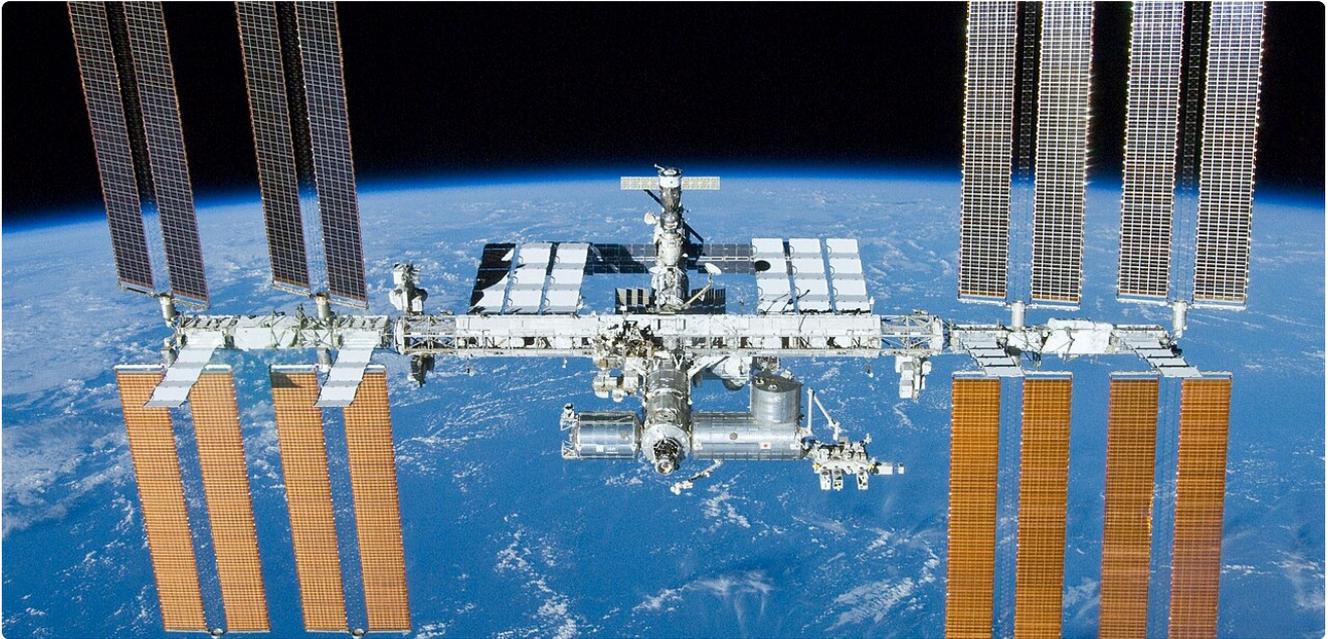


Living in Space

Survival, Adaptation, and What It Means to Leave Earth Behind

Humans & The Universe -- Lesson 4 of 8

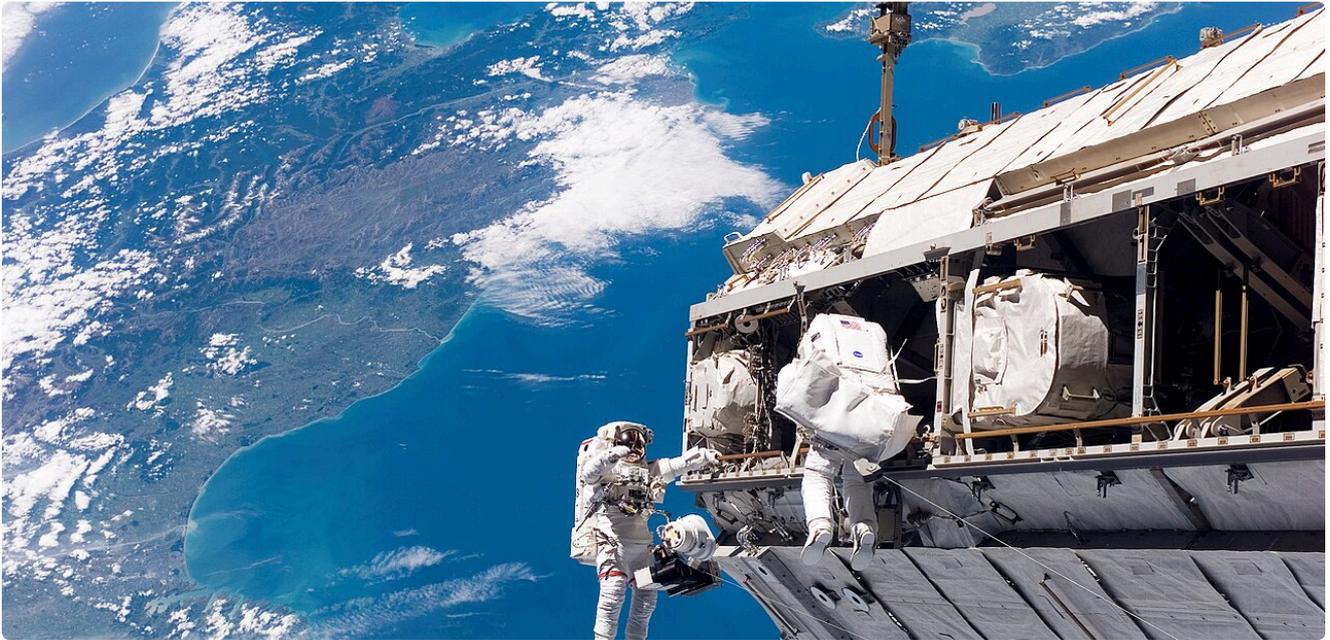


The International Space Station -- humanity's only permanent home beyond Earth since the year 2000

PART 1: THE HUMAN BODY IN SPACE

The human body evolved over millions of years to function in one specific environment: Earth, with its particular gravity, atmosphere, temperature, and magnetic field. Take a human being off this planet, and things start to go wrong almost immediately. In **microgravity**, astronauts lose approximately 1-2% of their bone density per month. Their muscles **atrophy** without the constant resistance of gravity. Fluids shift upward toward the head, causing puffy faces, increased **intracranial** pressure, and vision problems that scientists call Spaceflight Associated Neuro-Ocular Syndrome, or SANS.

The problems go deeper than bones and muscles. Without Earth's magnetic field, astronauts are exposed to high levels of cosmic **radiation** -- energetic particles from the sun and distant supernovae that can damage DNA, increase cancer risk, and potentially cause cognitive decline. On the International Space Station (ISS), astronauts receive radiation doses roughly ten times higher than on Earth's surface. A mission to Mars, which could take six to nine months each way, would expose travelers to even higher levels. NASA's current **permissible** exposure limits would likely be exceeded during a round trip to Mars.



An astronaut during an extravehicular activity -- protected from the vacuum of space by only a few layers of suit material

PART 2: THE PSYCHOLOGY OF ISOLATION

Physical challenges may actually be easier to solve than psychological ones. Imagine living in a space the size of a small apartment with the same three to six people for years. There is no weather, no fresh air, no open sky. You cannot step outside for a walk. Communication with Earth has a time delay -- on Mars, messages take between 4 and 24 minutes each way, making real-time conversation impossible. Astronauts on the ISS report that the most difficult aspect of long missions is not the physical discomfort but the **monotony** and the distance from loved ones.

Studies from **analogous** environments on Earth -- Antarctic research stations, submarine crews, isolated research habitats like HI-SEAS in Hawaii -- reveal consistent patterns. After several months of confinement, crews experience increased conflict, depression, sleep disorders, and a phenomenon called the "**third-quarter effect**" -- a psychological low point that occurs roughly three-quarters of the way through a mission, when the initial excitement has faded and the end still feels far away. Managing crew psychology may be the single most important factor in a successful Mars mission.

"The hardest part wasn't floating or the experiments or even the risk. It was looking out the window at Earth and knowing that everyone I loved was down there, living their lives without me."

-- Scott Kelly, after 340 consecutive days aboard the ISS

PART 3: BUILDING A HOME BEYOND EARTH

If humanity is to become a **multi-planetary** species, we need more than rockets -- we need habitats. On Mars, the average temperature is minus 60 degrees Celsius. The atmosphere is 96% carbon dioxide, with almost no oxygen. Atmospheric pressure is less than 1% of Earth's, meaning

exposed liquid water would boil instantly and an unprotected human would lose consciousness within 15 seconds. Any Mars habitat must provide breathable air, stable pressure, thermal protection, radiation shielding, water recycling, and food production -- all with minimal resupply from Earth.

Current proposals range from the practical to the **audacious**. SpaceX envisions pressurized domes and underground shelters. NASA studies **in-situ resource utilization** (ISRU) -- using Martian soil and ice to produce building materials, fuel, and breathable oxygen. The MOXIE experiment on the Perseverance rover has already demonstrated that oxygen can be extracted from the Martian atmosphere. Other concepts include inflatable habitats, 3D-printed structures using regolith (Martian soil), and even **terraforming** -- the centuries-long process of transforming Mars's atmosphere to make it Earth-like.

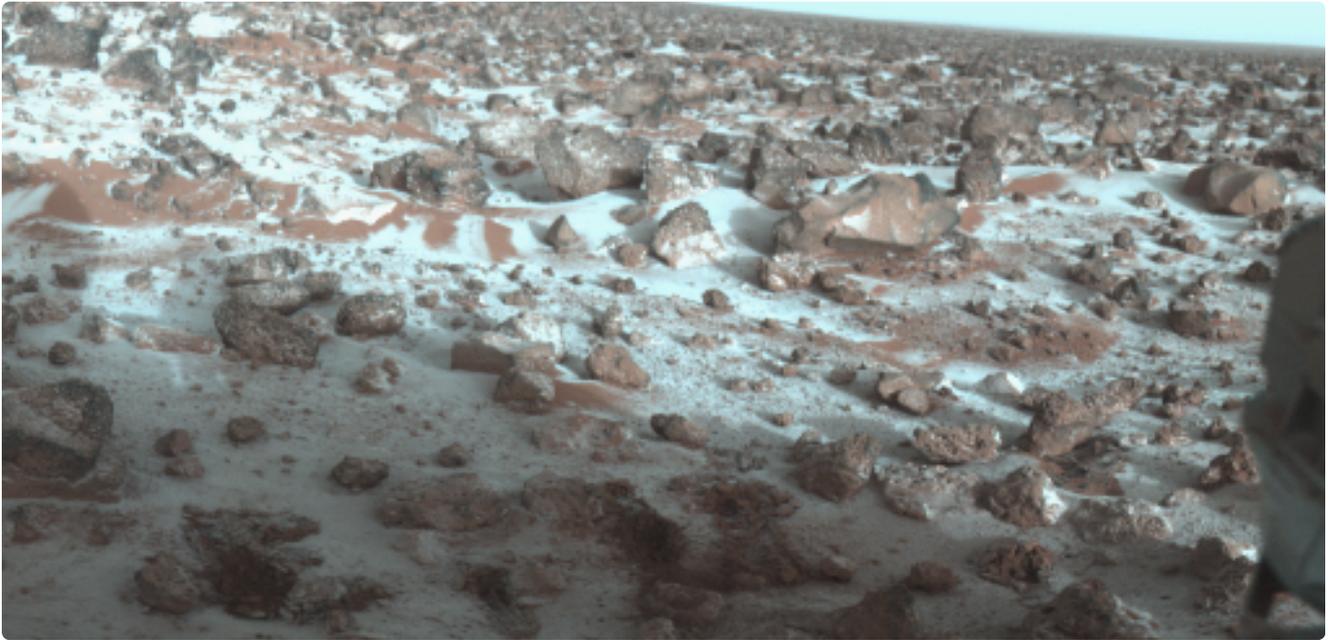
Life Support: Earth vs. Space

On Earth, the biosphere provides air, water, food, and waste recycling for free. In space, every one of these systems must be engineered. The ISS Water Recovery System recycles approximately 90% of all water on board -- including sweat and urine. A Mars colony would need to achieve close to 98% recycling efficiency to be sustainable.

PART 4: WHO GETS TO GO?

Perhaps the most profound question about living in space is not how but who. Early Mars missions will carry only a handful of people. If we are selecting the founders of a new civilization, what criteria should we use? Physical fitness? Scientific expertise? Psychological **resilience**? Genetic diversity? The first Mars colonists will make decisions that shape a society for generations. What language will they speak? What laws will govern them? Will they be employees of a corporation, citizens of a nation, or something entirely new?

Elon Musk has stated his goal of putting one million people on Mars. But who can afford the ticket? If space colonization is driven by private companies, it risks becoming a **privilege** of the wealthy -- a new world built by and for those who could pay to leave the old one. Others argue that space settlement should be a public project, funded by governments and open to all. The philosopher Hannah Arendt warned that the desire to leave Earth reflects a dangerous alienation from our own world. Are we building a backup for humanity, or running away from our problems?



The surface of Mars -- average temperature minus 60 degrees Celsius, with an atmosphere humans cannot breathe

KEY VOCABULARY

microgravity -- very weak gravity, as experienced on the ISS (not truly zero gravity)

atrophy -- to waste away or weaken from lack of use

intracranial -- inside the skull; relating to pressure within the head

radiation -- high-energy particles or waves that can damage living tissue

permissible -- allowed; within accepted limits

monotony -- tedious lack of variety; the same thing over and over

analogous -- comparable in certain respects; similar enough to be useful for comparison

multi-planetary -- existing on more than one planet

audacious -- showing a willingness to take bold risks

terraforming -- transforming a planet's environment to resemble Earth's

resilience -- the ability to recover quickly from difficulties

privilege -- a special advantage available only to certain people

in-situ -- in the original place; using materials found on location

third-quarter effect -- a psychological low point occurring roughly 75% through a long mission

A. COMPREHENSION

1. Name three physical effects of living in microgravity on the human body.
2. Why is radiation a bigger concern for Mars travelers than for ISS astronauts?
3. What is the "third-quarter effect" and why is it relevant to long space missions?
4. Why would liquid water boil on the surface of Mars?
5. What is ISRU and how could it help Mars colonists?
6. What did the MOXIE experiment demonstrate?
7. What concern does the reading raise about private companies leading space colonization?

B. VOCABULARY IN CONTEXT

Complete each sentence with a word from the vocabulary list:

1. After three months in a hospital bed, the patient's leg muscles began to _____ from disuse.
2. Antarctic research stations provide _____ environments for studying the isolation of space travel.
3. The plan to build a city on Mars in 20 years was criticized as overly _____.
4. Cosmic _____ can damage DNA and increase the risk of cancer in astronauts.
5. The _____ of submarine life -- the same routines, same faces, same walls -- is psychologically exhausting.

6. Access to quality education should not be a _____ reserved for wealthy families.
7. Becoming a _____ species is often described as humanity's insurance policy against extinction.

C. CRITICAL THINKING

1. If you were selecting six people for the first permanent Mars colony, what five qualities or skills would you prioritize? Explain why.

2. Do you agree with Hannah Arendt that wanting to leave Earth is "a dangerous alienation from our own world"? Or is it the opposite -- a sign of ambition and survival instinct?

3. The ISS recycles 90% of its water, including urine. Mars colonists would need 98%. How does this fact change your idea of what "normal life" would look like on Mars?

4. Should Mars colonists be governed by Earth's laws, or should they create their own? What are the risks of each approach?

D. COLONY DESIGN CHALLENGE

Your task: You are the chief planner for the first Mars colony of 50 people. Design your colony by making decisions about the following categories. Be prepared to defend every choice.

1. Location

Near the equator (warmer, more sunlight) or near the poles (water ice available)? Underground, on the surface, or in lava tubes?

2. Energy

Solar panels (free but dust-prone), nuclear reactor (reliable but heavy to transport), or wind (Mars has thin atmosphere)?

3. Food

Hydroponic greenhouses? Insect protein farms? Lab-grown meat? How much food should come from Earth as backup?

4. Governance

Democracy, appointed leadership, or rotating council? Who resolves disputes? What laws apply?

5. Communication

Messages take 4-24 minutes each way. No video calls. How do you maintain relationships with Earth? Do you limit contact?

6. Mental Health

How do you prevent the third-quarter effect? What recreational facilities do you include? How do you handle conflict?

E. THE GREAT DEBATE: SHOULD WE COLONIZE MARS?

Context: The United Nations is voting on whether to fund a \$500 billion international Mars colonization program. Earth faces climate change, poverty, and resource depletion. Should humanity invest in becoming multi-planetary, or focus on fixing Earth first?

Position A: Yes, colonize Mars.

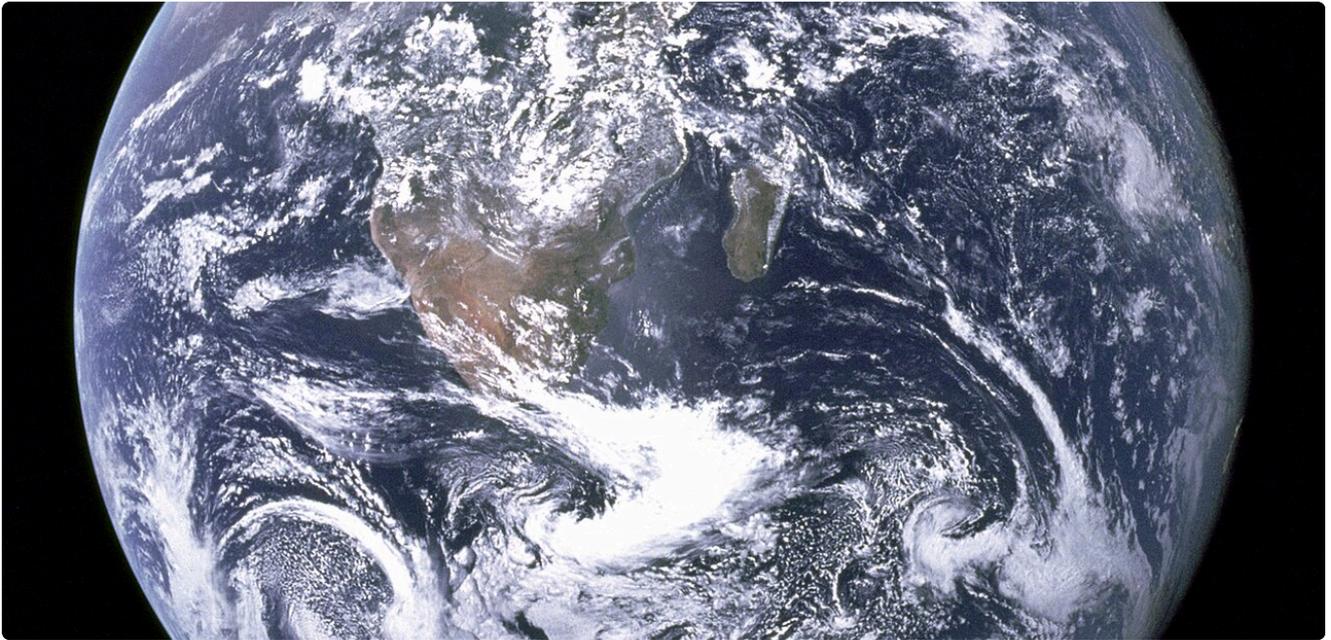
Earth won't last forever. Asteroids, pandemics, nuclear war, climate collapse -- any of these could end civilization. Mars is a backup drive for the human species. The technology developed for Mars (recycling, energy, food production) will benefit Earth too. Waiting until Earth is "fixed" means waiting forever.

Position B: No, fix Earth first.

\$500 billion could eliminate global poverty, fund renewable energy, and reverse environmental damage. Mars is a barren desert with no oxygen -- why build a worse version of Earth instead of saving the real thing? Space colonization is escapism for billionaires while billions suffer here.

Position C: Both, but Earth is the priority.

Continue Mars research at current levels. Send robotic missions. Develop the technology. But the bulk of resources should address Earth's urgent problems. Colonization can wait until we've proven we can sustain one planet before we attempt two.



Earth at night -- our only home. Should we protect it, leave it, or both?

F. ESSAY PROMPT

Choose ONE of the following prompts. Write a well-organized essay of 300-500 words on a separate sheet of paper.

Option A: "Humanity has no future if it stays on one planet." Do you agree or disagree? Use evidence from the reading and your own knowledge to support your position.

Option B: You have been selected for the first Mars colony. Write a letter to your family on Earth explaining why you chose to go, what you expect life to be like, and what you will miss most.

Option C: Compare the challenges of living on Mars with the challenges faced by early colonists, polar explorers, or submarine crews on Earth. What can we learn from history about surviving in extreme environments?

Teacher's Notes & Answer Key

Living in Space -- Instructor Guide

LESSON OVERVIEW

Level: Advanced (B2-C1) | **Duration:** 60-90 minutes | **Focus:** Reading, colony design, debate
Series: Humans & The Universe, Lesson 4 of 8 | **Prerequisite:** None (standalone compatible)

SUGGESTED LESSON FLOW

Warm-up (5 min): "Would you go to Mars if you could never come back? Why or why not?" Quick poll and discussion.

Pre-reading (5 min): Review key vocabulary. Focus on: microgravity, atrophy, radiation, terraforming, resilience.

Reading (15-20 min): Parts 1-4. Students can read in pairs, alternating paragraphs.

Comprehension (10 min): Section A -- oral or written.

Vocabulary (10 min): Section B fill-in-blanks.

Colony Design (15-20 min): Section D -- pairs or small groups. Each team presents their colony plan. Class votes on best design.

Debate (10-15 min): Section E -- assign positions or let students choose. Push for real-world evidence.

ANSWER KEY -- SECTION A

1. Bone density loss (1-2% per month), muscle atrophy, fluid shift causing puffy face and vision problems (SANS), increased intracranial pressure. Any three acceptable.
2. Mars journey is 6-9 months each way (vs. ISS which is in low Earth orbit with some magnetic field protection). Mars travelers would be exposed for much longer and beyond Earth's protective magnetosphere, likely exceeding NASA's permissible exposure limits.
3. A psychological low point occurring roughly 75% through a long mission, when initial excitement has faded and the end still feels distant. Relevant because Mars missions would last 2-3 years -- crew mental health could collapse at the critical 75% mark.
4. Because Mars's atmospheric pressure is less than 1% of Earth's. At extremely low pressure, water's boiling point drops dramatically, so liquid water boils at surface temperatures.
5. In-Situ Resource Utilization -- using materials already on Mars (soil, ice, atmospheric CO₂) to produce building materials, fuel, and oxygen, reducing the need for expensive resupply from Earth.
6. That oxygen can be extracted from the Martian atmosphere (which is 96% CO₂). The experiment was carried out by the Perseverance rover.
7. That space colonization could become a privilege of the wealthy -- a new world built by and for those who could afford to leave, deepening inequality rather than offering opportunity for all.

ANSWER KEY -- SECTION B

1. atrophy
2. analogous
3. audacious
4. radiation
5. monotony
6. privilege
7. multi-planetary

DISCUSSION EXTENSIONS

Film connection: "The Martian" (2015) -- compare the film's depiction of Mars survival with the real challenges described in the reading. What did the film get right? What did it simplify?

Ethics extension: If Mars colonists have children, those children never chose to live on Mars. Is it ethical to raise children on another planet? What rights should "Martian-born" humans have?

Link to Lesson 3: Hibernation technology (Lesson 3) could solve many of the psychological challenges discussed here. How would suspended animation change the calculus of Mars colonization?

Current events: Research SpaceX's Starship program, NASA's Artemis missions, or China's Tiangong space station. How close are we really to a permanent presence beyond Earth?

KEY DISCUSSION LANGUAGE

Prioritizing: "The most critical factor is..." / "Above all, we need..."

Trade-offs: "The advantage of X is... but the cost is..."

Feasibility: "In theory this works, but in practice..."

Ethics: "Is it right to...?" / "Who benefits and who suffers?"

Comparing: "This is similar to... because..." / "Unlike Earth, Mars..."

Defending: "I chose this because..." / "The evidence suggests..."