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たんぽぽ計画:
1年間宇宙曝露したアミノ酸関連試料の分析

Tanpopo Mission: Analysis of Amino Acid-Related Samples After 1 Years' Space Exposure

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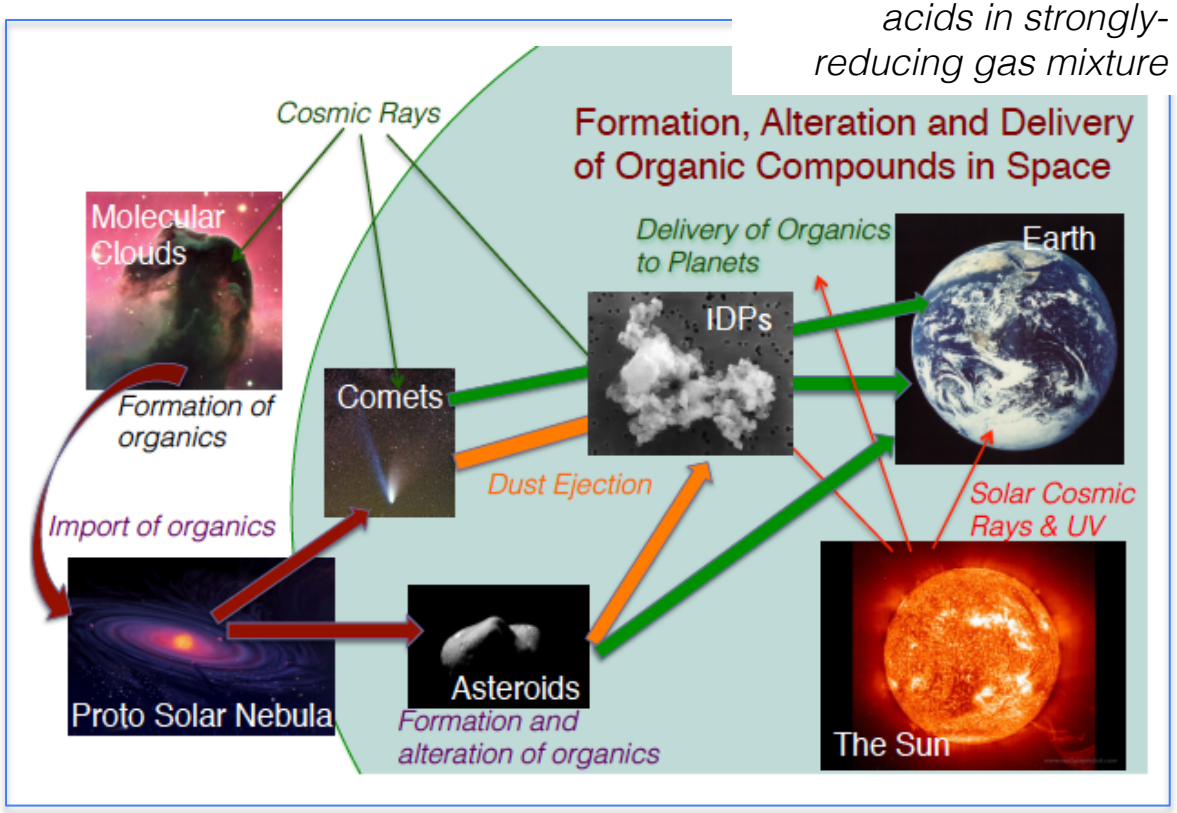
Organic Compounds for the Generation of Life: Exogenous Delivery by Interplanetary Dusts (IDPs)

If primitive Earth atmosphere was not strongly reducing, endogenous production of organics (including amino acids) were restricted.

Formation of amino acids in strongly-reducing gas mixture

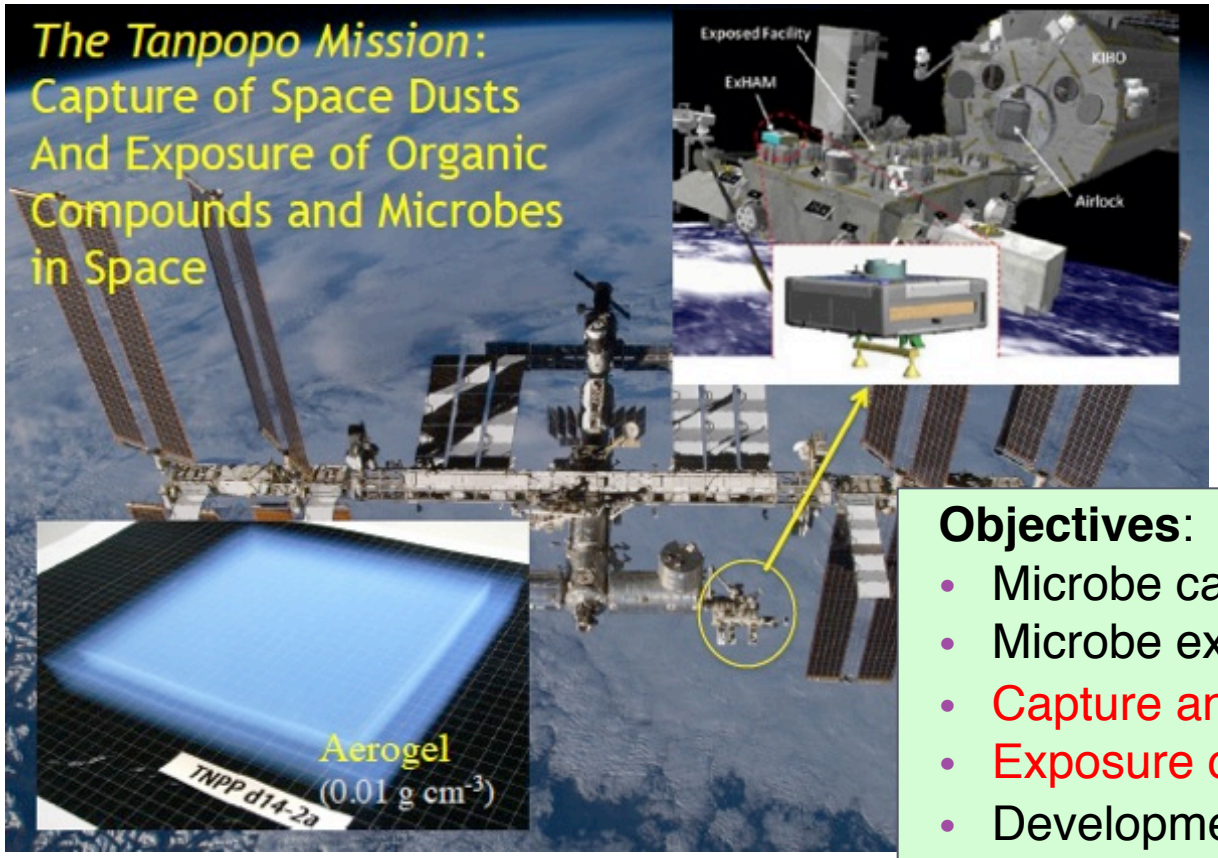
- ✓ Wide variety of organic compounds have been detected in extraterrestrial bodies [1]
- ✓ L-excesses of amino acids were observed in carbo-naceous chondrites [2]

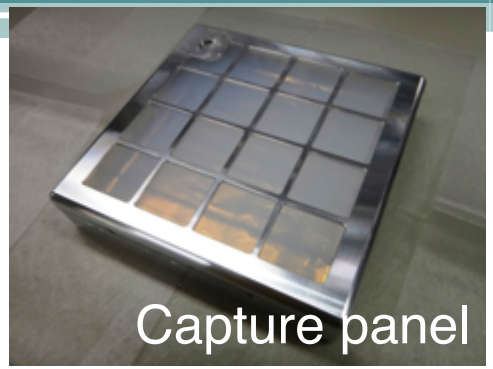
Extraterrestrial organics were essential for the generation of life on the Earth.

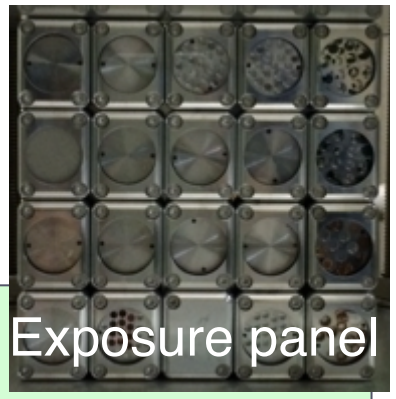


- ○ IDPs delivered more organics to to the Earth than meteorites and comets [3]
- ○ IDPs delivered organics more safely than meteorite and comets

The Tanpopo Mission on the Exposed Facility of JEM, ISS







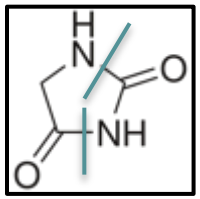
Objectives:

- Microbe capture
- Microbe exposure
- Capture and Analysis of IDPs
- Exposure of organics*
- Development of new aerogel
- Monitoring of space debris

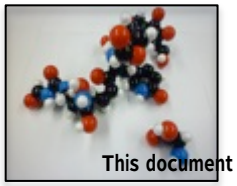
*Amino acids and their precursors

Glycine	Hydantoin
Isovaline	5-Ethyl-5-methyl hydantoin

"CAW" (Complex amino acid precursors)[5]



Hydantoin



CAW (imaginary) and glycine

Ground Simulations: Evaluation of stability of organics by irradiation

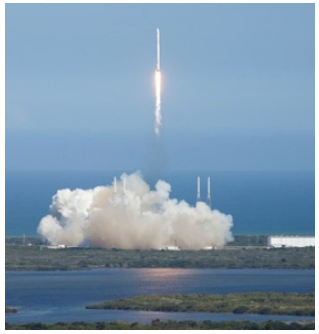
Type	Compounds	Recovery (%)				
		UV***	γ-Rays	Heavy ions	Temperature	Total
Free amino acids	Glycine	0.002	100	100	100	0.002
	Isovaline	0.003	> 99	100	100	0.003
Amino acid precursors	Hydantoin	29	100	100	100	29
	EMHydantoin*	72	> 99	100	100	72
	CAW**	36	100	100	100	36

* 5-Ethyl-5-methyl Hydantoin

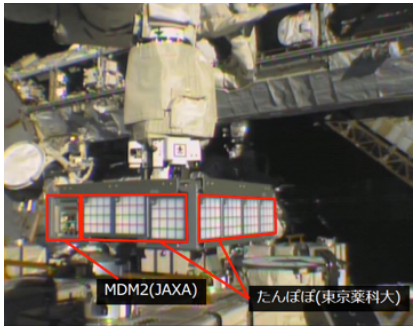
** Complex organics synthesized by proton irradiation of a mixture of CO, NH_3 and H_2O

*** λ = 172 nm (Exima lamp)

Space Experiments:

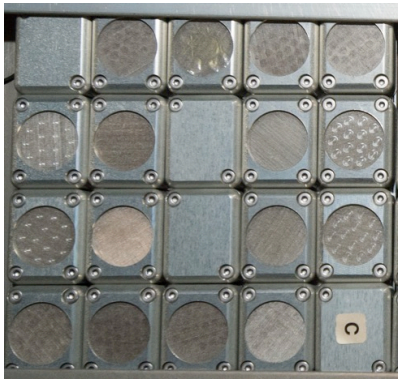


Launched in April, 2015



Space exposure started in May, 2015

Returned to the Earth in August, 2016

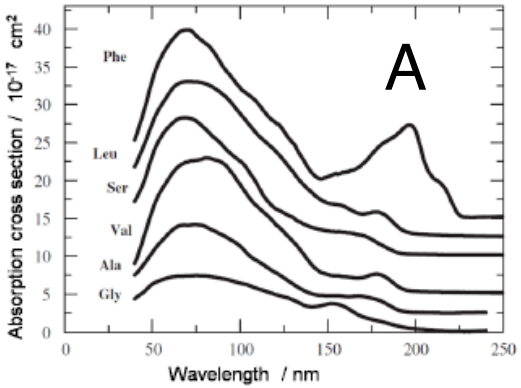


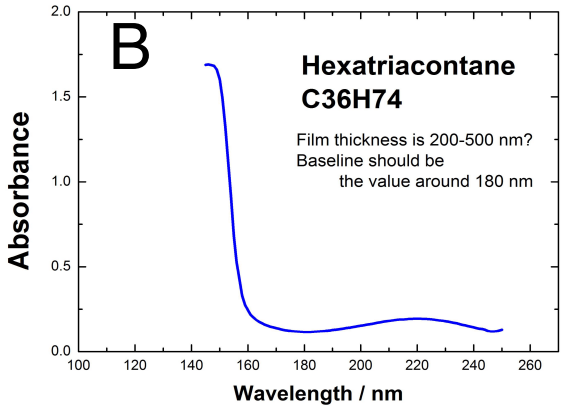
Exposure plates after recovery

Recovery of the Exposed Organics

- ✓ After exposed to solar UV, isovaline was decomposed as expected
- ✓ Glycine's decomposition was less than expected.
- ✓ Hydantoins were decreased even in dark control.
- ✓ CAW was stable as expected.

By-Products after Exposure





A: VUV/UV spectra of amino acids; B: VUV/UV spectrum of hexatriacontane ($C_{37}H_{74}$)

- ✓ CAW was also stable in space as a precursor of alanine and β-alanine.
- ✓ A major photolysis product of isovaline was alanine in the laboratory simulation [6], while glycine was predominant after isovaline was exposed in space.

Discussion

1. The reason why glycine's decomposition was less than expected seems to be:
   a) Hexatriacontane cut the shorter VUV (λ <160 nm) that is critical for glycine.
   b) UV dosimetry [7] showed that samples were exposed to solar UV for restricted period during exposure.
2. Hydantoins' recovery was much lower than glycine, even in the dark control. It seems to be due to volatility in space.
3. CAW had strong VUV/UV absorption, but still gave high recovery as amino acid precursors after solar UV-exposure. Complex precursors of amino acids could be robust molecules in space.
4. In the present space exposure experiment, solar UV whose wavelength was more than 160 nm was mainly used. Space experiments that utilize full solar VUV/UV spectrum should be done.

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Summary

1. The capture and exposure experiments in *the Tanpopo Mission* was designed to confirm the hypothesis that extraterrestrial organics played important roles in the generation of the first terrestrial life, as well as examination of the hypothesis of *Panspermia*.
2. The experiments started in May, 2015, and the first sample returned to the Earth in August, 2016. The last samples will return in 2018.
3. Amino acids and their precursors (hydantoins and CAW (complex molecules synthesized by proton irradiation of possible interstellar media)) were exposed in space in the Tanpopo Mission.
4. Amino acids and hydantoins showed different behavior in the space exposure experiments than expected from the ground simulation experiments.
5. CAW also showed high recovery after exposure. Contribution of extraterrestrial amino acid and/or their precursors to the first life on the Earth would become clearer in this experiment.

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