NASA facts

PowerCell

Vision

To derive the greatest benefit from long-term human space exploration, we must learn to utilize resources found on site to reduce or perhaps ultimately eliminate reliance on re-supply missions from Earth, so-called "*in situ* resource utilization," abbreviated ISRU. On Earth, we rely on "primary producer" organisms, both plants and microbes, to transform basic resources like sunlight, water, and atmospheric gases (carbon dioxide, nitrogen) to provide the nutrients for "consumer" organisms (like us). Cyanobacteria and algae are two types of microbial primary producers capable of transforming solar energy, carbon dioxide, and water into carbohydrates, such as sugars, through the process of photosynthesis.

Using the tools of genetic engineering, synthetic biology will enable us to engineer specific PowerCell mini-ecologies that leverage the capabilities of microbes to perform useful tasks in cooperation with each other. Each PowerCell ecology will be customized for performance for a unique setting, taking advantage of *in situ* materials and energy sources to generate, on-demand, useful products that satisfy specific needs of long-term human presence away from Earth.

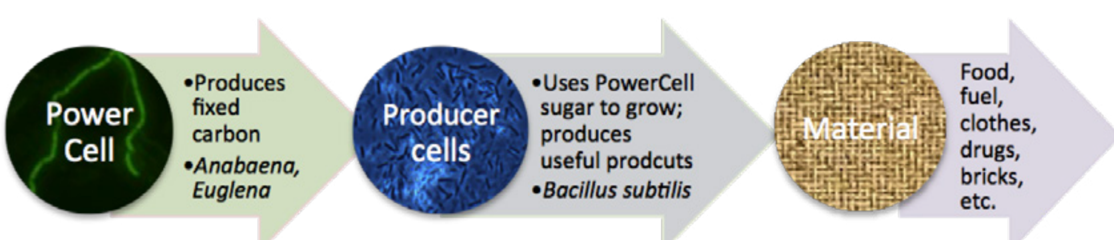
PowerCell Spaceflight Payload

In its first test flight, the PowerCell Payload will investigate the performance of microbial mini-ecologies containing both photosynthetic microbes and consumer organisms. Cyanobacteria will produce the carbohydrate sucrose (table sugar), which will feed *Bacillus subtilis*, a robust bacterium commonly found in soil and the gut, which has already proven that it can withstand the rigors of space while in the spore form.

As its mini-ecologies are exposed to several levels of artificially generated gravity, the PowerCell concept will be evaluated for effectiveness under non-terrestrial gravity environments. A rotating spacecraft will provide gravity similar to that of the International Space Station (ISS) for a few weeks, and then the Moon for six months, and Mars for an additional six months. The results will be compared to a series of identical experiments on Earth.

A second objective of the PowerCell Payload is to conduct synthetic biology remotely in outer space. The basic technique for introducing genetic material into a living cell, "transformation", involves the transfer across a cell's encasing membrane of molecules carrying genetic information. The PowerCell

Members of the PowerCell science team



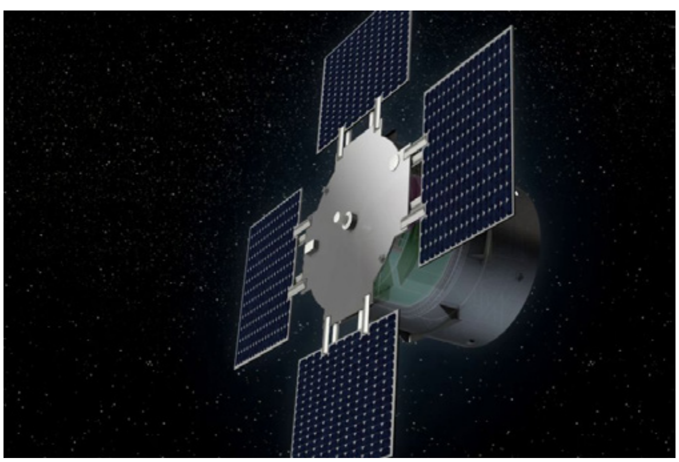
Payload will examine if and how reduced gravity levels affect transformation processes.

The third objective is to test protein production under different gravity regimes. Using the tools of synthetic biology, *B. subtilis* was engineered to produce several proteins which will be produced at the three different space gravity regimes. The ability to make proteins in space will be fundamental for human exploration, as proteins will be used to produce a range of critical substances, from on-demand food and vaccines to building materials.

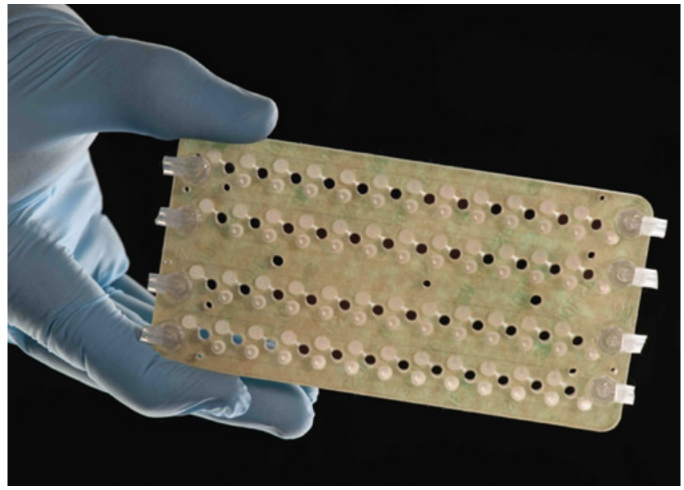
At each gravity regime, a payload fluidic system will deliver nutrients to the 48 microwells integrated into a microfluidic carrier or “card”. Each microwell houses one of the three experiments in dried form suitable for two years of stasis. The temperature will be stabilized as the dried organisms hydrate. Periodically, a sequence of optical measurements is made by the 3 LEDs—violet, cyan, and red— plus a dedicated photo-detector to monitor the growth and composition of each well.

Instrument Description

The PowerCell Payload System includes a pair of independent air-tight enclosures. Each measures 15 inches x 3.16 inches x 10.6 inches (38 centimeters x 8 centimeters x 27 centimeters), weighs 15 pounds (6.8 kilograms), and consumes 10 watts when active. Each houses two of the 48-well microfluidic cards plus fluidic, thermal, optical, electronic, and control subsystems. One microfluidic card carrying its full complement of microbes will be filled and measured at each artificial gravity level. The entire sequence of spaceflight experiments is expected to span one year.



The DLR-operated Eu:CROPIS Satellite



PowerCell 48-well microfluidic card

Partnership with DLR

The German Aerospace Center (DLR) invited NASA Ames Research Center to participate in their *Euglena* & Combined Regenerative Organic-food Production In Space (Eu:CROPIS) Mission. DLR’s flight platform is a spinning satellite capable of providing a range of artificial gravity environments as it flies in a Sun-synchronous orbit at 600 km altitude, with experiments conducted over a one-year period. The launch vehicle for Eu:CROPIS is a SpaceX Falcon 9, scheduled for lift-off in July 2017.

The PowerCell Project is managed by Ames Research Center and leverages experience gained from prior flight experiments aboard multiple small satellite space biology missions, the Space Shuttle, and the ISS.

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