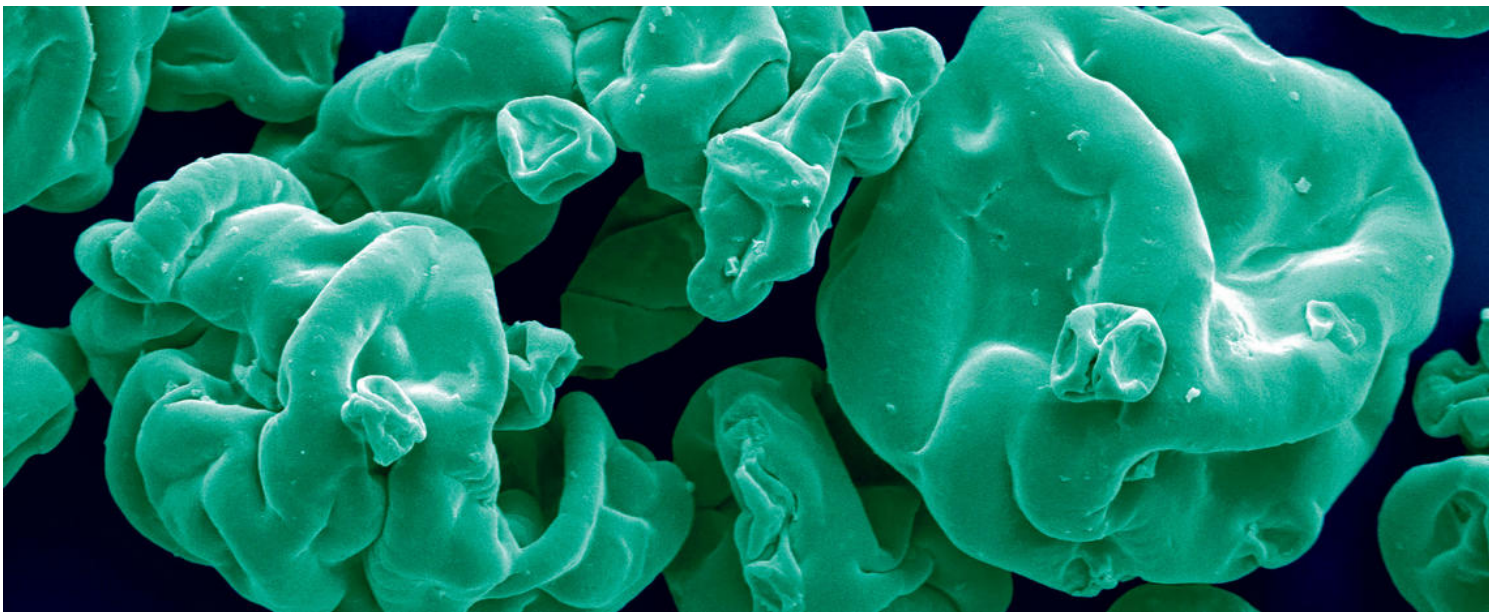
COSMOS

NEWS | SPACE | 16 MAR 2015

Packing light for Mars

A microbe factory could more than halve a mission's payload weight. Cathal O'Connell reports.



We've all had trouble squeezing our luggage down to the allowed weight for a flight. But for a trip to Mars that problem is magnified. The NASA rule-of-thumb is that for every kilogram to be launched into space, you need 99 kilograms of fuel and rocket to get it there. Forget the spare toothbrush.

But maybe a solution to all the stuff we'll need on Mars lies within the bodies of the astronauts. A manned spacecraft produces about a kilogram of carbon dioxide a day from the exhaled breath of each astronaut. Add to that the urine and wash-water, and a crew of six could arrive on Mars carrying more than six tonnes of potentially valuable organic material. This, together with the basic raw materials available on Mars, could provide the building blocks for four of life's necessities: fuel, food, plastics and medicines. All it takes is a little help from genetically engineered microbes.

At least that's what Amor Menezes at the University of California, Berkeley, in collaboration with scientists from NASA, proposes in a paper published in the *Journal of the Royal Society Interface* in November. The paper estimates that employing microbes on a two-and-a-half year trip to Mars could deliver huge savings in the mass of the outbound rocket's payload.

Fuel

The trip to Mars would take seven months. And the fuel for the return journey would talke up two thirds of the mission cargo. To reduce the load, the Berkeley/NASA team considered generating methane fuel from Martian resources for the return leg. Generating it requires CO2, which is 95% of the Martian atmosphere, and hydrogen, which could be sourced from the planet's frozen water using electricity to slit it into hydrogen and oxygen.

The chemical reaction requires heavy duty equipment to reach high temperatures and pressures, which rather defeats the purpose. But lightweight microbes such as *Methanobacterium thermoautotrophicum* are designed for the task. On Earth, they live on hydrogen and CO_2, spewing out methane as a by-product. In a vat filled with CO_2 and hydrogen, the team calculate the microbes could make all the fuel needed for the return journey in 205 days, less than half the planned stay on Mars. The incubator needed for the microbes would weigh less than half that needed for the chemical synthesis of methane.

A day in the life of a Martian astronaut.

CREDIT: JEFFREY PHILLIPS

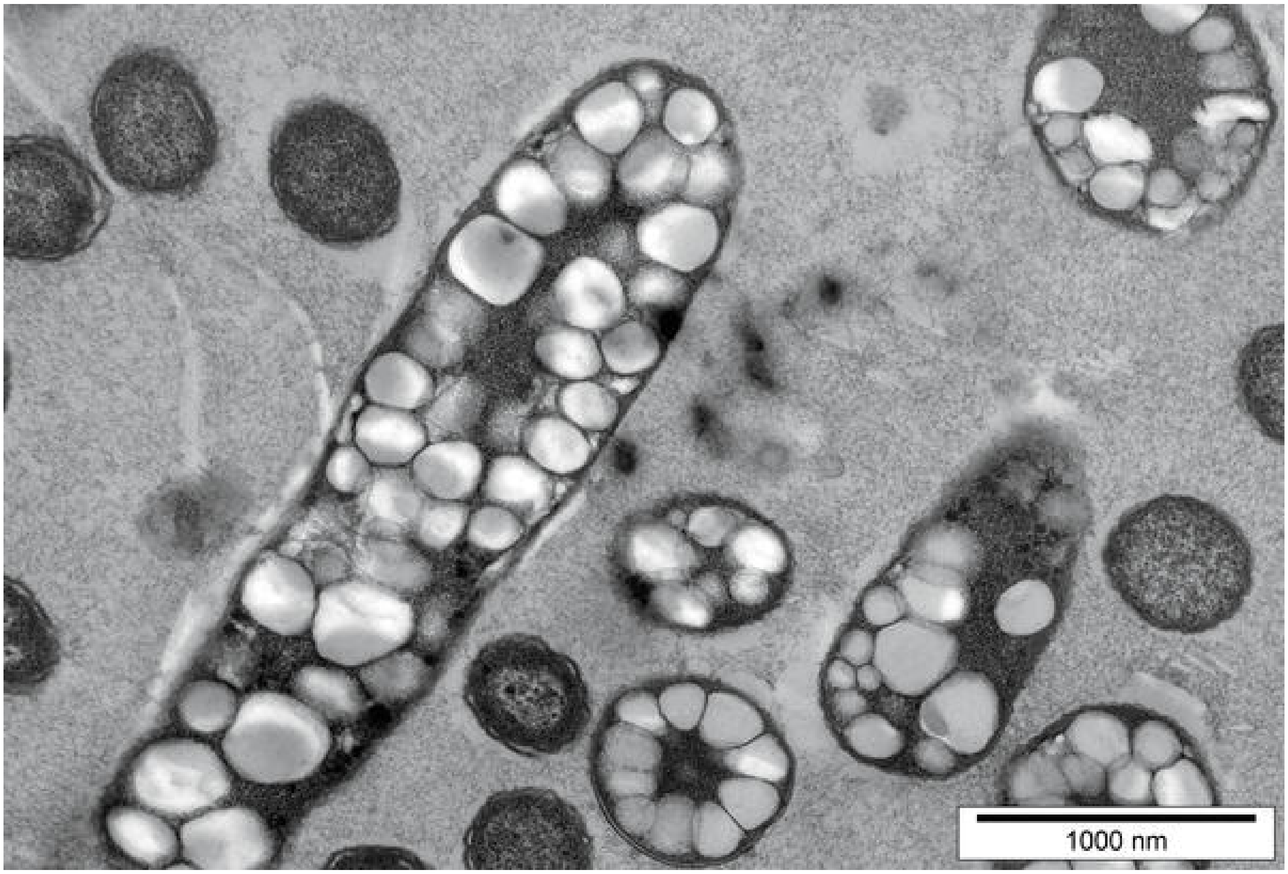
Food

On the International Space Station astronauts subsist on a combination of freeze-dried meals that must be rehydrated before eating, and packets of “wet food” that are quick to prepare and also more appetising. Feeding Martian astronauts for 30 months would require more than 10 tonnes of wet food.

The biotech solution proposed by the team is for the astronauts to eat spirulina – a green, flaky foodstuff made from photosynthetic algae that grows naturally on the surface of saltwater lakes in Central America and Africa. It’s been eaten by humans since the time of the Aztecs, and recently surged in popularity as a “superfood”.

Spirulina production would cut by 38% the mass of wet food that would have to be shipped to Mars. It is also more nutritious than wet food so astronauts need less of it. The Berkeley and NASA researchers calculate that more than five kilos of spirulina a day – enough for the whole crew – could be grown in bioreactors the size of two kids’ paddling pools. This would save about a third of the mass-cost of sending wet-food to Mars. And, as Menezes adds, by genetically manipulating the algae, “you can change the flavours and textures of the spirulina, so you don’t feel like you’re eating the same thing every time”.

Building materials



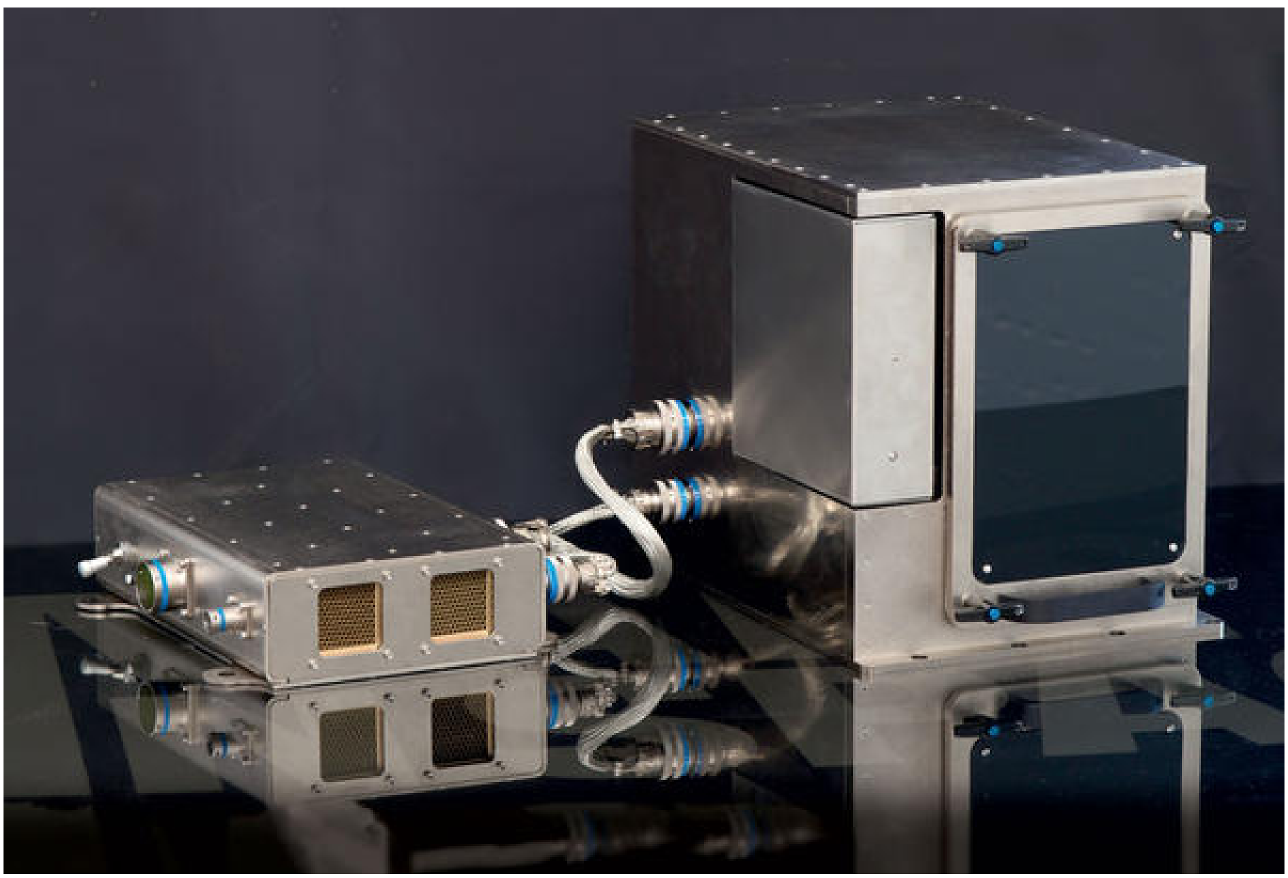
The biopolymer, polyhydroxybutyrate, can be produced by modified bacteria and used to print 3D plastic construction blocks in space.

CREDIT: CSO POLYBATICS LTD

NASA is researching 3D printing in space. A printer could be used to make interlocking blocks for building a Martian habitat. NASA's idea is to print blocks by bonding a mixture of minerals in the Martian soil with salts brought from home. But printing a six-person habitat from this material would add up to at least 24 tonnes to the mission's weight, much of that due to the weight of the salts.

Instead, Menezes proposes using bacteria to produce a light-weight biopolymer, polyhydroxybutyrate, which could be 3D printed to form plastic construction blocks. All the necessary ingredients, including CO_2, hydrogen and oxygen, should be available on the spacecraft.

Even the ammonia the bacteria need could be taken from the astronauts' urine. The crew could start printing pieces for their new home before they arrive. According to the team's calculations, this approach could save 85% of the mass-cost of the mineral-based 3D printing approach.



A specially modified 3D printer could fabricate spare parts and construction blocks.

CREDIT: MADE IN SPACE

Drug production

Drugs tend to expire faster in space due to higher radiation levels. But what if there's a medical emergency after the use-by-date? The team identified a bacterium, *Synechocystis*, which, with a bit of genetic modification, could be used to create paracetamol from available resources.

The bacteria could be frozen in a small lead container until needed. After thawing out the bacteria, paracetamol stocks could be replenished in days.

Christophe Lasseur, who has researched long-term human habitats for the European Space Agency, has no doubt microbes can be used to create products in space, but adds that we don't know how the radiation levels will affect the bacteria's survival.

"Mars contamination is another issue," he adds. The search for life would be a prime goal of any mission to Mars. Deliberately bringing microbes from Earth could have the unwanted effect of tainting the planet.

"This is why it is extremely important to arrive on Mars with the cleanest vehicle possible," he says.

Previous Martian probes, such as Spirit, Opportunity, and Curiosity, were all thoroughly decontaminated before their launch.

Menezes admits that containment will be important, but emphasises his work is the first step in examining microbes as potential shipmates on a trip to Mars. Initial results are promising, he adds.

"Already we can compete with non-biological technologies – imagine what would happen if you engineer them to be even better."

Cathal O'Connell is a science writer based in Melbourne.