

A Future Made Visible by Protein

The Key to Life Explained in Space

High-Quality Protein Crystal Growth Experiment aboard the International Space Station,
the Japanese Experiment Module, Kibo



In progress
aboard the International
Space Station,
the Japanese
Experiment Module,
Kibo!

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Protein Crystal Growth Experiment Web Site
<http://iss.jaxa.jp/kiboexp/theme/first/protein/en>
Space Experiment Web Site
<http://iss.jaxa.jp/en/>



Protein: The Key to unlocking the mysteries of life

All living things, including the human body, are made from proteins.

Studying proteins means understanding the workings of life.

Proteins are the key to unlocking the mysteries of life.

And presently, our experiments in space are bringing about great advances in protein research.

1 Opening the Doors of Possibility with Protein

There are said to be around 10 billion proteins in the entire natural world, with more than a hundred thousand in the human body alone.

Every single protein supports our life through its specific function. Our skin, for example, is made of a protein called collagen, while another protein, hemoglobin, carries oxygen through our bodies.

The human body is made up of more than ten thousand proteins.



Protein Research Is Advancing in a Variety of Fields

Proteins perform a variety of functions, and as such, research on them is being conducted in a wide range of fields.

Development of New Medical Products

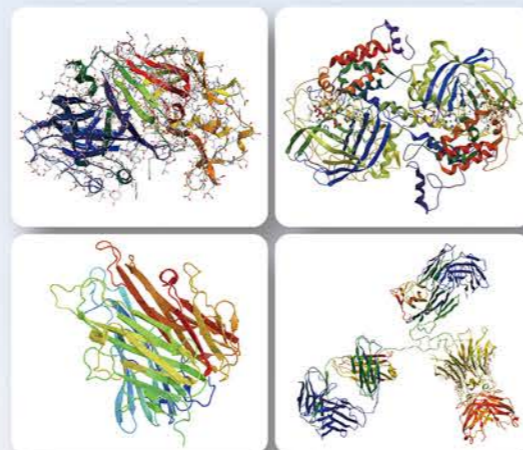
Realization of Environmentally Friendly Waste Processing

Invention of Bio-energy ...and more!

2 The Key to Solving the Mystery Is in Its Structure

All proteins possess a defined structure. Collagen has its own structure, as does hemoglobin. Forming the right structure is essential for a protein to be functional. Studying a protein structure in detail could reveal the protein's function and mechanism, and will lead to a new stage of research on controlling protein function.

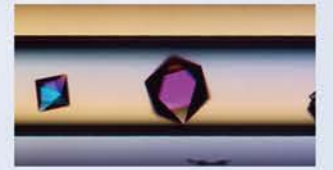
Clarifying the structure of each protein. That is the point of protein research.



An infinite variety of protein structures

3 Crystal Growth Is Necessary to Analyze the Structures

Since protein molecules are too small to see using a light microscope, a special technique called X-ray crystallography is used. Protein is first crystallized so that many protein molecules are well aligned in a crystal, and then the crystal is exposed to an X-ray beam.



The data obtained from the crystal is used to determine the structure. Crystal growth is an essential step in structure determination.

Explaining Structural Analysis through Photography — 1

Imagine taking a group photo. If each person stands in a different direction or moves around, you cannot clearly capture all of their faces.



The same applies to the analysis of protein structures. In other words, crystal growth ensures that all the proteins **"line up, face the camera, and stay still"**

4 Does Gravity Hinder Crystal Growth?

Growing crystals is actually very difficult. It is not unusual for the successful growth of a single protein crystal to take several years. This giant hurdle has troubled a great number of researchers.

One thing that makes crystal growth so difficult is gravity. Gravity causes distortions and disarray, which prevent the growth of high-quality crystals.

Explaining Structural Analysis through Photography — 2

Wind musses everyone's hair and blows dust in their eyes, making it hard to get everyone smiling at the same time. The same applies to the analysis of protein structures. The ideal solution would be **"to take the photo where the wind, or in our case, gravity, isn't blowing and where there is no dust floating around."**



To conduct productive research on protein function, high quality crystals that can provide a detailed protein structure are necessary. Since the structure of a protein plays a decisive role in its function, even if you discover a protein that causes a disease, you cannot control its function unless you understand its structure.

Growing crystals not affected by gravity. This is one of the dreams of advancing protein research.

5 Growing High-Quality Crystals in the Microgravity Environment of Space

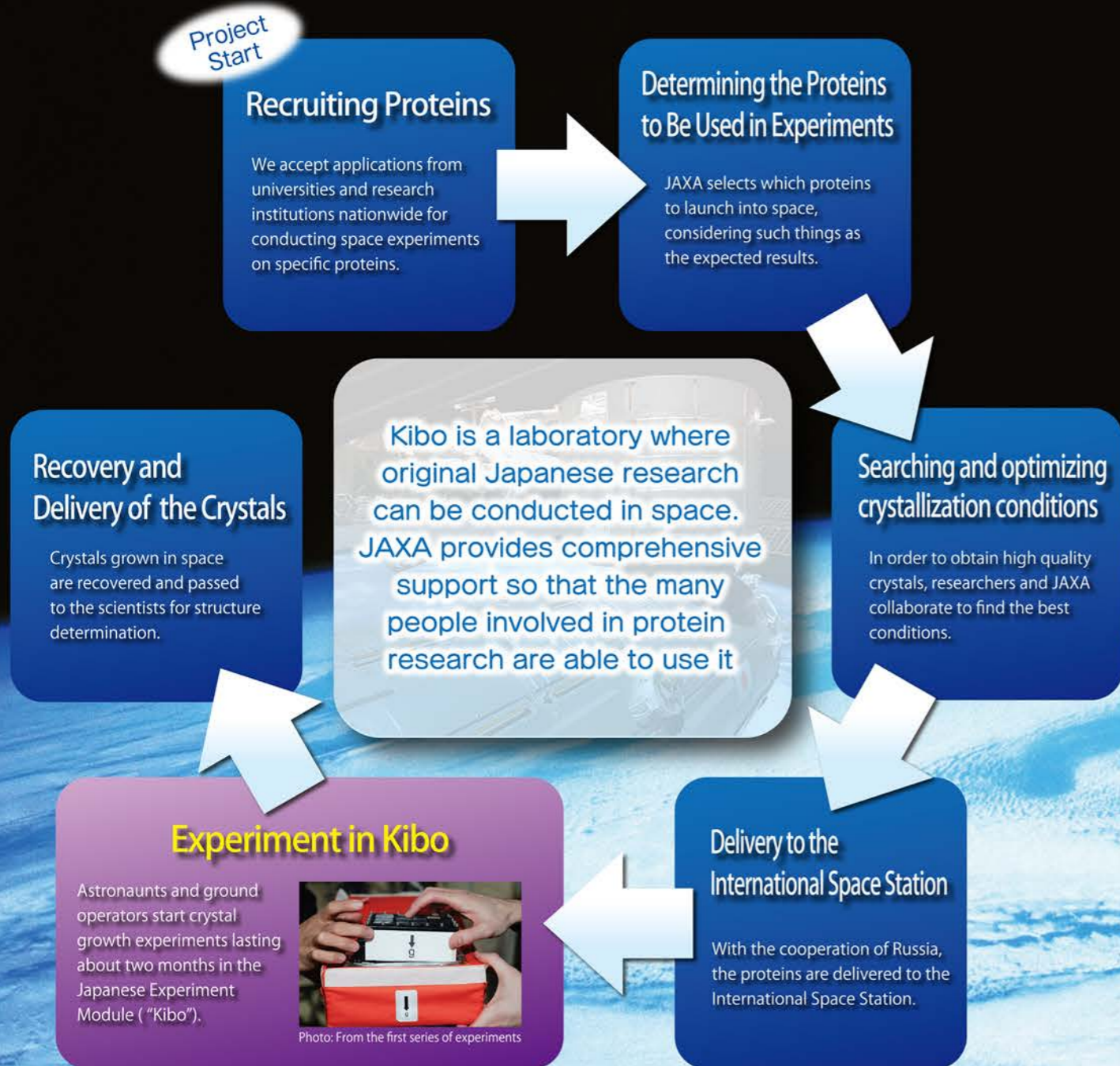
The crystal growth experiment aboard the International Space Station has made that dream a reality.

We have already taken a variety of proteins into space to form crystals, very small protein crystals which formed in the microgravity environment of space, and brought them back to Earth. Great research results may soon follow.

Taking a Variety of Proteins into Space

JAXA and researchers have cooperated to conduct the Protein Crystal Growth experiment aboard the International Space Station. The first series of experiments (six sessions) began in 2009, followed by the second series of six experiment sessions in the latter half of 2013. The flow of each space experiment is described as follows.

Project Flow



International Space Station and Kibo

The International Space Station is a massive manned experimental facility constructed approximately 400 km above the Earth's surface. Ten countries, including US, Japan, Canada, and Russia, participate in a variety of experiments and research. The station contains an experiment module developed by JAXA called "Kibo".

International Space Station
Japanese Experiment Module, Kibo



Introduction of Experimental Equipment

Experiments on Kibo utilize containers for crystal growth created using cutting-edge technology and equipment to control the environment inside them. This equipment enables stable experiments in space.

Crystallization Container "JCB-SGT"※

This is the standard crystallization container. It is a long and narrow cylindrical bag made of a PET sheet, in which crystallization conditions can be set individually. Featuring a simple structure, light weight, and high accuracy, it is perfect for experiments in space.

※JAXA Crystallization Box - Sealbag Gel Tube



Cell Unit

One Cell Unit can hold up to 12 JCB-SGTs, which means 72 different conditions can be tested. The temperature inside the unit is measured in real time. It can be monitored and adjusted from Earth. The temperature data from launch to recovery is also recorded.



Protein Crystallization Research Facility (PCRF)

The PCRF accommodates up to six Cell Units. As it can adjust the temperature of the Cell Units individually, crystallization experiments involving many different proteins can be conducted simultaneously.



Protein Research Opening up a Bright Future for Us

How do protein crystal growth experiments in space contribute to research on the ground? Here are some promising research projects opening up a bright future for us.

Toward the design of drugs effective against muscular dystrophy

Medicine

Researcher Professor Yoshihiro Urade, Tsukuba University, Japan

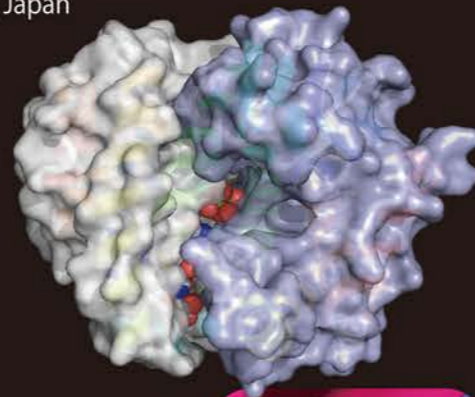
Target protein H-PGDS

Among the most difficult to treat diseases, Duchenne muscular dystrophy is caused by abnormality affecting a protein called dystrophin, which is an essential component of skeletal muscle.

Although no curative treatment is currently available, recent animal studies indicate that inhibition of a protein called Hematopoietic prostaglandin D2 synthase (H-PDGS) could slow down the progress of the disease.

Tsukuba University and JAXA work together to establish a pipeline for developing medicine based on the three-dimensional structure of H-PDGS.

Eventually the results are passed to the pharmaceutical industry for further development.



Crystals grown on the ground

Crystals grown in space

Inventing Efficient Hydrogen Catalysts

Industrial Enzyme

Researcher Professor Yoshiki Higuchi, University of Hyogo

Target protein Hydrogenases

Since ancient times, microorganisms have utilized hydrogen as a source of growth energy, while being able to release surplus energy in the form of hydrogen.

A group of enzymes known as hydrogenases play the central role in hydrogen catalysis. Hydrogenases can synthesize and decompose hydrogen more efficiently than any other known catalysts. Wide-ranging hydrogenase research is now underway toward developing fuel cells and achieving efficient hydrogen production.

High quality crystals of hydrogenases grown in space could help us to better understand the mechanism of hydrogen synthesis and decomposition.



Aiming to design a universal anti-influenza drug

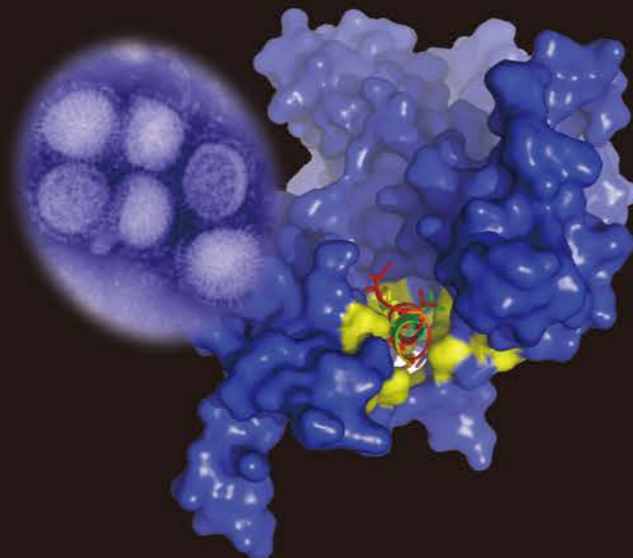
Medicine

Researcher Professor Sam-yong Park, Project Leader, Kanagawa Academy of Science and Technology

Target protein RNA polymerase from H. Influenza

You may remember the influenza pandemics in 2009 and 2012 caused by new strains of virus.

An outbreak of influenza can put public health in danger. Prof. Park's research group has identified the structure of RNA polymerase, which plays a crucial role in virus proliferation. A drug designed based on protein structure could be a breakthrough anti-influenza drug, effective against any type of virus.



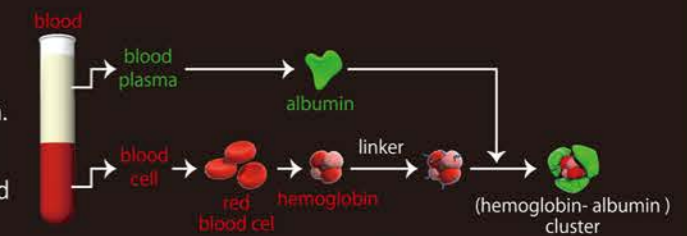
Developing blood substitute for transfusion

Medicine

Researcher Professor Teruyuki Komatsu, Chuo University

Target protein Hemoglobin-Albumin Cluster

One of the top items on the agenda of next-generation healthcare is developing an artificial oxygen carrier as a blood substitute for transfusion. It can be transfused to anyone regardless of blood type, and has huge potential to relieve an expected blood shortage in the near future.



Professor Komatsu and his colleagues have created a hemoglobin-albumin cluster by linking hemoglobin and albumin, a protein in blood serum, with a linker and demonstrated in animal studies that the cluster can work as a stable oxygen carrier. The structure of the hemoglobin-albumin cluster could provide important information for preparing the final product as well as improving safety and effectiveness.

