Arriving and Surviving

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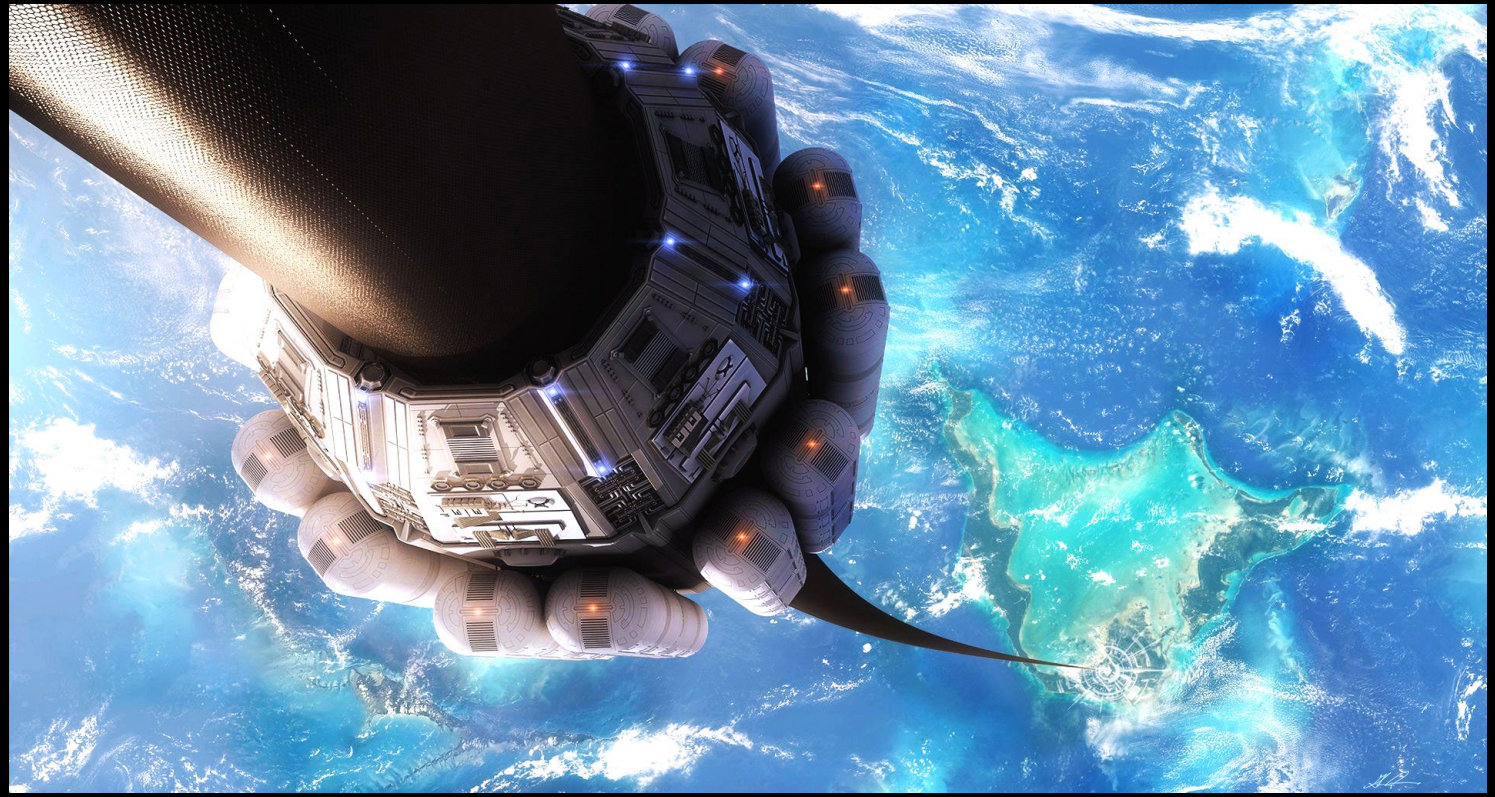
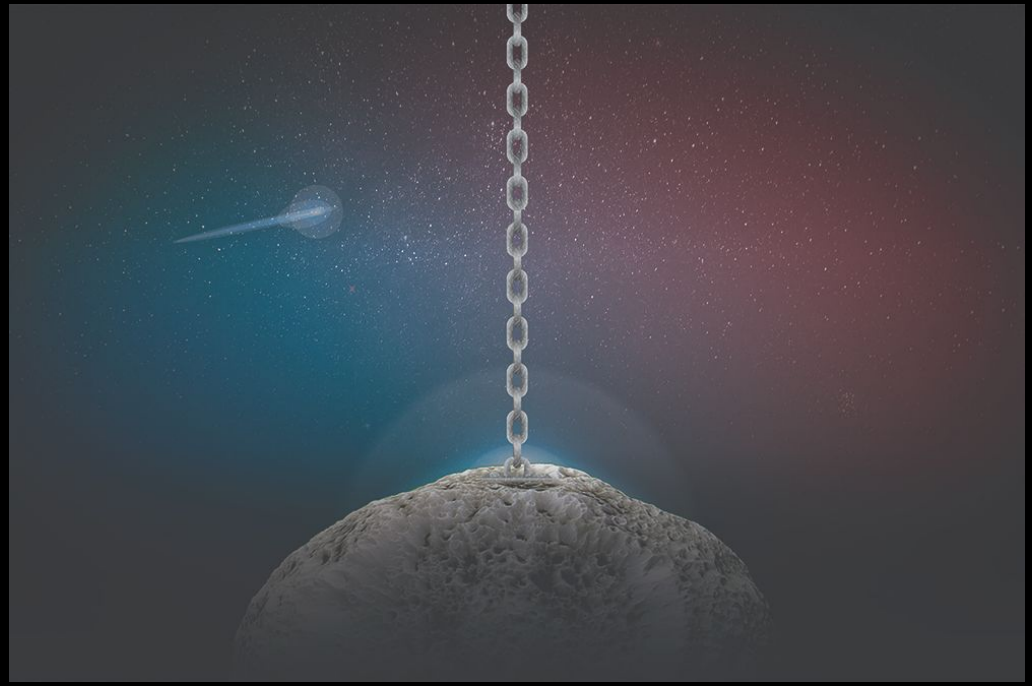
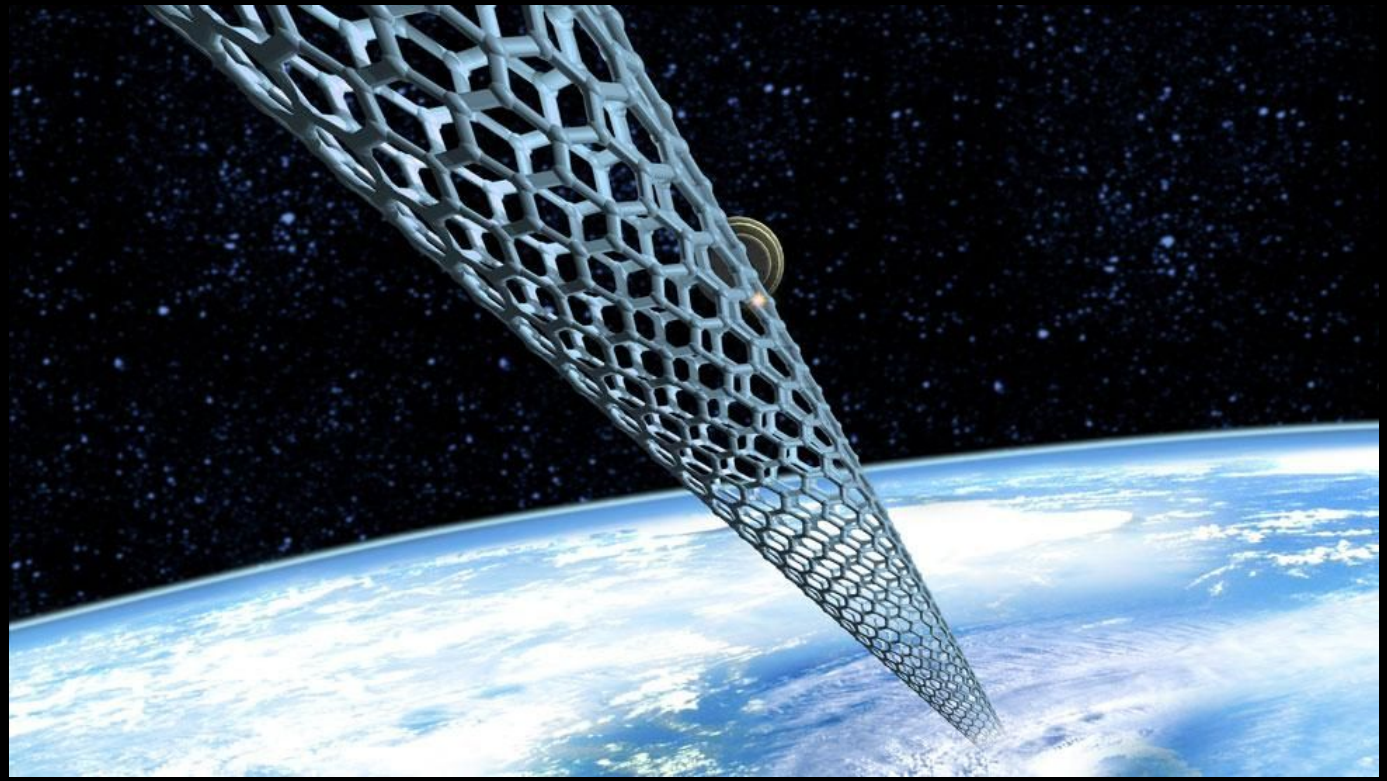
How do we get to the Moon?

Lunar Space Elevator

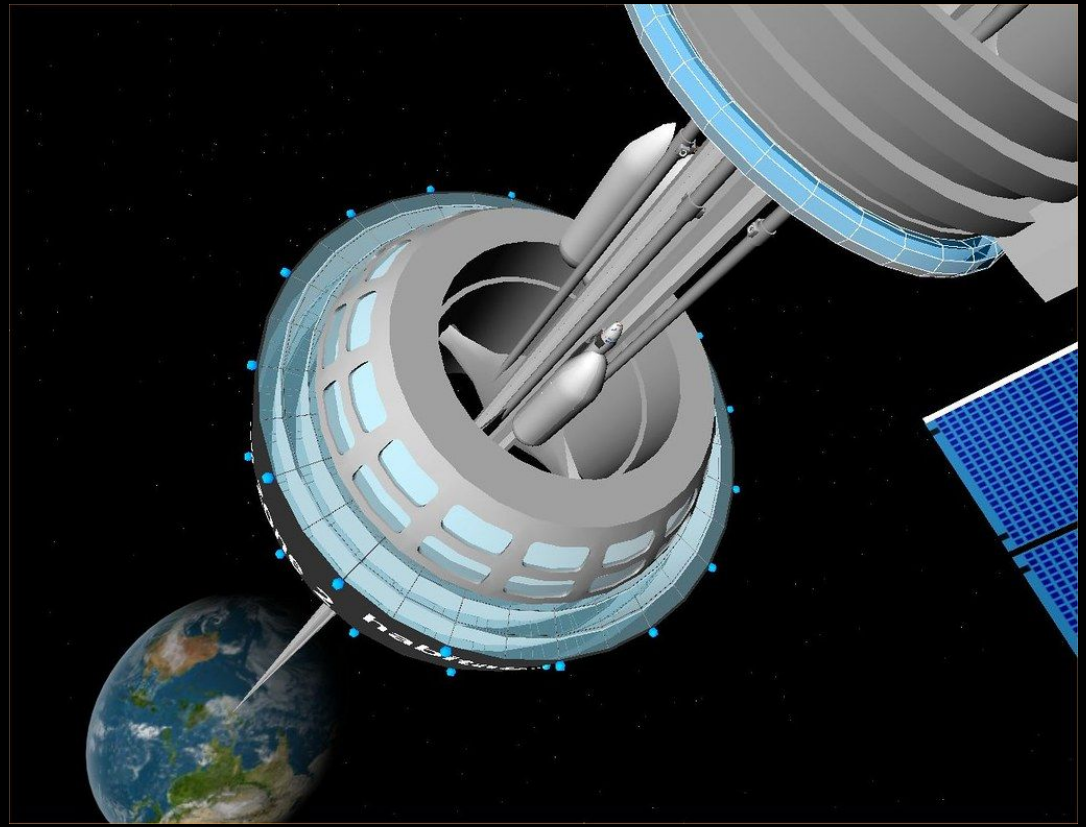




First, the ground station (anchor), using factors of less gravity on the moon, installs the anchor on the surface of the moon as the starting point of the cable and plays the role of fixing the cable.



Second, the tether provides a lifting track for transportation and is the most important thing in the overall structure.



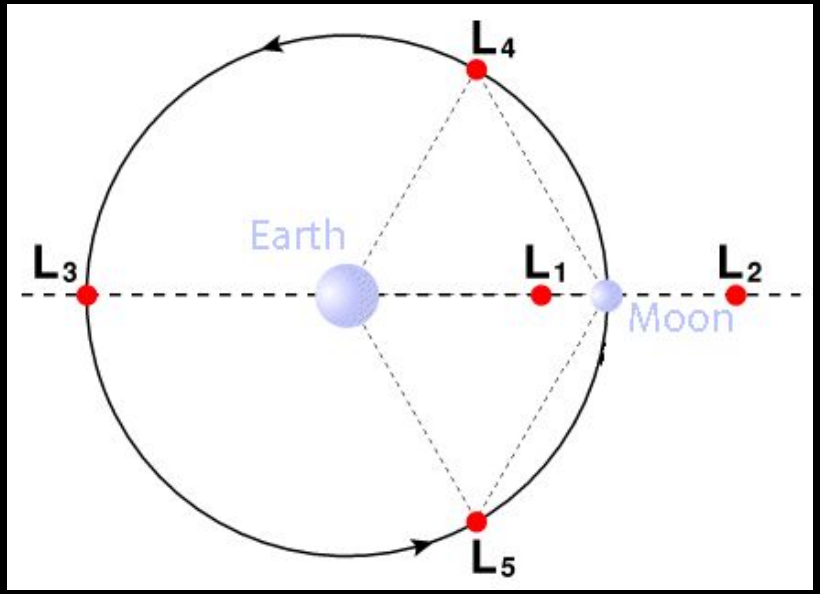
And a GEO station (synchronous rail station) for receiving the goods.

Why spend millions of $ building a lunar space elevator instead of relying on existing rocket technology?

According to NBC News:

“the former might ultimately be more economical, especially for bringing raw materials back to Earth from moon-based mines.”

https://www.nbcnews.com/mach/science/space-elevator-moon-could-be-doable-surprisingly-cheap-ncna1051496



Importantly, the Spaceline would pass through the Earth-Moon Lagrange point, where there is effectively zero gravity and no other physical interference, which would save even more power for further use.

https://techcrunch.com/2019/09/12/scientists-propose-spaceline-elevator-to-the-moon/

Surviving on the Surface of the Moon

- 14 Lunar Days and 14 Lunar Nights
- Temperature ranges from +200℃ to - 200℃
- Solar Radiation/ Galactic Cosmic Rays/ Micrometeoroids
- Energy Resource
- Lack of Air
- Food
- Muscle Degeneration from ⅙ G
- Lunar Dust
- Water

How would Life on the Surface of the Moon be Difficult?

- Constant contact with Space Radiation like Solar Particle Events and Galactic Cosmic Rays
- Extreme Surface Temperatures of the Moon
- Facing Potential Harm from Micrometeorites
- Lunar Regolith Debris from Landings and Take-offs

What Is Our Solution to this Problem?

An Underground Colony!

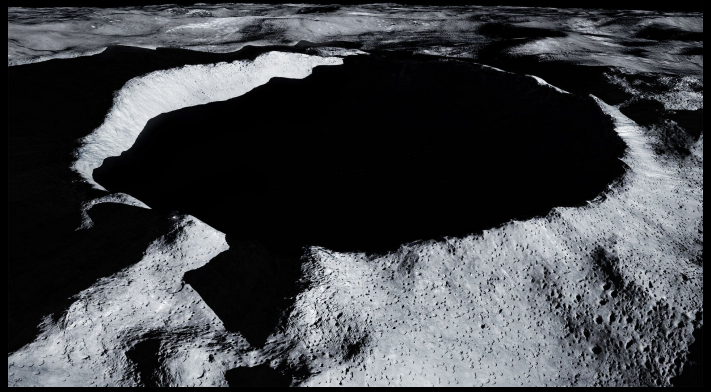
Using the Underground Lava-tubes detected on the Moon, we can make for a more efficient construction of a Lunar base by manipulating the tunnel system already made by the past events that have taken place in forming our current Moon.

Philolaus Crater
→
Formed 1.1
Billion years ago

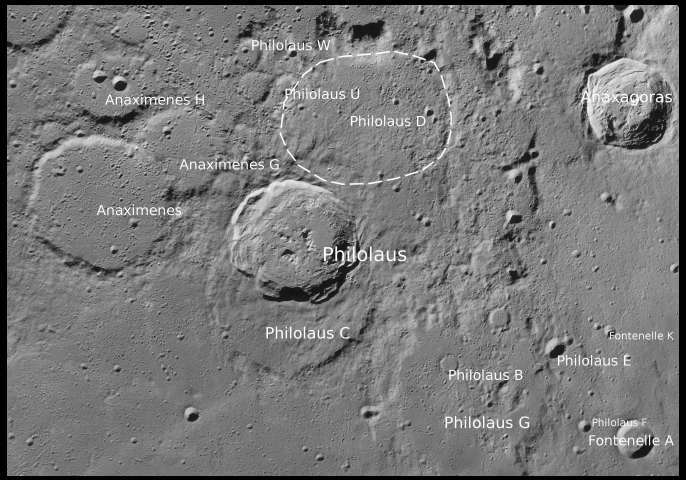
https://www.youtube.com/watch?v=EJDjyN3ni3U

https://www.space.com/39404-lava-tube-skylights-discovered-moon-images.html
https://www.space.com/moon-colonists-lunar-lava-tubes.html
https://www.scientificamerican.com/article/will-future-lunar-bases-be-underground/

Possible spots to Settle



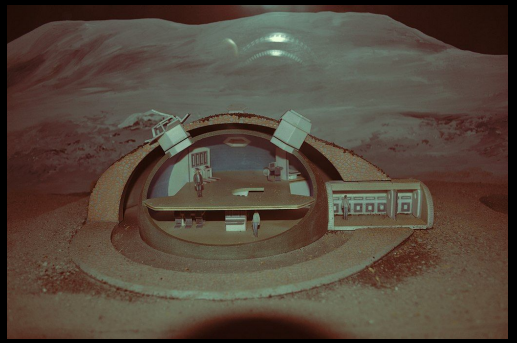
Shackleton Crater at the Lunar South Pole



Philolaus Crater

A potential spot for a moon base would be either the lunar north pole or south pole that's in near-constant sunlight, which is also close to permanently shadowed craters that store water ice which can be harvested for use. Both the Shackleton Crater and Philolaus Crater fulfills the criteria.

SOM's Master Plan



A giant lunar ant farm that consists of clusters of modules which are connected with pressurized tunnels to allow movement between structures.

https://dirt.asla.org/2020/02/24/lunar-life-plans-underway-for-a-moon-village/

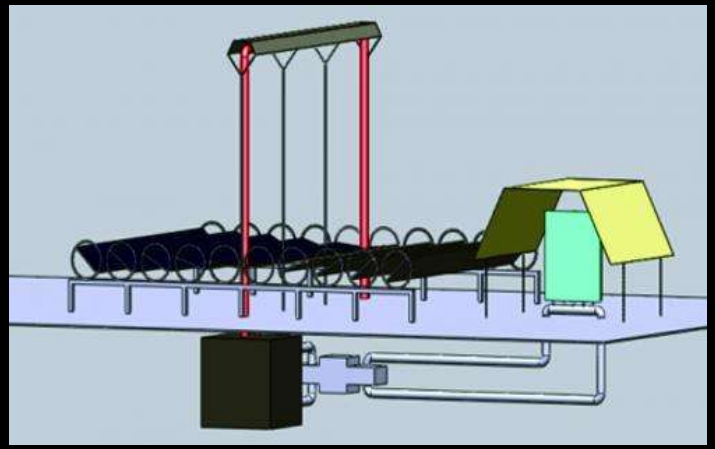
SOM's Design

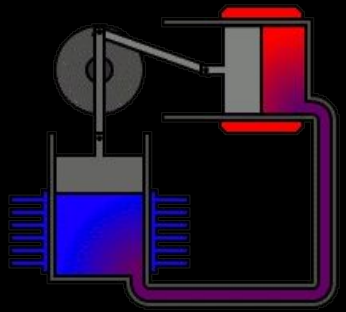
The modules are 3-4 story structures made out of 3D printed lunar regolith shells which are protective against extreme temperatures, projectiles, regolith dust, and solar radiation.

The structure can inflate and expand for userspace with pressurized space and life support systems.

https://www.som.com/news/som_releases_concept_for_moon_village_the_first_permanent_human_settlement_on_the_lunar_surface

Generating Energy on the Moon





Use Thermal Energy Storage (TES) to run a heat engine during the lunar night to produce electricity.

Modify fragments of regolith by incorporating elements such as aluminium so that it becomes a thermal mass.

Use systems of mirrors to focus the sunlight onto the thermal mass.

The heat from the thermal mass can be used to keep the base warm or transfered to the stirling engine to produce electricity.

https://phys.org/news/2013-12-electricity-moon-night.html

Origami Solar Panels

NASA engineer, Brian Trease designed a working prototype for origami solar panels which can be folded from a 25 meter wide solar panel to 2.7 meter sized panels.

Unlike the prior solar panels that collapse like a fan or an accordion, Trease uses an intricate fold which can unfold themselves with a single push or pull without needing any human assembly.

https://www.space.com/27485-origami-space-solar-panels-video.html

How do we sustain Life on the Moon?

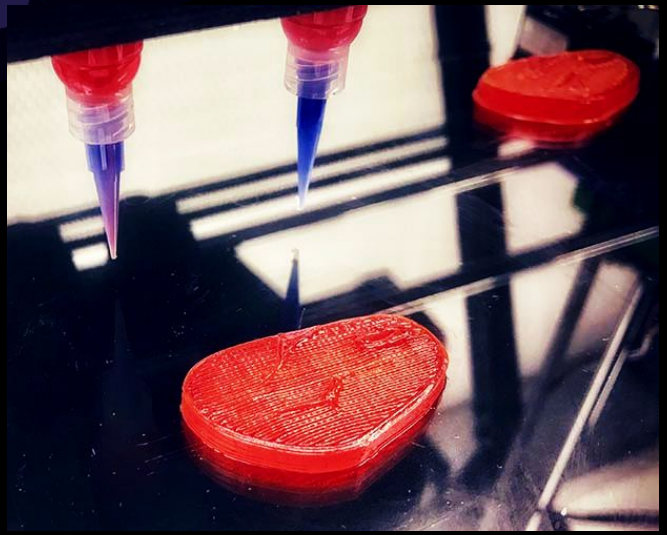
Bioregenerative Life Support System

NASA is currently in the middle of creating a **Lunar/ Martian Greenhouse**: hoping to provide a consistent flow of Oxygen, be used as a Carbon Dioxide/ Waste Sink and provide food for the ongoing crew at the colony.

https://www.nasa.gov/missions/science/biofarming.html

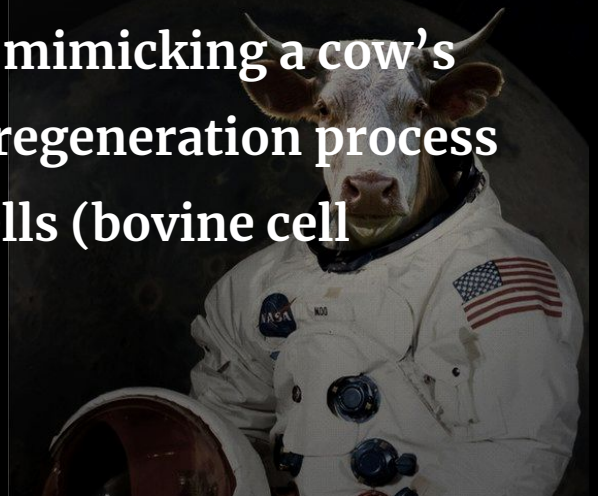
https://www.nasa.gov/feature/lunar-martian-greenhouses-designed-to-mimic-those-on-earth

Bioprinting Meat



Aleph Farms, an Israeli food company, managed to make its first-ever lab-grown meat in ISS. No animals were harmed in the making of this “space beef”.

They grow the meat by mimicking a cow’s natural muscle-tissue regeneration process from just a couple of cells (bovine cell spheroids).



https://www.space.com/meat-grown-in-space-station-bioprinter-first.html

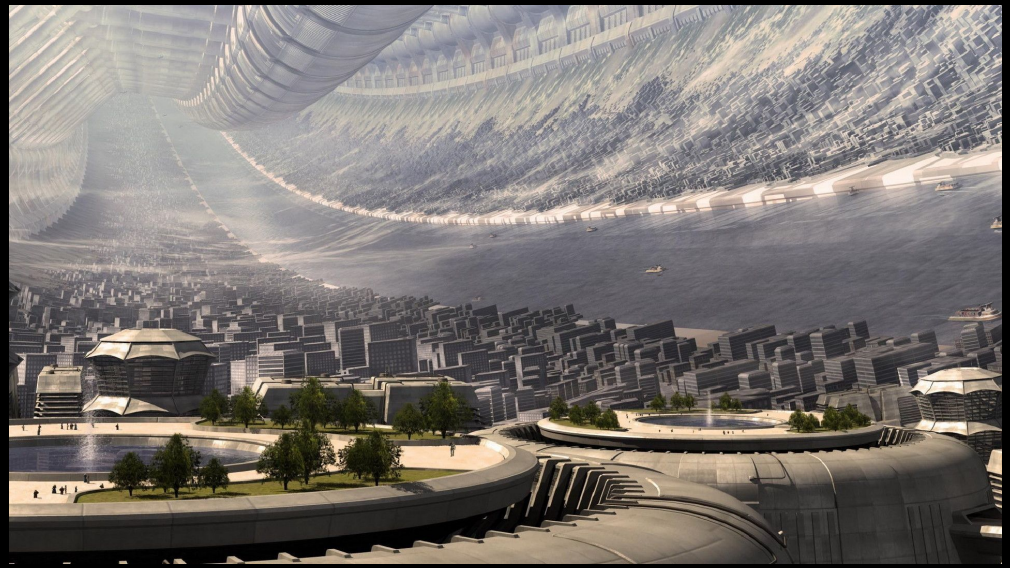
⅙ G

Perhaps the biggest change astronauts experience is bone and muscle loss. Humans on Earth work out these systems every day, simply by moving and standing against gravity. But without gravity to work against, the bones lose mineral density and the muscles risk atrophying.

https://www.youtube.com/watch?v=-TU1OkVctaI
3:40~5:30

https://www.theverge.com/2017/8/29/16217348/nasa-iss-how-do-astronauts-exercise-in-space

Simulate Space City



There is also a concept that is impossible to achieve regarding to the technology right now, but theoretically feasible: which is to build a city in a large, rotating loop, and then use centrifugal force to simulate gravity like the earth. In this way, people who is living on the moon will not have any gravity issue anymore.

AstroRad (Radiation Protection Suit)

Reduces **Radiation Exposure Induced Death (REID)** such as cancer while eliminating Acute Radiation Syndrome.

Selectively protects organs and tissues that are most sensitive to radiation such as lungs, bone marrow, colon, stomach, breasts and ovaries.

Form-fitted, takes up minimal space and allows for **enhanced mobility** in microgravity.

https://stemrad.com/astrorad-4/

Cleaning Lunar Regolith from Spacesuits

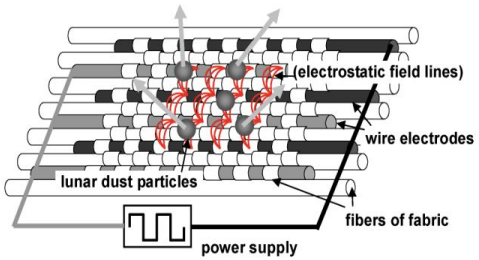


Fig. 1. Electrostatic cleaning system for removing lunar dust adhering to space-suit fabric

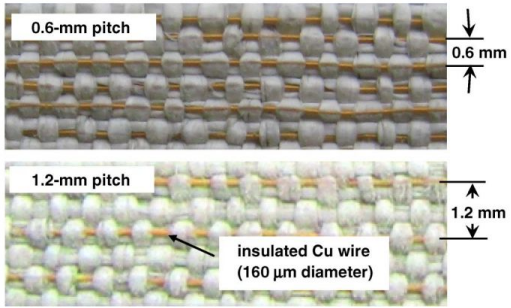


Fig. 2. Electrostatic flickers; insulated wire electrodes have been stitched into the plain-woven fabric of space suits

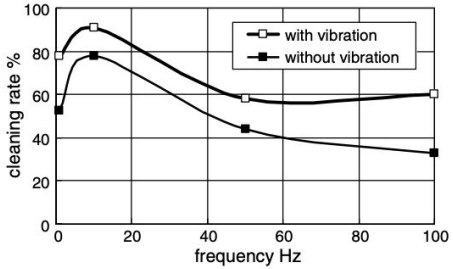


Fig. 4. Cleaning performance with and without applying vibration (0.6 mm pitch, 900 V)

Kawamoto, Hiroyuki, and Noritaka Hara. “Electrostatic Cleaning System for Removing Lunar Dust Adhering to Space Suits.” *Journal of Aerospace Engineering*, vol. 24, no. 4, Oct. 2011, pp. 442–444. *EBSCOhost*, doi:10.1061/(ASCE)AS.1943-5525.0000084.

Harvesting Water

Use a **hydrogen reduction reactor** to heat the regolith (moon dirt) at 1000 ℃ . The regolith has **iron oxide** in it which reacts with hydrogen to produce water at 1000 degrees Celsius.

$$Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$$

https://www.space.com/7350-nasa-hopes-water-moon.html

Harvesting Water

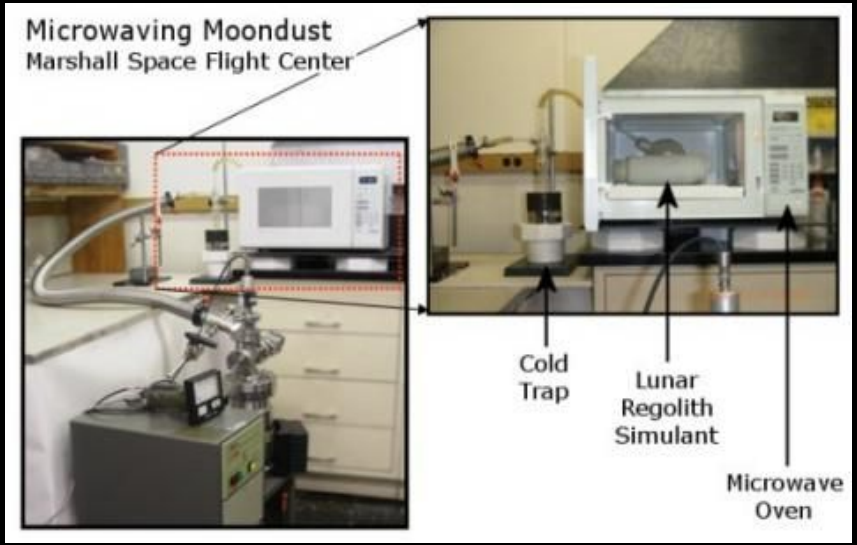
NASA has developed rovers to scoop up the moon dirt and carry it to the heating chamber.

Harvesting Water

Create a reusable lunar reactor which has airtight valves that can be opened and closed several times for many years.

https://www.space.com/7350-nasa-hopes-water-moon.html

Using Microwaves



Use Microwave to directly heat the water ice that's trapped in the pores of the lunar soil.

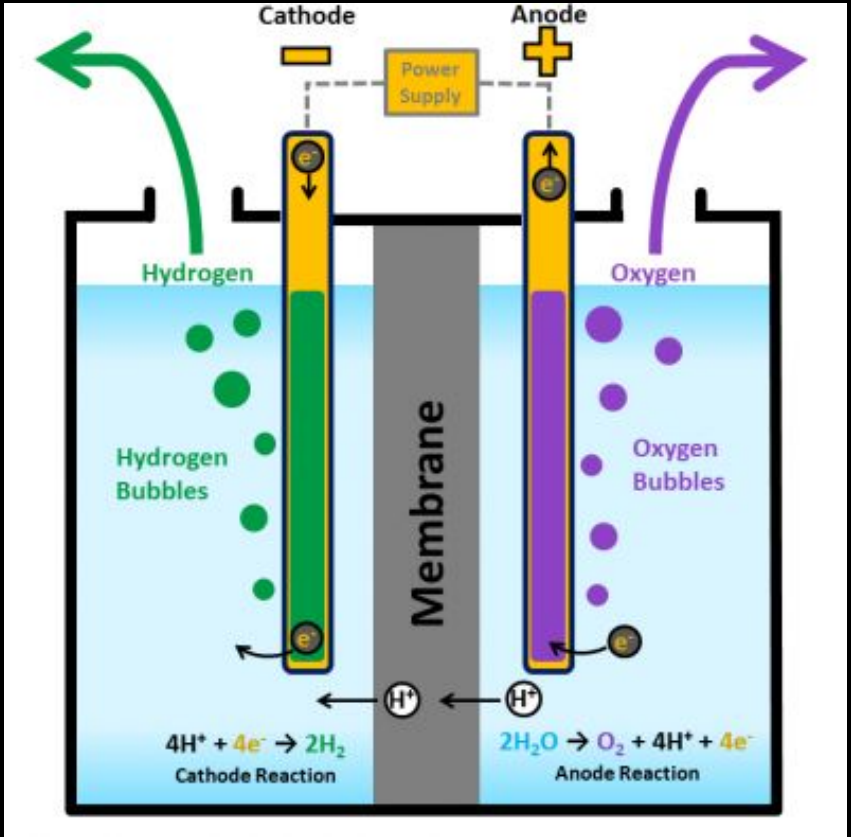
Heating to just -50℃ can sublimate 98 percent of the solid water ice into gas.

The vapor then diffuses out from higher-pressure pores in the soil to the low-pressure vacuum above.

The water vapor can be collected by holding a cold metal plate above the soil as frost which is then condensed to the liquid state.

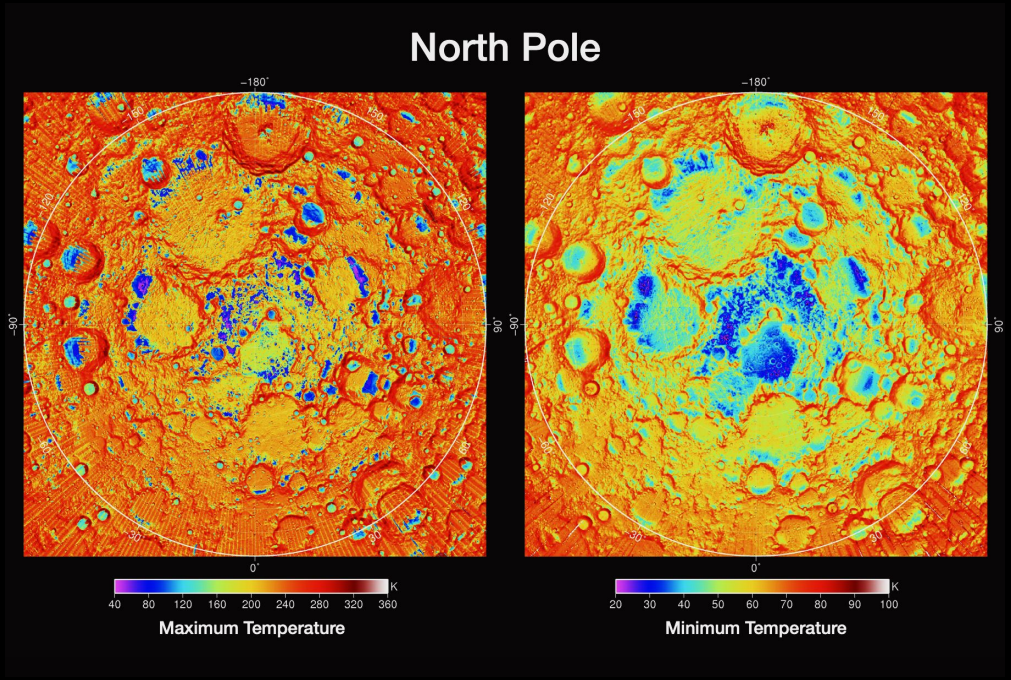
https://science.nasa.gov/science-news/science-at-nasa/2009/07oct_microwave
https://www.newscientist.com/article/dn17861-how-astronauts-could-harvest-water-on-the-moon/

Rocket Fuel



In addition to the maintenance of biological life, the water can be electrified into hydrogen and oxygen, cooling them to the necessary temperature. Then these two are the basic materials for rocket thruster fuel.

Rocket Fuel



According to a research from NASA: "Diviner found a place in the floor of the Moon's Hermite Crater that was detected to be -410 degrees Fahrenheit (-250° C, 25 K), making it the coldest temperature measured anywhere in the solar system," which will provide a natural environment to make them easier to preserve.

https://lunar.gsfc.nasa.gov/images/lithos/LROlitho7temperaturevariation27May2014.pdf

Summary

Those are some of the conclusions and methods that our group has learned about how to land and survive on the moon during our research. Going on the moon will play an essential role in human development. Whether it's deep space exploration or migration to other planets, being able to go to the moon will always be the basis of these operations. And we will eventually go out of the solar system and find more truth.

Thank You!