ISS/Kibo Utilization Strategy in Japan
ISS Symposium 2012

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Topics

- “Kibo” Utilization Scenario till 2020
- Life Science Scenario
- Space Medicine Scenario
- Physical/Chemical Science Scenario
- International Collaboration for Advanced Research Capability on ISS: Enhance onboard Mouse/Rat research Capability
- Kibo/ISS Utilization Announcement of Opportunity
“Kibo” Utilization Scenario till 2020

- “Kibo” Utilization Scenario is scoping research areas in Life Science, Space Medicine and Physical/Chemical science performed in JEM-PM till 2020. JAXA President asked an external advisory committee to produce this scenario.

- Highly-prioritized research areas will be established among three research areas (Life Science, Space Medicine, Physical/Chemical science).
  
  【Category①】 Forefront science & technology research only achieved in ISS & “Kibo”
  【Category②】 Fundamental technology development for space activity

- JAXA will select some large scale research projects in highly-prioritized research areas through AO process by this summer and promote them directly.

- JAXA will invite some foreign research teams to the selected research projects. JAXA plans to review the proposals by the international peer reviewers.
【Category①】 Forefront science & technology research only enabled by ISS and “Kibo”

(1) Long-term Target (Over 5 yrs)
   ・Life Science and Physical/Chemical Science
(2) Short-term Target (About 3 yrs)
   ・Contribution to resolving social problems such as aging society and chronic disease
   ・Contribution to resolving energy and environmental problems
   ・Contribution to disaster recovery including education and out-reach activities.

【Category②】 Fundamental technology development for space activity
Accumulate key technologies and knowledge for Japan’s future space activities
   ・Space medicine, Space technology development
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**Current Scenario Coverage**
- Various themes to explore space environment utilization
- Implement leading scientific researches
- Foster utilization to meet society need and citizen’s expectation
- Forefront science & technology research only enabled by ISS & “Kibo”
- Fundamental technology development for space activity

**Theme Selection Process**
- Bottom-up ▲
- Highly-Promised ▲

**Category ① Forefront science & technology research only enabled by ISS & “Kibo”**
1. **Long-term target area**
   - Life Science and Physical/Chemical science
2. **Short-term target area**
   - Contributing to aging society and chronic disease
   - Contributing to energy and environmental problems
   - Contributing to disaster recovery

**Category ② Fundamental technology development for space activity**
- Space medicine, Space technology development

**Scenario Study**
- JEM-PM Utilization Themes
Life Science

- Plants
- Microbe
- Cells
- C. elegans
- Vertebrates (Small Fish)
- Mammal (Mice/Rats)
- Human

Timeline:
- 2015
- 2020
ISS/Kibo utilization scenario in life sciences toward 2020

Highly-promised Research Areas in Life Science

**LS1:** “Integrative understanding of biological responding mechanisms to the space environment” as forefront science & technology research only enabled by ISS and “Kibo”, utilizing cutting-edge analysis technologies to achieve high-quality sciences.

**LS2:** “Establishment of scientific foundations to expand human activity to space” as fundamental technology development for space activity, such as future human space exploration.

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**Model Organism**

- Plants / Microbe / Cells
- Vertebrates
- Mammals (Rodent)
- Human

**Current life sciences experiment facilities onboard Kibo**

- Clean Bench (CB)
- Cell Biology Exp. Facility (CBEF)
- Fluorescence Microscope
- Aquatic Habitat (AQH)

**Study necessary experiment facility / devices based on the scenario**

**Contribute to society on earth using pathological animal models**

**Habitat for mice, rats, hibernant animals**
Space Medicine

- Medical PC
- USB camera
- Electronic stethoscope
- Measuring instrument for blood oxygen saturation level (pulseoximeter)
- Electroencephalograph
- Holter monitor

On the ground
Aboard KIBO in orbit
ISS/Kibo utilization scenario in Space Medicine toward 2020

◆ Highly-prioritized Research Areas in Space Medicine

SM1: ”Space medicine research to improve health care technologies of astronauts” as key technology development for future human space activity.

SM2: ”Space biomedical research to elucidate fundamental mechanisms of the effects of space flight on humans and animals” to achieve the goal of SM1, as forefront science & technology research only enabled by ISS and “Kibo”,

◆ Highly-prioritized Research Area Candidates (Research Areas and Critical Questions)

(1) Physiological Countermeasure
- Countermeasures to prevent bone loss and metabolic disorder of bone mineral
- Monitoring & countermeasure to sleep and biological rhythms
- Evaluation & preventive countermeasure to muscle atrophy
- Mechanism clarification & preventive measures to bone loss and muscle atrophy
- Space environmental stress responses in Cardio-vascular, neuro-vestibular, and immune systems
- Multi-generation effects of space flight by use of model animals (medaka fish, mouse, rat)

(2) Psychological Support
- Monitoring/countermeasure of Stress/Fatigue

(3) Health Care against Space Radiation
- Advanced space radiation dose monitoring technology

(4) Space Environmental medicine
- Monitoring of water, air, microorganism, and noise & Work environmental management

(5) Space Telemedicine
- Bio-monitoring & Disease prevention
- Dose assessment of low-dose, long-duration space radiation exposure & Development of bio-maker
- Prevention & Protection of biological effects from space radiation exposure
Physical/Chemical science

Ice crystal in ground (not symmetric)

Ice crystal in microgravity (symmetric)
ISS/Kibo utilization scenario in Physical/Chemical science toward 2020

◆ Prioritized policy in Physical/Chemical science
(1) Systems significantly influenced by gravity, and science areas with great significance and spin-off to the society
(2) Prioritize new research areas with less former space experiments
(3) Not limit to research themes utilizing existing experiment payload

◆ Highly-prioritized Research Area Candidates in Physical/Chemical science

PCS1: The forefront science enabled by ISS
【Long term target】
✓ “Contribution to New Combustion System for Sustainable Earth”
✓ “Science and Technology of Bubbles, Droplets and Films”
✓ “Researches on self-organization phenomena in strongly coupled plasmas”
【Short term target】
✓ “Producing new materials from super cooled phase by container-less processing”
✓ “Survey of soft matter useful on the ground”

PCS:2 Basic technology development for space activity
✓ “Fundamental research for fire safety standard in space”
International collaboration for advanced research capabilities on ISS: Enhance onboard mouse/rats research capabilities

1) In both life sciences and space medicine scenarios, onboard mammal (mice, rats) habitation is strongly recommended as a good animal model for human.

2) Some IPs have already conducted mouse/rat experiment in space.

3) This research capability in a whole ISS is expected to be enhanced by the International collaboration.

Candidates for the collaboration

• Development and/or mutual use of IP’s unique onboard experiment facilities and analysis devices
• Launch and retrieval capability
• Research collaboration & joint experiment (sample share)

- Due date is June 29, 2012.
- JAXA will select the high priority proposals based on the “Kibo” Utilization Scenario.
- Annual AO is planned from this year so that the researchers can prepare their proposals based on their long term research planning.
Back up Charts
# Status of Life Science Experiments on Kibo

Life science experiments on Kibo began (in Feb. 2009).

## Year 2009

### Cell & Life
- Nematode (RNA interference) [Higashitani]
- Frog kidney cell (dome formation) [Asashima]
- Human cell p53 influence [Ohnishi]
- Silkworm egg [Furusawa]
- Mutant human cell [Yatagai]

### Technology for measuring the effects of radiation
- Arabidopsis thaliana cultivated (long term till 60th day) [Kamisaka]
- Oryza sativa cell wall (ferulic acid) [Wakabayashi]
- Root hydro-tropism (auxin) [Takahashi]
- Auxin dynamics [Takahashi]
- Plant’s gravity response system [Hoson]

### Plants
- Arabidopsis thaliana cultivated (long term till 60th day) [Kamisaka]
- Root hydro-tropism (auxin) [Takahashi]
- Auxin dynamics [Takahashi]
- Plant’s gravity response system [Hoson]

### Microorganism
- Experiment 1
- Monitoring microorganism in the Kibo module [Makimura & Nasu]
- Experiment 2
- Experiment 3

## Year 2010

### Cell & Life
- Muscle atrophy (ubiquitin) [Nikawa]
- Goldfish scale (bone metabolism) [Suzuki]
- Nerve cell (Mitochondria apoptosis) [Majima]
- Nematode (RNA interference) [Higashitani]

### Technology for measuring the effects of radiation
- Human cell p53 influence [Ohnishi]
- Silkworm egg [Furusawa]
- Mutant human cell [Yatagai]

### Plants
- Root hydro-tropism (auxin) [Takahashi]
- Auxin dynamics [Takahashi]
- Plant’s gravity response system [Hoson]

### Microorganism
- Experiment 1
- Monitoring microorganism in the Kibo module [Makimura & Nasu]
- Experiment 2
- Experiment 3

## Year 2011

### Cell & Life
- Muscle atrophy (ubiquitin) [Nikawa]
- Goldfish scale (bone metabolism) [Suzuki]
- Nerve cell (Mitochondria apoptosis) [Majima]

### Technology for measuring the effects of radiation
- Human cell p53 influence [Ohnishi]
- Silkworm egg [Furusawa]
- Mutant human cell [Yatagai]

### Plants
- Root hydro-tropism (auxin) [Takahashi]
- Auxin dynamics [Takahashi]
- Plant’s gravity response system [Hoson]

### Microorganism
- Experiment 1
- Monitoring microorganism in the Kibo module [Makimura & Nasu]
- Experiment 2
- Experiment 3

## Year 2012

### Cell & Life
- Medaka bone metabolism [Kudo]

### Technology for measuring the effects of radiation
- Mouse’s frozen and dried sperm [Wakayama]

### Plants
- Root hydro-tropism (auxin) [Takahashi]
- Auxin dynamics [Takahashi]
- Plant’s gravity response system [Hoson]

### Microorganism
- Experiment 1
- Monitoring microorganism in the Kibo module [Makimura & Nasu]
- Experiment 2
- Experiment 3

## Year 2013 -

### Cell & Life
- Cells: gravity response, muscle atrophy, bone marrow cell: osteogenesis
- Nematodes: gene effects through aging and alternation of generations in space

### Technology for measuring the effects of radiation
- Aquatic organisms: effects across generations (breeding across 3 generations), muscle atrophy, reproductive function, and stress evaluation

### Plants
- Effects on life by long-term radiation exposure (max. 3 years), evaluation of effects on reproduction, growth and multiple generations

### Microorganism
- Development of real-time radiation measuring technology
- Systems of graviperception and posture control
- Effective plant production, utilization technology, and life support
- In-orbit analysis and adaptation to monitoring and environment

### 15
Status of Space Medicine Research onboard the ISS

Initial Utilization of JEM:
- Verify KIBO’s utility

Medium-term utilization of JEM:
- High-level achievements from research, reducing risks, and identifying mechanisms
- Sophisticated research and preparation of post-ISS operations

Late ISS utilization:
- Sophisticated research and preparation of post-ISS operations
- Identify adaptability of living organisms to space environment
- Prepare human exploration of the Moon

Phase 1 (2008-2011):
- Complete

Phase 2 (2012-2015):
- Being considered

Phase 3 (2016-2020?):
- Being considered

- Measures for muscle atrophy and artificial gravity
- Adjustment of dynamic changes of cerebral circulation
- Adjustment of vestibular and blood pressure reactions
- Identification of lives of microbes and analysis of contamination
- Biological studies using killifish

Health Monitoring System

- Prevent bone loss and urinary calculi.
- Analyze live body rhythm.
- Analyze effects of space radiation.
- Monitor hair and fungi.
- Health monitoring system

Study on bone loss prevention with bisphosphonate

- Measures for muscle atrophy and artificial gravity
- Adjustment of dynamic changes of cerebral circulation
- Adjustment of vestibular and blood pressure reactions
- Identification of lives of microbes and analysis of contamination
- Biological studies using killifish

Artificial Gravity

- Measures for muscle atrophy and artificial gravity
- Adjustment of dynamic changes of cerebral circulation
- Adjustment of vestibular and blood pressure reactions
- Identification of lives of microbes and analysis of contamination
- Biological studies using killifish

Verification of biological mechanisms in model living organisms
## Status of Materials Science Experiments on KIBO

**Start of materials science experiments on KIBO (Aug. 2008)**

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<th>2008</th>
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