船外実験プラットフォーム（曝露部）実験施設を用いた太陽放射光の生物影響研究

Research of biological effect on plants by solar radiation using exposure area at ISS platform

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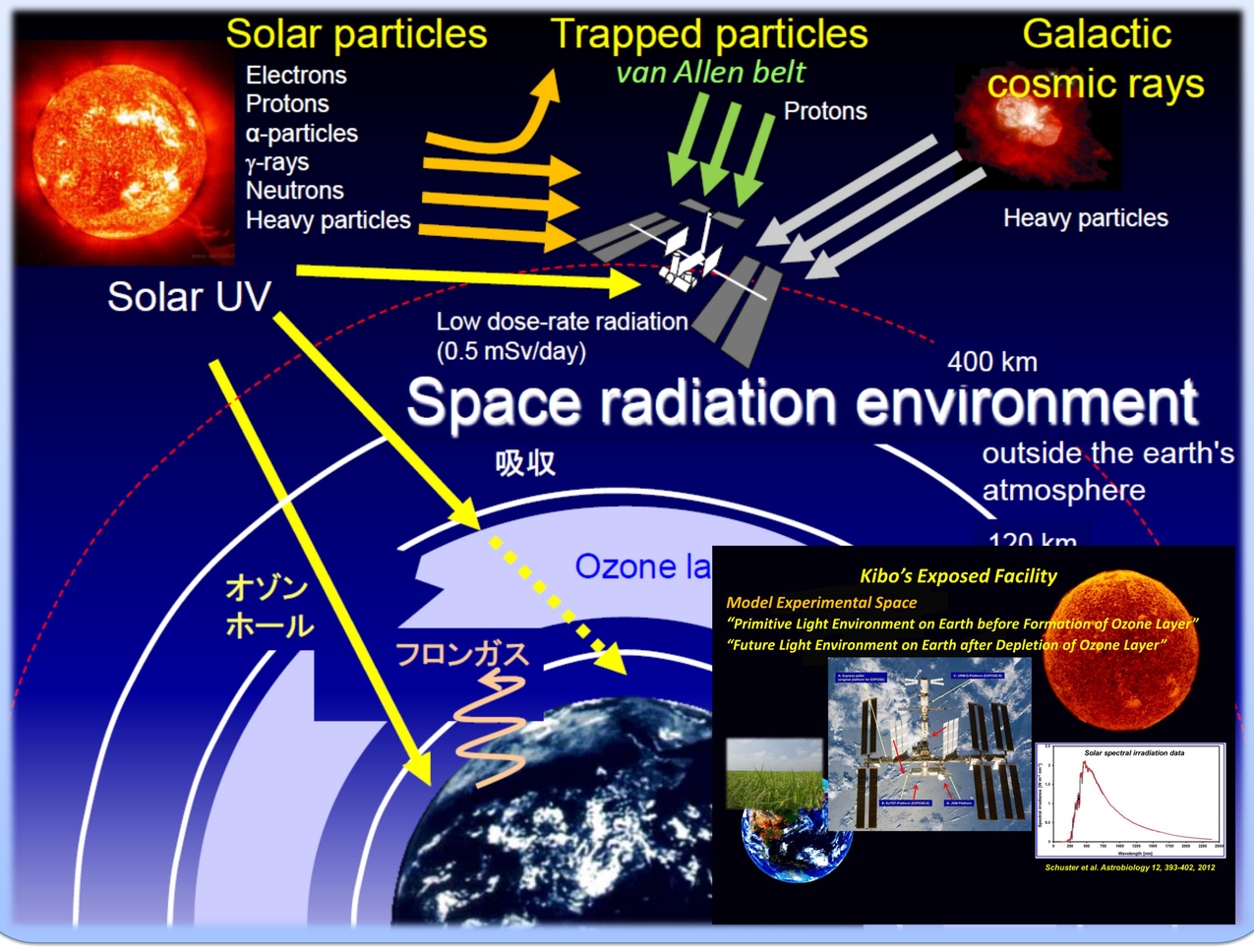
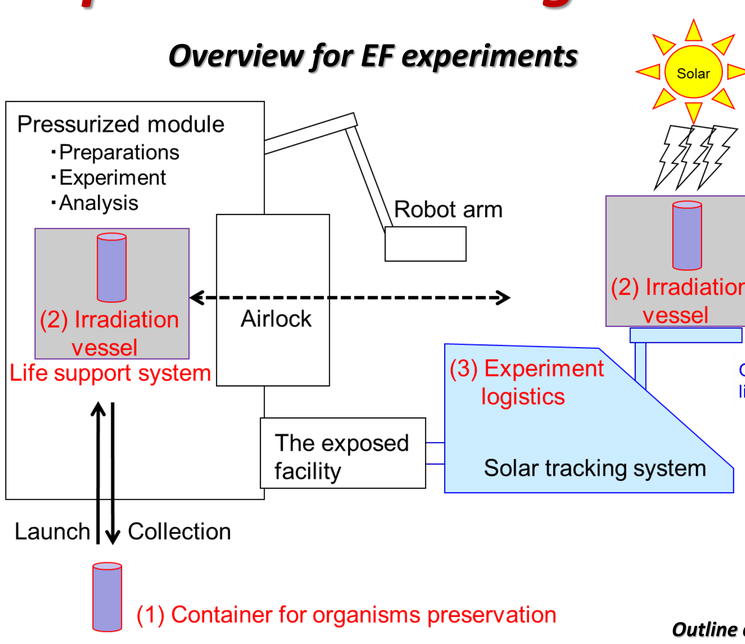
Background and aim of our research

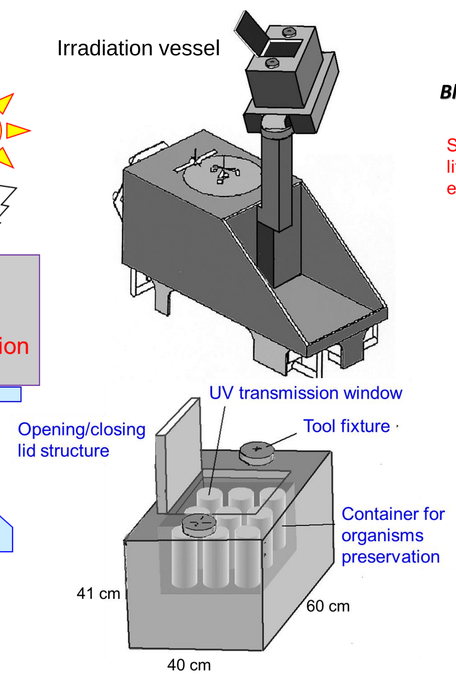
The Exposed Facility (EF) of Kibo on the International Space Station (ISS) has attracted much attention as laboratories for (1) the space radiation environment that is encountered during extravehicular activities. Since it provides an environment where sunlight is not blocked by the ozone layer, (2) modeling the primordial Earth environment before the ozone layer formed, (3) verifying chemical evolution reactions in a space environment, and (4) modeling the future Earth environment after destruction of the ozone layer, and there has been great anticipation of advanced analysis in research into the biological effects of solar radiation by using the EF. Previously used EFs have been conducted using dried biological specimens as samples. At the next stage, however, the active organisms are essential for investigating the biological effects of solar radiation. We therefore propose a Japanese-led project to develop the world's first extravehicular radiation exposure apparatus capable of controlled life support, and to use this apparatus to perform exposure experiments and high precision analysis on microorganisms, insects, small plants, and chemical substances while in the active state.



Experimental design

Overview for EF experiments





Outline diagram of external appearance of experimental apparatus

Block diagram of the life support functions inside the irradiation boxes.

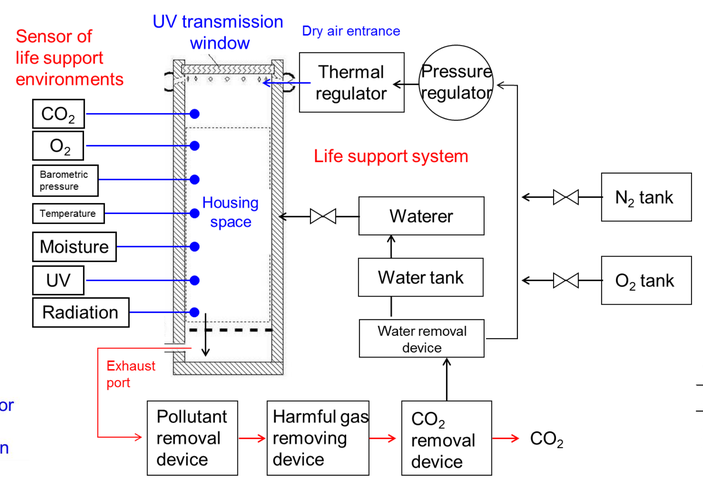
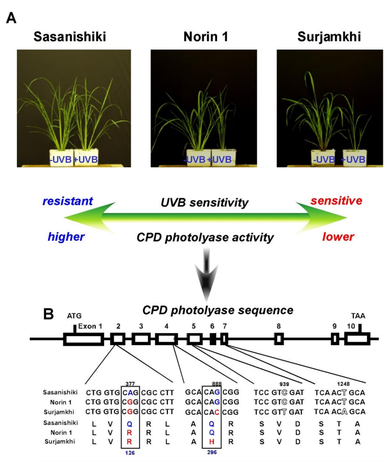


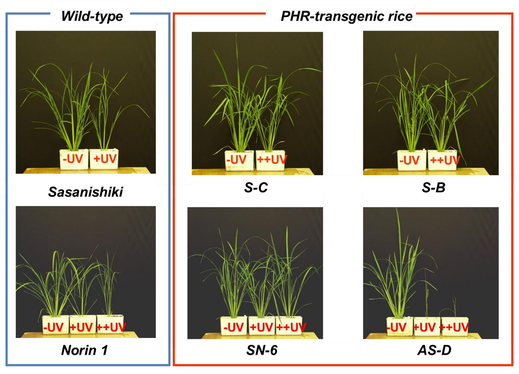
Table 1. Irradiation box life support functions.

Items	Function	Requested value	Methods	Remarks
Pressure control	Pressure control	100±5 kPa	・Circulation by the fan ・Supply by N_2 tank for loss	
	O_2 conc. control	21±2 kPa	・Supply by O_2 tank for loss	
	CO_2 conc. control	0.02-0.5%	・Release overboard by a vacuum film separation method	CO_2 conc. Control be bypass valve method
Harmful gas removing	Remove ethylene	≤ 1ppm	・Adsorption removal with the palladium chloride active carbon agent	Apply to plant experiments
	Others	TBD	・Using activated carbon adsorption *etc.*	Coping individual demand
Moisture control	Moisture control	20-80%RH	・Supply the water from tank to housing space	
	Dew condensation prevention of UV transmission window	Prevent the cloud and dew condensation	・Dry air spraying to the window inside ・Warming with the heater of lid opening /closing inside	
	Dry air	Dew-point ≤ -5℃	・Dehumidification by the cooling condensation ・Water removal by the centrifuging	Reusing the recycled water
Thermal control	Disposal of the incident solar energy	Housing space: exhaust 20W Opening: exhaust 56W	・Adjustment of the circulation wind velocity	
	Maintain a temperature	4-42℃ (±1℃)	・Adjustment of the circulation wind velocity	Cooling by the Peltier element
	Heat insulating and a temperature keeping	Suppressing heat dissipation in shadow	・Set up a heater by the cover inside	

Table 2. Biological materials for space EF experiments.

Material or organisms	Assays to be used
DNA	DNA damage, repair, mutation, transformation
Procaryote（*E. coli*, *etc*）	DNA damage, survival, repair, mutation, *umu*-induction
Eucaryote	
Yeast	DNA damage, survival, repair, mutation
Insect (fruit fly, silkworm, *etc*)	DNA damage, repair, developmental abnormalities, mutation
Plankton (paramecium, euglena, *etc*)	DNA damage, repair, growth rate
Plant (thalecress, *etc*)	DNA damage, survival, repair, growth rate



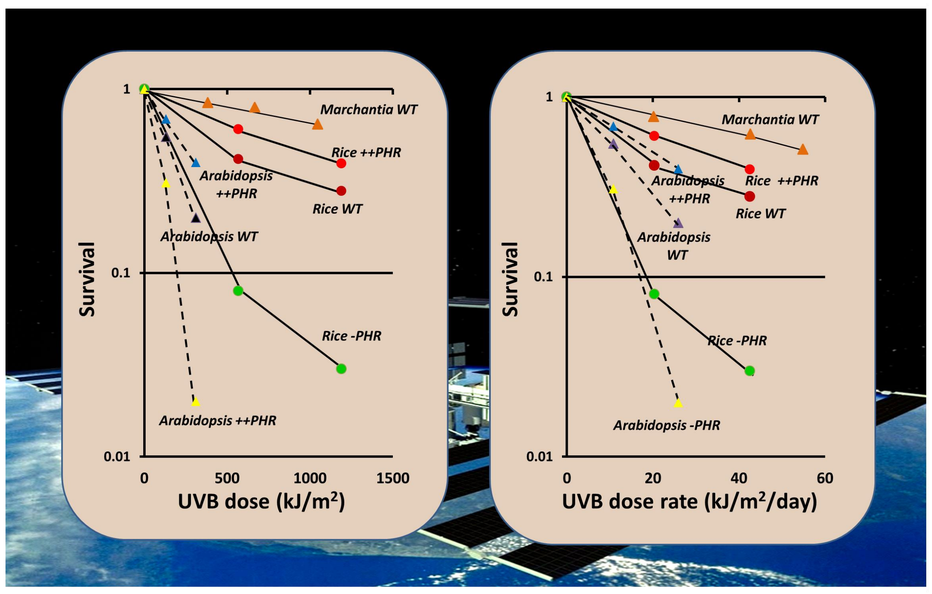


Hidema et al. 2007. Plant J.

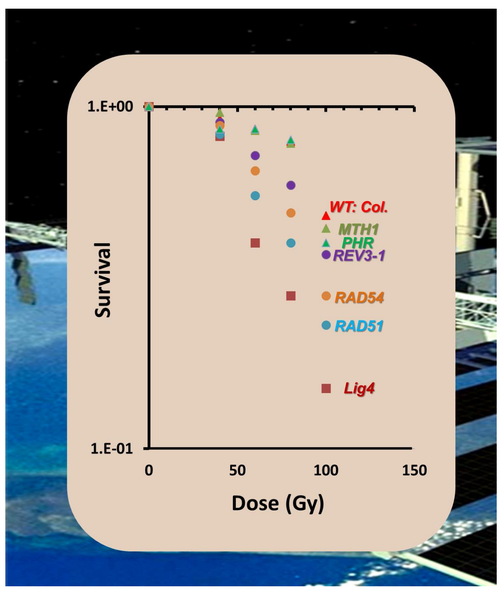
Differences in UVB sensitivity depend on differences in CPD photorepair activity resulting from spontaneously occurring mutations in the CPD photolyase gene, and the increasing CPD photolyase activity can significantly alleviate UVB-caused growth inhibition in rice.

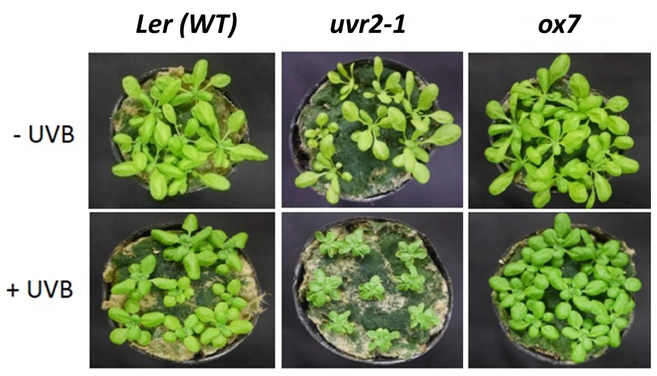
UVB-induced CPDs are one of principal causes of UVB-induced growth inhibition in rice plants grown under supplementary UVB radiation.

UVB dose and dose rate effectiveness curves in rice and Arabidopsis

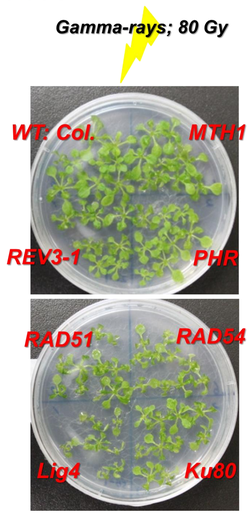


X-ray dose effectiveness curves in repair-deficient mutants of Arabidopsis





Sensitivity to UVB radiation in Arabidopsis. uvr2-1; PHR deficient mutant, ox7; overexpressing PHR line



Conclusion

1. UVB-induced CPDs are one of the principal causes of UVB-induced growth inhibition in plants. The increasing CPD photolyase activity can significantly produce alleviation of UVB-caused growth inhibition in rice.
2. Gamma-rays mainly induce DSBs in plant, and a LIG4, related to NHEJ repair system, *Arabidopsis* mutant is hypersensitive to gamma-rays.

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