NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

Protein Crystal Growth (PCG) Single-locker Thermal Enclosure System (STES) housing the Diffusion-Controlled Crystallization Apparatus for Microgravity (DCAM)

Missions: Expedition 6, ISS Mission 11A, STS-113 Space Shuttle Flight
Experiment Location on ISS: U.S. Lab EXPRESS Rack No. 4
Principal Investigator: Dr. Daniel C. Carter, New Century Pharmaceuticals, Inc. Huntsville, Ala.
Project Manager: Clark Darty, NASA's Marshall Space Flight Center in Huntsville, Ala.

Overview

Structural biology experiments conducted in the Diffusion-controlled Crystallization Apparatus for Microgravity (DCAM) may improve our understanding of the function of important macromolecules and possibly contribute to the development of new therapeutics.

Scientists select macromolecules, crystallize them, and use the crystals to determine the atomic arrangements of atoms within the molecules using intense beams of x-rays or neutrons — a process and field of research known as 'crystallography.' Knowledge gained through crystallography has played a key role in understanding many important chemical and biological processes. The determination of the three-dimensional structures of important proteins and other macromolecules, such as DNA, has contributed significantly over the past 50 years to the scientific understanding of fundamental processes in disciplines ranging from material science to biochemistry and medicine. NASA fuels discoveries that make the world smarter, healthier and safer.

Microgravity — the near-weightless condition created as a spacecraft free-falls in orbit around the Earth — has been shown in many cases to produce crystals of improved perfection. This improvement can allow scientists to determine with greater precision the three-dimensional structure of the molecules making up the crystal.

The International Space Station provides for longer-duration experiments in an acceleration-free (no change in the rate of speed, or velocity, of the spacecraft that could affect the experiments), dedicated laboratory, than that provided by the Space Shuttle. Macromolecular crystals require from several days to several months to grow to optimum size. Mission 9A provides for longer-duration experiments in a more research friendly environment. One of the principal objectives of DCAM on the STS-113 mission was to produce extremely large highly ordered crystal specimens specifically for neutron diffraction applications (a more highly specialized subdiscipline of 'crystallography') — a long duration experiment series well suited for the International Space Station.

Experiment Operations

The Single-locker Thermal Enclosure System (STES) for the structural biology experiment is an incubator/refrigerator module that can house different devices for growing biological crystals in microgravity.

On the Shuttle STS-113 mission to the International Space Station, launched in November 2002, the STES unit will house the Diffusion-Controlled Crystallization Apparatus for Microgravity (DCAM). Once on board the International Space Station, the unit is located in the U.S. Lab EXPRESS Rack No. 4. After an extended growth period, the experiments are scheduled to return to Earth aboard a later mission.

The DCAM is designed to grow crystals using the liquid-liquid diffusion method. A total of 81 individual experiments are housed inside the STES in three separate tray assemblies. In each tray, there are 27 reservoirs, each containing a different protein sample. Each device is slightly smaller than a 35mm film canister. The inside of the container is molded into two cylindrical chambers joined by a tunnel. The smaller chamber contains a buffer/precipitant solution. The end cap for this chamber holds the biological sample solution, covered by a semi-permeable membrane. This membrane allows the precipitant solution in the larger chamber to pass into the biological sample solution. A plug filled with porous material separates the two chambers and controls the rate of diffusion. Exposure to the precipitant causes the biological sample to crystallize. Diffusion — the mixing of the biological sample solution with the precipitant solution — starts on Earth as soon as the chambers are filled. However, the rate is so slow that no appreciable change occurs before the samples reach orbit one, two — or even several weeks later.

Sample Proteins

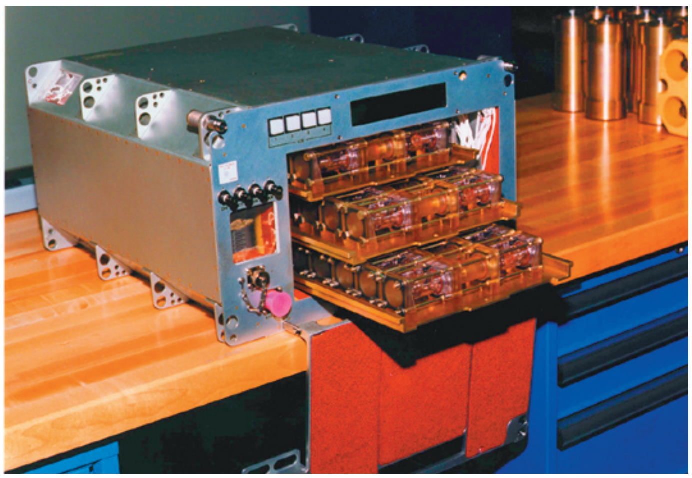
Protein samples that will be processed on the Station include:

- Albumin, the major protein of the circulatory system, chiefly responsible for blood osmotic pressure and pH, is capable of transporting many small molecules, including the majority of currently-known pharmaceuticals;
- Apoferritin/Ferritin, Catalase, Thaumatin, represent a complement of protein molecules aimed at shedding light on the effects of microgravity on various crystal growth processes;
- Nucleosome Core Particle, the fundamental building block of chromatin, a component of cell nuclei responsible for packaging DNA and also involved in gene expression;
- Glucose Isomerase, an enzyme widely used in the food processing industry;
- Basic fibroblast growth factor, a protein that induces growth and division of numerous cell types, including bone, muscle and blood vessel, and plays a role in some diseases such as cancer;
- Glucocerebrosidase, a protein instrumental in treating Gaucher disease, which displaces healthy normal cells in the liver, spleen and bone marrow and leads to organ dysfunction and skeletal deterioration;
- Superoxidedismutases (SODs), important antioxidant enzymes that protect all living cells against toxic superoxide radicals associated with aging;
- Cytochrome P450, involved in a wide variety of biochemical processes, such as carcinogenesis, drug metabolism, biosynthesis of lipids, and steroids;
- Gamma-E crystalline, which provides the optical properties of the eye lens and may provide insights into cataract formation.

Flight History

Hardware	STES DCAM
Mission Year	STS-73 1995
Mission Year	STS-76 1996
Mission Year	STS-79 1996
Mission Year	STS-81 1997
Mission Year	STS-84 1997
Mission Year	STS-86 1997
Mission Year	STS-89 1998

(DCAM) Diffusion Controlled Crystallization Apparatus for Microgravity Tray Assembly



(DCAM) Diffusion Controlled Crystallization Apparatus for Microgravity

Crew Operations

The DCAM has no mechanical system. No crew interaction is necessary except for transferring the PCG-STES unit to the Space Station and back to the Shuttle at the end of the mission.

Benefits

With science being performed on the International Space Station, scientists are no longer restricted to relatively short-duration flights to conduct structural biology experiments, opening the application of microgravity to a greater selection of important macromolecules. This research will enhance the accuracy of the 3-dimensional structures of specially selected macromolecules, providing improved crystallographic information, which has the potential to impact, a broad base of scientific research on Earth.

Additional Information/Photos

Additional information on structural biology crystal growth in microgravity is available at:
http://crystal.nasa.gov/
http://www.nasa.gov

Photos of a DCAM experiment in a STES unit and a DCAM experiment tray assembly are available at:
http://mix.msfc.nasa.gov/ABSTRACTS/MSFC-9512543.html
http://mix.msfc.nasa.gov/ABSTRACTS/MSFC-9512537.html

Explore. Discover. Understand.

May 2005 FS–2005–05–55–MSFC Pub 8–40421