Kick Off Greenport Hub
Berkel en Rodenrijs
22/06/17

SPACE FARMING

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TU Delft | IPStar | LIQUIFER | SEAD

HI-SEAS Mission 1, Mauna Loa, Hawai'i, 2013

HI-SEAS Mission 1, Mauna Loa, Hawai'i, 2013

Photos by Sian Proctor & Yajaira Sierra Sastre

Astronaut food, Mercury, NASA, 1958-1963

Space food, International Space Station, today

HI-SEAS Mission 1, Mauna Loa, Hawai'i, 2013

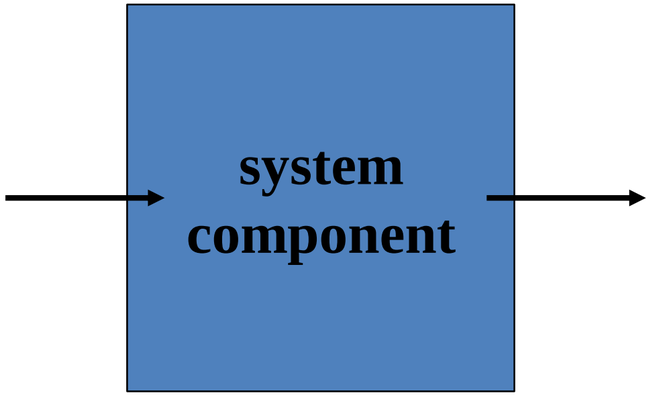
Photos by Sian Proctor

HI-SEAS Mission 1, Mauna Loa, Hawai'i, 2013

4KWALLPAPERS.ORG

Today

“Juvenile” life support system

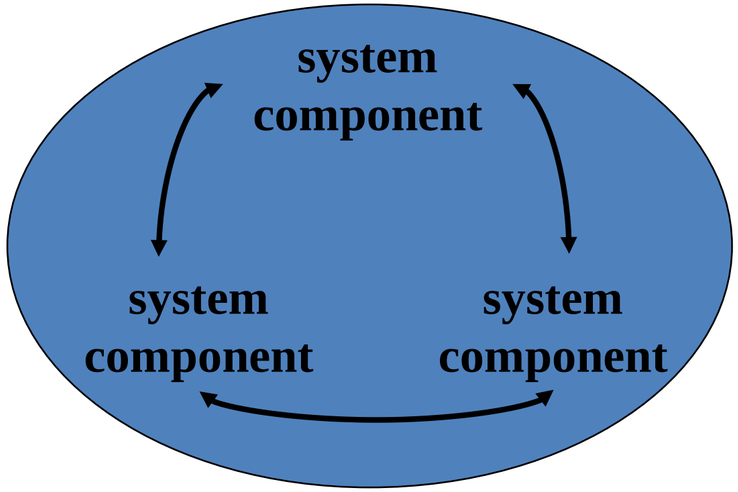


Unlimited Resources

Unlimited Waste

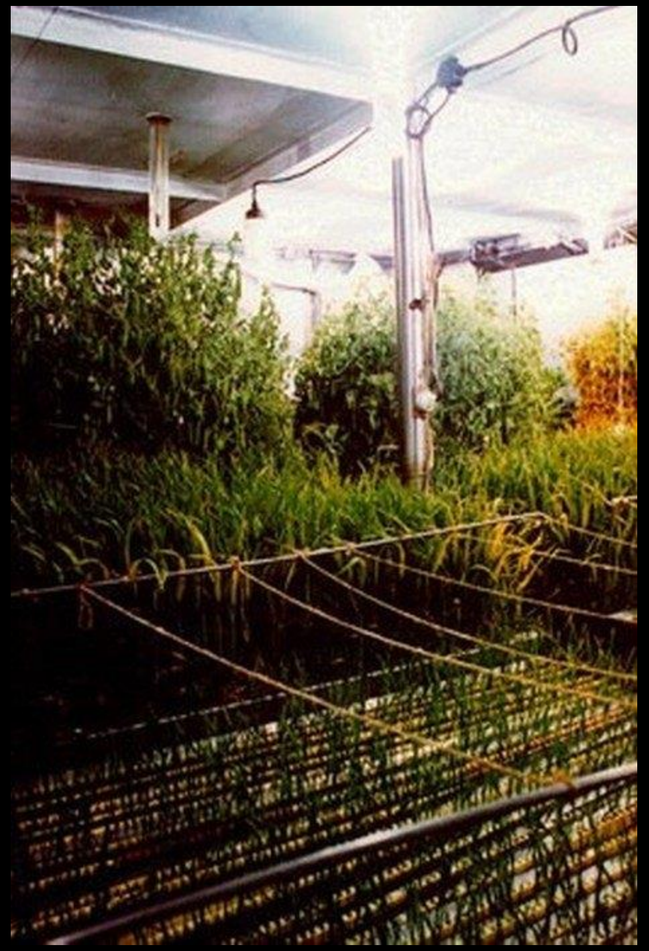
Tomorrow

“Mature” life support system

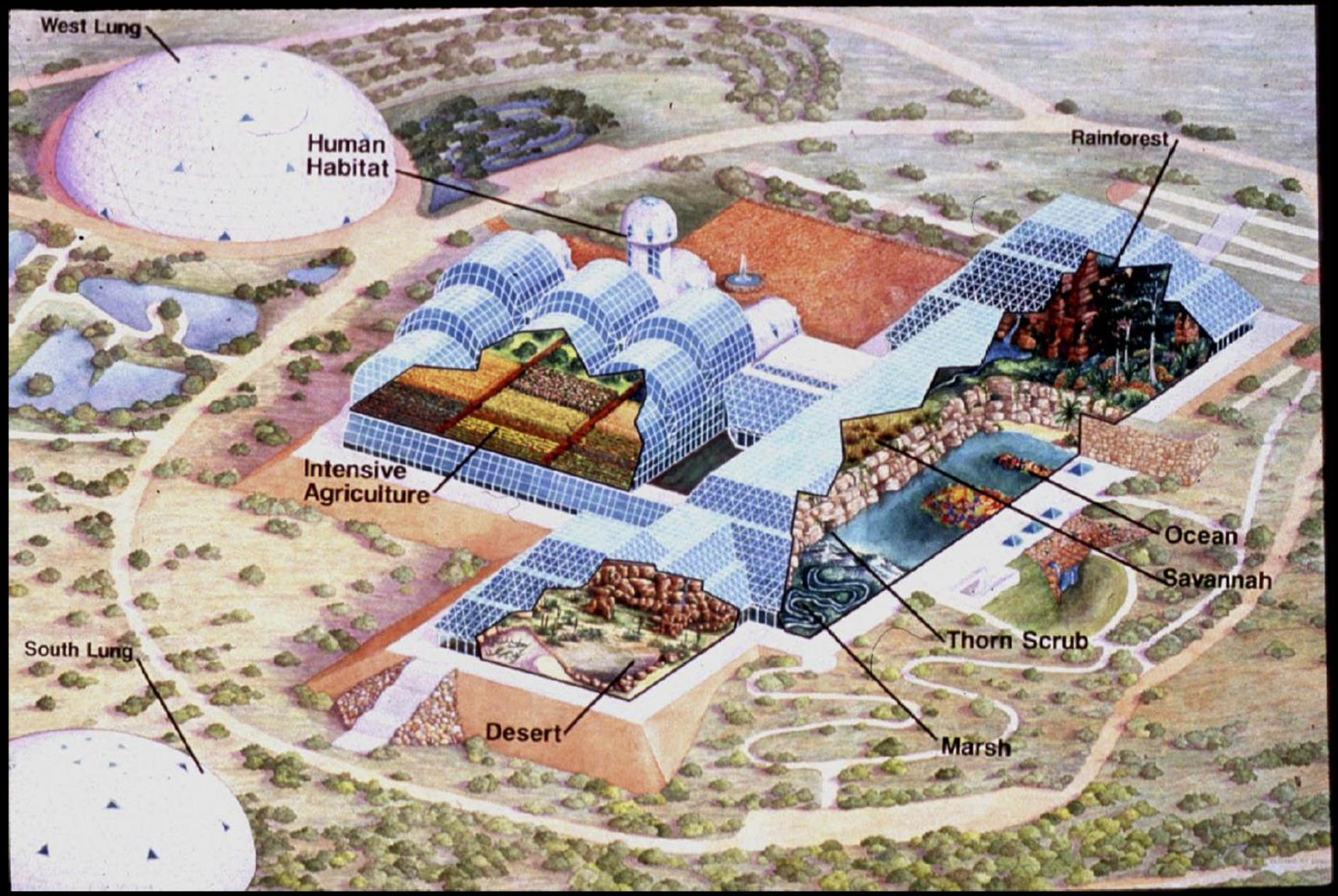


- **Low consumption of resources**
- **Quasi-cyclical flows of materials**

BIOS-3, USSR, 1965-(ongoing)

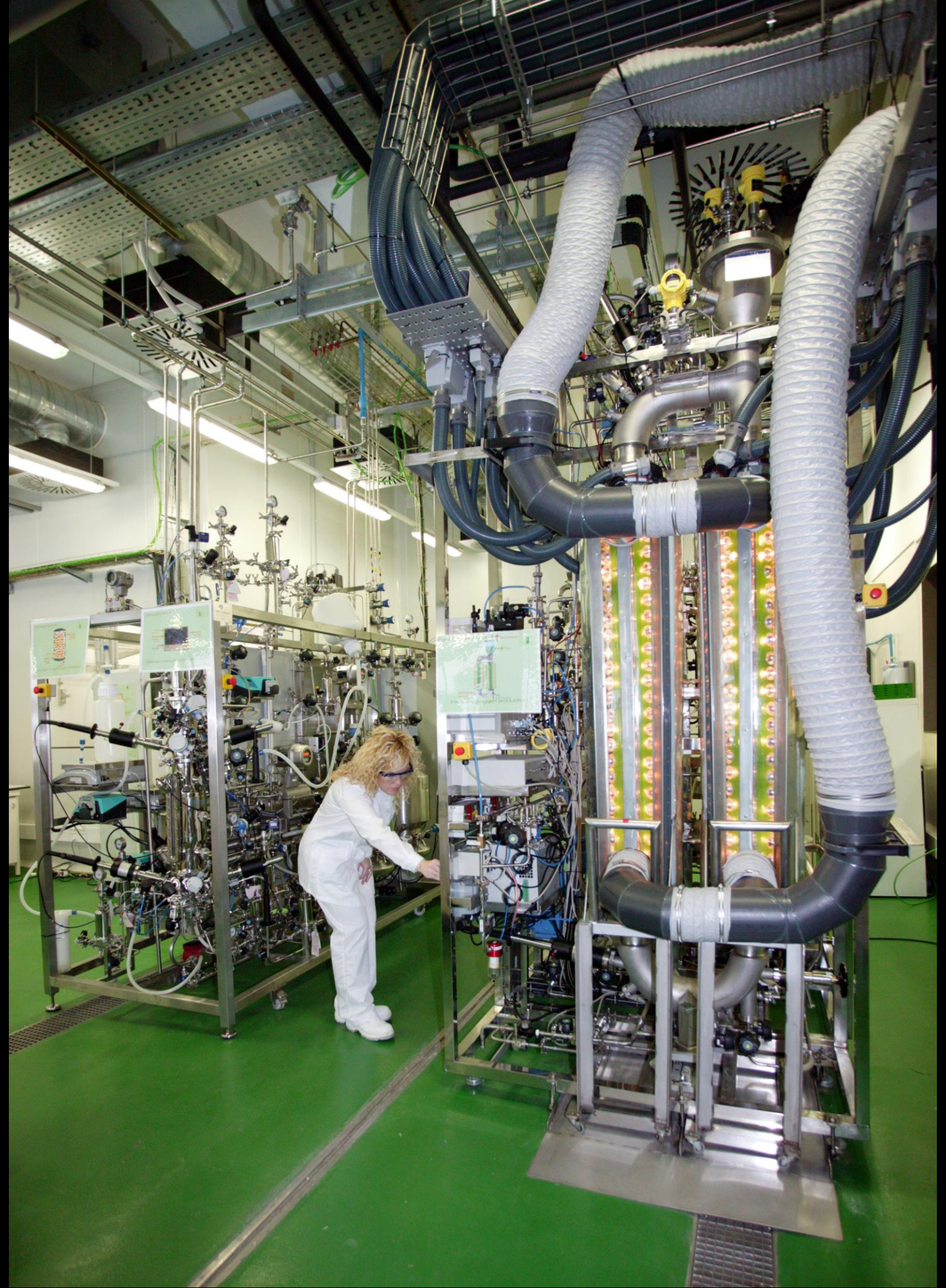


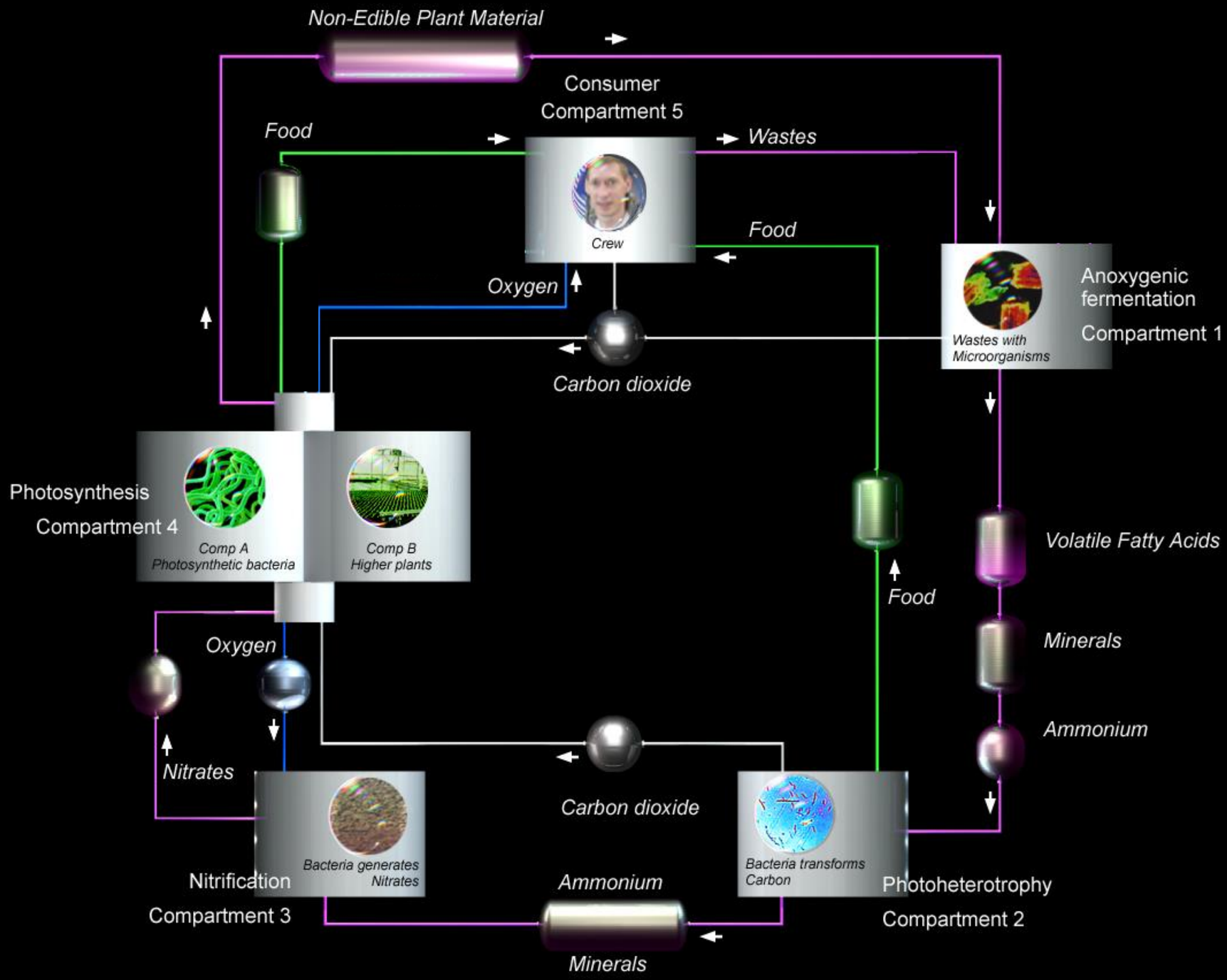
BIOS-3, USSR, 1965-(ongoing)



Biosphere 2, Arizona, 1991-1994

Biosphere 2, Arizona, 1991-1994



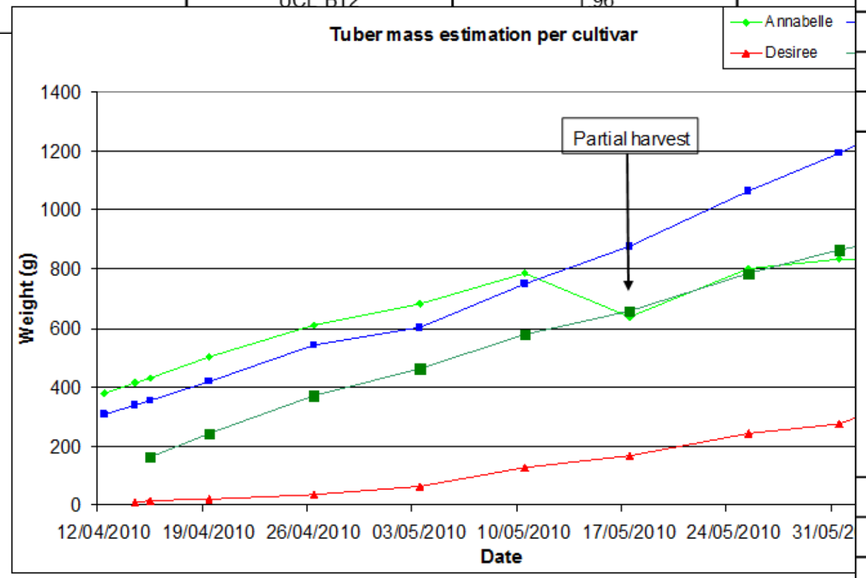

Non-Edible Plant Material
Consumer
Compartment 5
Food
Wastes
Crew
Food
Oxygen
Anoxygenic
fermentation
Compartment 1
Wastes with
Microorganisms
Carbon dioxide
Photosynthesis
Compartment 4
Comp A
Photosynthetic bacteria
Comp B
Higher plants
Volatile Fatty Acids
Food
Minerals
Oxygen
Ammonium
Nitrates
Carbon dioxide
Bacteria generates
Nitrates
Bacteria transforms
Carbon
Nitrification
Compartment 3
Ammonium
Photoheterotrophy
Compartment 2
Minerals

Challenges

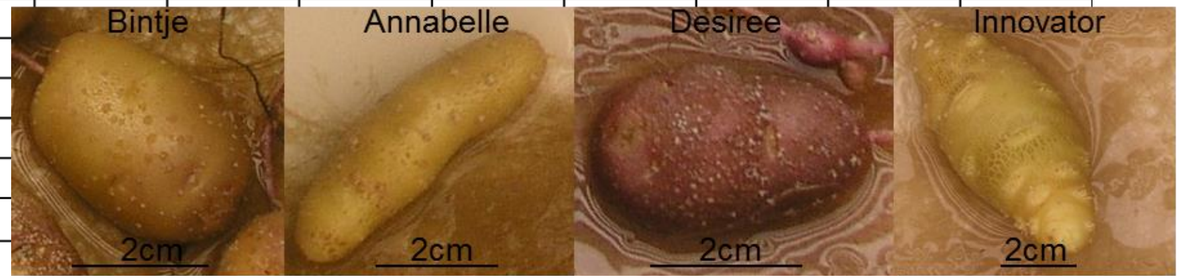
- Plant selection and characterization
- Modelling and control of biological processes
- Space environment (reduced gravity, radiation)
- Very long-term genetic drift
- Including technological progress
- …

Crop Cultivar Testing

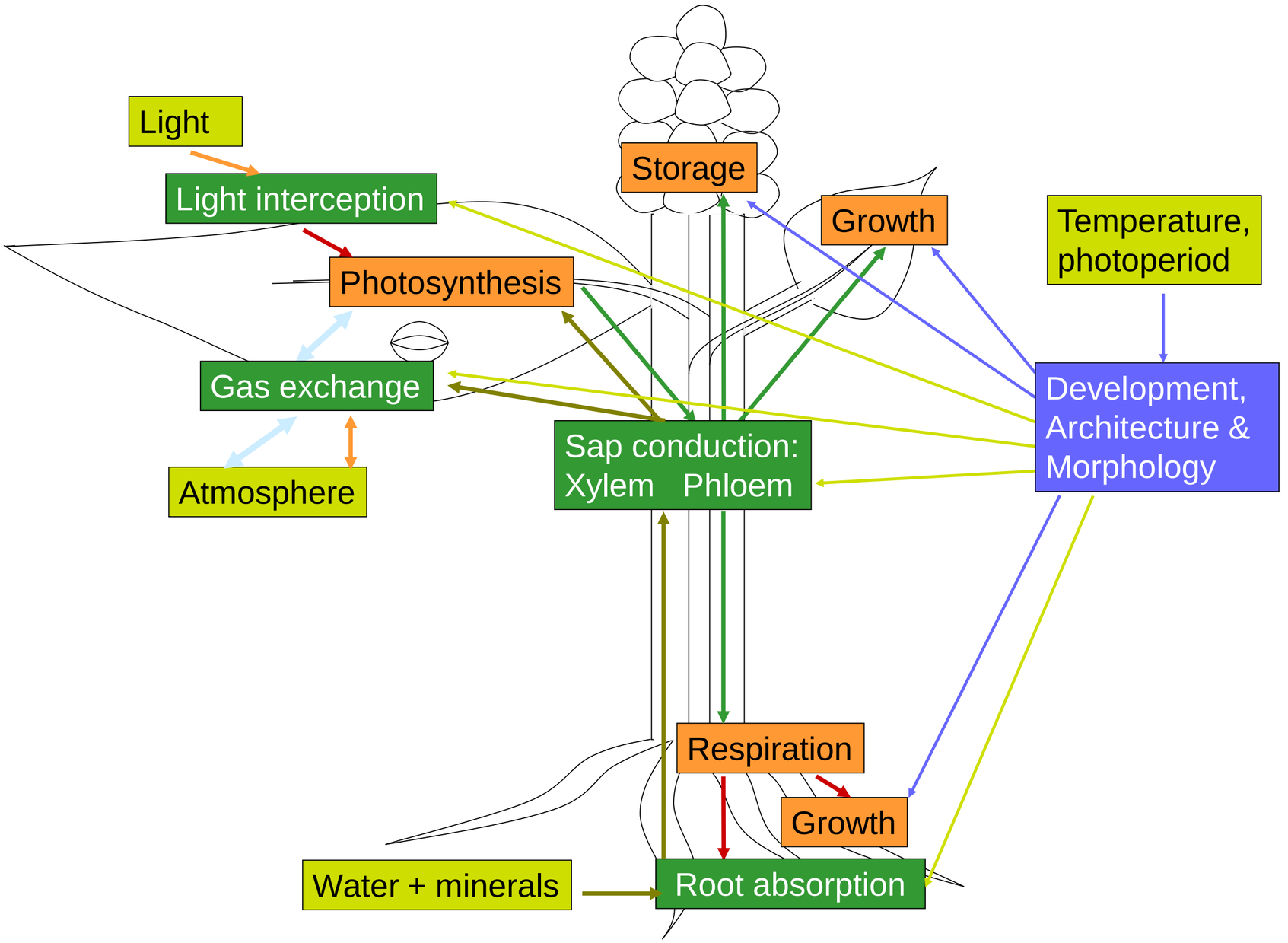
		Annabelle	Bintje	Desiree	Innovator
Tuber harvest (kg/m²)	HZPC 2008	2.5	-	1.52	0.9
	HZPC 2009	4.91	2.2	4.442	0.74
	UGent BT1	0.660	0		
	UGent BT2	0.94			
	UCL BT1	0.829	0		
	UCL BT2	1.96			

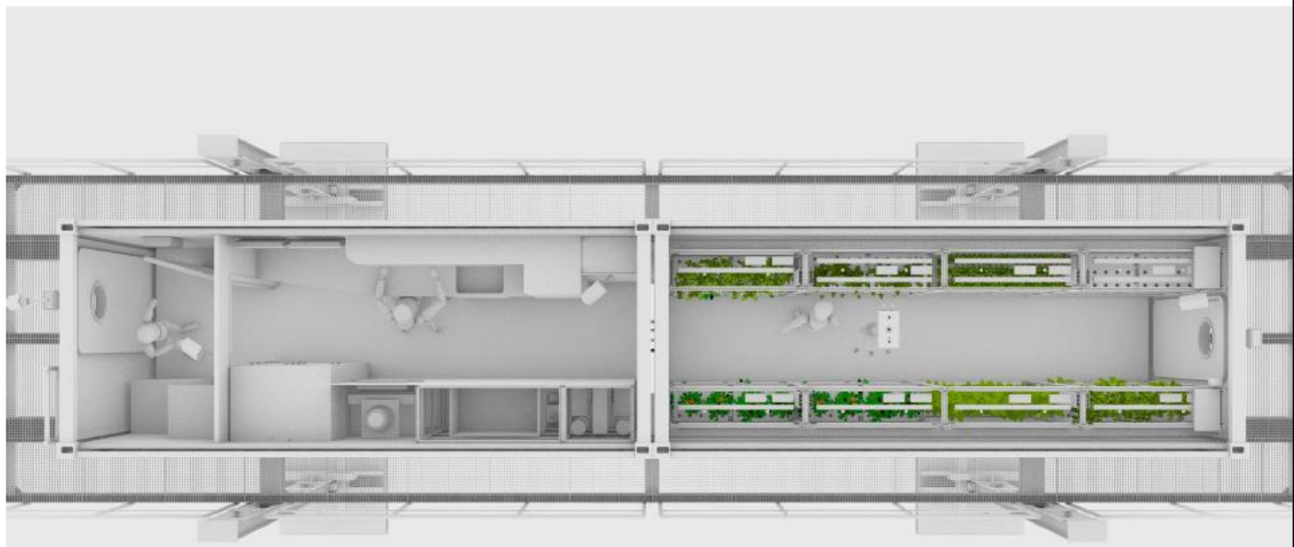


		Hydroponic				Field			
BT2 UGent		Annabelle	Bintje	Desiree	Innovator	Annabelle	Bintje	Desiree	Innovator
Water (%)		78,2	81,1	84,2	77,9	81,8	76,5	79,7	77,6
Protein (%)		1,62	1,20	1.58	1,39	1,33	1,57	1,49	1,43
Fat (%)		0,06	0,04	0.08	0,04	0,07	0,08	0,07	0,07
Available carbohydrates (%)		14,23	14,40	10.79	14,15	14,42	18,75	15,98	17,92
Total Dietary Fibers (%)		1,53	1,80	2.2	1,79	1,66	2,14	1,86	2,09
Minerals (%)		1,16	1,18	1.13	1,08	0,75	0,93	0,87	0,9
Of which (mg/100g)	Potassium	504	507	477	440	432	248	234	192
	Calcium	5,5	7,5	7.4	8,7	16,4	21	22,9	14,9
	Magnesium	29,4	22,2	22.6	26,7	20,6	17	21,2	19,3
	Iron	0,7	0,8	0.4	0,6	1,9	2,5	4,7	2,4
	Copper	1,1	0,5	0.7	0,8	0,3	0,4	0,16	0,3
	Zinc	1,1	0,9	1	1,9	0,3	0,2	0,4	0,26
	Manganese								
	Phosphorus								
Solanine (mg/kg)									
Chaconine (mg/kg)									
Energy (for 100g)	kcal								
	kJ								



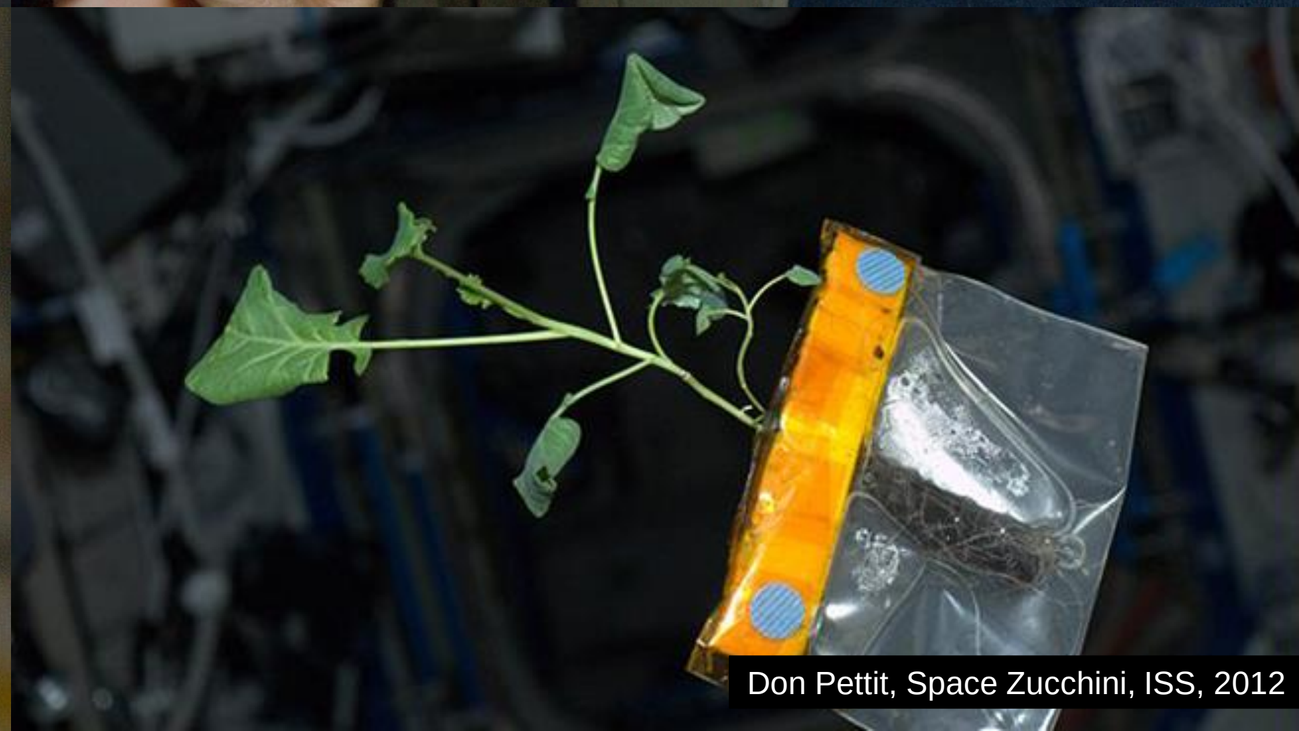
Plant Growth Modelling



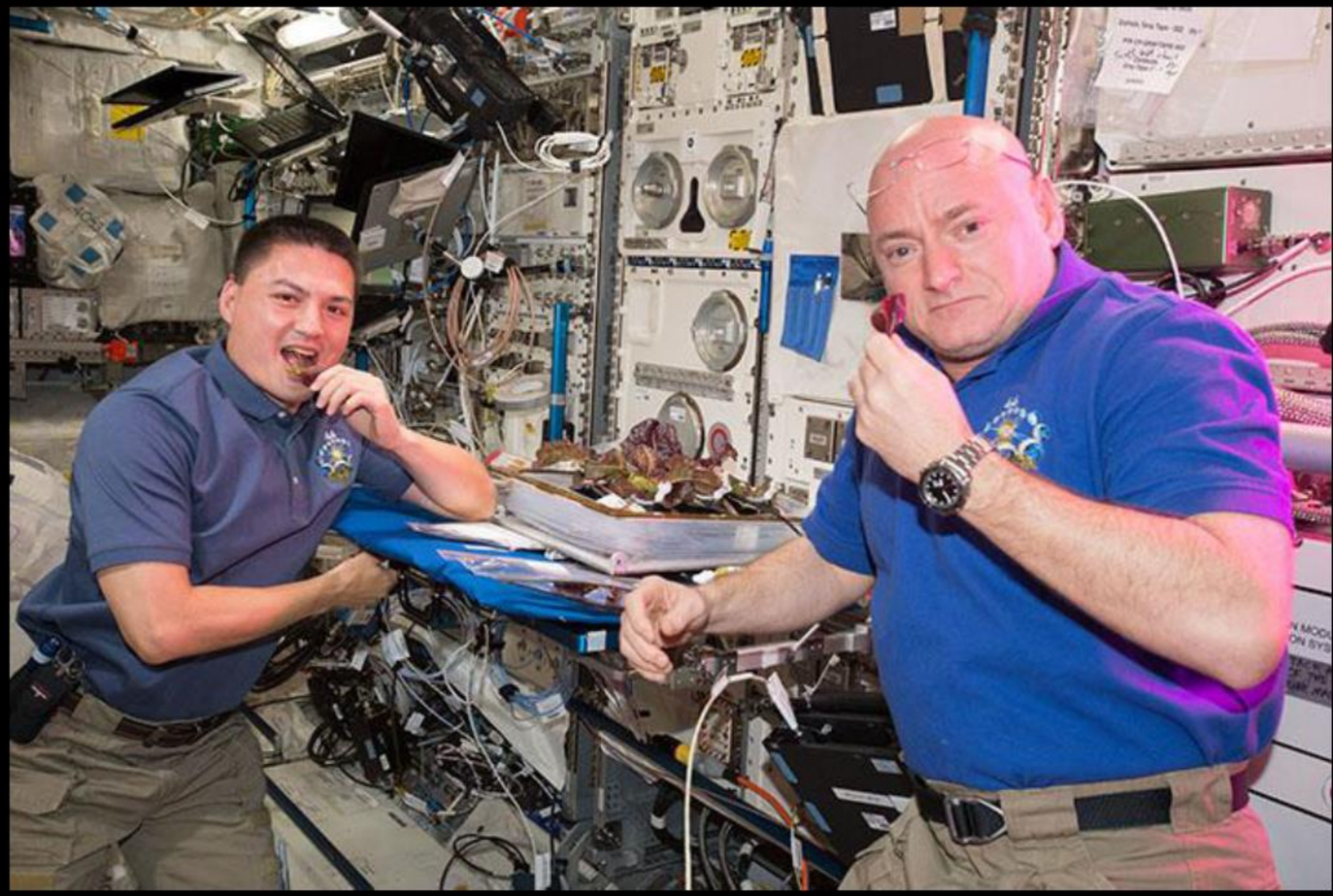


EDEN ISS, DLR & ESA, scheduled 2017

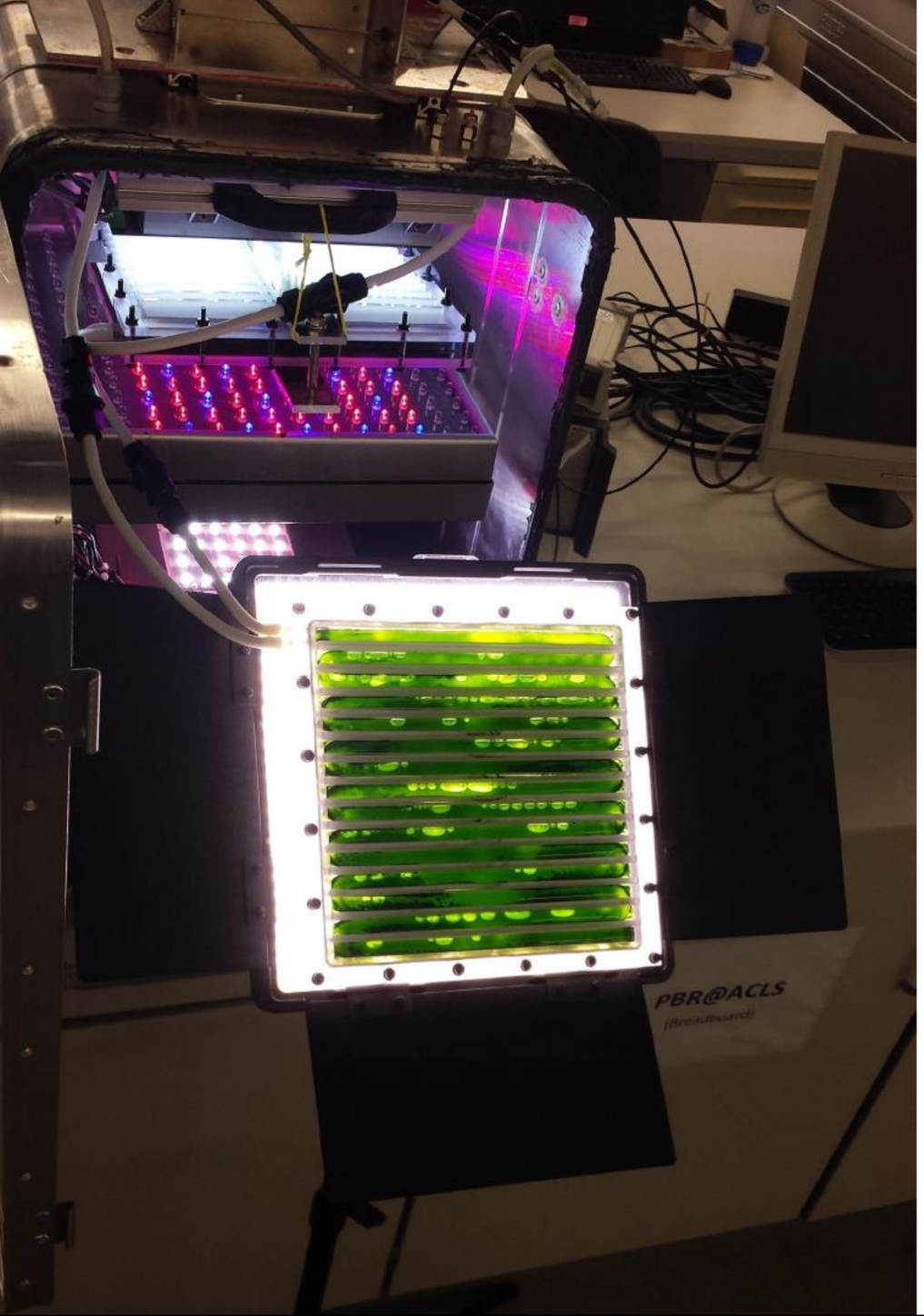
Lada, Institute of Biomedical Problems & Space Dynamics Laboratory, ISS, launched 2002

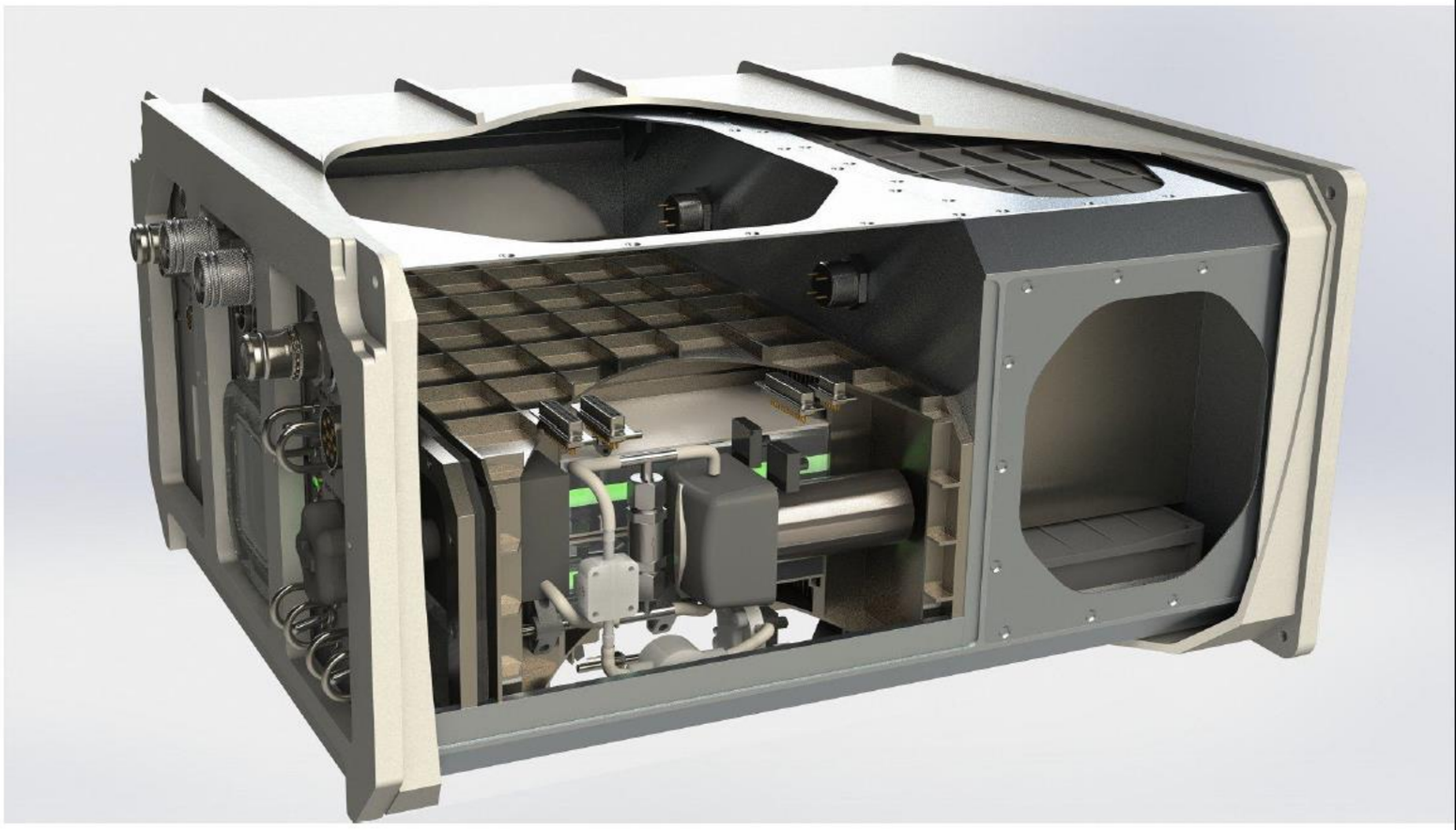


Don Pettit, Space Zucchini, ISS, 2012



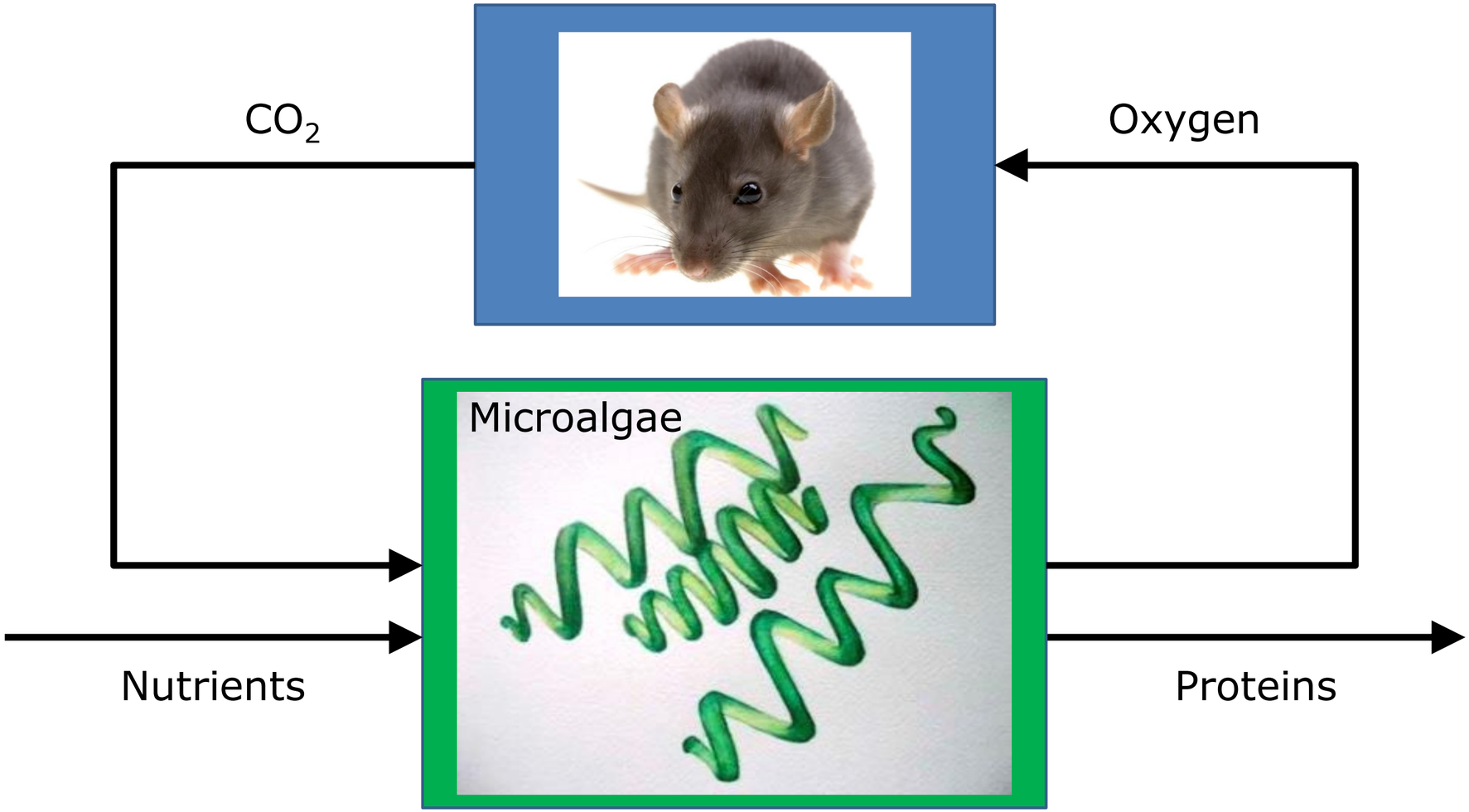
VEGGIE, NASA, ISS, launched 2014



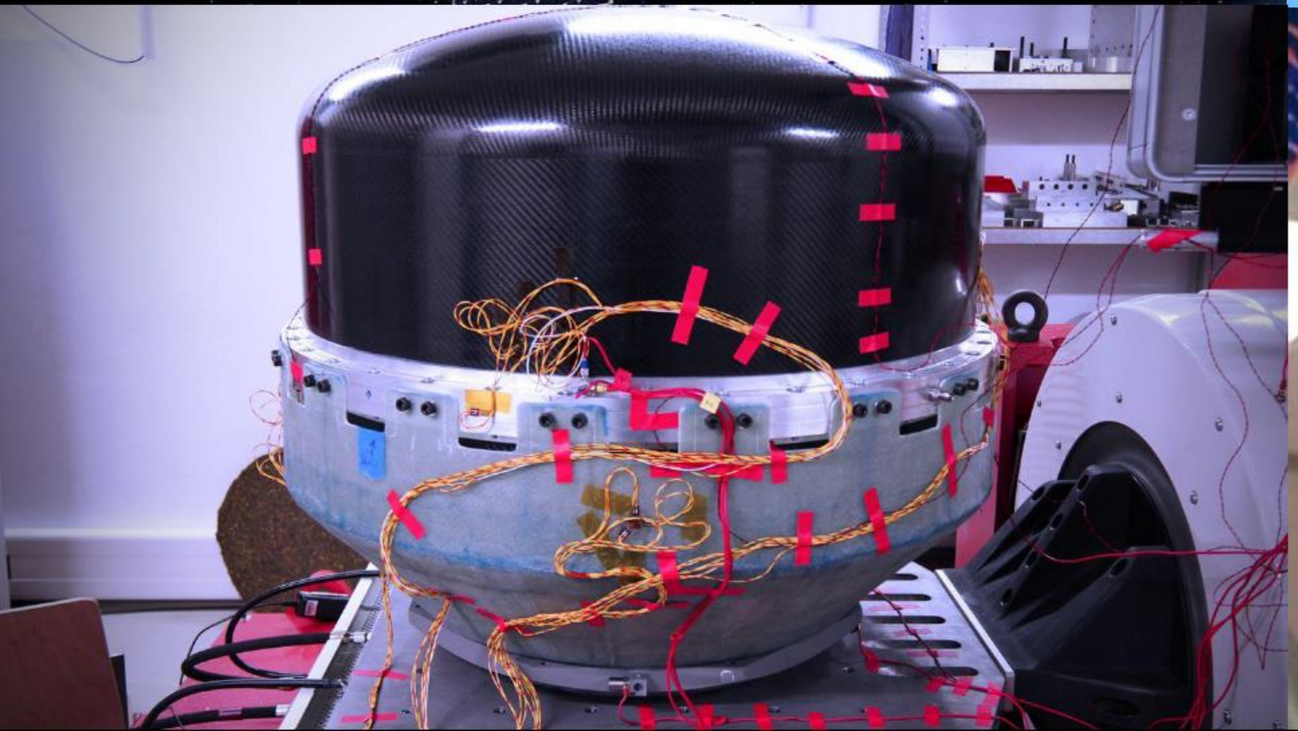


PBR@LSR, DLR & ESA, ISS Destiny Module, scheduled 2018

BIORAT 2: ISS



DLR
Eu:CROPIS



Eu:CROPIS, DLR & ESA, scheduled 2017

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