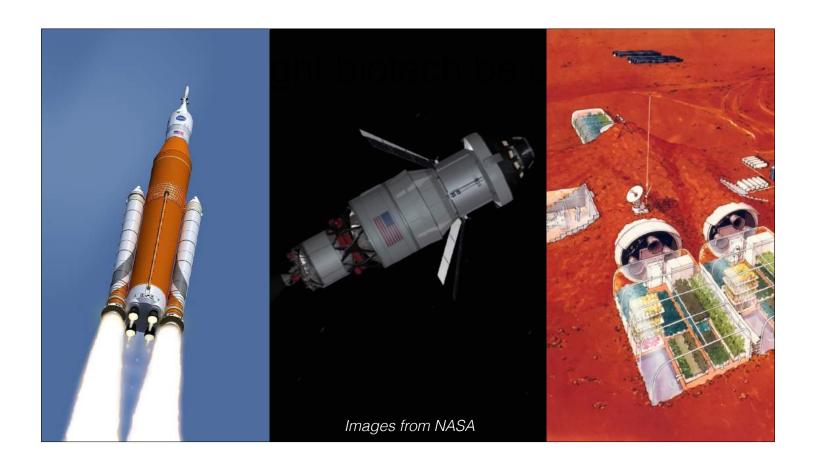
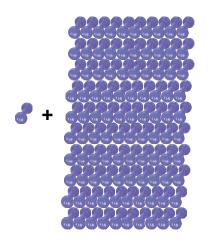


How can Biotech...

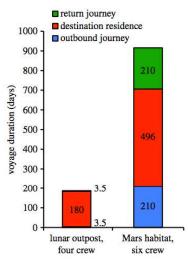
help us reach and colonize Mars?



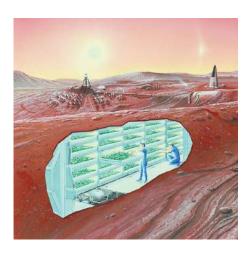
Key considerations



each pound of payload launched into space requires an additional 99 pounds of supporting materials (mostly fuel)

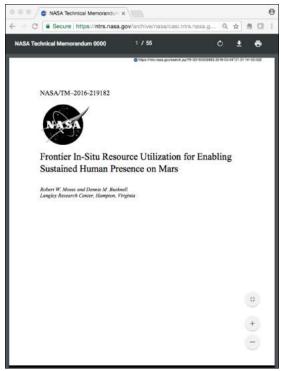


the transit time and time at location vary dramatically with mission type



high levels of cosmic radiation pose a hazard for astronauts during the round-trip between Mars and Earth as well as time spent on the planet





https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160005963.pdf

sequencing in space

July 2016 - first-ever-in-space DNA sequencing experiment (Oxford Nanopore's minION) arrived at the International Space Station

August 2016 - astronaut Kate Rubins, Ph.D. sequences mouse, bacteria and viral DNA - matching results previously obtained on earth

Future studies: microbiome of spacecraft, astronaut health, extraterrestrial life



https://blogs.nasa.gov/ISS_Science_Blog/2016/10/19/downlink-with-nih-director-highlights-research-from-dna-sequencing-to-heart-cells/

Health Effects of Long-Term Space Travel

NASA's Twin Study

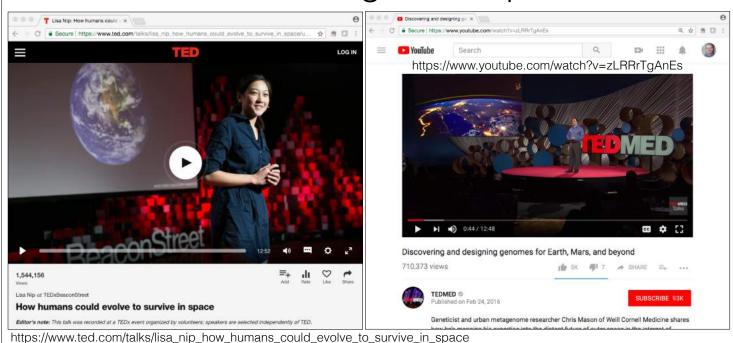
While in space, Scott's:

- white blood cell telomeres lengthened
- gut microbiome shifted
- DNA methylation increased
- expression patterns changed for thousands of genes (some remaining altered post flight)
- cells showed a fluctuation in "epigenetic age"



https://www.nasa.gov/feature/nasa-twins-study-confirms-preliminary-findings

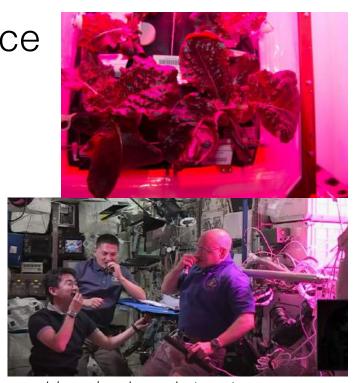
Health Effects of Long-Term Space Travel





Food grown in space

"Expedition 44 crew members, including NASA's one-year astronaut Scott Kelly, are ready to sample the fruits of their labor after harvesting a crop of "Outredgeous" red romaine lettuce Monday, Aug. 10 [2015], from the Veggie plant growth system on the nation's orbiting laboratory."



https://www.nasa.gov/mission_pages/station/research/news/meals_ready_to_eat

Food grown on Mars?

plants grown in "extraterrestrial soil" include mesculun, green beans, radish, peas, carrots, tomatoes, herbs, rye, hops

mixing vermiculite (or coffee grounds) and other organic material into the regolith simulant improved plant growth

earthworms can live and reproduce in the regolith simulant

Martian soil includes toxic perchlorates and heavy metals - how to overcome that challenge?

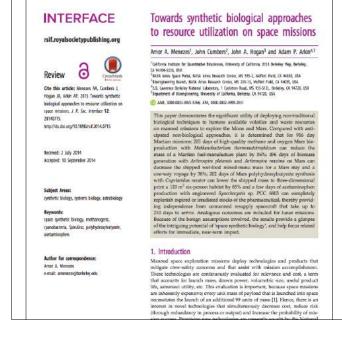
THE MARTIAN GARDEN
MARS REGOLITH SIMULANT & KITS

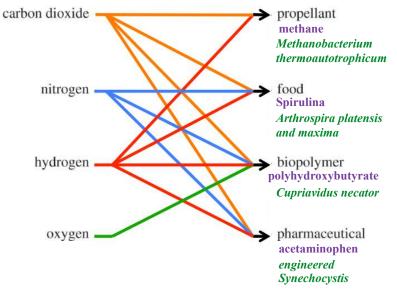
EXPLORE

The Martian Garden supplies Mojave Mars Regolith
Simulant and Kits to Researchers, Hobbyists, and
Educators Around The World. Based on NASA and

https://www.nytimes.com/2018/01/12/science/mars-plants-soil.html

Using synthetic biology in space





https://www.sciencefriday.com/articles/to-survive-on-mars-byo-bacteria/

current method

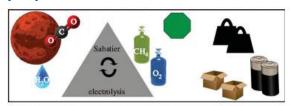
proposed biological method

cost ratio

2.17:1

1.62:1

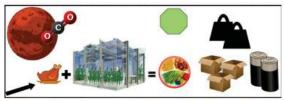
propellant



(c) The anticipated fuel generation option using available water is not at all risky, somewhat massive (545 kg plant), requires significant power (23.11 kW), and takes up a bit of volume (0.61 m³).

(d) The proposed fuel generation option using available water is somewhat risky, not very massive (251 kg plant), requires little power (938.5 mW), and takes up a lot of volume (1.553 m³).

nutrition



(e) The anticipated shipped food provisions option is not very risky, somewhat massive (3850 kg), requires significant power, and takes up a significant amount of volume.

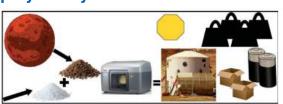


(f) The proposed food production option is not very risky, not very massive (2382 kg), requires little power (12.687 W), and takes up a bit of volume (14.844 m3).

Menezes et al. 2015 Towards synthetic biological approaches to resource utilization on space missions. J. R. Soc. Interface

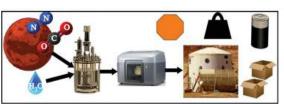
current method

polymer synthesis



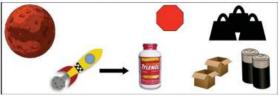
(g) The anticipated three-dimensional printer feedstock option using imported dry salts is somewhat risky, very massive (11.4 T), requires significant power, and takes up a bit of volume.

proposed biological method



(h) The proposed biopolymer synthesis three-dimensional printer feedstock option is risky, not very massive (1.6 T), requires little power (7.221 W), and takes up a bit of volume (9.896 m3).

pharmaceutical synthesis



(i) The anticipated pharmaceutical delivery option is very risky, quite massive, requires significant power, and takes up a bit of volume.



(43.7 mW), and takes up little volume.

(j) The proposed pharmaceutical manufacture option is risky, not very massive, requires little power

Menezes et al. 2015 Towards synthetic biological approaches to resource utilization on space missions. J. R. Soc. Interface

cost ratio

7.13:1

105:1

OK....so we've made it to Mars what happens next?

