The “Kibo” laboratory
400 km above Earth
in the palm of your hand
The Japanese Experiment Module (JEM), known as “Kibo”, is Japan’s first human-rated space facility on the International Space Station (ISS). The ISS orbits about 400 km above Earth in 90 minutes.

In “Kibo”, the special environment of space, mainly characterized by microgravity, is used to perform various activities. The results from these activities are applied to medicine, manufacturing, and other areas, and some are already used in our daily lives.

The ISS is humankind’s only laboratory in which a microgravity environment can be obtained over a long period of time. Experiments utilizing this environment that cannot be recreated on Earth are expected to solve problems of interest to companies, universities, and research institutions, leading to the growth of business and research.
About the International Space Station

The International Space Station (ISS) is a manned laboratory built in space approximately 400 km above the Earth through the cooperation of 15 countries including Japan, the U.S., Russia, Canada, and several European countries. Construction began in 1998 and was completed in 2011. It is approximately the size of a soccer field, and orbits the Earth in about 90 minutes. The ISS has six onboard astronauts who perform various experiments. Japan has committed to participating in the operation of the ISS until 2024.

Characteristics of the space environment

- **Microgravity**: The apparent gravity that acts on the ISS is very small, from one millionth to one ten thousandth of that on Earth.
- **Hard vacuum**: The pressure at the altitude of the ISS orbit is 10^-5 Pa, which is one ten billionth of that on Earth.
- **Complex space radiation**: There are various types of space radiation, including galactic cosmic rays, solar particle radiation, Van Allen belt particle radiation, and secondary particle radiation.
- **Wide field of view**: The ISS orbits the Earth in about 90 minutes and has a wide field of view. This is useful for Earth and space observations.
- **Living in a closed environment**: Measures are required to prevent harm to human health, for example, due to psychological stress or microbial infections.

Characteristics of microgravity

- **Changes to the body**: Since there is no gravity in space, a variety of changes are observed at a genetic level and a functional level in the body. Investigating the causes of these problems and their solutions may lead to new treatments and countermeasures for problems such as osteoporosis and deterioration of immune function.

- **No sedimentation**: On Earth, materials sink or float depending on their density. In microgravity environments, even materials with different specific gravities such as water and oil disperse evenly. This can be useful in creating highly functional materials.

- **No thermal convection**: On Earth, when liquids and gases are heated, convection occurs due to differences in specific gravities. In microgravity environments, the differences in specific gravities do not cause convection. It is thus possible to create high-quality polymer and material structures that cannot be created on Earth.

- **Floating without a container**: In microgravity, the levitation of material is possible, and melted material stays in a stable (spherical) state without a container. This method of handling materials without a container is called "containerless processing." This processing allows us to closely investigate the behavior of materials in their molten states, which is difficult on Earth.

About “Kibo”

“Kibo” is Japan’s first manned laboratory on the ISS. Experiments commenced in “Kibo” in 2008. The area for experiments consists of the Pressurized Module, which is filled with air at a pressure of 1 atmosphere and can accommodate activities performed in the same clothes as on Earth, and the Exposed Facility for performing experiments in space.

- **Kounotori**: The space station supply vehicle for transporting cargo to the ISS.
- **JEM Airlock**: Used when growing experimental equipment through the pressure differential between the pressurized module and space.
- **Kibo, the Japanese Experiment Module (JEM)**: The area for experiments consists of the Pressurized Module, which is filled with air at a pressure of 1 atmosphere and can accommodate activities performed in the same clothes as on Earth, and the Exposed Facility for performing experiments in space.
01 Supporting a healthy society with longevity.

See P.8 and 9

In Japan, where one in four people is 65 years of age or older, people hope to stay healthy as long as possible. In microgravity, bones weaken extremely quickly, at approximately 10 times the rate seen in people with osteoporosis, and muscles become atrophied.

Along another line, because convection and sedimentation do not occur in microgravity, protein crystals can be grown with higher quality than on Earth. Using these high-quality protein crystals makes it possible to determine the structure of proteins in more detail, and this is useful for drug research and development.

In the future, we will conduct new experiments, such as crystallizing membrane proteins for drug targets and producing 3D tissues/organisms from stem cells for regenerative medicine. We also plan to conduct epigenome research to clarify genetic changes caused by microgravity.

High-quality protein crystals grown on “Kibo”.

02 Contributing to a prosperous, safe, and secure life.

See P.10 and 11

Global warming, an increased frequency of extreme weather events, and the food shortages that accompany them … Humanity is currently facing a variety of problems. On “Kibo”, we are working to help solve these kinds of problems and to ensure a prosperous, safe, and secure life. For example, observation of Earth from space is useful for predicting environmental variations and monitoring disasters that cover wide areas. Furthermore, experiments on cultivating plants in microgravity environments are expected to deliver results such as the creation of rice that will not easily be damaged, even by typhoons.

Surgical robots that are now actively used in medicine were created from the technology of Canadarm2, the Canadian robotic arm mounted on the ISS. The Japanese robotic arm (Remote Manipulator System) on “Kibo” is also a practical robot that is capable of fine operations by remote control. This technology is also applicable to medical treatment and nursing care on Earth.

We are beginning a trial to provide the opportunity to perform space experiments more easily, so that “Kibo” can be used to explore a wider range of applications and new ideas contributing to innovation and social benefits.

Contributing to a prosperous, safe, and secure life.

03 Improving technologies in manufacturing

See P.12 and 13

On “Kibo”, it is possible to manufacture materials with physical properties that would be difficult to obtain under the influence of gravity on Earth. For example, we successfully created large single crystals of next-generation high-performance semiconductor materials by using the environment in which no convection or sedimentation occurs.

We are also currently performing an experiment to clarify the mechanism that changes the structure of macromolecules thought to contribute to the maturation of alcoholic beverages and making them mellow.

In the microgravity, liquid can be levitated easily and does not need containers. Also, melted materials can keep them in a stable (spherical) state. This method of handling materials without containers is called “containerless processing”. This processing allows us to closely investigate the behavior of materials in their molten states, which is difficult to do on Earth.

The data obtained from experiments on “Kibo” are useful for creating new innovations and technologies, and for increasing the competitiveness of Japanese manufacturing.

04 To unexplored space.

See P.14 and 15

We are currently discussing international space exploration to the Moon, Mars, and beyond. For preparing long-duration human spaceflight, we are developing new systems and equipment on “Kibo”, incorporating technology from Earth.

For example, we are developing water recycling systems that are compact, require little power, and do not need filter replacement; remote medical treatment systems for astronauts; and next-generation spacesuits that are lightweight and easy to move in, even on celestial bodies that have gravity.

Japan has many excellent technologies outside of the space development field. By actively incorporating more of these technologies, we will contribute internationally and also establish the technology needed for manned space missions.

05 Pioneering new fields.

See P.16 and 17

Humankind was born in the gravity of Earth, and science and technology have been developed through research “with our feet on the ground”. Eventually, we leap from the Earth and put our effort into “Kibo”, a facility that allows us continuously perform experiments in space, where we are free from the effects of gravity.

On “Kibo”, we are also conducting scientific research rooted in the intellectual curiosity of humankind. X-ray observation of the entire sky and elucidation of the mechanisms of ice crystal growth are examples of research that can only be performed in space. In addition, observation of the atmosphere over a wide range from the Earth’s surface up to the upper atmosphere will lead to the creation of new academic fields. We are also making advances in observations aimed at clarifying the acceleration mechanisms of high-energy cosmic rays and the true nature of dark matter.

On “Kibo”, we are looking deeply into scientific truths and pioneering new fields that are possible only in space.

Pioneering new fields.
Supporting a Healthy Society with Longevity.

Why do bones and muscles become weak in space?
Research to answer this question can provide insight into ways to extend people’s healthy lifespan.

In microgravity environments, the bones and muscles that support the body become weak, even in healthy astronauts. The reduction in bone density is approximately 10 times larger in astronauts than in osteoporosis patients on Earth. The daily reduction in calf muscle size is equivalent to the reduction seen in a person who is bedridden for 2 days or an elderly person during a roughly 6-month period.

On “Kibo”, we are conducting research on this phenomenon, which has been called an accelerated model of aging-like physiological changes. As a result, we have clarified that the reduction in bone density in space is triggered by activation of osteoclasts, a type of cell that breaks down bone, and identified an enzyme that causes muscle atrophy. Based on these results, new medical treatments for osteoporosis and functional foods that prevent muscle atrophy are being developed. The astronauts themselves have become the subjects of experiments investigating mechanisms for maintaining muscle and validating training equipment for effectively suppressing muscle atrophy.

Locomotive syndrome, in which motor organs such as bones and muscles become atrophied, has recently become a growing problem. We are also planning to conduct pre-clinical trials on “Kibo” for identifying the factors that enable early diagnosis of aging-like phenomenon and for investigating the efficacy and safety of preventive drugs and treatment candidates by introducing a new research platform using a good mammal model, such as mice. The results from these studies are expected to extend healthy life through prevention and treatment of locomotive syndrome.

High-quality protein crystal growth experiments on the ISS will contribute to the design of drugs with high efficacy and fewer side effects.

Over 100,000 kinds of proteins are at work in a human body. Forming the right 3D structure is required for them to function. Knowing the structure of a disease-associated protein allows us to design new drug candidates, which modulate the activity of the protein by binding to its active site. This approach is called structure based drug design (SBDD). Compared with the high-throughput screening widely used in the pharmaceutical industry, SBDD is permits designing a new compound with fewer side effects and at less expense.

High-quality protein crystals are necessary to determine a precise protein structure. It is not easy to grow highly ordered crystals, partly because of convection driven by gravity. Thus, better crystals can be grown in the microgravity of “Kibo”.

Over one hundred different proteins provided by universities and companies have been crystallized on “Kibo”. Prior to the experiment on the ISS, crystallization conditions are optimized to make the most of the space experiment. In approximately 60% of the proteins, crystals grown in space contributed more detailed structural information than those grown on Earth.

We have conducted crystallization experiments of proteins related to drugs for treating diseases such as influenza, cancer, and muscular dysrophy. The obtained structural information has contributed to drug research and development.

CHECK

All human activities, ranging from those involving food, clothing, and shelter to medical treatment, relating to aging in some way. On “Kibo”, we are conducting research on aging-like phenomena that will advance business and research on Earth.

CHECK

Space environment allows us to create high-quality protein crystals. This leads to useful data by analyzing 3-dimensional structure of target proteins, such as for the design of drugs or industrial enzymes.
02 Contributing to a Prosperous, Safe, and Secure Life.

"Kibo" gives a bird’s eye view of Earth. Enabling prediction of environmental changes and monitoring of wide-area disasters.

Getting a fast and accurate understanding of global-scale changes such as global warming and ozone layer depletion is essential for predicting environmental changes and implementing measures to address them. It is therefore effective to observe the entire Earth from space.

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES), which was mounted on the Exposed Facility, made the first ever high-precision observation of the increases and decreases in the amount of ozone over the course of one day. This result has attracted much attention, and was cited in the "Ozone Assessment Report 2014" report issued by the United Nations Environment Programme and the World Meteorological Organization. Furthermore, images and videos of Earth captured from the ISS are provided to analysis teams on the ground through the international framework of cooperation between Sentinel Asia and the International Disasters Charter, and are useful for analyzing the state of wide-area disasters such as floods and forest fires.

**CHECK**

"Kibo" can put within your grasp the wide field of view that only a satellite had provided so far. Furthermore, you can see a different face of the Earth by observing at different frequencies of electromagnetic waves. You can see Earth as humankind has never seen it before.

What happens if you grow plants in space? This research may lead to rice that is resistant to wind damage.

On "Kibo", we are conducting experiments in which plants are grown in the microgravity environment. For example, we have investigated the strength of cells walls by growing Arabidopsis thaliana (thale cress) grown in microgravity on "Kibo". The result of experiments is high. However, "Kibo" provides the opportunity for more people to use a wider range of methods to perform space experiments by utilizing the features of both the airlock and the robotic arm. In the development of materials for space and other applications, there was the problem that experimental samples could not be returned to Earth and evaluated directly. By using the Exposed Experiment Handrail Attachment Mechanism (ExHAM), it is possible to return experimental samples to Earth after attaching them for a long time outside of "Kibo".

The fine motion connected the greatly different scales of space and time. The Japanese robotic arm on "Kibo" also has high performance, and is used for external installation of experimental equipment and for launching small satellites. This technology is expected to be applicable not only to future manned probes, but also to medical treatment, nursing, and work in dangerous places on Earth.

**CHECK**

"Kibo" is a test bed that allows you to easily try out the space environment. Saying that space quality is proven could bring great changes to your business and research. The robotic arm performs heavy lifting and fine manipulations instead of astronauts. Surgical robots were born from this technology.

SSRMS (Space Station Remote Manipulator System) mounted on the ISS has been used for various applications including assembling the ISS, moving supplies and experimental equipment around, and helping astronauts with extravehicular activities. The world's first robot able to perform surgical procedures inside magnetic resonance imaging (MRI) equipment was developed from the SSRMS technology for performing fine movements.

The Japanese robotic arm on "Kibo" also has high performance, and is used for external installation of experimental equipment and for launching small satellites. This technology is expected to be applicable not only to future manned probes, but also to medical treatment, nursing, and work in dangerous places on Earth.
Improving Technologies in manufacturing.

A still environment without convection or sedimentation. This allows the creation of uniform, high-performance materials.

When a material is created, the regularity of its structure is disturbed due to the effects of convection and sedimentation, which occur due to gravity on Earth. In microgravity environments where there is no convection or sedimentation, distortions in the material structure less readily occur and highly regular materials can be obtained.

For example, we succeeded in creating the first large single crystals of silicon germanium (Si0.5Ge0.5), which is expected to serve as the semiconductor material for next-generation high-speed low-power devices. Although it is extremely difficult to fabricate large single crystals of Si0.5Ge0.5, the experimental results from “Kibo” demonstrated that it is possible, even on Earth, and this was a big step toward practical application.

In experiments on fabricating nanoscale porous materials (Nanoskeleton®) by using self-organization, we succeeded in enlarging the pore size and aligning the pore directions. This made it possible to give the pores various physical properties, and we are currently investigating application to high-efficiency photocatalysts, solar cells, and devices for removing harmful materials such as environmental pollutants.

Alcoholic beverages that mature in space become mellow? it is known that for many varieties of alcoholic beverages, a mellow taste is created by a long period of aging. However, the full details of the mechanisms have not been clarified.

One hypothesis is that the water, ethanol, and other components contained in the alcoholic beverages contribute to mellowness by forming polymer structures. Because the formation of polymers is thought to be promoted by the absence of convection, we have focused on the microgravity environment where convection does not occur and we are conducting an experiment in which alcoholic beverages are stored for a long time on “Kibo” in order to clarify the relationship between convection and the effect of the alcohol becoming more mellow.

Levitating and melting materials using Coulomb force without a container.

On Earth, a liquid needs a container to stay put. Because no containers are suitable for temperatures higher than 2,000 °C, it is difficult to melt materials with a high melting point on Earth. Containers react to high temperature and contain the materials.

In microgravity, liquid can be levitated easily and does not need containers. This method of handling materials without a container is called “containerless processing.” This processing allows us to closely investigate the behavior of materials in their molten state, which is difficult to do on Earth.

The electrostatic levitation method, which is one containerless processing technique, uses the Coulomb force between charged samples and electrodes and controls the sample position by using high-speed feedback from the camera image.

In 2015, JAXA completed the development of the Electrostatic Levitation Furnace (ELF) for the ISS. The ELF is a facility for materials science that melts levitating materials having a very high melting point, measures their properties, and then solidifies them from a supercooled phase by taking advantage of the microgravity environment. The target sample of the ISSE mission is oxides. The melt oxides cannot be levitated by electromagnetic force, and it is difficult by Electrostatic Levitator on ground because the electric charge of nonconductors is much less than that of conductors. During the preparatory research for the ELF on “Kibo,” the technique of measuring the thermophysical properties of high-temperature melts has been improved with a ground-based facility. Many thermophysical properties of refractory melts have been revealed for the first time.

Moreover, containerless processing can provide a large supercooled state that allows formation of different crystalline structures and phases, from which new materials can be created.

We levitated and melted barium titanate (BaTiO3) without a crucible during a ground-based experiment and crystallized it through supercooling. As a result, we succeeded in developing a high-performance material that has a huge dielectric constant and is unaffected by temperature changes.

The thermophysical data acquired from “Kibo” will dramatically improve the thermophysical properties of materials through crystalization using containerless processing.
Go further for longer. Searching for measures to live in space.

To sustain and develop human space activities, it is essential to have technology for maintaining health over a long period of time in an enclosed microgravity environment. To accomplish this, it is important to first correctly understand the effect of the space environment on the human body. In the past, we have confirmed that changes appear in the vestibular system, which governs sense of balance, intracranial pressure, and we have been accumulating knowledge. Suppression of immune function is another risk of long-term residence in space. Microorganisms called probiotics are known to improve intestinal microbiota and to regulate immune function. We are investigating in cooperation with companies whether probiotics are also effective in space.

Human activity in space is expected to spread to the Moon and Mars. Since it is difficult to get assistance from Earth, we are investigating remote medical treatment systems and autonomous health management methods. Furthermore, although the amount of radiation exposure while staying on the ISS is approximately 150 times that on Earth, it becomes even higher outside of the magnetosphere of Earth. We are further developing the technology for predicting accumulated exposure on ISS in order to utilize the results in radiation shielding designs for future spacecraft.

Life has the mechanism of plasticity that allows adaptation to changes in the external environment. However, life cannot continue if irreversible damage builds up. In the extreme environment of space, what is the extent of the plasticity of life? We have started to gain an overall understanding of the plasticity and failure of living organisms that transcends existing research fields.

Simply transporting cargo is a waste. “Kounotori” can also be used for experiments.

After the Japanese H-II Transfer Vehicle “Kounotori” has transported cargo to the ISS, it is loaded with waste materials, such as experimental equipment that has finished being used, and reenters the atmosphere, where it burns up. We have performed experiments that make use of this property.

One is the reusable data collection unit (i-Ball). i-Ball was mounted on “Kounotori” and collected data and images such as acceleration, position, and temperature during atmospheric reentry. This data was used to increase the prediction accuracy of the range over which the fragments fall to the Earth, and was useful for increasing safety. It will also be used for developing spacecraft that can reenter the atmosphere from space.

In the future, we plan to perform proving experiments of conductive tethers (KITE) as one of the main technologies for removing large pieces of space debris.

An effective cooling spacesuit that is easy to wear, easy to move. JAXA has been conducting research on a lightweight spacesuit that can be used for human space exploration activity.

The American and Russian spacesuits that are currently used on the ISS require several hours to prepare for conducting extravehicular activities (EVA). Aiming for future human space exploration to the Moon and Mars, JAXA has been continuously researching on developing a lightweight spacesuit that can be prepared in a much shorter time and is easy to move.

Inside the spacesuit, because of its high thermal insulation, the temperature gradually rises from the heat produced by the astronaut’s body during EVA, possibly resulting in astronauts experiencing a heatstroke. To solve this problem, a liquid cooling undergarment is worn inside the spacesuit to efficiently cool the body. As one of the outcomes from the spacesuit research, a vest-style cooling undergarment has been developed and commercialized. It is expected to be effective for lowering the risk of heatstroke for people working under hot sun and for people wearing special garments, such as fireproof clothing or chemical protective clothing.

We are researching with the aim of developing a sophisticated spacesuit by bringing together various technologies at which Japan excels, such as advanced materials, clothing design, and precision machining.

Water recycling is a key technology for human space activities [JAXA1]. JAXA realizes maintenance-free operation by using cutting-edge technology.

In human space activities, astronauts cannot survive without drinking water. However, since the amount of transportation into space is limited, water is extremely valuable. To reduce the transportation mass, the moisture contained in the breath, sweat, and urine of astronauts needs to be recycled. JAXA is developing a water recovery system with a high recovery rate, low mass, and low power consumption, in cooperation with leading-edge Japanese companies. The system allows consumables to regenerate and does not have any parts or consumables that need to be replaced periodically.

This water recovery system will be of benefit not only for the ISS, but also for future manned missions to the Moon and Mars.

JAXA is aiming for a size reduction to one quarter of the system currently used on the ISS. The photo shows the prototype model.
05 Pioneering New Fields.

High-energy cosmic rays, dark matter, gamma ray bursts
Searching dynamic deep space that is invisible to the human eye.

Although deep space appears calm to our eyes, it is actually very dynamic and violently crossed by high-energy cosmic rays such as X-rays and gamma rays which are not visible to the human eye.

The Calorimetric Electron Telescope (CALET) mounted on the Exposed Facility of "Kibo" uses the latest detection and electronics technology to measure the energy, species, and direction of particles traveling through space. The observations by CALET are expected to clarify the mechanisms of acceleration and propagation of high-energy cosmic rays, which remain unexplained even now, 100 years after they were first discovered. Other major aims of CALET are searching for dark matter and explaining the nature of gamma ray bursts.

Where Earth’s atmosphere and space plasma mix.
Various phenomenon in this mixing can be observed through meteorology and astronomy in the atmosphere.

Where the Earth’s atmosphere gives way to space, a variety of phenomena occur due to mixing between the atmosphere and space plasma. However, understanding this from Earth is challenging due to obstruction by clouds and other difficulties.

The Ionospheric, Upper Atmosphere, and Plasmasphere Mapping Mission (IMAP) and Global Lightning and Sprite Measurement Mission (GLIMS) were mounted on the Exposed Facility. IMAP observes disturbances in the atmosphere by capturing images of airglow. We have successfully captured the state of the upper atmosphere violently shaken by the rotation of a wide area. This has shown the relation between the upper and lower atmosphere. GLIMS is continuing to clarify the overall phenomenon of lightning, which was previously not completely understood, by observing sprites—a luminous phenomenon directed toward space that occurs in the upper parts of thunderclouds accompanying lightning discharges.

The observation results of IMAP and GLIMS both show the importance of the new concept of the "whole atmosphere," where a wide range of the atmosphere—from near the Earth's surface to the upper layers—is treated as a single system.

Discovering more about the most familiar of substances. Why ice crystals form.

You have likely seen, at least once, snow on your sweater, or frost on your windows. Yet, the formation process of ice crystals (the crystal growth process) is complex, and the detailed formation mechanism remains unknown. We were able to obtain precise data related to the crystal growth process for the first time by repeatedly performing experiments to check the reproducibility of the measurements under different temperature conditions in the microgravity environment without heat convection. As a result, we confirmed that ice crystals grow more slowly in space compared with on Earth and constructed a new theory of the crystal growth process for the first time by repeatedly performing experiments to check the reproducibility of the measurements under different temperature conditions in the microgravity environment without heat convection.

Research into the crystal growth of ice is useful for understanding a variety of items including crystal growth of other materials, weather phenomena, living organisms that live below water's freezing point without freezing, frozen food quality, and methane hydrate formation.

CHECK
By using the feature of the ISS in Earth orbit, we have implemented all-sky observation without any moving parts. Although some wondered whether the ISS would be suitable for observation of celestial bodies, we continue to produce results that dispel any doubts.

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Our New Challenges.

Since “Kibo” went into operation in 2008, a variety of experiments have been performed on it, and we have accumulated the advanced technology and knowledge required for space experiments. In response to further requests from users, we will tackle experimental challenges that have previously been difficult.

Crystallization of high-quality crystals of membrane proteins, which are targets for drug development.

In recent years, membrane proteins, which are present in the biomembranes of cells, have been focused on as main targets for drug research and development. However, it is very difficult to crystallize membrane proteins. We are therefore aiming to develop techniques for growing high-quality membrane protein crystals on “Kibo”, using the knowledge obtained by previously developed techniques for water soluble protein crystallization.

Furthermore, we are also working to enlarge the crystal size of the existing water soluble proteins. If the high-quality crystals can be made larger, it will allow us to perform neutron beam analysis, which can determine the exact coordinates of the hydrogen atoms; this plays a critical role in the function of proteins. These results will enable the more precise design of better drug candidates.

For the remaining proteins that have an important function but are difficult to crystallize, particularly the membrane proteins that are targets for drug development, we are working on obtaining more accurate structural information.

Discovering methods for treating and preventing various aging-related phenomena.

Elderly people are subject to various aging-related diseases, including decreasing bone density, muscle atrophy, and decreased immune function. Establishing methods for the treatment and prevention of disease is a pressing problem, particularly for Japan with its aging society. Similar phenomena are also observed in healthy astronauts staying in microgravity environments, where they advance even more rapidly. We are therefore proceeding with experiments that use “Kibo” as a platform for research on aging-like phenomenon. We will first clarify what changes occur in the bodies of astronauts staying in a microgravity environment by performing omics analysis that connects information obtained through genes, transcriptomic products, proteins, metabolites, and phenotypes. We will also investigate the epigenome, a part of the genome that undergoes changes due to various environmental factors.

Furthermore, we will contribute to the prevention and treatment of aging-related diseases through genomic medicine, for example, by identifying factors that will allow aging-related diseases to be diagnosed earlier.

Measuring unknown properties of high-temperature molten materials.

When high melting point materials are used, knowing their physical properties, such as density, surface tension, and viscosity, is extremely important. However, in the past, at high temperatures of up to 3000 °C, the container holding the sample begins to melt first, and its components mix with the sample, making it impossible to perform accurate measurements.

We would like to measure the physical properties of high-temperature molten materials. The Electrostatic Levitation Furnace on “Kibo” answers this demand. By keeping samples floating while heating and melting them with a laser, it is possible to measure the physical property values of molten materials with high accuracy free from contamination from the container. The Electrostatic Levitation Furnace on “Kibo” is the world’s only equipment capable for measuring the physical property values of a wide range of high-temperature molten materials from metals to insulators. The obtained physical property values of these materials will contribute to advances in simulations of processes such as casting and welding, and improvements in manufacturing processes. Furthermore, since use of this furnace makes it easy to perform supercooled solidification, it is also expected to lead to the development of new materials that have never-before-seen functions.

Recovering experimental samples from space.

The samples obtained through experiments on “Kibo” are very precious. So, there have long been requests to recover the samples to Earth. In biology experiments, in particular, there has been a strong desire to analyze the samples on Earth. However, the means of transporting experimental samples to Earth has been limited to American and Russian spacecrafts, and it is not possible to carry all experimental samples. To meet this demand, it is essential for Japan to have an independent means of carrying samples back to Earth. We are therefore taking on the challenge of return technology, and we are proceeding with research and development of a compact return capsule that can bring experimental samples back to Earth.

Stem cells have the ability to differentiate into a wide variety of cells. Regenerative medicine is spotlighted because stem cells have high potential for recovery of tissues/organs lost to injury or disease. It is very difficult, however, to produce 3D organs with the proper function and with a complex structure on the Earth because gravity disturbs the growth of 3D organs.

Microgravity is a suitable environment for producing tissue/organs three-dimensionally, and we are hopeful that it will provide high-quality tissues/ organs. We believe that the knowledge of 3D culture technology gained on “Kibo” will widely contribute to the medical front.

Producin 3D tissues/organs from stem cells under microgravity for regenerative medicine.

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Introduction to the Experimental Facility on “Kibo”.

Pressurized Module

Five Japanese experiment racks are installed into the pressurized module. Two of them are Japanese multipurpose experiment racks, which can accommodate various exchangeable-type experimental facilities. In addition, “Kibo” is equipped with an American experiment rack, a freezer, storage racks, and other equipment.

Exposed Facility

The Exposed Facility is a multipurpose experiment area for performing observations of celestial bodies, observation of Earth, communications, robotics experiments, materials experiments, and other types of experiments that use aspects of the space environment such as microgravity and high vacuum. The Exposed Facility has 10 attachment points (ports), allowing various experiments to be performed by swapping out the experimental equipment.

Biological experiment rack
- Mouse Habitat Unit (MHU): For raising 12 mice
- Clean Bench (CB): For microscope observation

Gradient Heating Furnace rack
- Gradient Heating Furnace (GHF): A vacuum furnace for performing crystal growth of semiconductors and other materials using a variety of temperature profiles up to a maximum of 1600 °C

Fluid experiment rack
- Fluid Physics Experiment Facility (FPF): Observations of fluid phenomena using infrared light and ultrasound
- Image Processing Unit (IPU): Records experimental images and transmits them to Earth

Multipurpose experiment rack
- Protein Crystallization Research Facility (PCRF): For controlling protein crystallization environment.
- Solution Crystallization Observation Facility (SCOF): For investigating the process of crystal growth

Exposed Experiment Handrail Attachment Mechanism (ExHAM): Up to a maximum of 20 experimental samples of size 10 cm square can be attached and exposed to space for a year or more and then returned to Earth.

JEM-Small Satellite Orbital Deployer (J-SSOD): Up to 6 small satellites of size 10 cm cubed can be launched into orbit at once by using the “Kibo” robotic arm.

IVA-replaceable Small Exposed Experiment Platform (i-SEEP): Expands possibilities for exposed testing and verification of equipment outside of “Kibo”.

Simple exposure experiments

Monitors of All-sky X-ray Imaging (MAXI): For observation of active celestial bodies such as black holes inside and outside the Milky Way by using an X-ray camera with the world’s largest field of view.

Space Environment Data Acquisition Equipment - Attached Payload (SEDA-AP): Measures the space environment (neutrons, plasma, atomic oxygen, dust, etc.) in the orbit of the ISS.

Source: NASA/CXC/ASU/J. Hester et al.

Pulsars are thought to be one of the celestial bodies that accelerates cosmic rays.

Source: Takuya Ohkawa

Source: NAKA/CURL/JAXA, Hatanaka et al.

Perform observations of high-energy electrons and gamma rays to understand the acceleration and propagation mechanisms of high-energy cosmic rays, to search for dark matter, etc.