neil Katz, Colin Koop
Skidmore, Owings & Merrill LLP
Advenit Makaya, Marlies Arnhof, Hanna Lakk
European Space Agency, ESTEC
Aidan Cowley
European Astronaut Centre, EAC,
Claudie Haignere, Piero Messina
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Valentina Sumini, Joseph Paradiso
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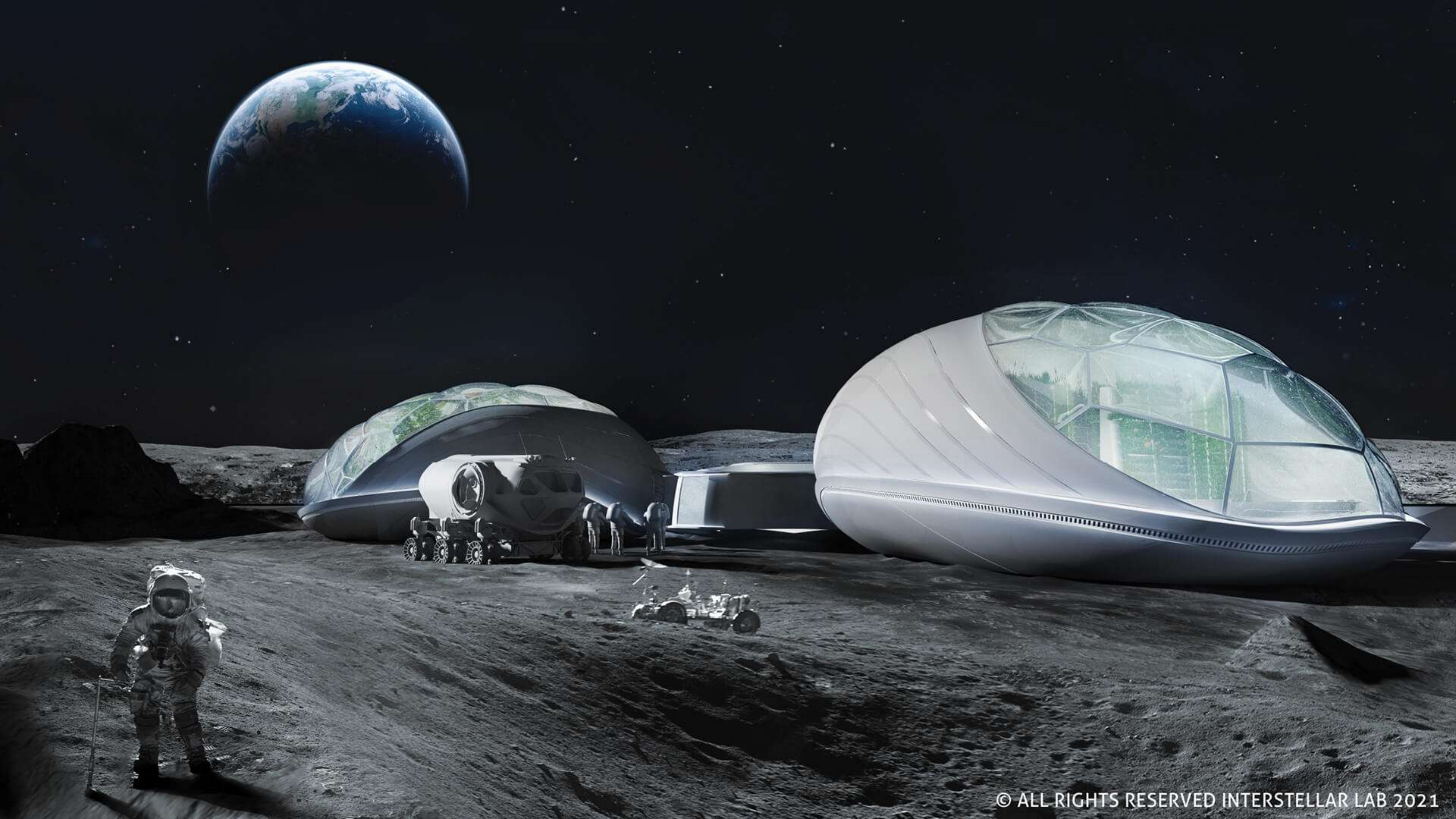
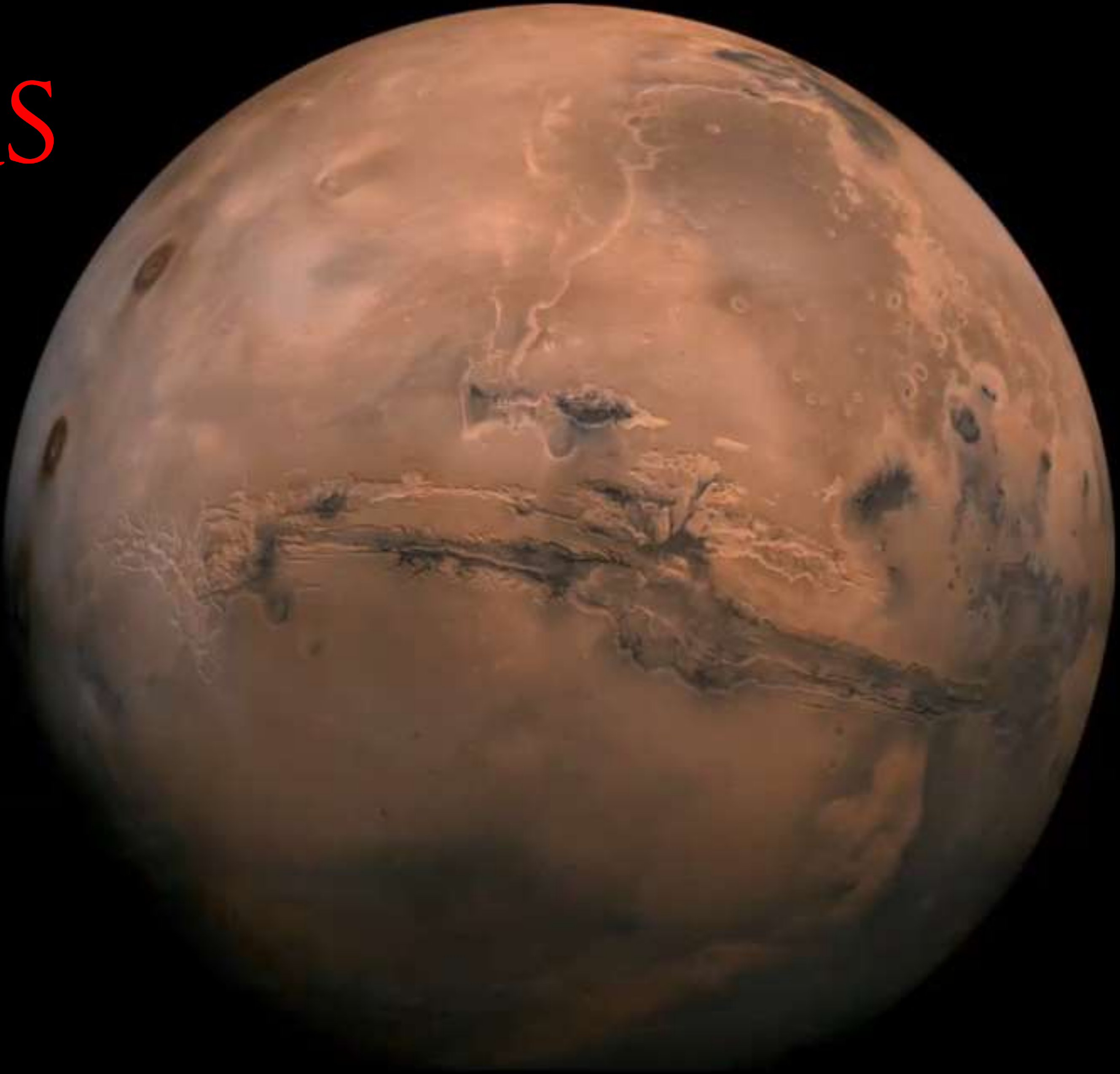
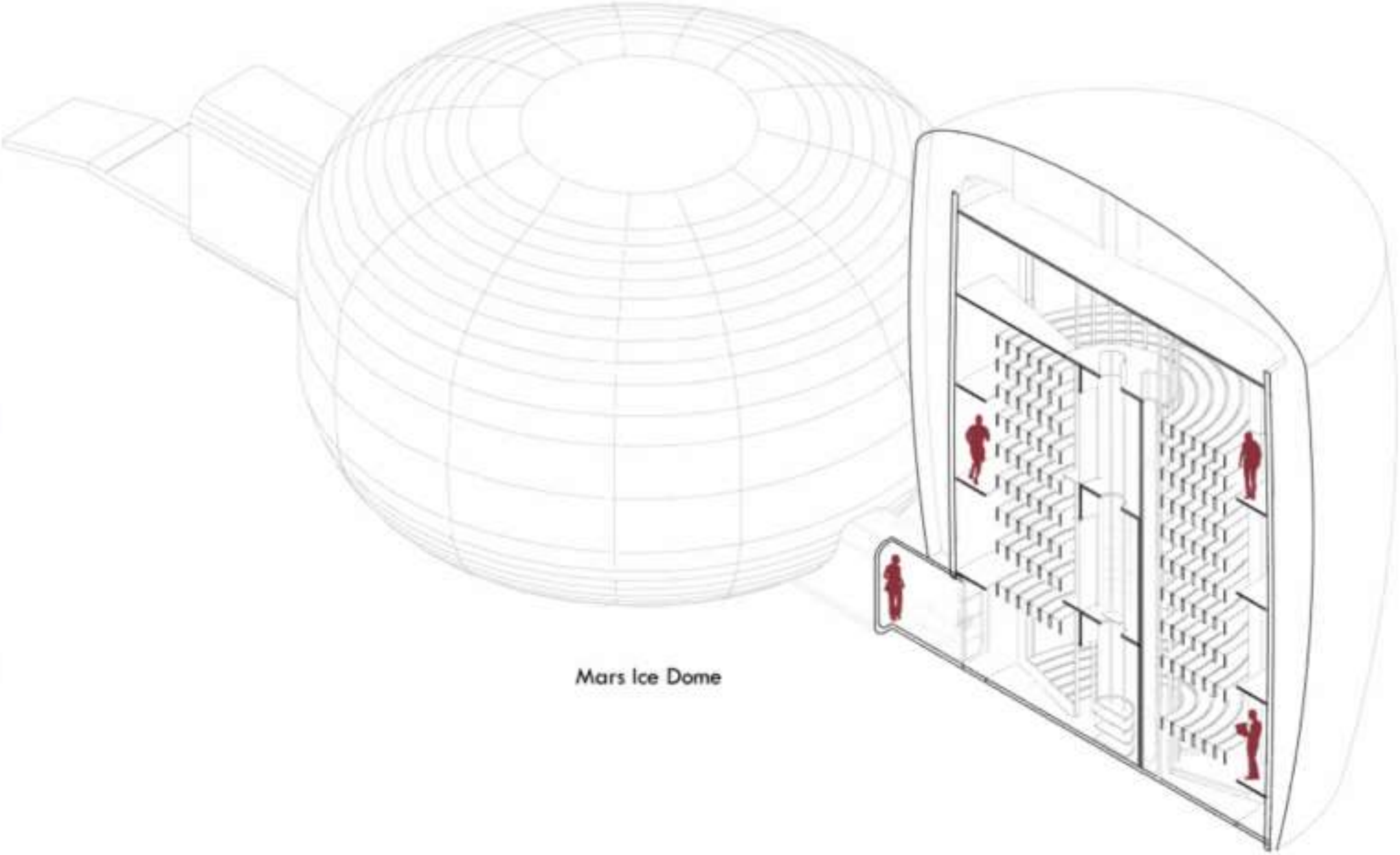
Jeffrey A. Hoffman
MIT Department of Aeronautics and Astronautics

Haney, Max; Inocente, Daniel; Katz, Neil; Petrov, Georgi I., Sumini V., et al. "Moon Village Reference Masterplan and Habitat Design." International Conference on Environmental Systems. Skidmore, Owings & Merrill LLP, 2019.



MARS





NASA BIG IDEAS CHALLENGE

Mars Greenhouse

PRESENTED BY THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

Eric Hinterman	Zhuchang Zhan
Natasha Stamler	Sam Seaman
Sheila Baber	Tajana Schneiderman
Hans Nowak	Joe Kusters

UNDER THE DIRECTION OF THE FOLLOWING ADVISORS:

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Doctor Vladimir Aerapetian	*Senior Astrophysicist*
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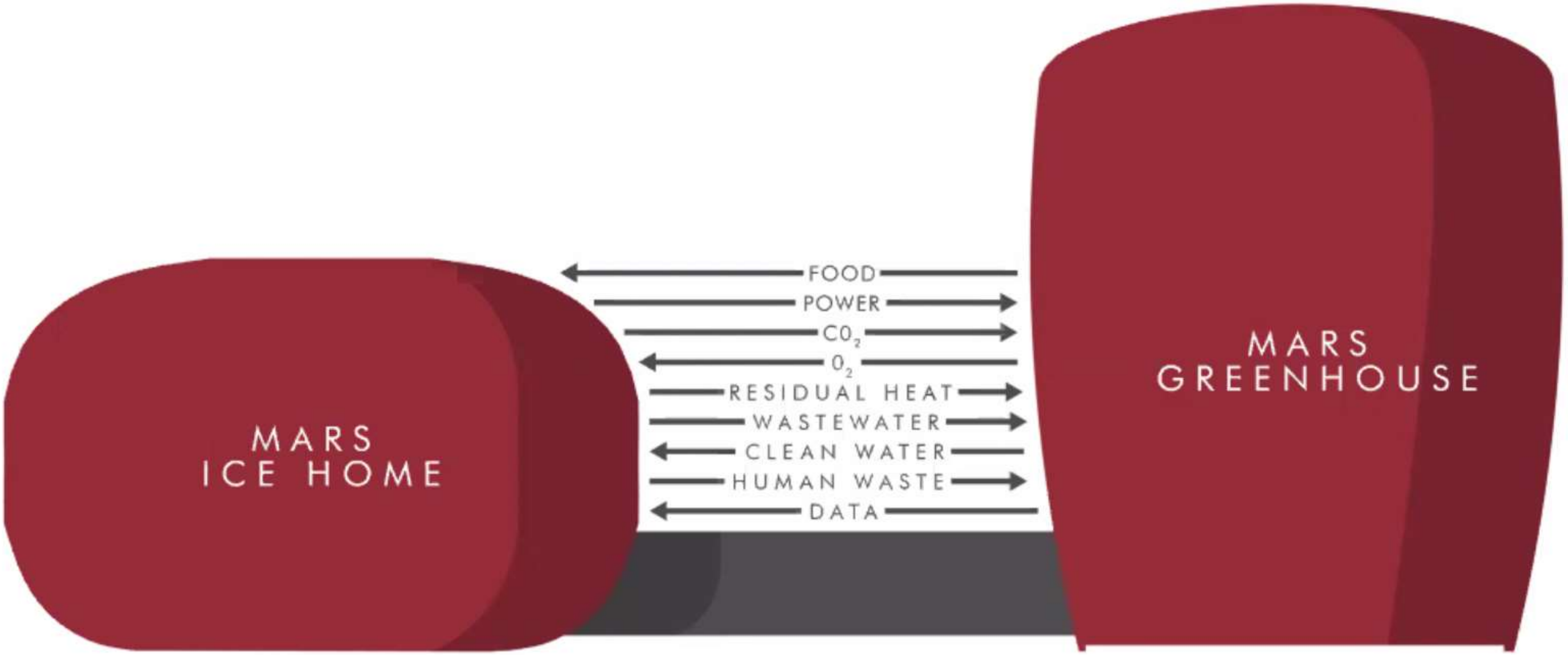
WITH SPECIAL THANKS TO:

Tommy Smith	Jana Lukic
Siranush Babakhanova	Samuele Sciarretta
Aldo Mazzia	George Lordos
Fabio Maffia	Ana Iris Correa Muler

BEAVER

BIOSPHERE ENGINEERED ARCHITECTURE FOR VIABLE EXTRATERRESTRIAL RESIDENCE



MARS ICE HOME

← FOOD
POWER →
CO_2 →
← O_2
RESIDUAL HEAT →
WASTEWATER →
← CLEAN WATER
HUMAN WASTE →
← DATA

MARS GREENHOUSE

HUMAN ACTIVITIES

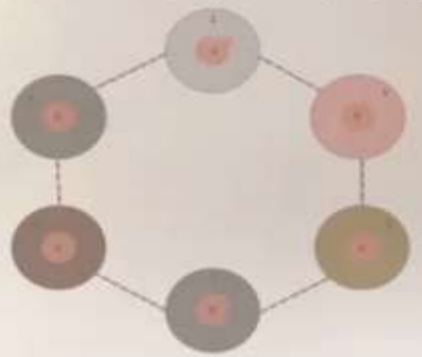
Sleep Hygiene Food Work Leisure

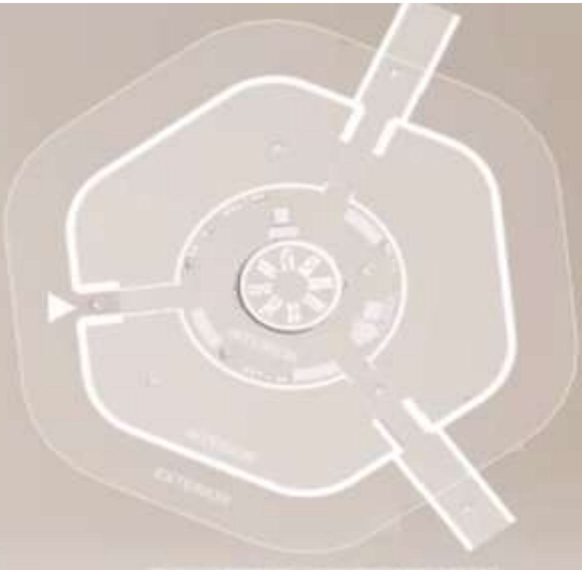
-OUR GOAL-

A manned long term mission with a 4 people crew to Mars is the goal. There, to explore efficiently and make discoveries that would utterly change the world. While our robotic missions accomplish remarkable and often astonishing things on Mars, they are precursors in exploration. Astronaut researchers on Mars will make discoveries and create stories that will be shared by all humankind for generations to come.

How we managed this activities in our project for 4 people?

1. Exercise and health	135 sqm	☐
2. Main lab and console	195 sqm	■
3. Food processing area sqm	195 sqm	■
4. Rover and exploration lab	195 sqm	■
5. Relaxing area sqm	190 sqm	■
6. Storage	40 sqm	■





General Plan - Rover & Exploration Lab

The External Layer + The Internal Layer

Building Strategy

1-Decent 2-Landing 3- WaSIBo Drop 4-Reservoir&House Deploy
5-Sinter Foundation 6-Inflate Membrane 8-Deploy Airlock 9-Printing Process

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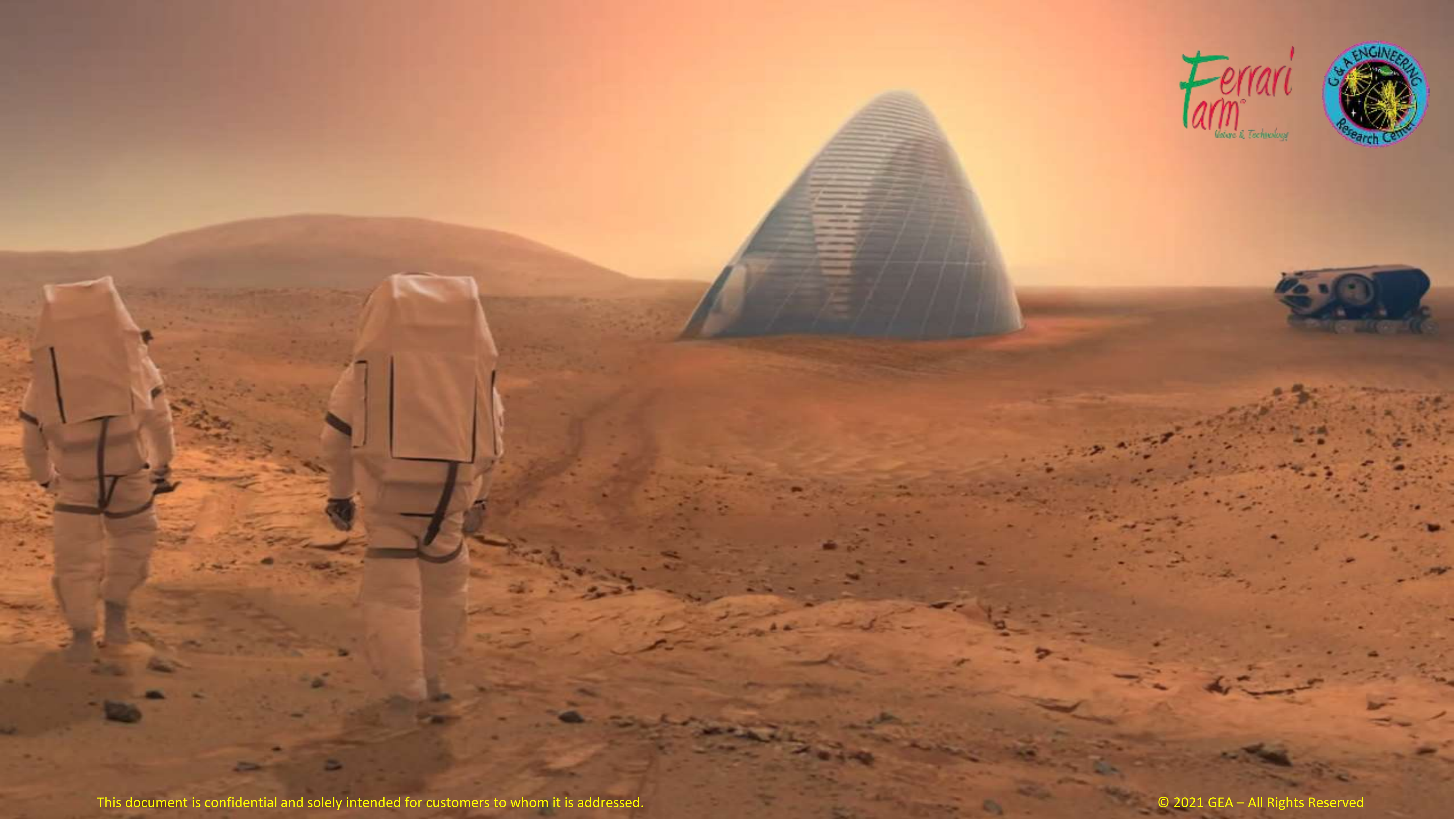

WHAT WE HAVE DONE

Design & Development of Ferrari Farm's Hydroponic Plant

Unique in Europe: Sterile, Selaed, Fully Computerized

2 glass greenhoused and 1 phytotrone LED Lighted


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WHAT WE HAVE DONE

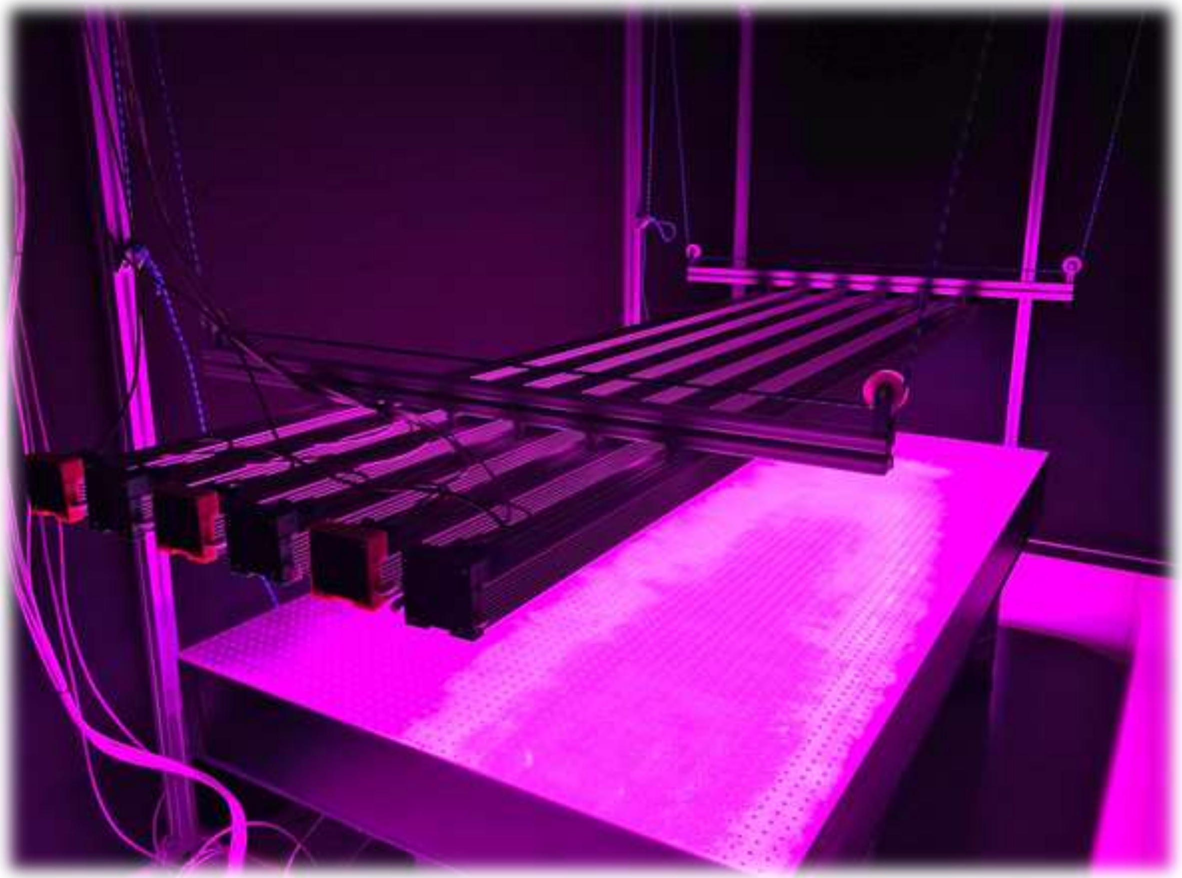
New Generation LED Lamp with Multispectral light.

Each wavelength is independently commanded and controlled

1.000 µmol m^{-2} s^{-1} @ 200 mm

NO Thermal Load in the cultivation area (Air & Liquid Thermal Dissipation)

1m and 3m versions



WHAT WE HAVE DONE

Design & Development of a Clean Room Vertical Farm for military purposes, to cultivate in extreme environments, inside a shelter.

Co-financed by the Italian Defense.

Endorsed by ASI and CNR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WHAT WE ARE DOING

The goal of the SOLE project is the definition of an artificial hydroponic cultivation system to be used as a demonstrator on Earth of a future space greenhouses.

It is realized a completely artificial environment suitable for plants to grow.

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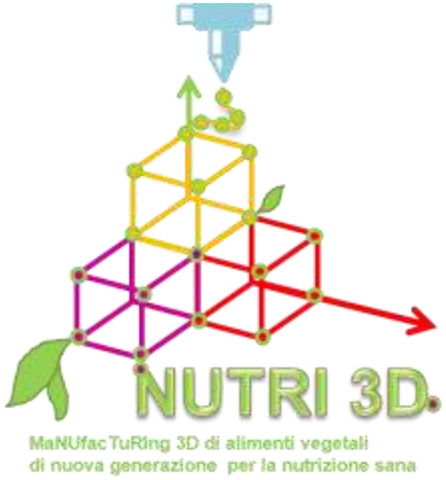
REGIONE
LAZIO

G & A ENGINEERING - ENEA BIOAG - ASI
SOLE

WHAT WE ARE DOING

NUTRI3D

The goal of NUTRI 3D is to study "the food of the future" with a production process that uses 3D printing technology for a new idea of designing healthy and natural dietary/nutritional foods, personalized for special nutritional needs or for health-related needs or simply for a normal diet.



THERE'S NO WAY WE CAN LEAVE EARTH WITHOUT THE PLANTS