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Overview of Kirara service and its new results on material bioproduction

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‘Kirara’ Service

- **‘Kirara’ service was launched in 2019.**

- **An initial target: high-quality protein crystal growth**

⇒ **challenging to other experimental field.**

- **A tiny incubator: ICE Cubes facility in the ISS Columbus module.**

- **96 samples can be installed.**

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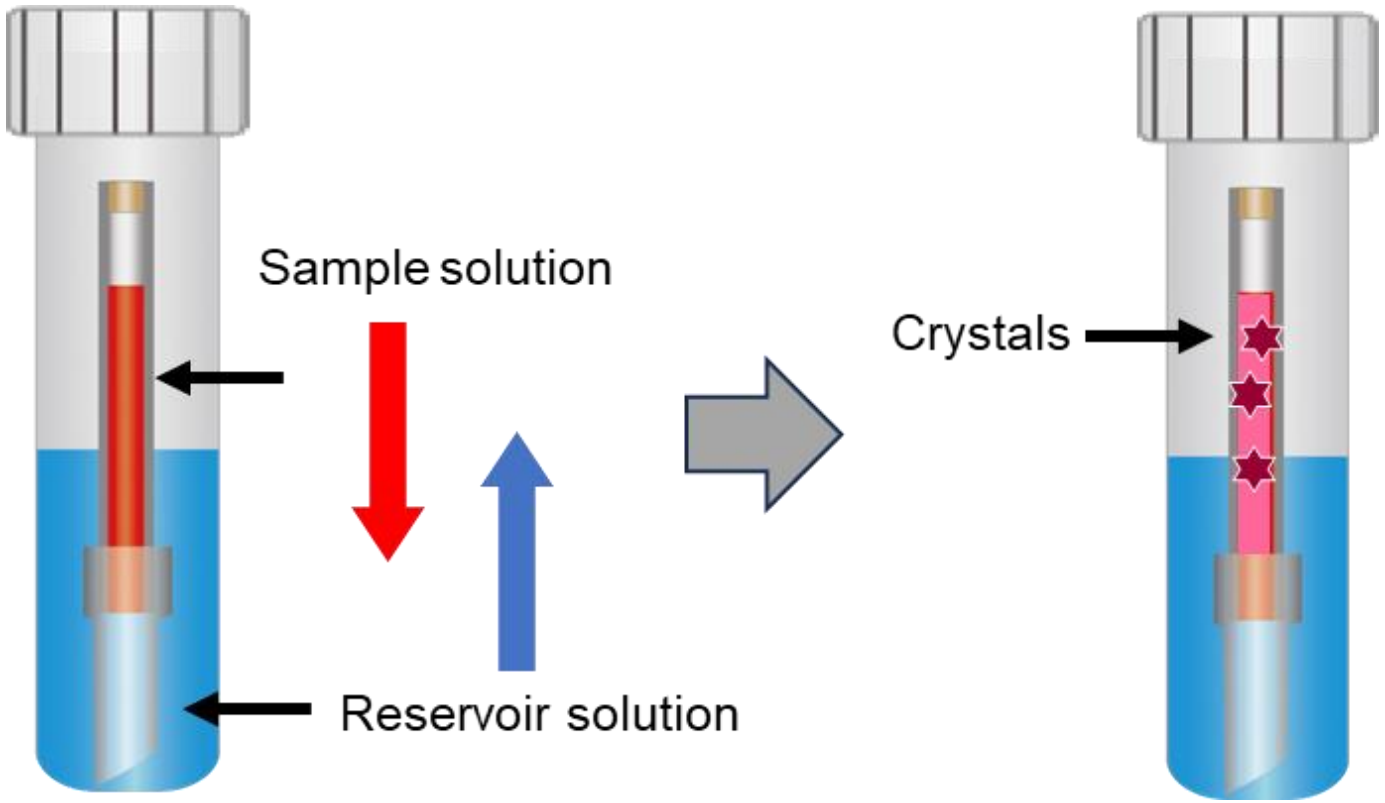
The principle of the counter diffusion



- Glass capillary: A protein sample is loaded.
- Gel-Tube: A silicon-tube pre-loaded with agarose gel.
- The device is dipped in a reservoir solution.

- The reservoir solution diffuses in.
- The concentration increases and a protein crystal starts growing.

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Sample configuration for Kirara

- **Double containment:**

Outer bag ← **Inner bag (C-SGT) ×2** ← **Inner vessels ×4**

Clipping here

- **Bags: non-gas-permeable soft plastic sheet, sealed by heat.**
- **Inner vessel: glass capillary with silicon tube**
- **Mixing two solutions:**
  - **One in the inner vessel and the other in the tube.**

- **Bags, vessels, experimental methods, and procedures can be customized.**

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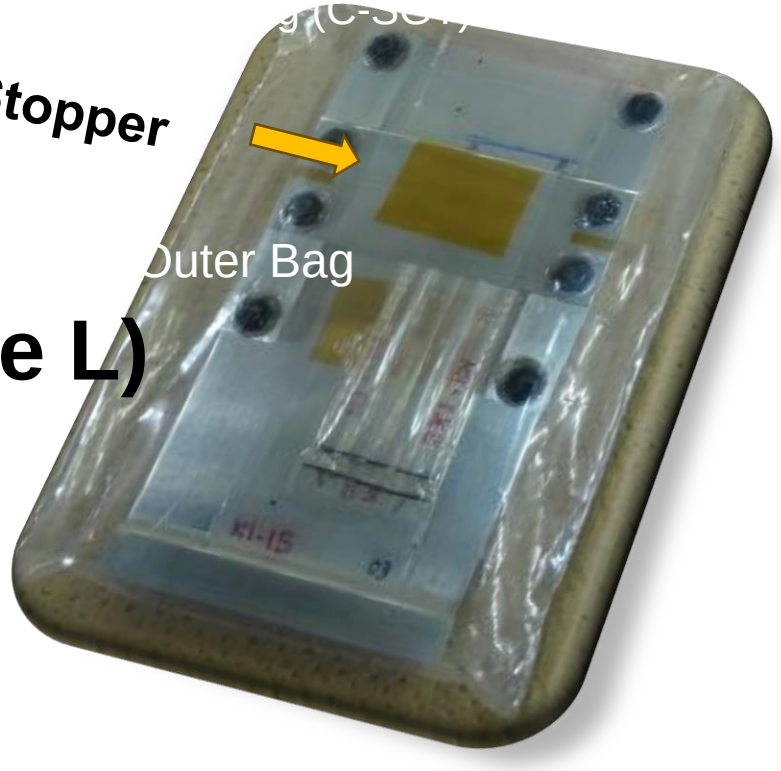
Loading sample & starting reaction

- **Loading sample at CS Lab. (2~4 weeks before launch)**

- **Suppress reaction**
  - **apply diffusion stopper: clip the bags**
  - **store in 4 ℃ or in dry ice.**



- **At Kennedy Space Center (~2 days before L)**
  - **Removing the stopper**
  - **Heating to 20 ℃**

⇒ Reaction Starts!

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Time-Line of the service

-4 months	Application data sheet
-3 months	Samples for the optimization (optional)
-3 weeks	Sending samples (nominal)
-2 to 4 weeks	Loading samples
-1 week	Transporting samples
-2 days	Install samples @ Kennedy Space Center(20 ℃)
0 day	**Launch to the ISS (20℃)**
+1 month	Recovery from ISS (20℃)
+1.5 months	Delivery to users (20℃)

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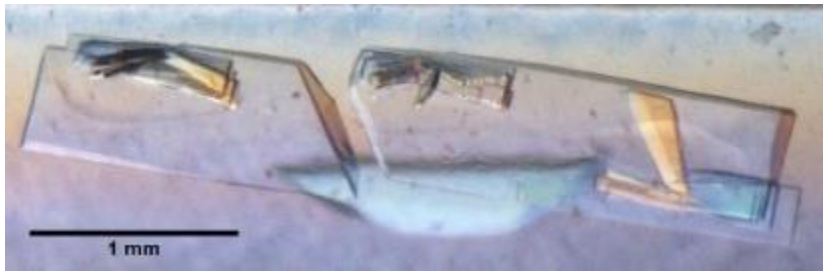
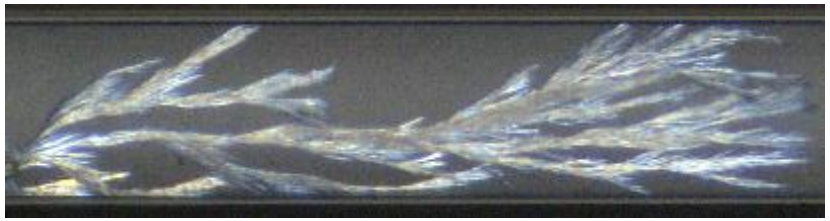
Kirara launched samples (# of entry)

- **Protein crystallization**
  - **For X-Ray diffraction (13)**
  - **For neutron diffraction (3)**
  - **For STEAM education (3)**



- **Biomolecular Structure Formation (2)**
- **Colloid crystallization (3)**



- **Small molecular crystallization (4)**
- **Small molecular complex formation (1)**
- **Enzymatic cellulose synthesis (5)**
- **Bacterial cellulose production (2)**

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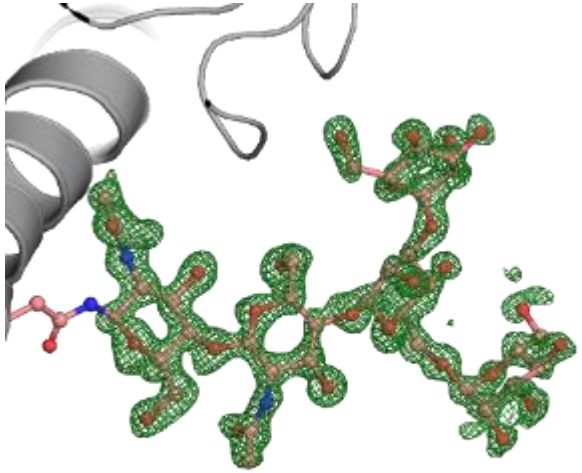
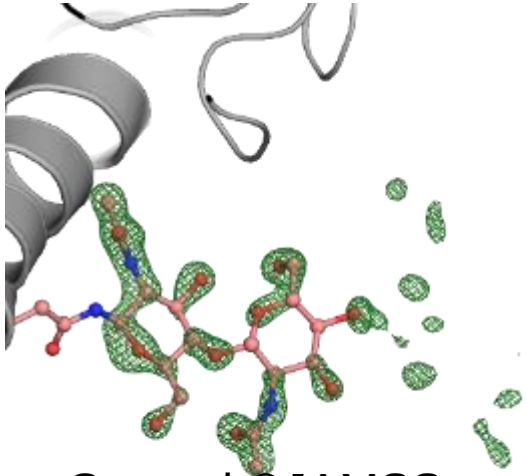
Benefits for the protein crystallization

- Cluster → Single crystal

	Space	Ground
Data Collection		
Space group	P21	P21
Unit cell dimensions		
a, b, c (Å)	50.26 127.49 63.04	50.55 127.94 63.68
α, β, γ (°)	90.00 91.44 90.00	90.00 91.15 90.00
Resolution (Å) ↓	46.74-1.06 (1.08-1.06)	63.97-1.67 (1.70-1.67)
Mosaicity (°) ↓	0.33-0.64	0.24-1.64
Completeness (%)	98.8 (94.6)	98.1 (95.8)
Mean I/ σ (I)	8.2 (1.6)	5.3 (3.3)
Rmeas	0.102 (0.984)	0.426 (2.210)
Refinement		
Rfree ↓	0.188	0.212
Twin fractions(%) ↓	N/A	7.5*
Precipitant solution	PEG 4000 / NaCl	PEG 4000 / NaCl



Space ©JAMSS



Grownd ©JAMSS

Clear electron density map.
⇒ The atomic coordinates become more accurate.

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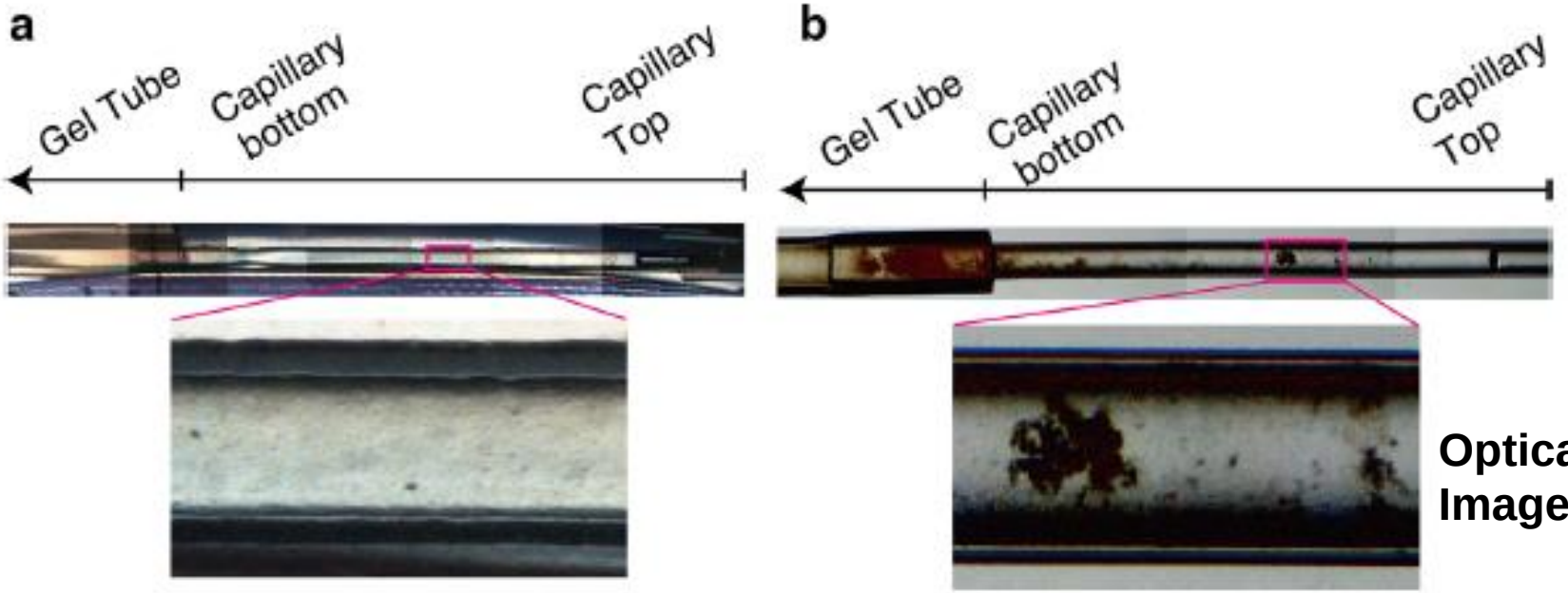
Enzymatic cellulose synthesis

- **CDP + cellobiose (Capillary)**
- **α-G1P (Reservoir)**

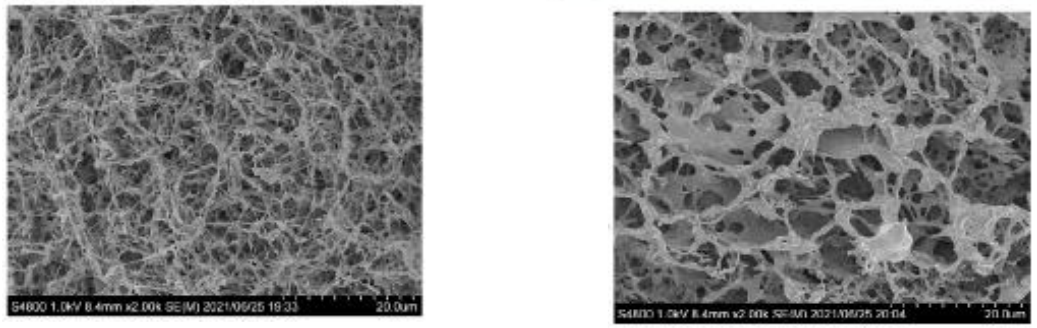
Cellulose

Uniform outlook.

Sparse network in SEM image.



Optical Images



SEM Images

in space

on ground

- **Launched in Kirara #1, 2019**
- **The enzymatic cellulose synthesis in space is the first in the world.**

T. Kuga, et.al., (2022) Cellulose, https://doi.org/10.1007/s10570-021-04399-0

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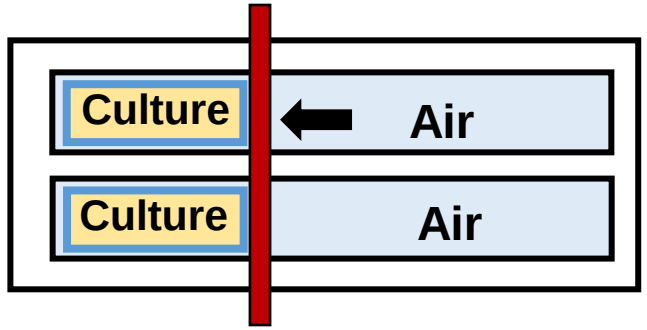
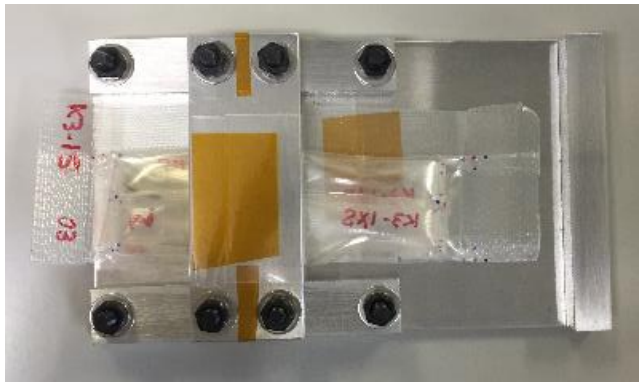
Bioproduction using Kirara: Type 1 (Kirara#4)

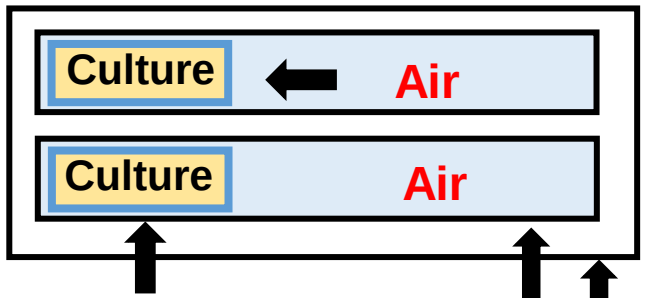
Sample preparation & transport to KSC



Separator, 4 ℃



Cultivate at 20 ℃ on ISS



Gas-permeable bag

Non-gas-permeable bags

Bacterial cellulose

Biosafety level ≤ 1

The first time in the world. Cellulose production is possible in space.

A. Tanaka, et.al., Int. J. Microgravity Sci. Appl. 41 (2024) 410302, https://doi.org/10.15011/jasma.41.410302

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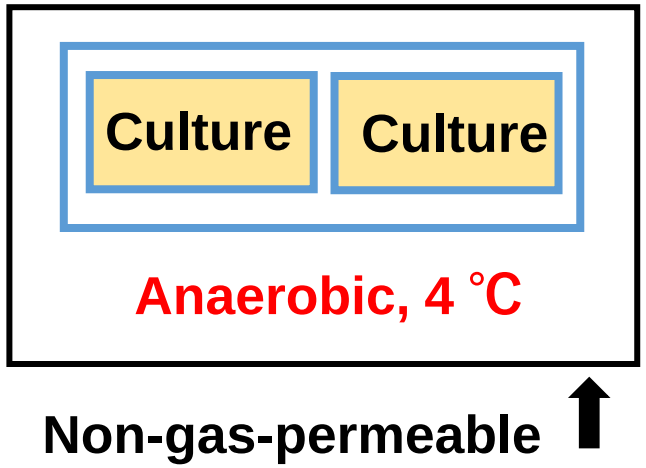
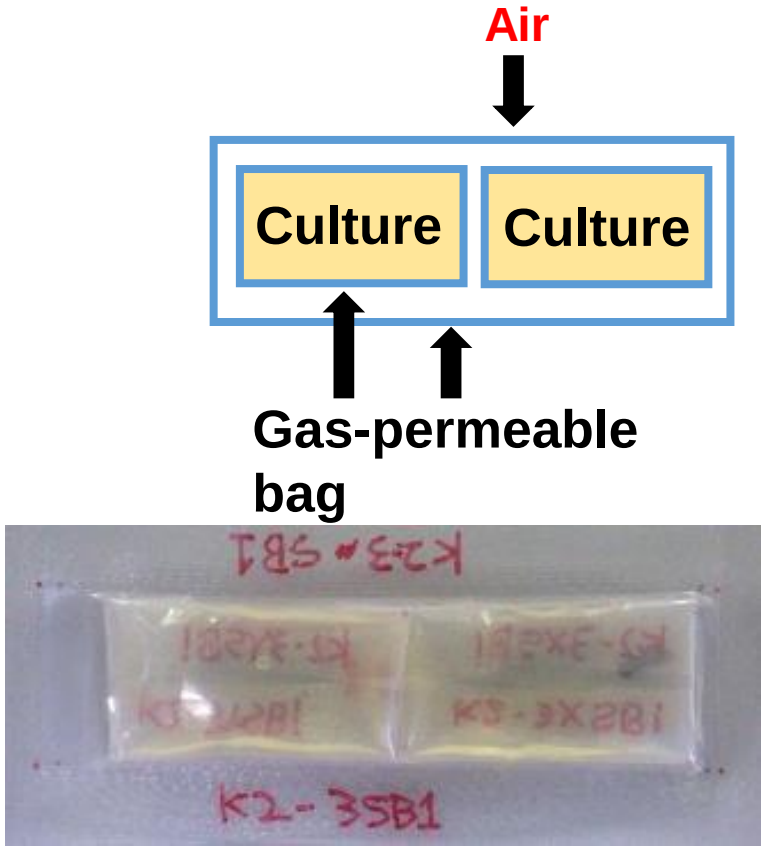
Bioproduction using Kirara: Type 2 (Kirara#5)

Sample preparation & transport to KSC



Cultivate at 20 ℃ on ISS



Bacterial cellulose

Biosafety level ≤ 1

Large-scale production is possible in space.

A. Tanaka, et.al., Int. J. Microgravity Sci. Appl. 41 (2024) 410302, https://doi.org/10.15011/jasma.41.410302

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Contact JAMSS

- **Containers, experimental methods, and procedures can be customized according to user's request.**

  As earlier is preferable to contact us!!

- **JAMSS Kirara:**

  https://www.jamss.co.jp/en/space_utilization/kirara/

- **JAMSS Kirara Data Sheets etc:**

  https://www.jamss.co.jp/en/space_utilization/kirara/

- **JAMSS inquiry form**

  https://www.jamss.co.jp/en/contact_service/

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