The 1st Space Exploration Workshop
and Kibo Utilization for Asia

Space Utilization Activities

2015/5/28

MITSUBISHI HEAVY INDUSTRIES, LTD.
Space Equipment Design Section

AGENDA

MITSUBISHI HEAVY INDUSTRIES, LTD.

1. About MHI

2. Aquatic Habitat Latest Status

3. Mice Habitaion Unit Developping Status

4. New concept of space utilization

About MHI


Energy & Environment Domain
The Challenge to Generate
Energy & Environment offers optimal solutions in the energy-related fields of thermal power, nuclear power and renewable energy, in such environmental areas as water and flue gas treatment, and for chemical plants and other industrial infrastructure elements. By integrating large-scale infrastructure projects that support society, MHI generates new power for the future.
Commercial Aviation
& Transportation Systems Domain
The Power to Progress
Commercial Aviation & Transportation Systems delivers advanced land, sea and air transportation systems, including civilian aircraft, commercial ships and transit networks. MHI moves society, supporting its transportation and logistics infrastructures with superior safety, guaranteed quality and reliability backed by technology.
Future
Aiming to become a highly profitable company with a business scale of 5 trillion yen
2013
Sales ratio by domain
Machinery, Equipment
& Infrastructure Domain
The Means to Connect
Machinery, Equipment & Infrastructure provides a wide range of products that form the foundation of industrial development, such as machine tools, material handling, construction machinery, air-conditioning and refrigeration systems. MHI applies its vast business endeavors and high reliability as a corporation that supports social and industrial infrastructure to connect people to people, businesses to businesses, and the present to the future.
Integrated Defense
& Space Systems Domain
The Technology to Safeguard
Integrated Defense & Space Systems provides integrated land, sea, air and space defense systems, including naval ships, defense aircraft, launch vehicles and special vehicles, as well as space-related services. MHI uses the technology and expertise cultivated in its defense and space business to provide security on the planet.

About MHI

Space Systems

Launch vehicles have been developed under the leadership of the National Space Development Agency of Japan (now Japan Aerospace Exploration Agency). Since the launch of the N-I, which was developed with technical assistance from the U.S. in 1975, the N-II, H-I, and H-II have been developed and improved in Japan. MHI has played a primary role in developing these launch vehicles. In anticipation of demand from both government and the private sector, MHI now provides satellite launch services with H-IIA and H-IIB. In 2014, MHI was also selected as the prime contractor in charge of development, manufacture and launch services of a new national flagship launch vehicle, and work in this area is already underway.

Launch Vehicles

Launch of H-IIA Launch Vehicle

Launch of H-IIB Launch Vehicle

Rocket Launch Complex

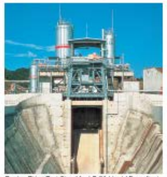
H-IIB Rocket Launch Complex at Launch Pad 2 for Japan Aerospace Exploration Agency (JAXA)

Rocket Engines

LE-5B LOx/LH2 Engine
Thrust: 14.0 tons (Vacuum)
for H-IIA and H-IIB Launch Vehicle Second Stage

LE-7A LOx/LH2 Engine
Thrust: 112 tons (Vacuum)
for H-IIA and H-IIB Launch Vehicle First Stage

Rocket Engine Firing Test Stand



Engine Firing Test Stand for LE-7A Liquid Propellant Rocket Engine for JAXA

H-II Transfer Vehicle (HTV)

The HTV (H-II Transfer Vehicle) is a cargo transport and supply vehicle that delivers supplies, including water, food, clothes and experiment devices, to the International Space Station, both for the Japanese Experiment Module (JEM) and for crew members from other countries.

H-II Transfer Vehicle (HTV) KOUNOTORI
(Courtesy of JAXA/NASA)

Japanese Experiment Module "Kibo"

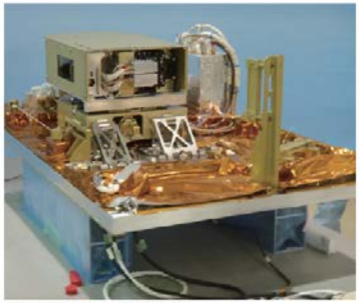
The experiment logistics module pressurized section (interior storage section) and pressurized module (interior laboratory), both manufactured by MHI, were launched in 2008. In addition, subsequent experiment payloads have been launched for conducting astronomical observations, earth observations, material experiments and manufacturing, life sciences experiments (including space medicine and biotechnology) and communications experiments.

Japanese Experiment Module (JEM) "Kibo"
[Development Share: Pressurized Module (PM) & Experiment Logistics Module Pressurized Section (ELM-PS)]

Utilization of Space Environment

International Space Station (ISS)
Cell Biology Experiment Facility (CBEF) aboard "Kibo" Module

International Space Station (ISS)
Aquatic Habitat (AQH) aboard "Kibo" Module



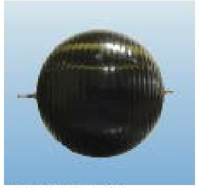
International Space Station (ISS)
EVA Support Robotic Experiments on Exterior of "Kibo" Module
(REX-J: Robot Experiment on JEM)

Space Propulsion Systems

Monopropellant Thrusters

Bipropellant Thrusters

Propellant Tank



High-Pressure Gas Tank

Space Equipment

DELTA IV Upper Stage LH2 Tank

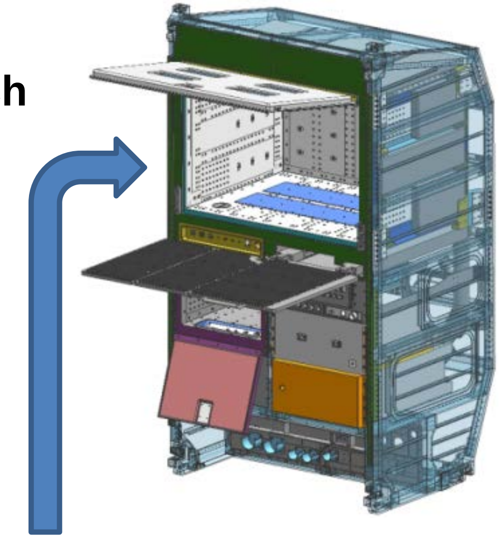
Data Processor for "Suzaku" Satellite

Mission Data Processor for "Hinode" Satellite

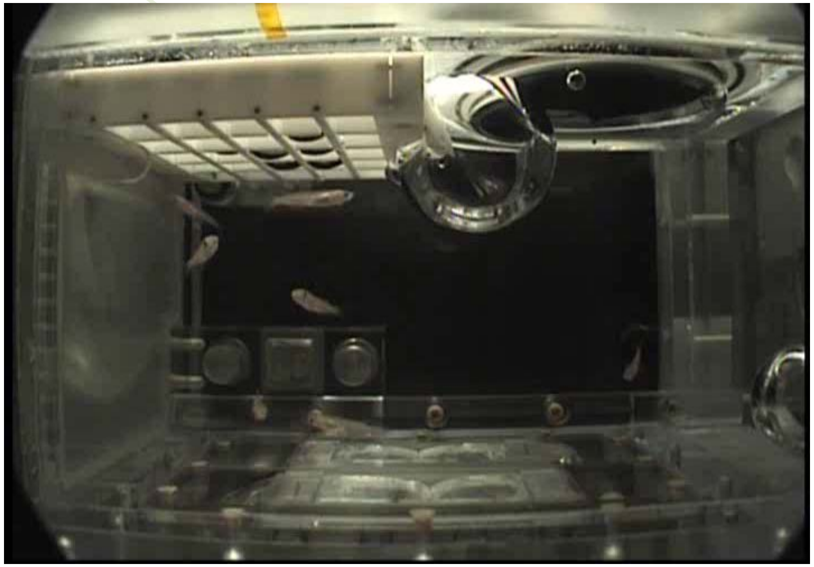
RS-68 Engine Main Valve

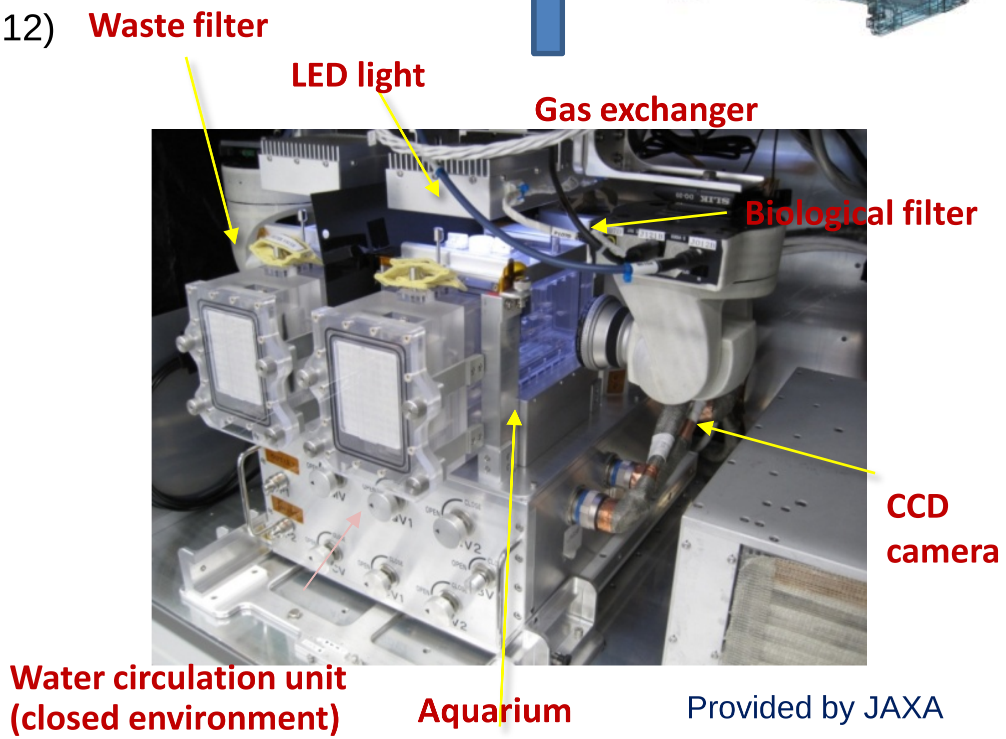
◆ **Why aquatic experiment using medaka or zebra fish in space?**

1. Medaka genome has been decoded by extensive ground research
2. Visibility of medaka: transparent embryo and body.
3. Fish is vertebrate: usable for bone or muscular research
4. Multigenerational breeding: 45 days from hatch to spawn.
5. Japan has experienced a lot in aquatic experiments in space.
6. Small biology; Low resources; High number of samples



First Aquatic Habitat Experiment in Kibo (Oct. 26, 2012)



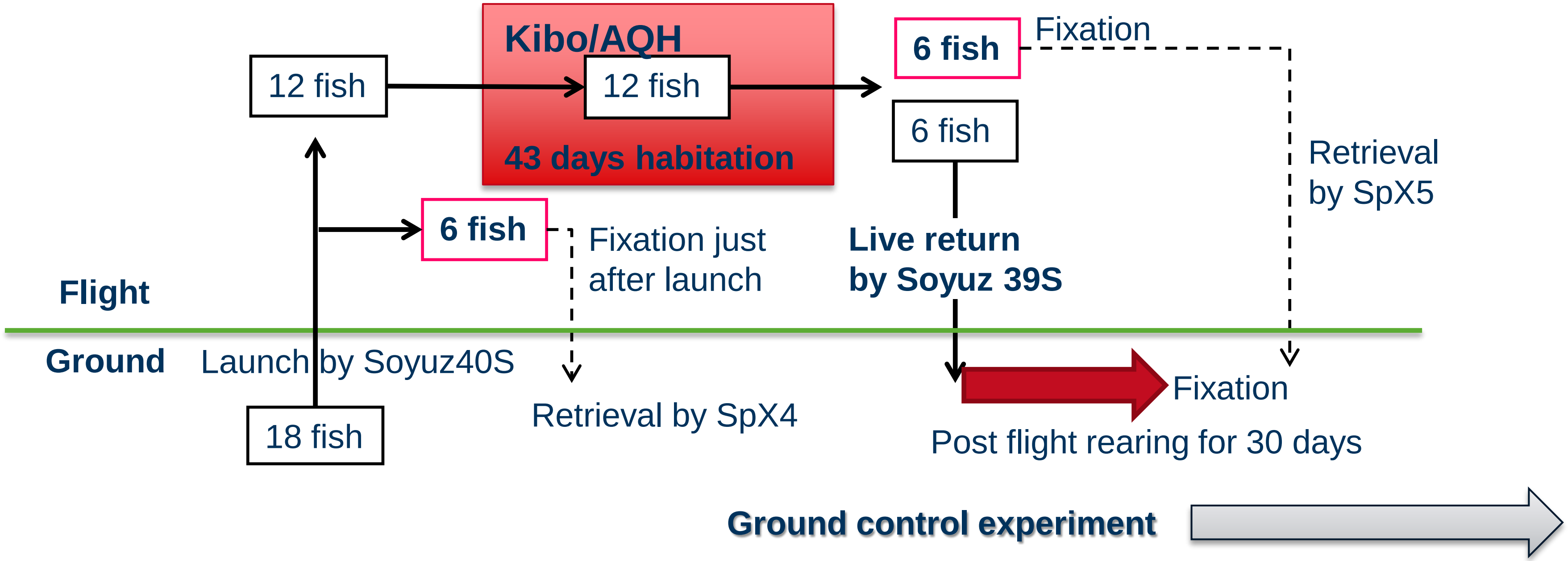


Provided by JAXA

Provided by JAXA

Zebrafish experiment

- A long term (43 days) habitat experiment of zebrafish using Aquatic Habitat (AQH) was conducted from September 27 to November 9, 2014.
  - ✓ Part of the zebrafish was returned in living condition for the first time by Russian Soyuz vehicle, and 30 days rearing with observation followed by fixations was conducted.
  - ✓ All flight (fixation) samples were retrieved. The ground control experiment was completed.



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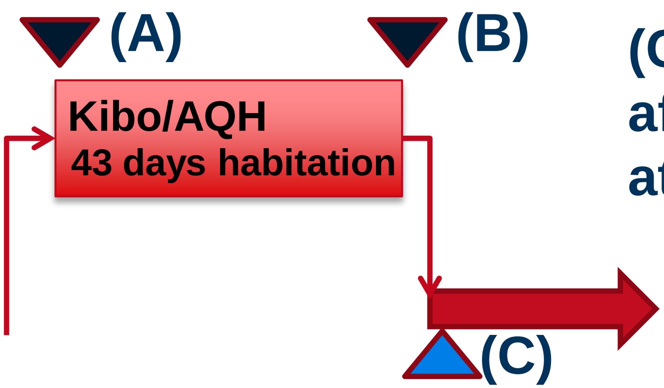
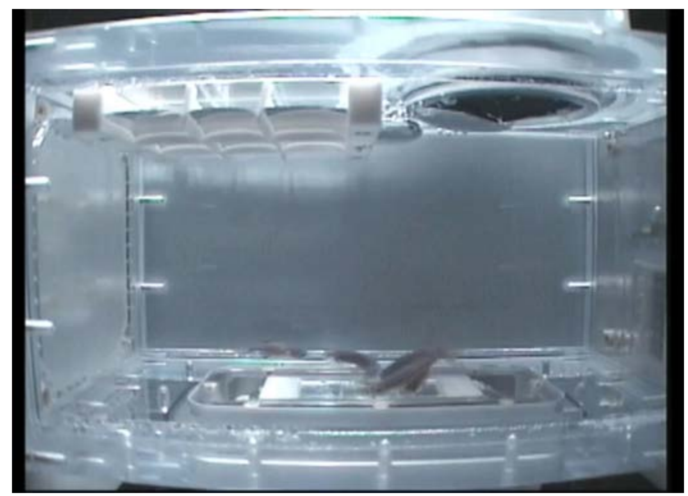
Aquatic Habitat Latest Status

(A) Day 0

(B) Day 42



(C) 16hrs after landing at IBMP



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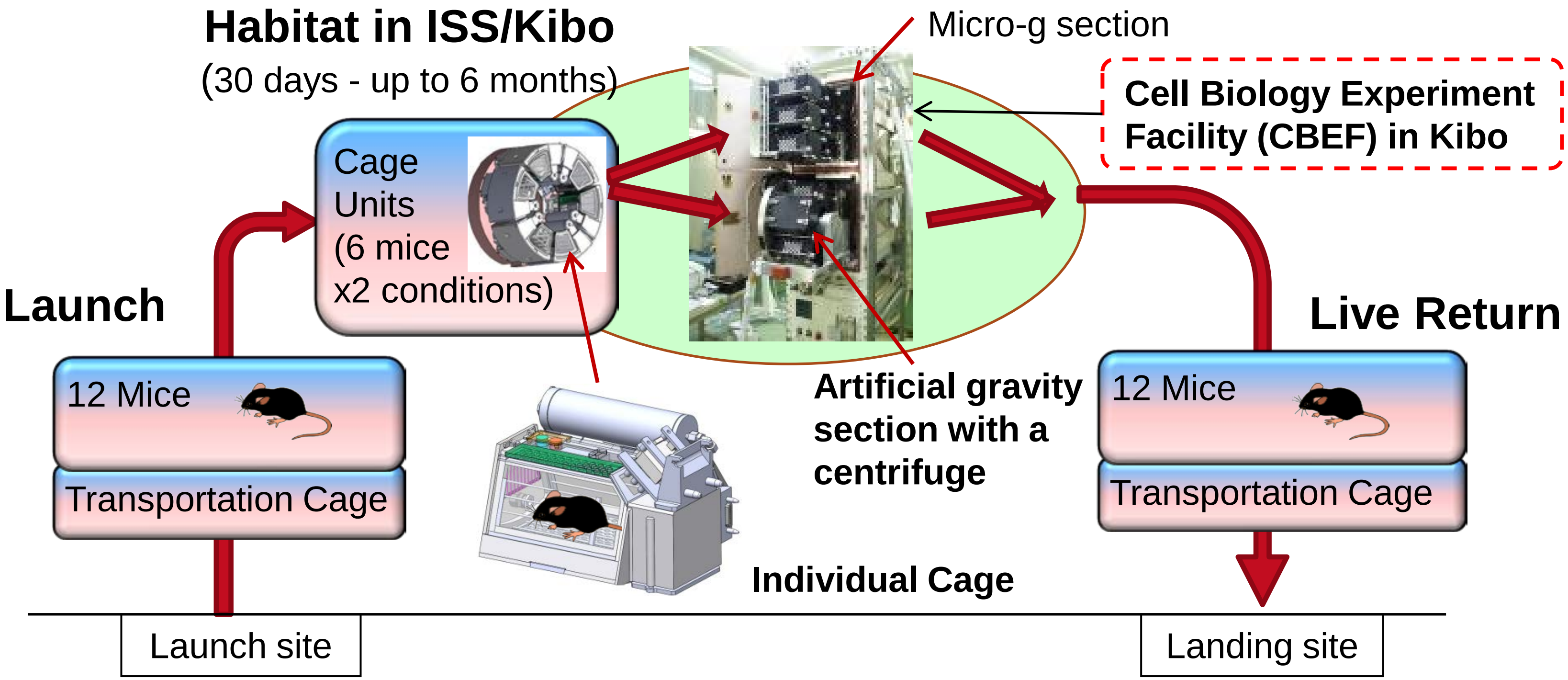


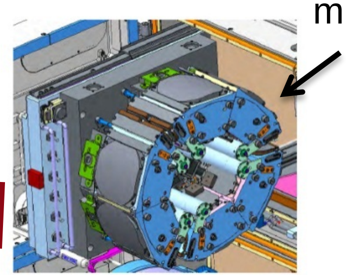
Concept of JAXA mice experiment

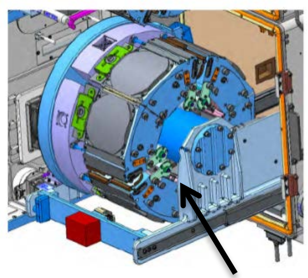
1. **Comparison between micro-G and artificial-G (1G) conditions in space**
   Provide the world's first, long-term artificial gravity environment for mammal in space
2. **Individual Habitat (1 mouse per cage**)
   Able to accommodate male mice which may fight each other in a group habitat condition; Able to monitor behavior of individual mouse
3. **Return mice to the ground in living condition**: Skilled researchers can dissect mice for their detailed analysis with cutting-edge techniques

Provided by JAXA

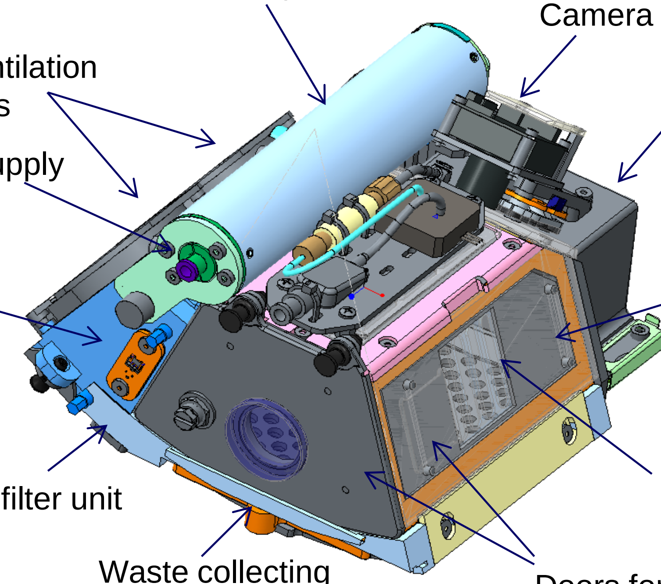
Habitat Cage Unit (HCU)

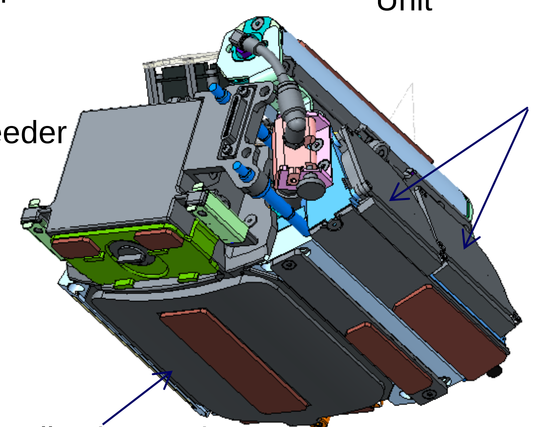
Cell Biology Experiment Facility (CBEF) in Kibo





Artificial gravity section (with a centrifuge)





Features

- 30days ～6months keeping with maintainance
- LED Lighting (0-50 lux) with on/off cycle
- Cage refreshing requirement once a week
- Feed/water resupply requirement once a week
- Temperature, humidity, and concentration of CO_2 and NH_3, video Images are monitored.

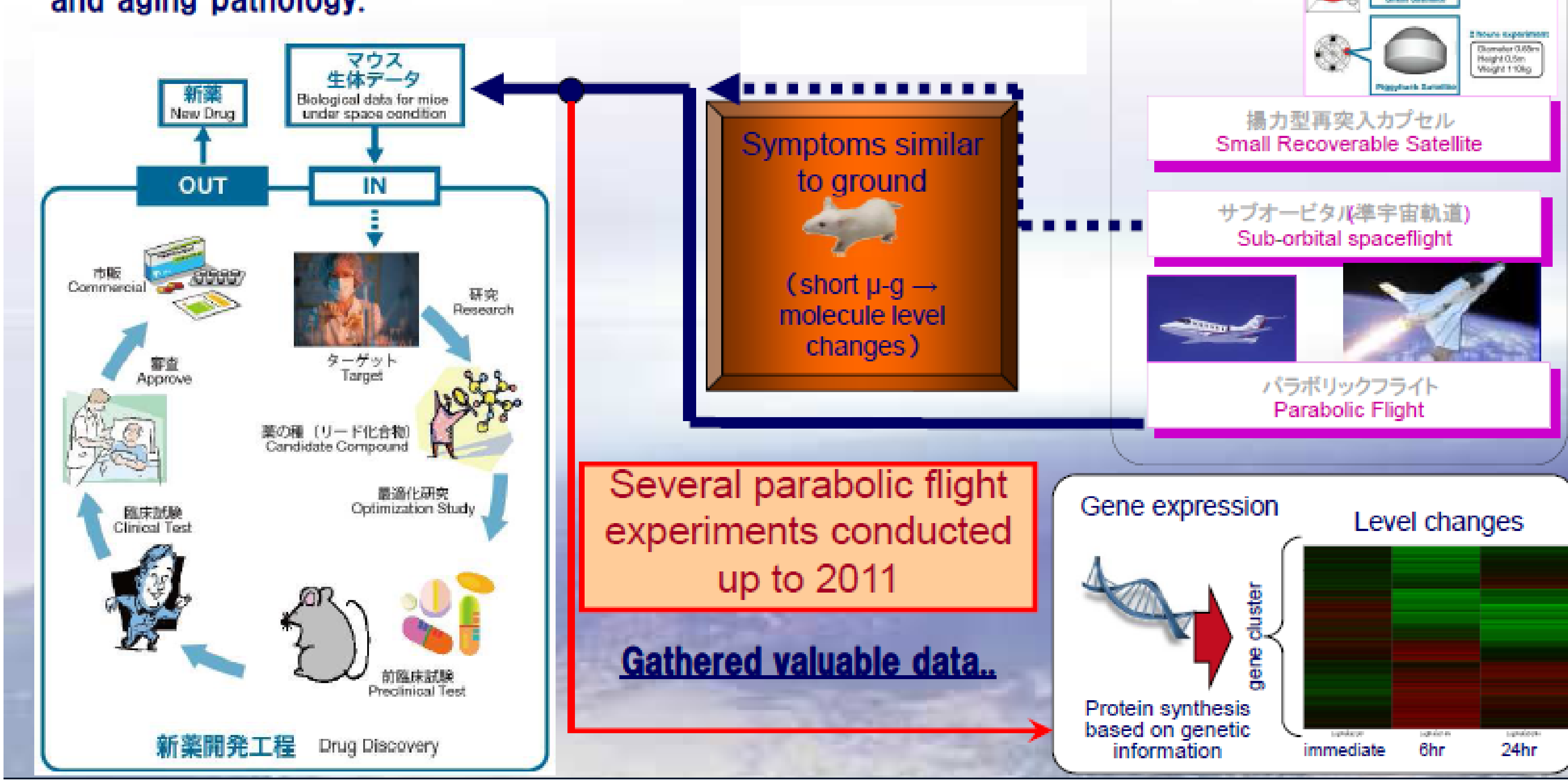
Provided by JAXA

Pharmaceutical Uses of Outer Space

Concept

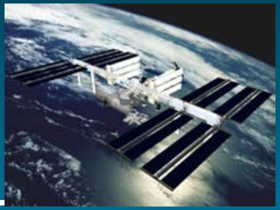
◆To discover mechanisms of target gene or proteins via mice in micro-g, which the pathogenesis mechanism are not resolved.

◆Target disease are: mental illness, osteoporosis, muscle atrophy, and aging pathology.



New concept of space utilization

Microgravity environment

400km

ISS（0G）

100km

Suborbital flight（3min　0G）

10km

Parabolic flight（20sec 0G）

0km

Clinostat（Ave. 0G per 10min）

Gene Expression Analysis

- Alteration of gene expression in CNS
- Alteration of immediate early gene expression in muscle
- Alteration of gene expression in immune system of Crural muscle
- Alteration of gene expression in circadian rhythm

Patent applied for Stress model Animal

Mouse
In Parabolic flight

Physiological Analysis

- Increase in heart rate
- Elevation of blood sugar level
- Alteration of Cortisol
- Alteration of Plasma Arginine Vasopressin

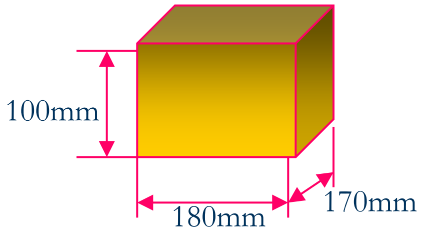
Effects of Parabolic Flight on Plasma Arginine Vasopressin as a Sensitive Marker for Emotional Stress in Humans.

New concept of space utilization

Simulated Microgravity･･･using 3D Clinostat

- Motion control for generating trajectory
- Offset gravitational vectors in all directions on an average per 10 minutes
- Continuous running for several days

Average of accelerations X=0G, Y=0G, Z=0G
Variance of accelerations X=1/3G, Y=1/3G, Z=1/3G



Sample Weight: Max. 1kg (2.2 lb)

3D-CLINOSTAT culture is that ES cells maintained in an undifferentiated state and increased cell proliferation.

It has the potential to promote the development of regenerative medicine research.

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