BBC

WHY LIFE ON EARTH WASN'T AN ACCIDENT

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A NEW RACE TO THE MOON HAS BEGUN

What China's pioneering lunar mission means for the future of space exploration

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SPACE

FIRST PLANT GROWN ON THE MOON

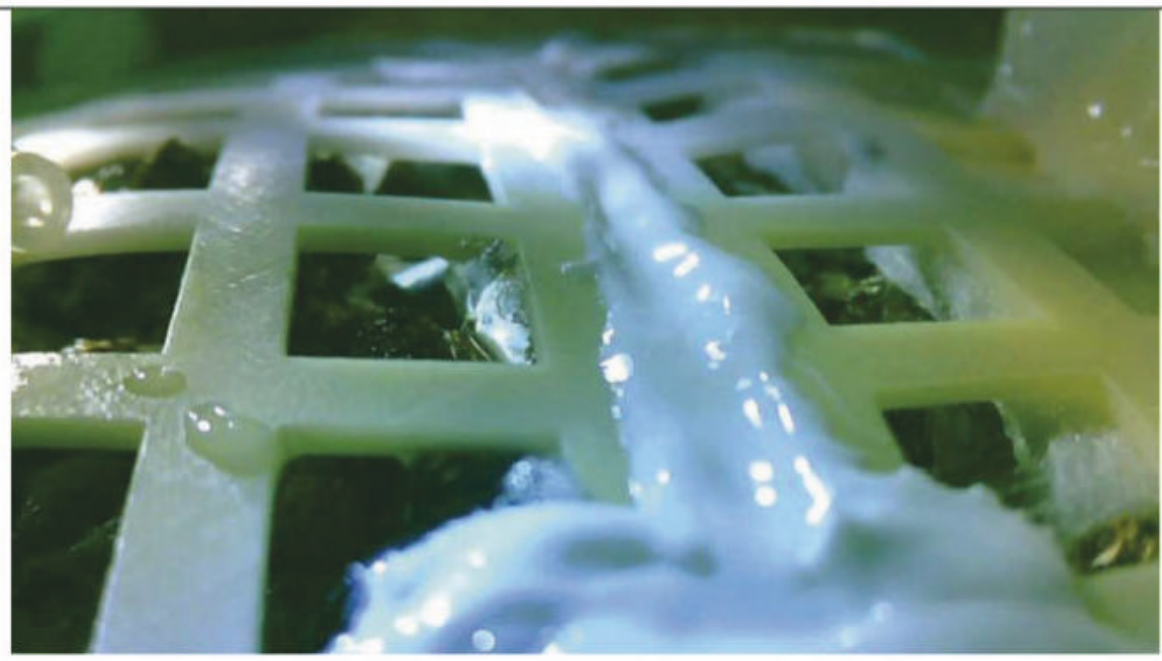
A tiny cotton seed aboard China's Chang'e 4 probe became the first ever plant to sprout on the Moon, but was unable to make it through the freezing lunar night

SHUTTERSTOCK

On 3 January China's Chang'e 4 became the first lunar probe to land on the far side of the Moon. Two weeks later, the probe achieved another first when it sent back a grainy photograph showing tiny green shoots sprouting from a cotton seed stored inside its Lunar Micro Ecosystem biosphere experiment.

The success was short-lived, however: on 16 January it was reported that the shoot had failed to survive the freezing temperature of the lunar night. None of the other organisms on board – potatoes, rapeseed, mouse-ear cress, yeast or fruit fly eggs – showed any signs of life and the experiment was called off just a few days into its planned 100-day stint.

Shortly after landing, the 3kg, 18cm biosphere was powered up, the internal temperature adjusted to 24°C and the seeds watered. Twelve days later, the Advanced Technology Research Institute at Chongqing University reported that the cotton seed had sprouted and released an image of the shoot. A second photo followed 24 hours later showing that the shoot had perished (above).



The second shot sent back from the Chang'e 4 probe showed the cotton shoot had perished in the cold lunar night

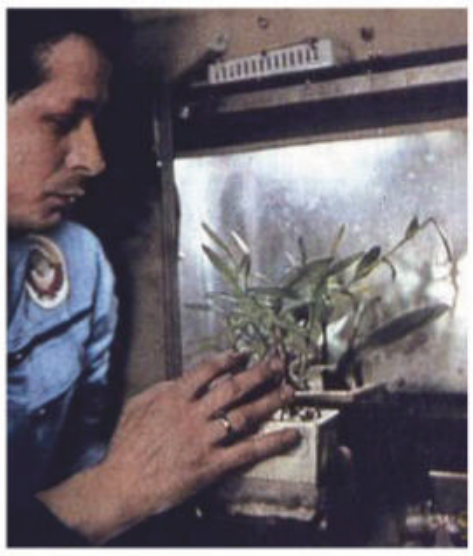
"THE SUCCESS WAS SHORT-LIVED, HOWEVER: ON 16 JANUARY IT WAS REPORTED THAT THE SHOOT HAD FAILED TO SURVIVE THE FREEZING TEMPERATURES"

The successful harvesting of plants is seen as a vital part of any attempt to establish a permanent base on the Moon or even long-term expeditions, such as a manned mission to Mars.

China's next mission, Chang'e 5, which is scheduled for launch in December, will attempt to collect samples of lunar rock and soil from the surface of the Moon and return them to Earth. There are also whispers that the Chinese National Space Administration plans to build a space station near the Moon within the next decade.

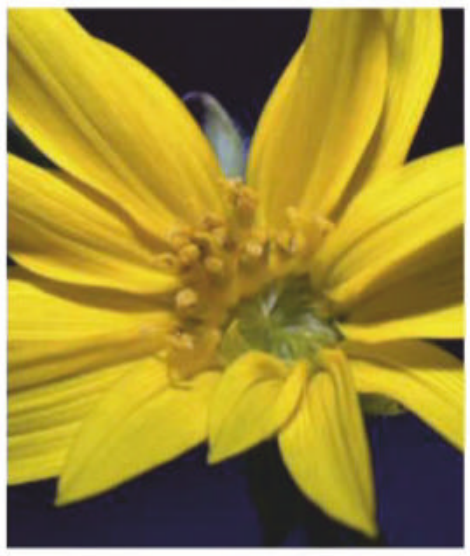
For a full breakdown of the Chang'e 4 mission, turn to p42

OTHER PLANTS GROWN IN SPACE



Rock cress

Way back in 1982, the crew of the Soviet Salyut 6 space station successfully grew a small crop of rock cress using a Fiton 3 micro greenhouse. These were the first plants to flower and produce seeds in space.



Sunflower

Green fingered astronaut Don Pettit grew several different plants as part of his personal biology experiments during his time aboard the ISS in 2012. Among them was this sunflower.

Zinnia flowers

On 16 January 2016 Commander Scott Kelly shared photographs of a blooming zinnia flower grown using the Vegetable Production System (Veggie) on board the International Space Station.

Space salad

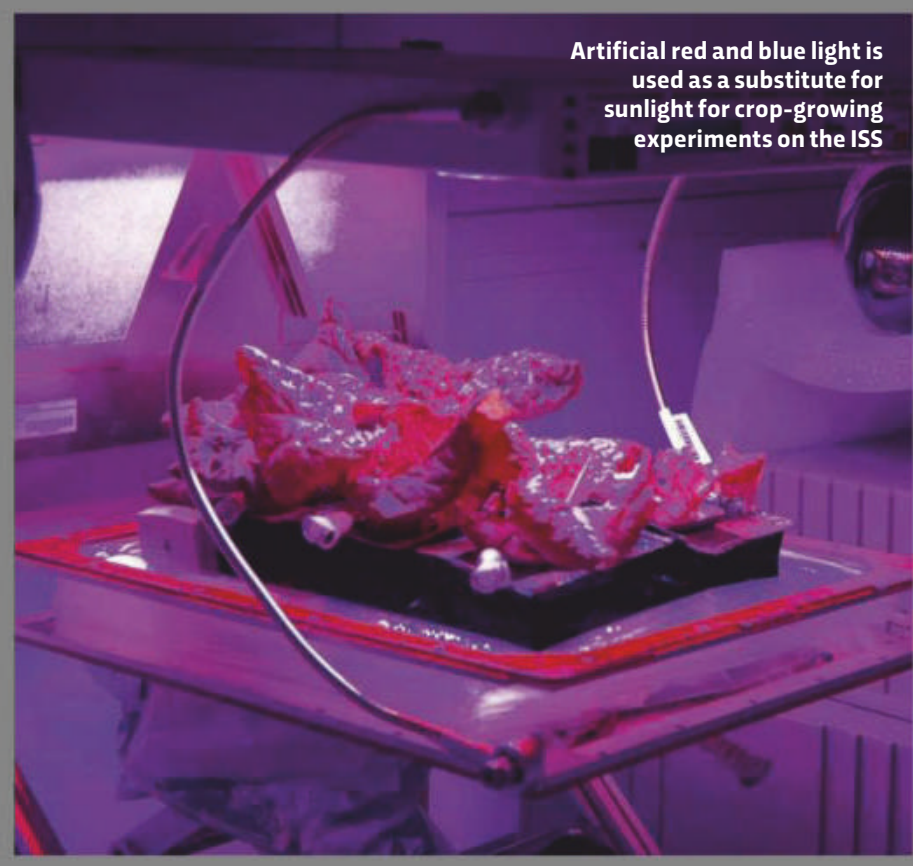
In October 2017 a group of astronauts led by astronaut Joe Acaba tucked into a salad made with mizuna mustard leaves, green lettuce and red romaine lettuce, again grown using the Veggie system.

SHUTTERSTOCK, NASA X5, RSA

EXPERT COMMENT

Lewis Dartnell

Prof Lewis Dartnell is an astrobiology researcher and author of Origins: How The Earth Made Us



Artificial red and blue light is used as a substitute for sunlight for crop-growing experiments on the ISS

Although the Lunar Micro Ecosystem experiment ultimately did not run for as long as had been planned, it still represents a significant step forward in our attempts to provide for off world explorers. Like an automated, miniaturised version of Matt Damon's character in the film *The Martian*, this sealed biosphere was briefly able to grow plants on the surface of another world.

Previous space farming experiments have focused on two main approaches: either testing plant growth in the microgravity environment of the International Space Station (ISS), or Earth based experiments that involve investigating how well different crops develop in simulated lunar or Martian soils.

The problem with the microgravity environment of spacecraft such as the ISS is that plant seeds need to sense the direction of gravity to know which way to send their roots and shoots. The ISS also has no onboard greenhouse to let in the natural sunlight, so these small scale farming experiments have to be conducted under artificial electric lighting: red and blue LEDs that give these experiments a lurid magenta glow.

Using the ISS's Vegetable Production System (Veggie), for example, astronauts have been able to successfully grow red romaine lettuce in space. The first crops successfully grown using the Veggie system appeared in 2014. The produce was harvested, frozen and taken back to Earth to be tested, but in 2015 the astronauts were able to actually eat the space salad they'd grown. And in 2016, US astronauts aboard the ISS posted photos of the zinnia flower they'd been nurturing. ISS astronauts are now moving on to try to grow other crops such as dwarf wheat.

Steve Swanson harvests a crop of red romaine lettuce grown aboard the ISS

Meanwhile, other experiments down on the ground have been trying to see if plants can be grown in soils like those present on the Moon or Mars. Previous space missions have measured the composition of the powdery regoliths of the lunar and Martian surface, and so these can be recreated as simulant soils in the lab. For example, in 2014 scientists at the Dutch Wageningen University and Research Center tested several wild weeds as well as crops in their ersatz extraterrestrial dirt. But the seedlings fared badly, if they had managed to germinate at all. The researchers realised that 'raw' lunar or Martian soil, made only of crumbled rocks, is very bad at holding water or providing essential nutrients. When they tried again with some organic matter mixed in, much more like the soil found in a garden on Earth, they achieved much better results. Ten species, including peas and tomatoes, yielded produce. One problem that's yet to be solved is that lunar and Martian regolith contain lots of heavy metals, and so plants grown in them and absorbing these elements through their roots could be too toxic to be eaten by astronauts.

But the Chang'e experiment is the first time that plant growth has ever been attempted on the surface of another world. And it was ground breaking for another reason, too. Most of the studies so far have focused on growing just a few plant types in isolation, but the Lunar Micro Ecosystem was attempting to establish a genuine synergy between the different species it kept alive. The plants growing to provide oxygen and food for the flies, these insects respiring to release carbon dioxide for the plants, and the yeast breaking down and recycling both when they died: a self contained mini ecosystem of primary producers, consumers and decomposers. It's this sort of 'closed loop' ecological approach that is exactly what will be required for the long term human colonisation of space. At the moment, food is regularly resupplied to the space station by rocket launches, but this would be impossibly expensive to support long term human habitation on the Moon or Mars. In the future we will have to become space farmers, and the Chang'e experiment is an important step towards that.