PowerCell

Vision

To derive the greatest benefit from long-term human space exploration, we must learn to utilize resources found ‘on site’ (or *in situ*) to reduce or eliminate reliance on resupply missions from Earth. 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 foods, or basic energy bundles, 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.

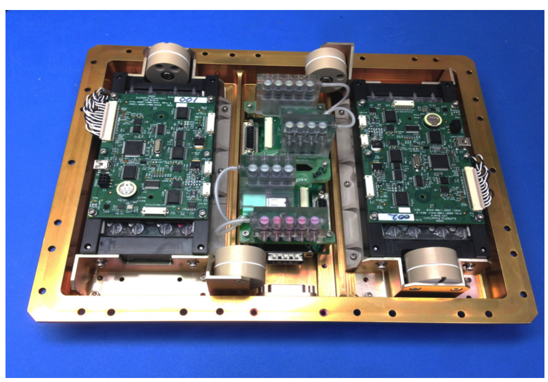
Using the tools of genetic engineering, synthetic biology will let us design specific PowerCell mini-ecologies that leverage the capabilities of selected microbes to perform useful tasks even as they cooperate with one another. Each PowerCell ecology will be customized for performance in a unique setting, 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

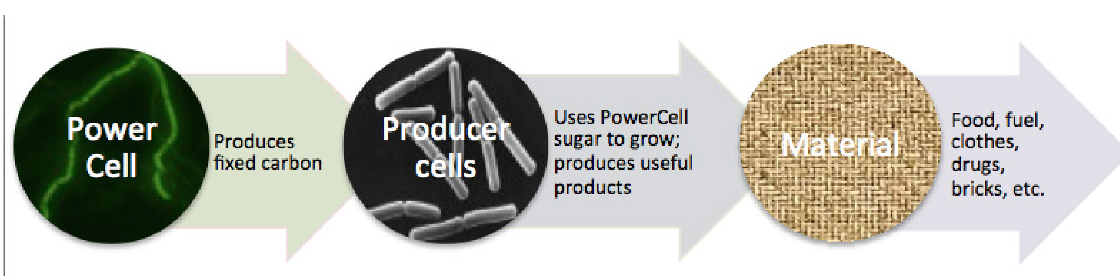
In its first flight, the PowerCell Payload will investigate the performance of month microbial mini-ecologies containing both photosynthetic microbes and consumer organisms. Photosynthetic cyanobacteria will produce the carbohydrate sucrose (table sugar), which will feed *Bacillus subtilis*, a robust bacterium commonly found in soil and the gut.

As its mini-ecologies are exposed to several levels of artificially generated gravity, the PowerCell concept will be evaluated for compatibility with non-terrestrial environments. A rotating spacecraft will provide gravity similar to 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.

In each gravity regime a payload fluidic system will deliver nutrients to 48 microwells integrated into a microfluidic carrier or “card”. Each microwell houses a PowerCell mini-ecology in dried form suitable for



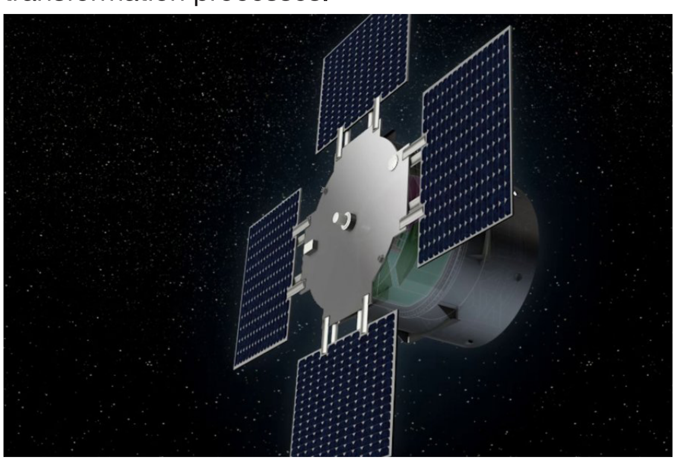
The PowerCell Payload System



many months of stasis. The temperature is stabilized as the dried organisms hydrate and 4 miniature LEDs provide white light to initiate photosynthesis. Periodically, a sequence of optical measurements is made by the other 3 LEDs—violet, cyan, and red—plus a dedicated photo-detector to monitor the growth and composition of each well's ecosystem.

Trends and changes in the data will tell us how well the primary producer—the cyanobacterium *Anabaena*—generates sucrose to support the growth of *B. subtilis*—the consumer—at the current gravity level. In addition to producing sucrose through photosynthesis, *Anabaena* can "fix" dissolved nitrogen gas to generate plant-fertilizing nitrogen compounds, a key trait of this particular PowerCell ecology.

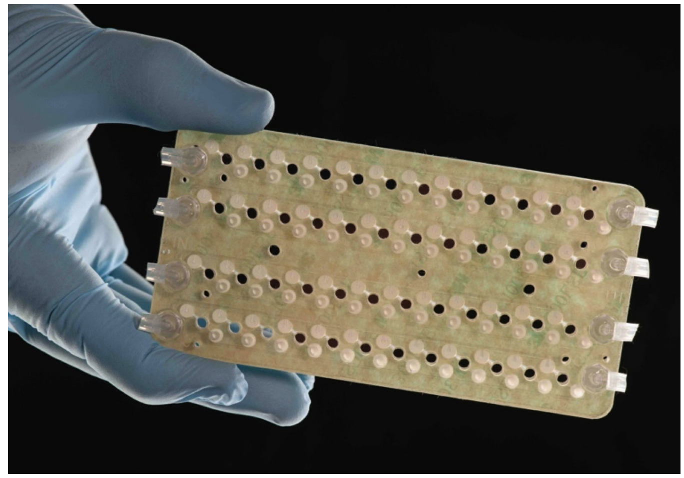
A second objective of the PowerCell Payload is to conduct synthetic biology remotely in outer space. The basic technique for introducing genetic material into a living cell, "transformation", involves the transfer across a cell's encasing membrane of molecules carrying genetic information. The PowerCell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



The DLR-orperated Eu:CROPIS Satellite

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), consumes 10 watts when active, and houses two of the 48-well microfluidic cards plus fluidic, thermal, optical, electronic, and control



PowerCell 48-well microfluidic card

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.

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 1-year period. The launch vehicle for Eu:CROPIS is a SpaceX Falcon 9, scheduled for lift-off in March, 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 International Space Station.

Points of Contact:

Scott Richey
PowerCell Project Manager
NASA Ames Research Center
Charles.S.Richey@nasa.gov

Lynn Rothschild
PowerCell Principal Investigator
Nasa Ames Research Center
Lynn.J.Rothschild@nasa.gov

National Aeronautics and Space Administration

Ames Research Center
Moffet Field, CA 94035

www.nasa.gov