The Role of Plants in Space Exploration:

Some History and Background

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Human Life Support Requirements:

Inputs

	Daily Rqmt.	(% total mass)
Oxygen	0.83 kg	2.7%
Food	0.62 kg	2.0%
Water (drink and food prep.)	3.56 kg	11.4%
Water (hygiene, flush laundry, dishes)	26.0 kg	83.9%
TOTAL	**31.0 kg**	

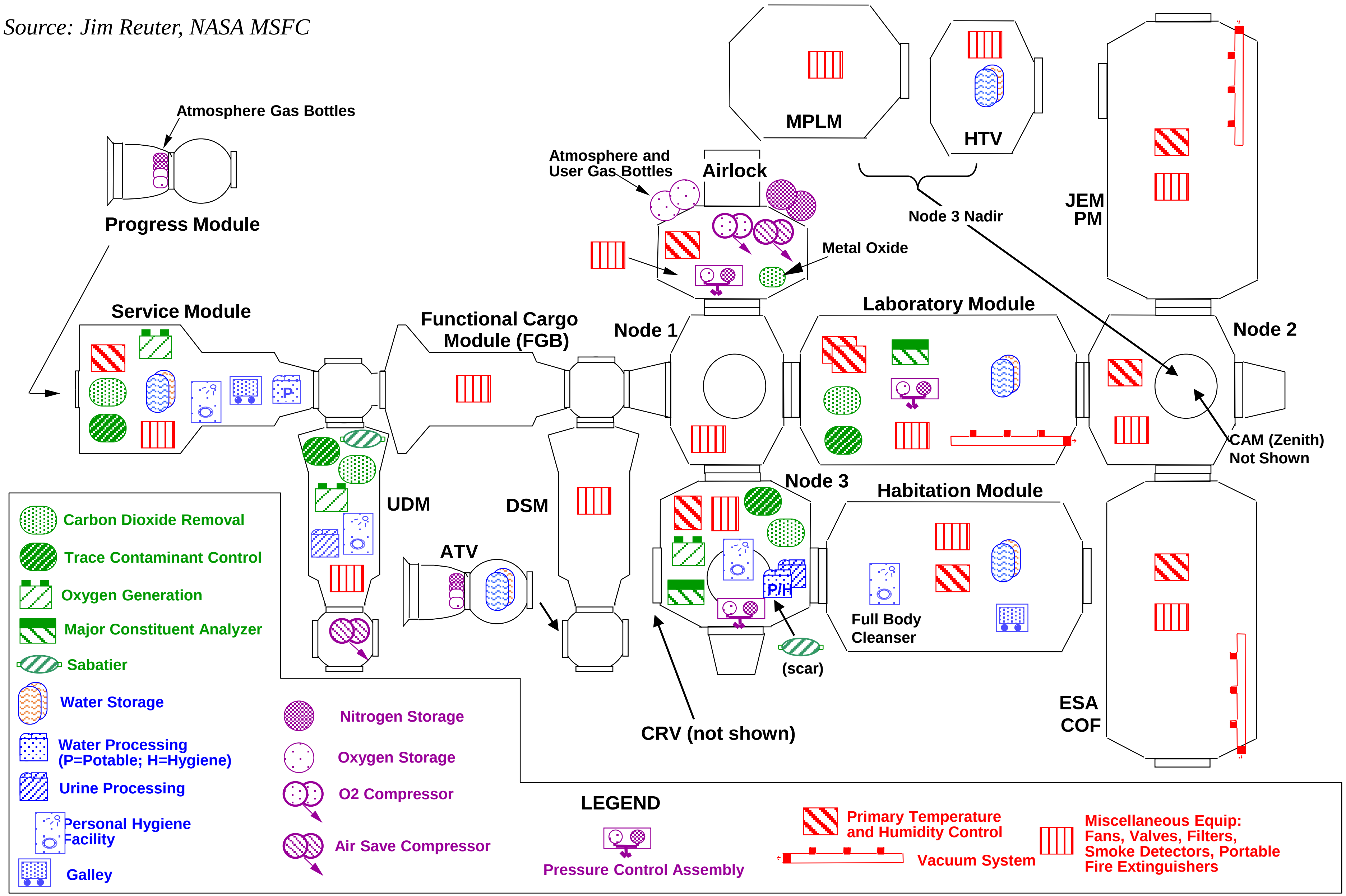
Outputs

	Daily	(% total mass)
Carbon dioxide	1.00 kg	3.2%
Metabolic solids	0.11 kg	0.35%
Water	29.95 kg	96.5%
(metabolic / urine		12.3%)
(hygiene / flush		24.7%)
(laundry / dish		55.7%)
(latent		3.6%)
TOTAL	**31.0 kg**	

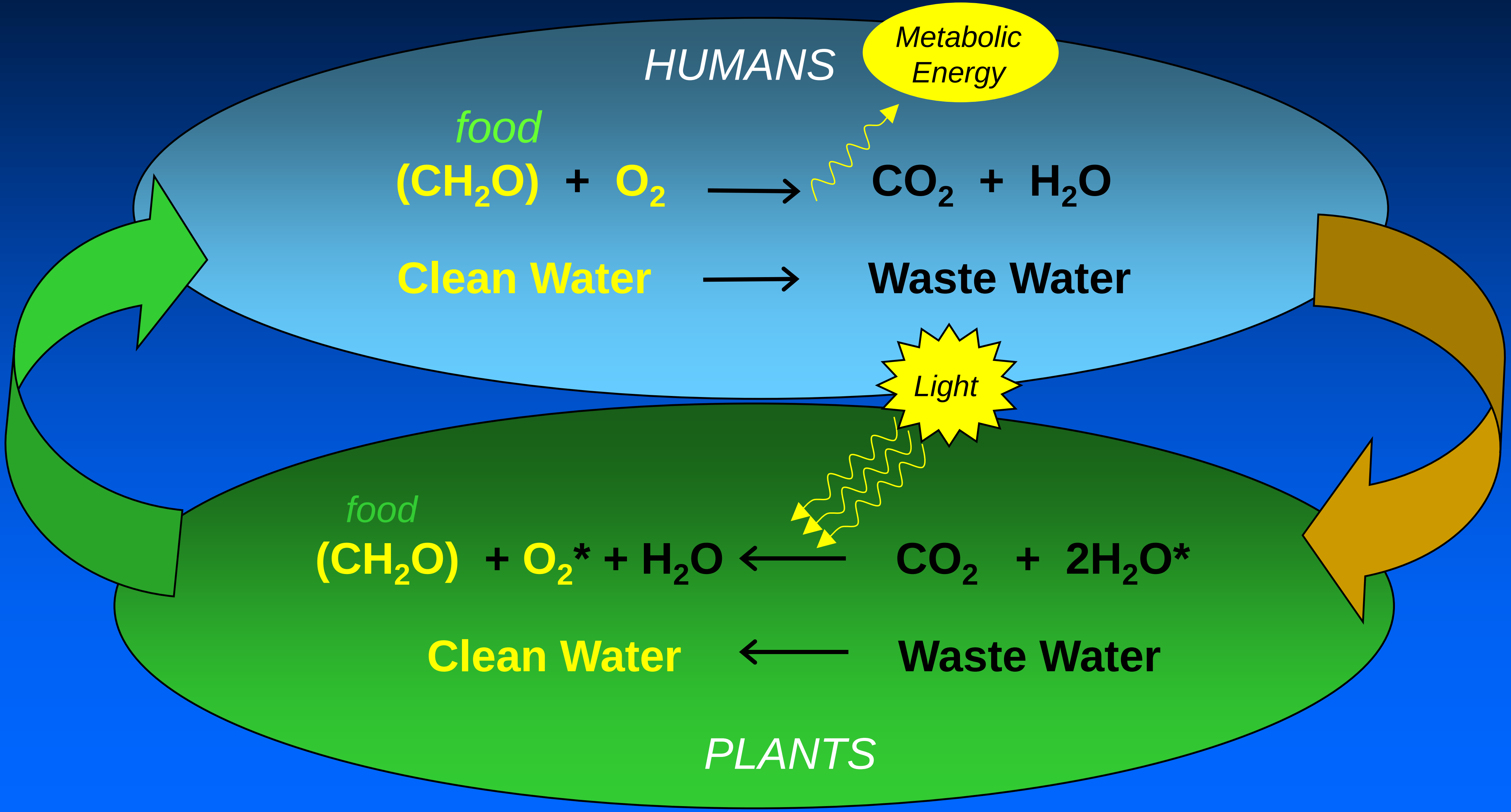
Source: NASA SPP 30262 Space Station ECLSS Architectural Control Document
Food assumed to be dry except for chemically-bound water.

International Space Station Life Support Systems

Source: Jim Reuter, NASA MSFC



Plants in Space for Life Support



Bioregenerative Life Support

Early references:

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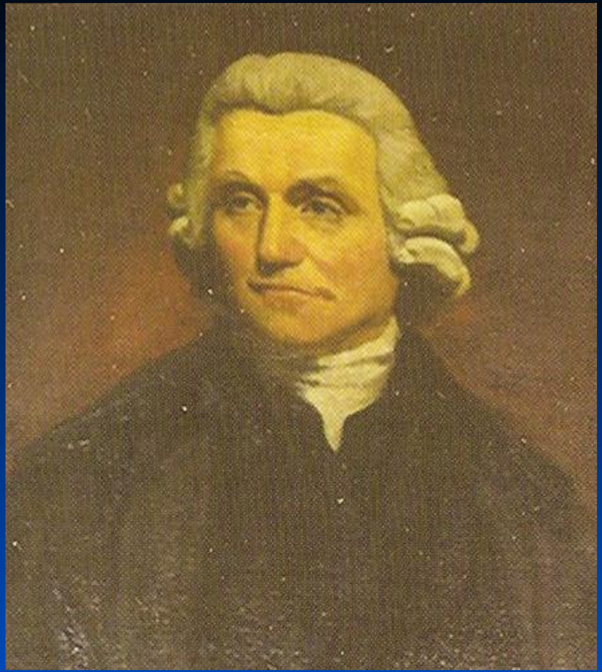
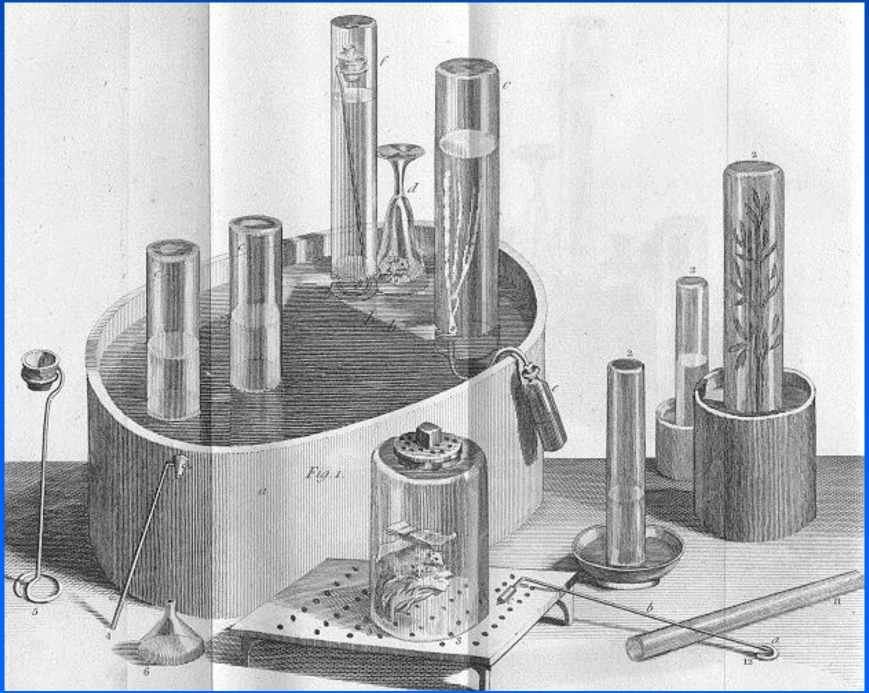


Joseph Priestley--1772

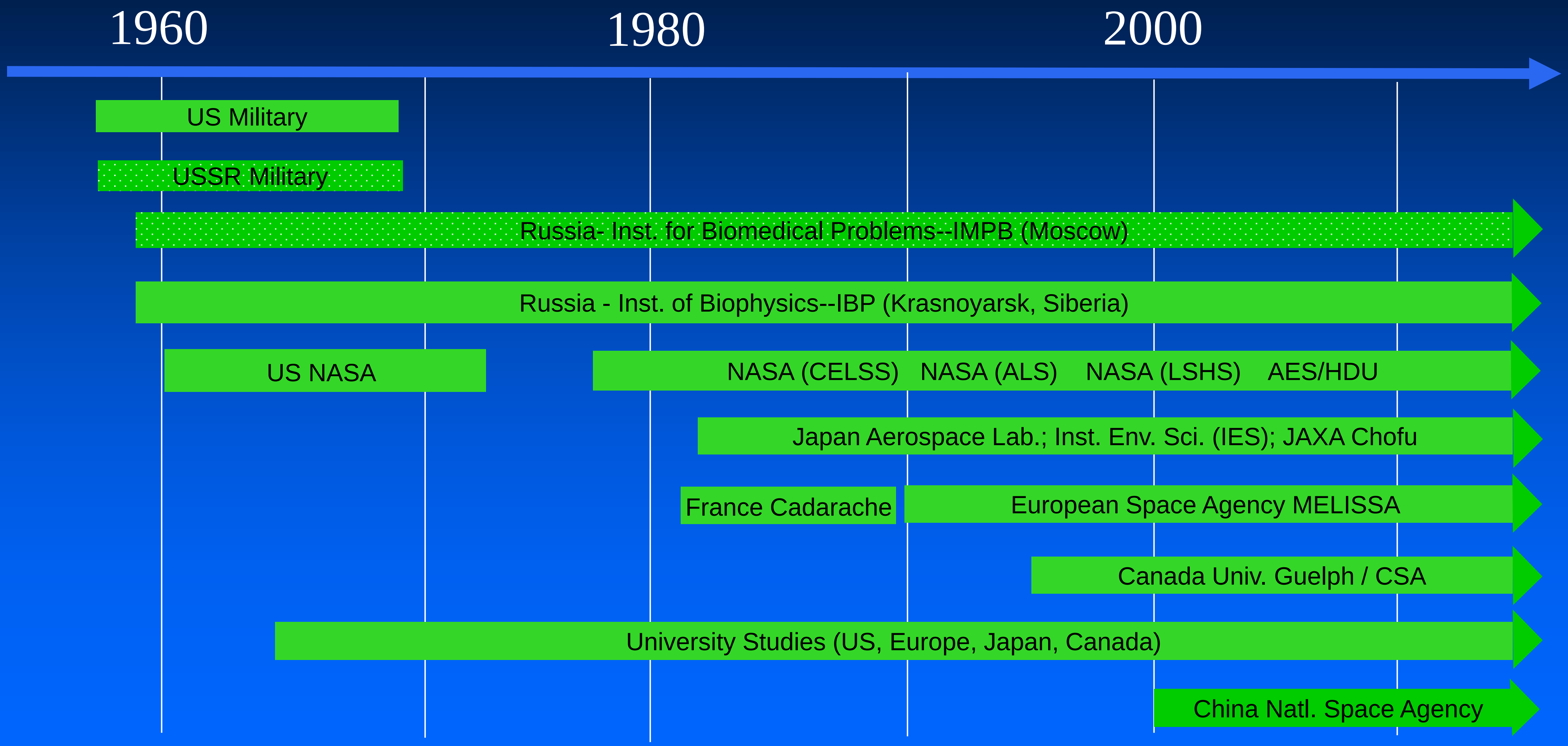
“Patron Saint” of Bioregenerative Life Support ?

“ I have been so happy as by accident to hit upon a method of restoring air, which has been injured by the burning of candles and I have discovered at least one of the restoratives...it is vegetation ”



“...when I first put a sprig of mint into a glass jar standing inverted in a vessel of water; it had continued growing for some months [and] I found that the air would neither extinguish a candle, nor was it at all inconvenient to a mouse...”

Bioregenerative Life Support Testing Around the World

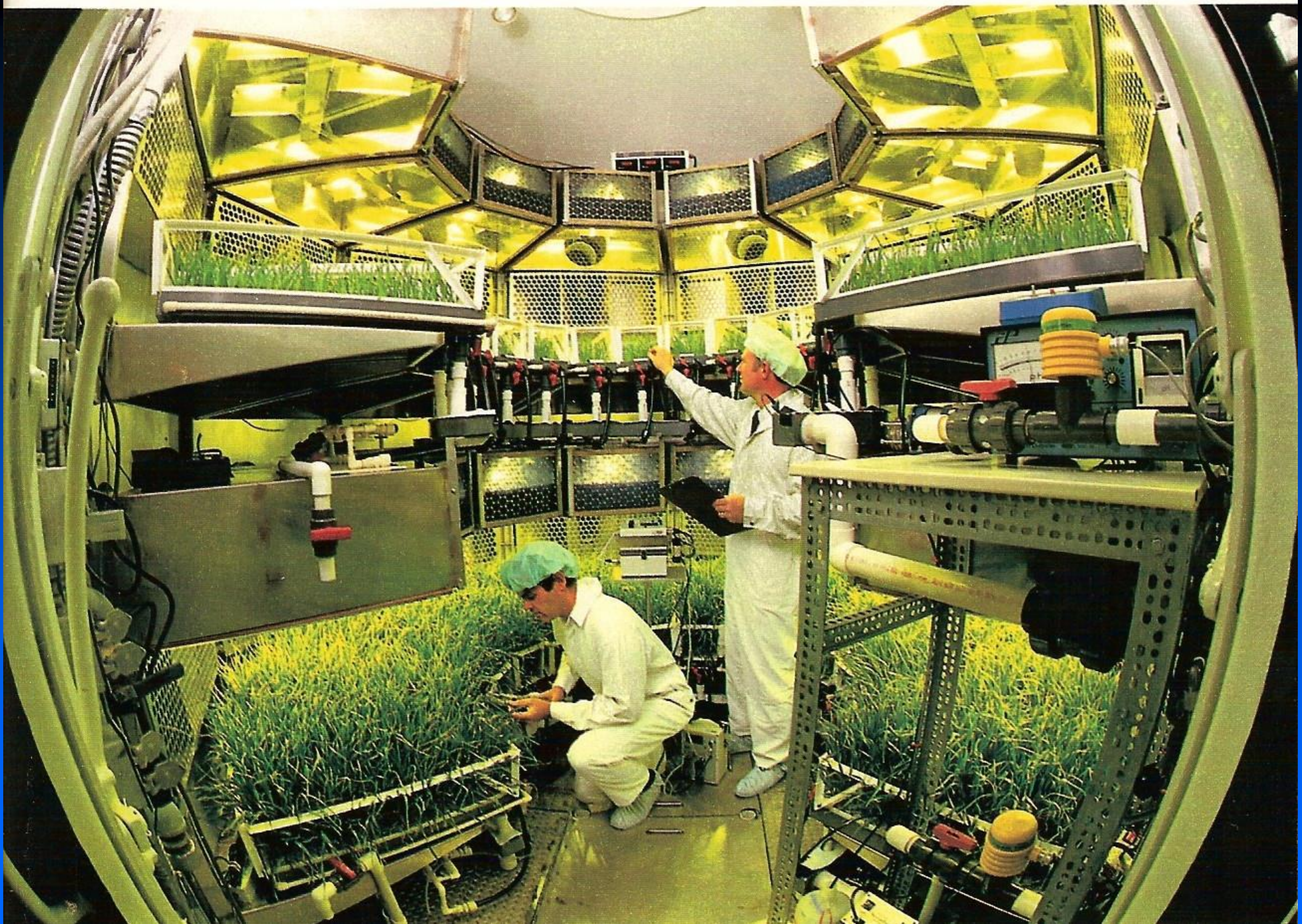


Crop Considerations for Space

- High yielding and nutritious
- High harvest index (edible / total biomass)
- Horticultural considerations
  - planting, watering, harvesting, pollination, propagation
- Environmental considerations
  - lighting, temperature, mineral nutrition, CO_2
- Processing requirements
- Dwarf or low growing types
- Cultural preferences for food

NASA's Biomass Production Chamber (BPC)

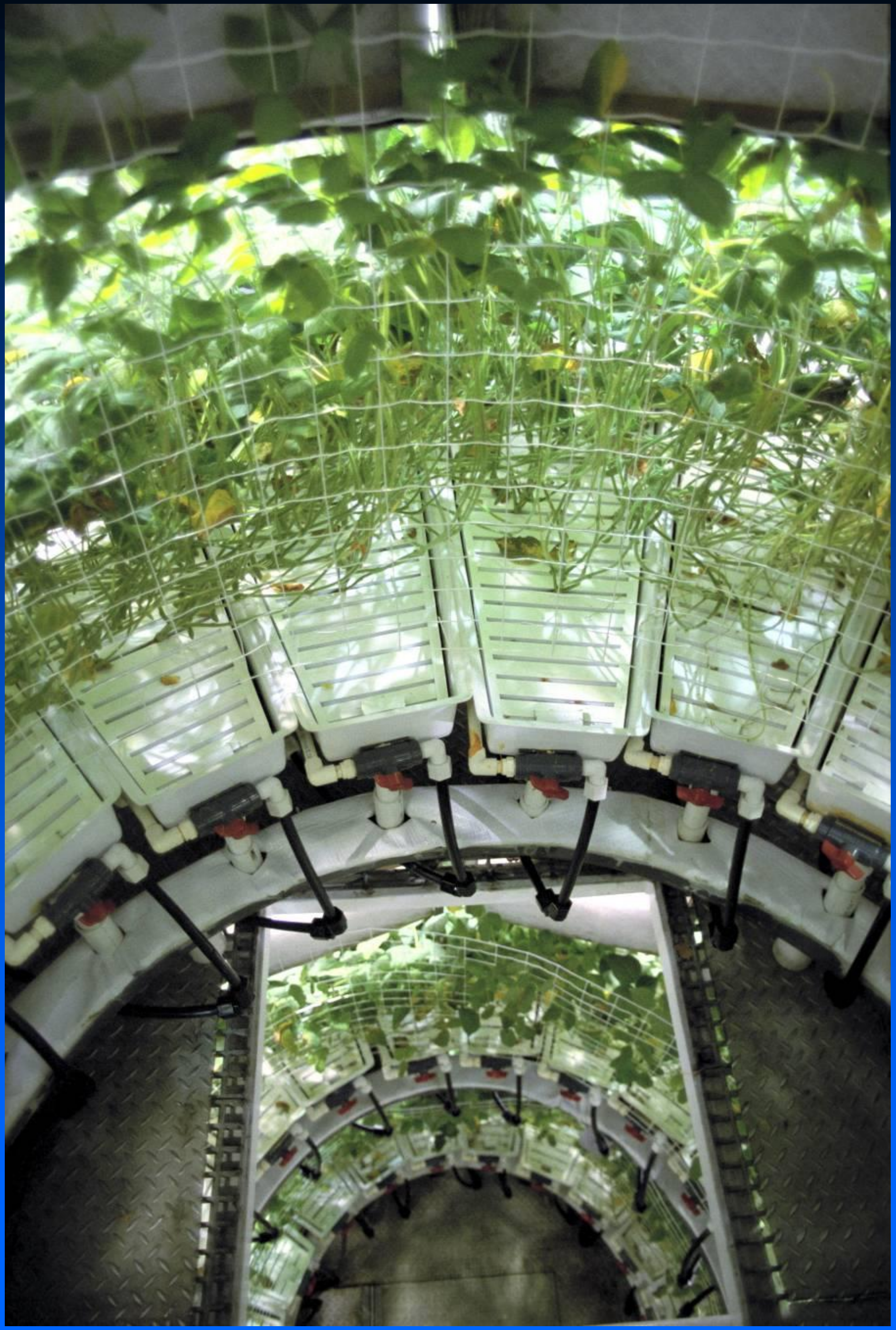
20 m^2 growing area; 113 m^3 vol.; 96 400-W HPS Lamps;
400 m^3 min^{-1} air circulation; two 52-kW chillers



Wheat

(Triticum aestivum)

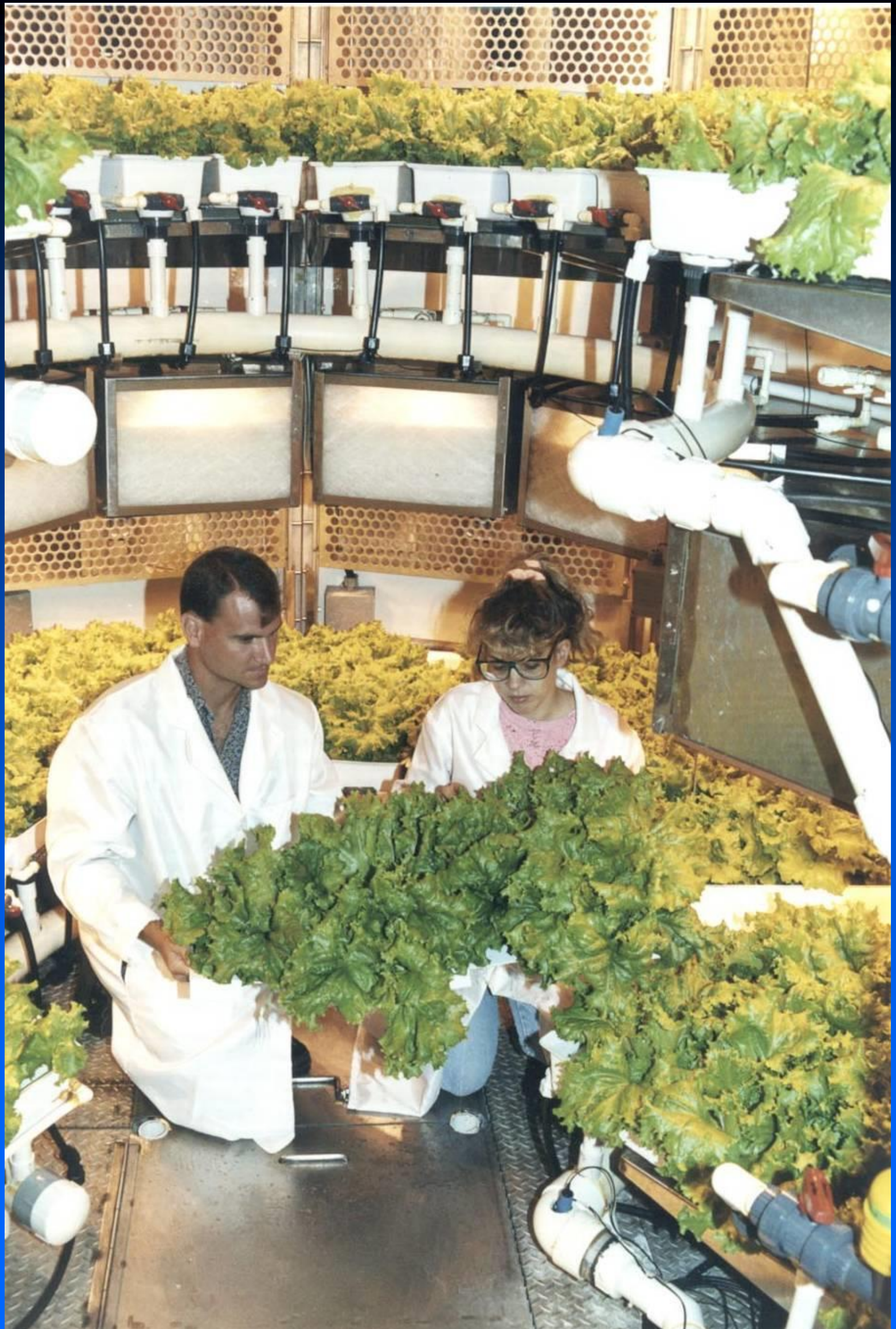
harvest



Soybean

(Glycine max)

Lettuce *(Lactuca sativa)*

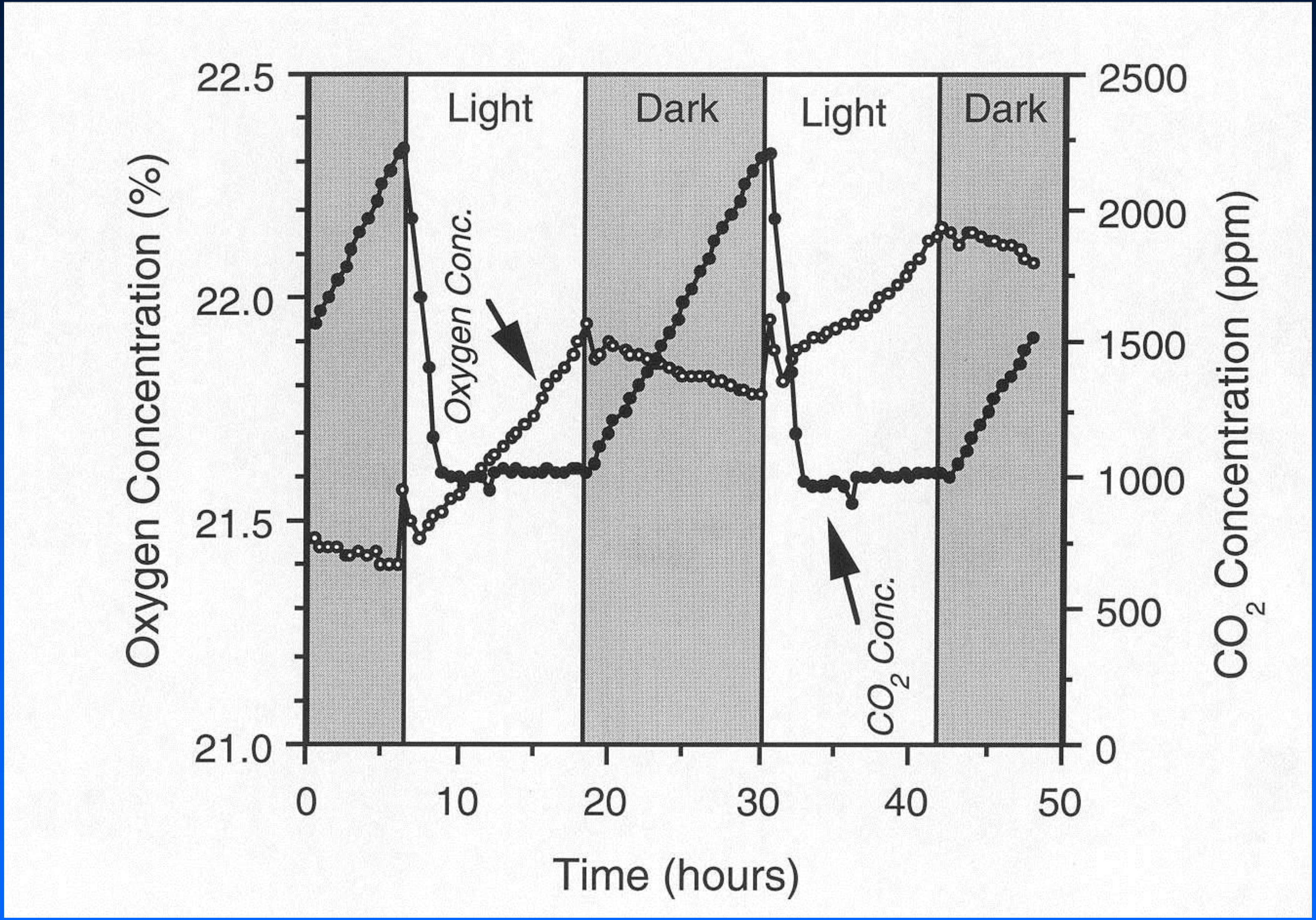


Potato

(Solanum tuberosum)

Closed System CO_2 Uptake / O_2 Production

(20 m^2 Soybean Stand)



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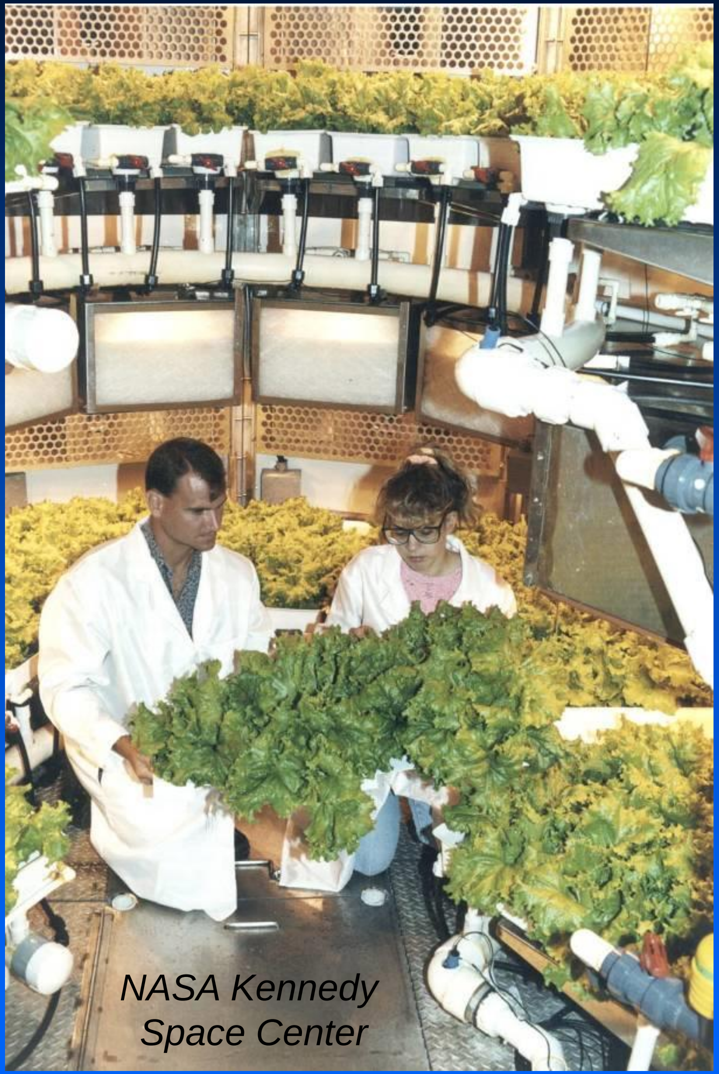
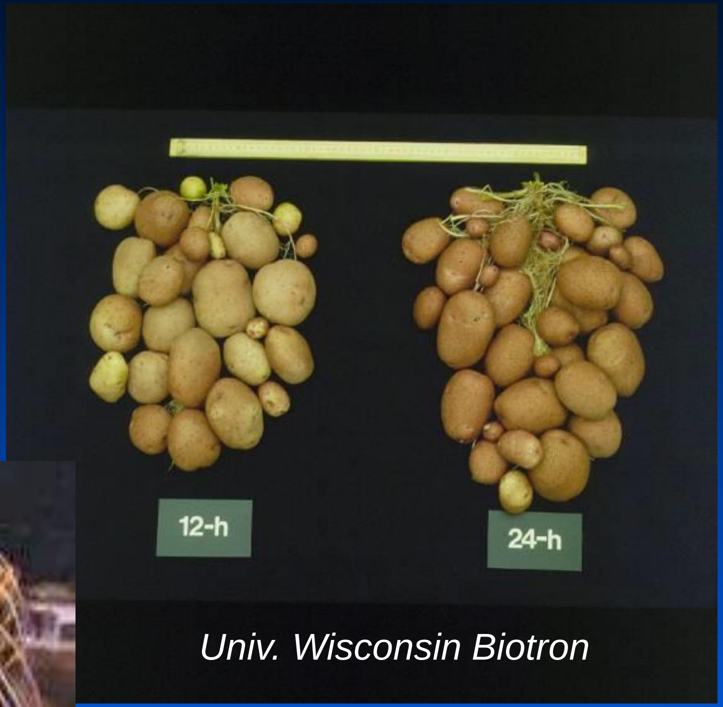
High Yields from High Light and CO_2 Enrichment



Wheat - 3-4 x World Record
Potato - 2 x World Record
Lettuce-Exceeded Commercial Yield Models



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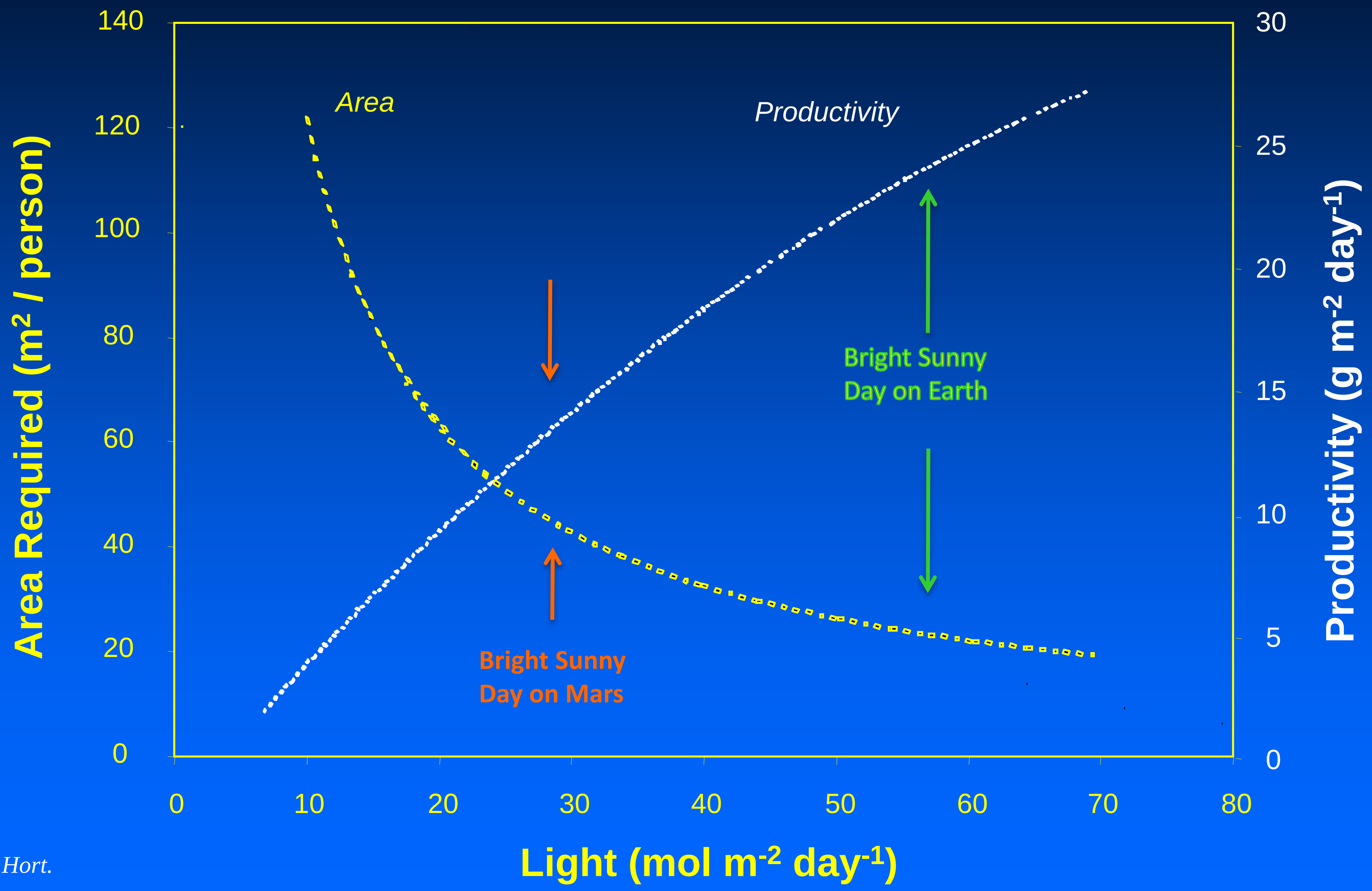
Light, Productivity, and Crop Area Requirements



Wheeler. 2004. Acta Hort.

Integrated Testing with Humans
→ *One Human and 11 m^2 of Wheat !*

Nigel Packham, NASA Johnson Space Center

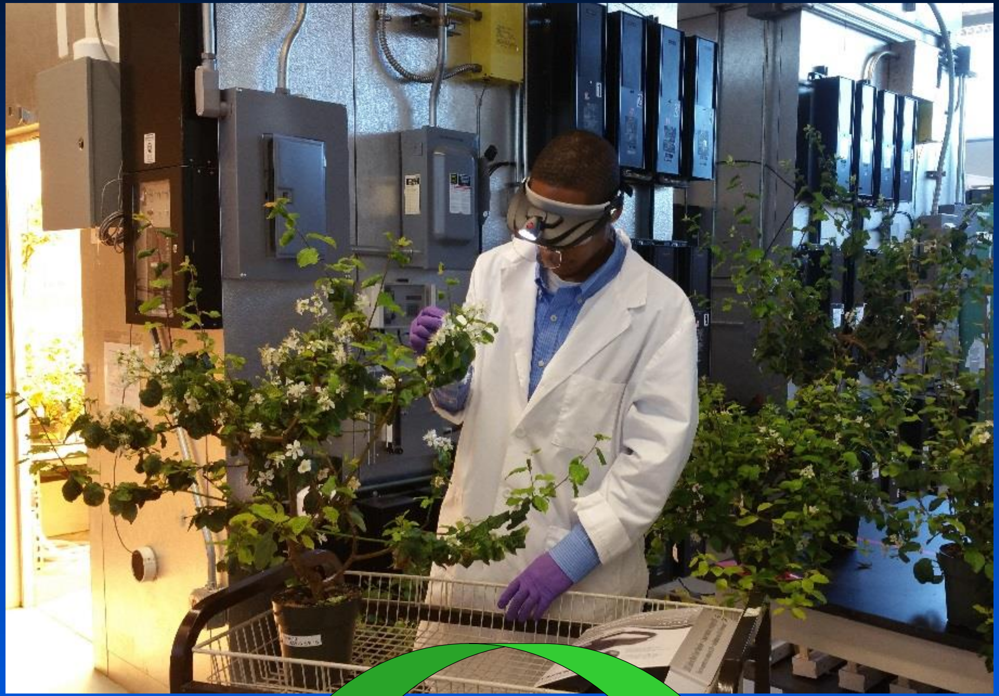
Metrics for Assessing Space Life Support Technologies

- Mass
- Power
- Volume
- Crew Time
- Concept of Equivalent System Mass or ESM

"Intangible" Aspects of Plants in Remote Environments; Biophilia?

(Photo from US South Pole Plant Chamber)

Novel Crops for Space



Dwarf plums with over-expressed FT flowering gene (USDA / ARS)

Current Estimates for Plants and Life Support (for one person)

- < 5 m^2 for drinking and hygiene water
- 20 - 25 m^2 for O_2 requirements and CO_2 removal
- 40 - 50 m^2 for food (2500 kcal day^{-1})

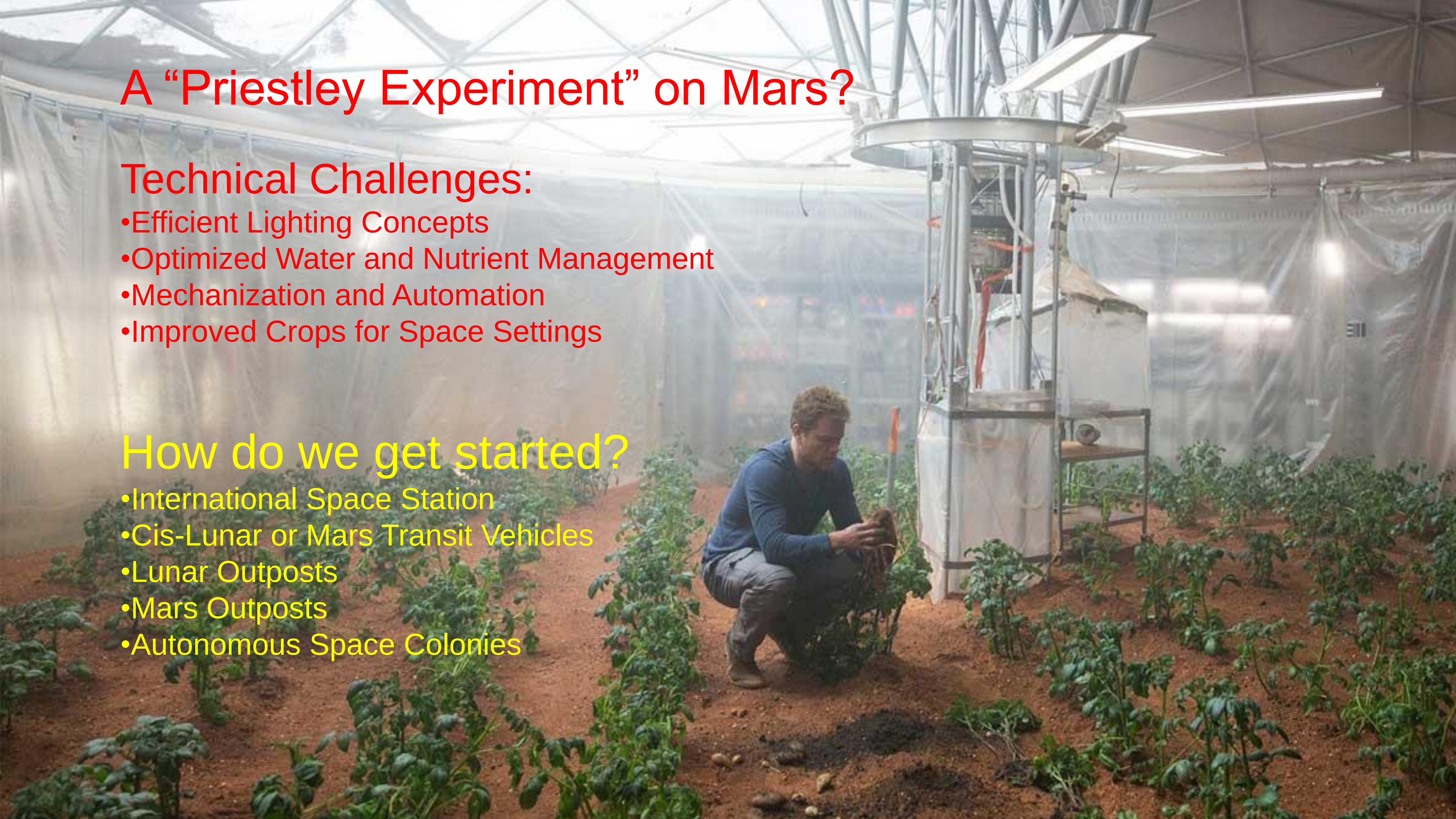
A “Priestley Experiment” on Mars?

Technical Challenges:

•Efficient Lighting Concepts
•Optimized Water and Nutrient Management
•Mechanization and Automation
•Improved Crops for Space Settings

How do we get started?

•International Space Station
•Cis-Lunar or Mars Transit Vehicles
•Lunar Outposts
•Mars Outposts
•Autonomous Space Colonies




Thank You !
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Florida