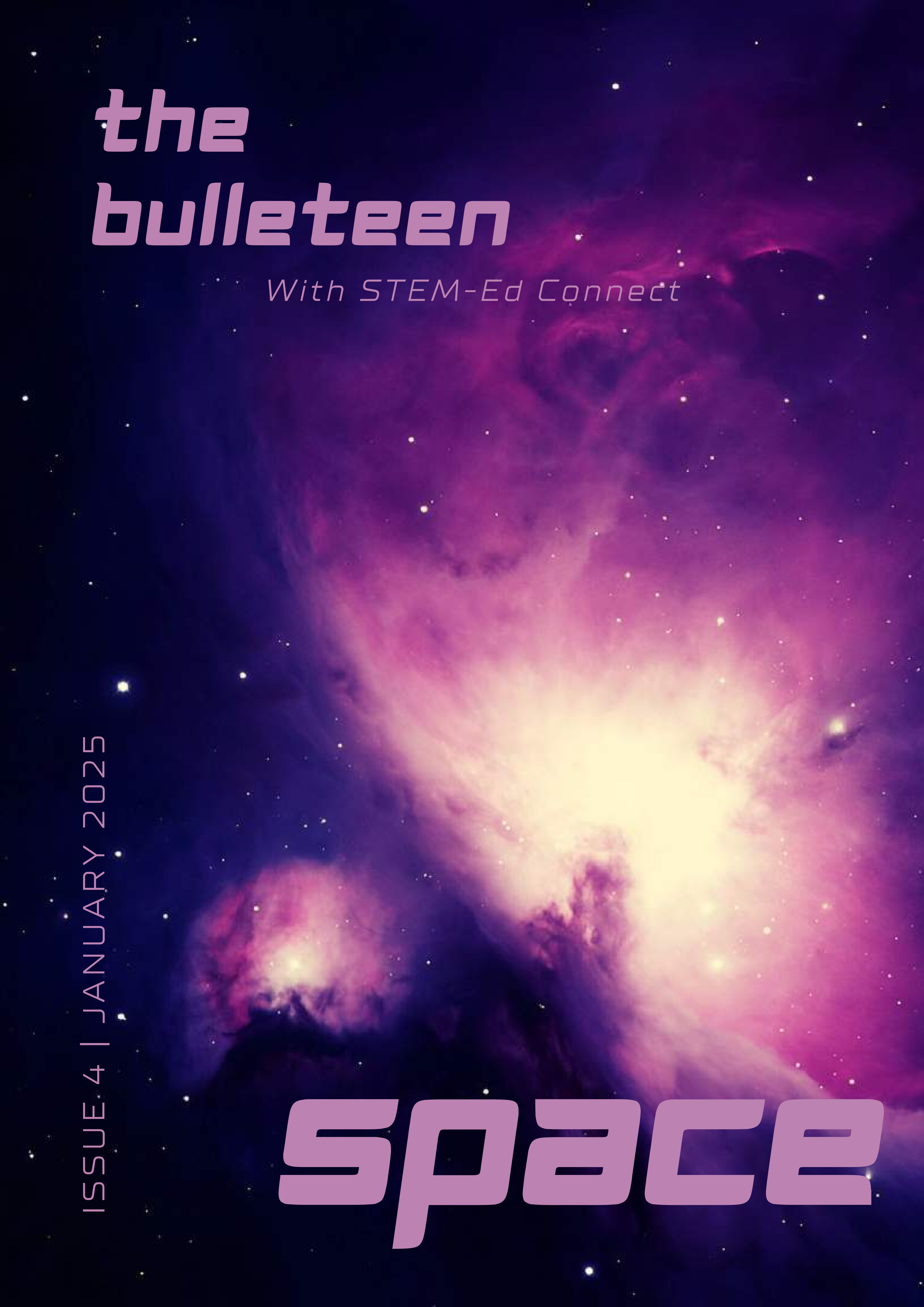

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With STEM-Ed Connect

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space

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sneha ruhil

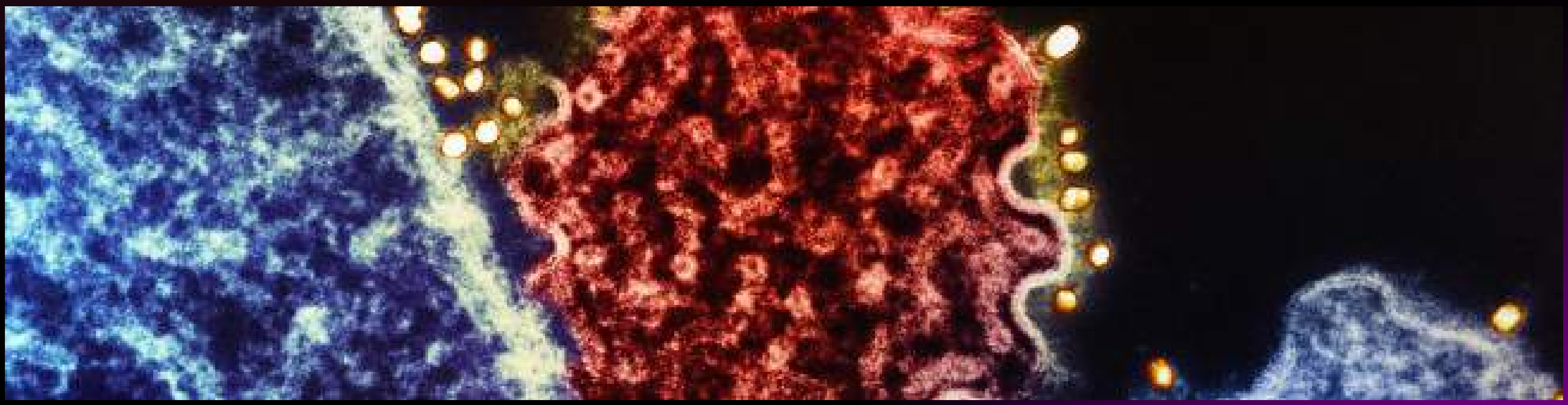
space microbes: the future of manufacturing

The manufacturing sector for space exploration faces numerous challenges, including high costs and limited resources. Supply missions are expensive, with costs reaching $10,000 per kilogram of payload sent to space. To address these challenges, microbes—bacteria and fungi—offer revolutionary potential. These tiny organisms can produce essential raw materials, facilitating sustainable living and manufacturing in space.

microbes as miniature factories

Microorganisms have long been utilized on Earth for producing medicines, clean energy, and food. In space, they could produce essential resources like metals, nutrients, and medicines. Bacteria, for instance, can extract metals through biomining by breaking down rocks into smaller particles. This process could provide materials for tools and habitats on the Moon or Mars (Anderson et al., 2021).
Another promising application is NASA's BioNutrients system, which uses microbes to produce essential vitamins and compounds during missions. This system reduces reliance on pre-packed supplies, ensuring astronauts have access to fresh nutrients (Brown et al., 2022).

niaid. (2024, february 4). national institute of allergy and infectious diseases



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advantages of microbial manufacturing in space

Cost Efficiency: Microbes can utilize local resources, significantly reducing the need for costly supply missions.
Versatility: Microbes can produce a diverse range of products, from pharmaceuticals to construction materials.
Sustainability: Microbial processes generate less waste and consume less energy compared to traditional manufacturing methods.

challenges and considerations

While promising, microbial manufacturing comes with its challenges:
Microgravity Effects: Microgravity alters microbial behaviour and growth, necessitating precise modifications for effective biomanufacturing.
Containment Risks: Engineered microbes must be contained to prevent contamination and protect astronauts and spacecraft environments.
Regulation and Ethics: The use of genetically modified organisms in space raises ethical concerns. International space agencies are working on frameworks to ensure safety and ethical compliance (Johnson et al., 2023).

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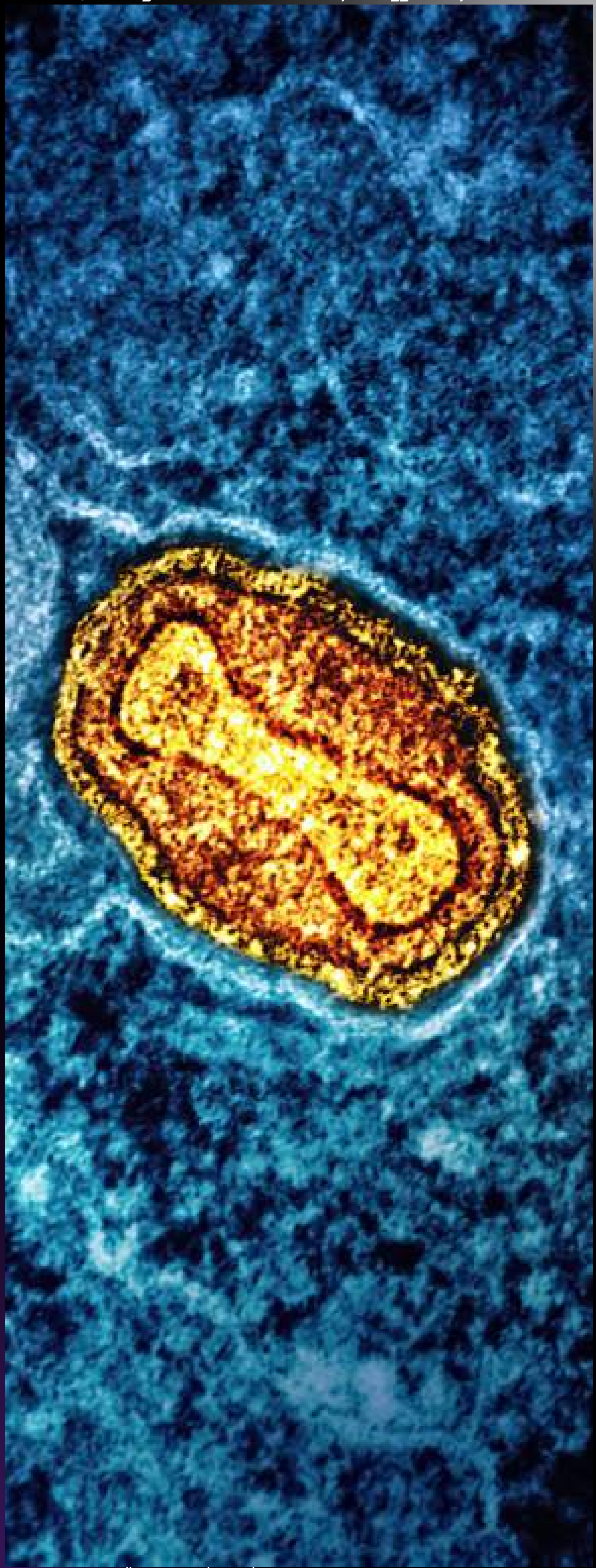

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future prospects

Advancements in synthetic biology and genetic engineering are enabling the creation of tailored microbes for space applications. Collaborative efforts between space agencies, universities, and private companies are accelerating progress in this field. In conclusion, microbes hold immense potential to revolutionize space exploration by providing efficient, sustainable manufacturing solutions. Harnessing their abilities could transform humanity's endeavours beyond Earth, paving the way for a self-sustaining future in space.

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the moon in poetry

the moon in poetry: from romantic symbolism to modern inspiration

khansa aamer

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unsplash. https://unsplash.com/photos/moon-wcujvcfojdw

The moon has been a central figure in poetry for centuries, serving as a symbol of love, mystery, and the sublime. It's there when we're dreaming, when we're searching for answers, or even when we're trying to find our way in the dark. For centuries, poets have looked up at that glowing orb and seen something more than just a celestial body. It's been a symbol of love, loneliness, mystery, and even hope.

romantic symbolism: the moon as a mirror of emotion

The Romantic Era (late 18th to mid-19th century) emphasized emotion, nature, and individualism. Poets like William Wordsworth, Percy Bysshe Shelley, and John Keats frequently depicted the moon not just as a part of the night sky; it was a companion, a muse, and sometimes even a character in their stories. For example, in Shelly's "To the Moon", the moon is portrayed as "wan and worn" but "still steadfast." It reflects the human condition, embodying the poet's longing for permanence and change. The imagery of the moon as "pale" and "tired" underscores the Romantic fascination with natural elements mirroring human struggles. Similarly, Keats's "Endymion" presents the moon as a goddess and a lover. The poem intertwines mythology and romantic idealism, where the moon personifies unattainable beauty. This celestial and intimate duality captures the Romantic yearning for connection with the sublime. The moon also symbolized solitude in Romantic poetry. In "Lines Written in Early Spring," the moon quietly watches over him as he reflects on life and nature. The moon acts as a silent companion. Its stillness offers to poet comfort mirroring his introspection. For the Romantics, the moon wasn't just decoration -it was a reflection of their deepest emotions.

modern poets and the moon: a shift in perspective

Moving into the 20th and 21st centuries, the moon remains a cherished and enduring source of fascination, but the way poets write about it has been diversified. Instead of being a silent companion or a romantic ideal, it's often used as a metaphor for contemporary struggles, identity, and human connection to the cosmos. Sylvia Plath's "The Moon and the Yew Tree", for example, conveys a sense of existential despair. Her moon isn't soft or comforting. It's cold, distant, and almost indifferent. It's a stark reminder of how isolated we can feel, even when something so constant is right above us. On the other hand, Mary Oliver's "The Journey" uses the moon as a symbol of guidance and hope. It's like a beacon, steady, and sure, offering direction when everything else feels uncertain. Oliver's moon is a reminder that even in chaos and amid life's uncertainties, there's still something that you can count on. The moon also appears in poems addressing collective experiences, such as environmental issues and scientific progress. In Margaret Atwood's poem "Procedures for Underground", she pairs the moon's timeless beauty with humanity's scientific progress. It's almost like she is questioning whether we've lost something in our pursuit of knowledge -whether the moon, once a source of wonder, has become just another object to conquer.

tegethoff, m. (2017, august 22).

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the moon across cultures: a universal language

What's fascinating is how the moon speaks to everyone, no matter where they're from. In Japanese haiku, for example, the moon often represents the fleeting nature of life. Matsuo Basho, one of the greatest haiku masters, captures this perfectly in his lines: Autumn moonlight / a worm digs silently / into the chestnut." It's such a simple image, but it says so much about beauty, decay, and the passage of time. In Urdu poetry, the moon is frequently likened to the beloved, whose beauty is ethereal and often beyond reach.

The soft glow of the moon, its serene presence, and its ability to light up the darkest nights have inspired countless verses. Consider Mirza Ghalib's timeless expression of emotions, where the moon often symbolizes the allure of a lover and his poetic fascination with celestial wonders like the moon. Poets like Mir Taqi Mir also used the moon to symbolize the beloved's face, highlighting its unmatched beauty and softness. The moon, in these cultures, becomes a symbol of longing, of beauty that's seen but never fully owned.

why the moon will always matter

krcmarek, n. (2016, december 15).

unsplash. https://unsplash.com/photos/full-moon-9dtg44qhxiq

The thing about the moon is that it's always there. No matter where you are or what you're going through, you can look up and see it shining back at you. And maybe that's why poets keep writing about it -it's a reminder that even when things feel uncertain, there's still something constant in the world. It's a bridge between the past and the present, between cultures and generations. And as long as we keep looking up, it'll keep lighting the way -for poets, for dreamers, and for all of us.

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radiation resistant fungi: nature's space shield

sneha ruhil

The presence of ionizing radiation in the vacuum of space poses a significant challenge for astronauts. This type of radiation can harm living tissues and lead to cancer. However, we can circumvent this issue by utilizing fungi, which have unique properties to counteract space radiation. Notably, some fungi have developed mechanisms that enable them to not only endure high radiation levels but also use it for their growth. Scientists are actively studying fungi, especially those with melanin content, as natural defenses against space radiation.

melanin's role

Melanin, a dark pigment present in many organisms, exhibits the extraordinary ability to absorb and dissipate harmful radiation. Evidence suggests that melanized fungi, including Cladosporium sphaerospermum, can thrive in hazardous environments such as the Chernobyl Nuclear Power Plant. These fungi not only persist under ionizing radiation but also grow more rapidly. Studies indicate that melanin interacts with radiation by converting it into chemical energy, which supports fungal growth (Smith et al., 2019).

omerović, d. (2018, november 22)

sunslpash. https://unsplash.com/photos/selective-focus-photo-of-mushroom-umagtammisi

potential for space exploration

The resilience of these fungi has opened doors for potential space applications. A study conducted on the International Space Station (ISS) investigated the use of melanized fungi as a defense against cosmic radiation. This study demonstrated that a thin coating of these fungi reduced ionizing radiation by approximately 2% under specific experimental conditions, such as exposure duration and intensity levels (Jones et al., 2020). While this percentage may seem modest, the self-repairing and regenerative nature of fungi could make them indispensable for long-term missions.

advantages of fungal shields

Self-repairing Nature: Unlike traditional shielding materials, living fungi can regenerate and provide continuous protection over time.
Lightweight Design: Fungal-based shields may weigh less than conventional materials like lead or polyethylene, potentially lowering launch costs and payload weights.
Sustainability: Fungi can be cultivated during missions, offering a renewable resource for radiation protection.

challenges and future prospects

Despite these advantages, practical implementation faces significant hurdles. Research is needed to optimize the growth conditions of fungi in space and address potential contamination risks. Furthermore, fungi's protective efficiency might not yet match that of traditional materials. Genetic and metabolic studies could uncover pathways to bioengineer fungi for enhanced performance, tailoring them for specific missions. To sum up, the unique ability of radiation-resistant fungi to endure and potentially harness ionizing radiation presents an intriguing prospect for creating autonomous, self-sustaining barriers in space. As humanity ventures further into the cosmos, fungi could become a crucial tool for astronaut safety

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can civilians handle space? lessons from inspiration

neelabh datta

What happens when ordinary individuals venture into the extraordinary domain of outer space? Historically, human spaceflight has been the field of strictly trained astronauts, selected and groomed for their physical resilience and mental toughness. This exclusivity created significant barriers to space travel for ordinary citizens, including the need for advanced technical skills, strict medical requirements, and access to immense financial resources. These barriers not only limited who could experience space but also constrained the diversity of perspectives and contributions The absence of broader participation meant that research and knowledge about space were largely shaped by a narrow subset of humanity, leaving untapped the potential insights, innovations, and discoveries that could arise from the inclusion of people from varied backgrounds. However, with the rise of private space exploration programs, the gates to orbit are opening to civilians—individuals from diverse walks of life, experiences, and even health conditions. Among these groundbreaking missions (Axiom Mission 1, Polaris Dawn, SpaceShipTwo, Genesis I and II), SpaceX's Inspiration4 stands out as the first fully civilian-crewed spaceflight, marking a significant shift in who gets to experience space and, more importantly, who contributes to its research.

maximilian, c. (2018, february 8).

unsplash . https://unsplash.com/photos/aerial-photography-of-high-rise-buildings-syzlbsko-na

Launched on September 15, 2021, from Kennedy Space Center, the Inspiration4 mission took four civilians aboard SpaceX's Crew Dragon capsule to an altitude of 590.6 kilometres—higher than any human space mission since NASA's Gemini program. Though it lasted only three days, this short jaunt into low Earth orbit provided a unique platform to study the human body's immediate reactions to the harsh conditions of spaceflight, including radiation, microgravity, isolation, and confinement [1]. These challenges mirror those faced by astronauts aboard the International Space Station (ISS), where missions typically extend for six months or longer [2]. By offering a glimpse into the earliest physiological and behavioural responses to space, Inspiration4 paved the way for understanding the feasibility of space travel for ordinary citizens.

nasa. (2016, february 6)

unsplash. https://unsplash.com/photos/astronaut-in-spacesuit-floating-in-space-yJimsrickk4

The mission's objectives centered on exploring the biological and behavioral adaptations of the civilian crew and assessing the practicality of conducting scientific research during a privately funded spaceflight [2]. Unlike professional astronauts who undergo years of rigorous preparation, the Inspiration4 crew relied on minimal training and just-in-time instructions to perform complex experiments and collect data. Their efforts encompassed a broad array of biomedical studies designed by the Translational Research Institute for Space Health (TRISH). These studies aimed to evaluate the crew's health before, during, and after the mission using a suite of cutting-edge tools, including portable ultrasound devices, wearable physiological monitors, and molecular assays [1].

One of the mission's most significant achievements was the successful collection of biospecimens—blood, saliva, stool, urine, and even skin biopsies—across all phases of the flight [1]. These samples revealed several biological changes that mirror those seen in longer-duration space missions. For instance, the crew exhibited inflammation, altered immune signaling, and even telomere elongation—changes previously observed in ISS astronauts after months in orbit. This mission introduced methodologies such as RNA methylation analysis and single-cell transcriptomics, pushing the boundaries of space biomedical research. Despite the short duration, the findings underscored that many space-induced changes occur rapidly, offering valuable insights for future missions of varying lengths.

Another cornerstone of the mission was its use of portable ultrasound imaging to study the impact of microgravity on human anatomy and physiology [1]. The researchers focused on three key areas: urinary bladder function, jugular vein flow, and ocular morphology. Interestingly, none of the crew experienced jugular vein flow anomalies, a common issue among ISS astronauts during long missions [1]. This finding suggests that certain cardiovascular risks may take longer to manifest, challenging assumptions derived from Earth-based microgravity simulations. Meanwhile, inspiratory resistance breathing showed promising but inconclusive results in facilitating blood flow. While most ultrasound procedures, like bladder and vein imaging, were executed successfully, ocular imaging proved more challenging due to its complexity, emphasizing the need for dedicated operators or enhanced automation in future missions.

Beyond biological metrics, the Inspiration4 mission also highlighted the behavioral and cognitive aspects of civilian spaceflight. The crew's neurocognitive performance, assessed through a series of tests, showed no major deficits in accuracy, though response times varied. This variability could be linked to neurovestibular challenges and sensorimotor adjustments that accompany microgravity. Interestingly, despite minor slowdowns in reaction speeds, the crew reported an increase in positive emotions—feeling happier and less bored post-flight compared to their pre-flight states [1]. Sleep quality, a known challenge for astronauts, was another focus. The Inspiration4 crew averaged 6.7 hours of sleep per night, a figure slightly higher than typical ISS reports, possibly mitigating cognitive fatigue. The mission highlighted the potential of civilian crews to operate autonomously in conducting scientific research. Unlike ISS missions, where real-time support from mission control is standard, the Inspiration4 team relied on preloaded instructions and their adaptability. This independence has significant implications for future missions, especially in scenarios where communication with Earth is limited, such as deep-space exploration. However, the findings also suggest that while most tasks can be managed autonomously, highly intricate procedures may still require specialist intervention.

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unsplash. https://unsplash.com/photos/black-hole-galaxy-illustration-oze6uemioyu

One of the most exciting implications of Inspiration4 lies in its potential to democratize space exploration. By demonstrating that ordinary individuals can complete missions and contribute to meaningful scientific research, the mission challenges traditional notions of who can be an astronaut. This shift could inspire new waves of engagement, from schoolchildren dreaming of space to scientists devising novel experiments. Moreover, the inclusion of diverse participants—spanning different ages, medical histories, and genetic backgrounds—enriches our understanding of how varied populations might fare in space, ultimately informing crew selection and mission planning for future long-duration expeditions.

Despite its successes, the mission faced inherent limitations. The sample size was small—just four astronauts—which limits the generalizability of the findings. Moreover, the lack of Earth-based control subjects matched for age, sex, and health complicates direct comparisons. However, the within-subject design, where each astronaut's pre-flight data served as their baseline, provided a robust framework for identifying space-induced changes. Future studies with larger, more diverse cohorts will be essential to validate these preliminary observations and to refine protocols for civilian spaceflight research.

Yet, Inspiration4 also raises critical questions. How do the physiological and psychological responses of civilians compare to those of professional astronauts who have trained rigorously for space? Can the short-term findings observed in missions like Inspiration4 predict long-term outcomes for spacefarers with less preparation? While this mission wasn't designed to answer such questions definitively, it has laid a foundation for future research. By building a comprehensive biomedical database from civilian missions, researchers can begin to establish reference ranges and predictive models that benefit both professional astronauts and private space travelers.

As the age of commercial spaceflight accelerates, missions like Inspiration4 represent a new frontier—not only for exploration but also for scientific discovery and public engagement. They challenge humanity to think differently about space, its accessibility, and the kinds of people who can contribute to its future. From innovations in medical diagnostics to insights into human adaptability, these missions are reshaping our understanding of life beyond Earth.
So, as private space travel becomes more common, the question remains: How will these experiences redefine not just our biology but our collective imagination about what it means to explore the final frontier?

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exoplanets - the alien worlds

devansh kumar tripathi

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1.exoplanets - unveiling alien world

Imagine standing under a sky filled with not just stars but also planets—worlds beyond our wildest dreams. Planets where it rains molten glass sideways or oceans span entire surfaces. These aren't scenes from a sci-fi movie; they're the realities of exoplanets –mysteries of our universe—planets orbiting stars beyond our Sun. But how did we find them? Could they support alien life?

Let's dive into the cosmic journey of discovery and what it tells us about our place in the universe. Since the discovery of the very first exoplanet just over two decades ago, astronomers have uncovered thousands of planets orbiting stars far beyond our solar system. These alien worlds come in a dazzling variety, many unlike anything found around our Sun. Entire planetary systems have been discovered with architectures that challenge our understanding of how planets form and evolve. What's even more exciting is the incredible pace of this research—scientists are not only identifying exoplanets but also uncovering remarkable details about their atmospheres, climates, and potential habitability. The rapid progress in exoplanetary science is nothing short of extraordinary, transforming what we know about our universe in just a few years.

2. the remarkable quest : the discovery

The discovery of exoplanets—planets orbiting stars beyond our Sun—has transformed our understanding of the cosmos. It all began in 1992 when Aleksander Wolszczan and Dale Frail made a startling revelation: planets orbiting a pulsar, a dense, rapidly spinning neutron star. This discovery was unexpected, as pulsars were considered inhospitable to planetary systems. Just a few years later, in 1995, Michel Mayor and Didier Queloz identified 51 Pegasi b, the first exoplanet found orbiting a Sun-like star. This "hot Jupiter," with its tight and swift orbit, broke every mould of what scientists thought planets could be. Since then, the field of exoplanet research has exploded, uncovering over 5,000 confirmed planets as of 2024. From gas giants larger than Jupiter to rocky, Earth-like worlds, these discoveries have revealed an astonishing diversity of planetary types. Cutting-edge missions like NASA's Kepler and TESS telescopes have played a pivotal role, employing advanced techniques to spot these distant worlds. What's even more remarkable is how much we've learned in such a short time. By advanced technologies, we can even identify the chemical composition of a planet and its significance as a supporter of life—the Alien World! The rapid pace of these discoveries reminds us that we are only beginning to unravel the mysteries of our galaxy's countless other worlds

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3. methods of detection

Discovering exoplanets, hidden amidst the vastness of space, is no easy feat. Astronomers rely on ingenious methods to detect these elusive worlds, as they are too distant and dim to observe directly. Let's look into these indigenous methods to find these:-

Transit photometry: How light dips indicate the presence of exoplanets. One of the most powerful tools for finding exoplanets is the transit photometry method. This technique works by monitoring a star's brightness for periodic dips, which occur when a planet crosses in front of the star from our viewpoint—a phenomenon known as a transit. These dips reveal vital clues: the size of the planet can be inferred from how much starlight it blocks, while its orbital period and distance from the star can be determined from the timing of the transits. For planets with atmospheres, analyzing the light spectrum during transits can even unveil their chemical composition. Missions like Kepler and TESS have used this method to uncover thousands of exoplanets, demonstrating its unmatched efficiency in identifying distant worlds. However, transit photometry requires precise alignment between the planet's orbit and our line of sight, making it only suitable for a fraction of planetary systems.

czerwinski, p. (2019, june 14).

unsplash. https://unsplash.com/photos/blue-planet-paintning-fad4u _ htggy

Radial velocity: The radial velocity method is another essential technique used to detect exoplanets. Unlike transit photometry, which observes the light dimming from a star, radial velocity measures the star's "wobble" caused by the gravitational pull of an orbiting planet. As a planet orbits, it subtly tugs on its host star, causing the star to move in a small but detectable motion. This motion shifts the star's light toward the red end of the spectrum when it's moving away from us and toward the blue when it's moving closer—known as the Doppler effect. By monitoring these shifts, astronomers can determine the planet's mass and its orbit.

Direct imaging and its challenges: The direct imaging method is one of the most challenging but fascinating ways to detect exoplanets. Unlike other techniques that rely on indirect observations, direct imaging involves capturing the actual light emitted by a planet. This method is particularly useful for detecting large, young planets far from their stars, where the planet's light is bright enough to be seen above the glare of the star. To achieve this, astronomers use special instruments like coronagraphs or starshades to block out the light from the parent star, allowing the faint light from the planet to be observed. These instruments can also capture detailed images of exoplanet atmospheres, giving clues about their composition, weather patterns, and potential for habitability. Despite its challenges, direct imaging has led to significant discoveries, including the direct observation of planets in the HR 8799 system and the potential of the James Webb Space Telescope to provide even more detailed images.

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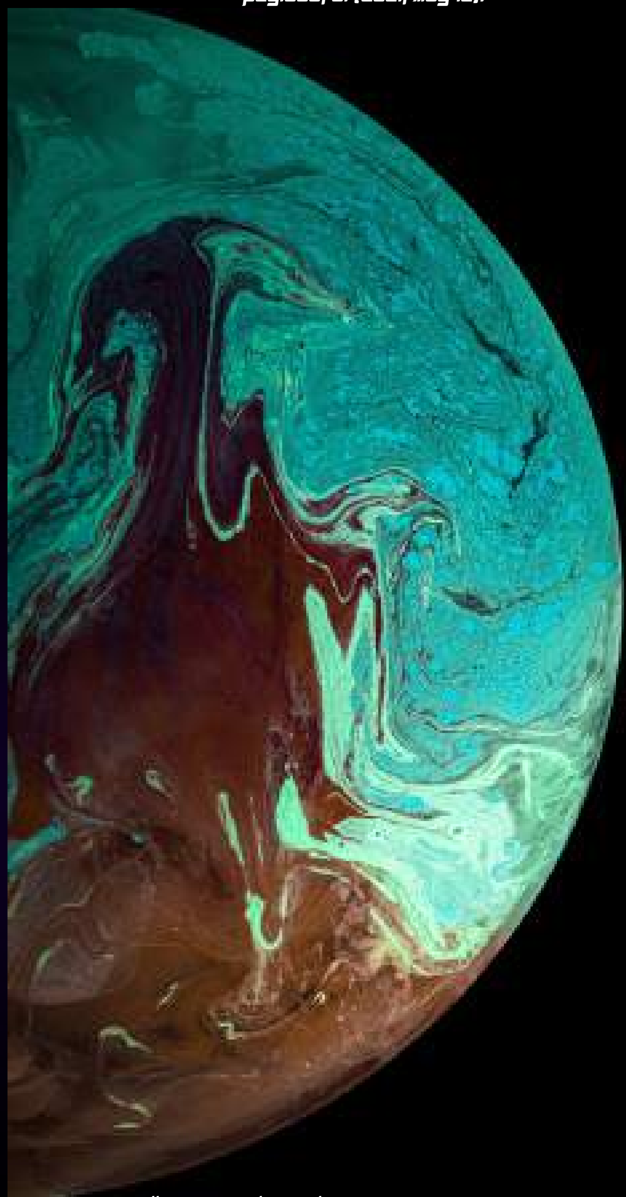

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Gravitational microlensing: Gravitational microlensing is an extraordinary method for detecting exoplanets that rely on the bending of light caused by the gravitational field of a massive object, like a star or planet, passing in front of a more distant background star. When this happens, the foreground object acts like a lens, magnifying the light from the background star. If the foreground object is a star with orbiting planets, the planets can cause subtle variations in the magnification, providing evidence of their presence. This technique is particularly powerful because it can detect planets that are far from their stars, in regions where other methods, like transit photometry, might not work. It has been used in surveys like OGLE and microlensing projects to find exoplanets in distant parts of the galaxy. Unlike other methods, microlensing doesn't require us to see the planet directly, making it one of the most versatile tools for exoplanet discovery.

4. the habitable zone: where life may survive

The habitable zone (often called the "Goldilocks zone") refers to the region around a star where conditions are just right for liquid water to exist on a planet's surface—not too hot and not too cold. This is considered a critical factor for the development of life as we know it. Planets within this zone could potentially support life, as water is an essential ingredient for life's processes. The habitable zone varies based on the size and temperature of the star. For instance, the habitable zone around a small, cool star would be much closer to the star than the habitable zone around a larger, hotter star. Identifying planets in this zone has become a major focus of exoplanet research, as finding planets in the habitable zone could bring us closer to answering the age-old question: Are we alone in the universe? The discovery of such planets has profound implications for astrobiology, as scientists look for Earth-like worlds that might harbor life.

The range and distance of these habitable zones depend on several factors:-

Stellar Type: Larger, hotter stars have a habitable zone that is farther from the star, while cooler, smaller stars have their habitable zone much closer. The size and temperature of the star directly impact the distance at which liquid water can exist on a planet's surface.

Planetary Atmosphere: A planet's atmosphere plays a crucial role in determining whether liquid water can exist. An atmosphere that is too thick can cause excessive greenhouse warming, while a thin atmosphere might not provide enough heat retention.

Planetary Size and Composition: The size of a planet impacts its ability to retain an atmosphere and regulate its climate. Earth-like planets with sufficient mass can hold onto an atmosphere, while smaller planets may struggle to maintain one.

Orbital Eccentricity: Planets with highly eccentric (elliptical) orbits may experience extreme temperature variations, potentially pushing them in and out of the habitable zone. A more circular orbit leads to more stable conditions for life to thrive.

Distance from the Star: The specific distance between a planet and its star determines whether it lies within the habitable zone. If a planet is too close, it could be too hot for liquid water, while if it is too far, it could be too cold.

Planetary Tilt and Seasons: A planet's axial tilt influences its seasons, which could impact the climate and the potential for habitability. Planets with extreme tilts could experience harsh seasonal shifts, while those with a more stable tilt might maintain a more consistent climate.

5. notable potential habitable exoplanets

Proxima Centauri b: Located just over 4 light-years away, Proxima Centauri b orbits the closest star to our Sun, Proxima Centauri. This exoplanet is within its star's habitable zone, and while its conditions are still under investigation, scientists believe it could have the right temperature for liquid water to exist on its surface.

Kepler-452b: Dubbed "Earth's cousin," Kepler-452b is about 1,400 light-years away and orbits in the habitable zone of a star similar to our Sun. This exoplanet is nearly the same size as Earth and is in the right temperature range for liquid water. Its composition and potential for a rocky surface make it one of the most promising candidates for habitability in the Kepler mission's discoveries.

van der hoeven, t. (2017, august 31).

unsplash. https://unsplash.com/photos/digital-wallpaper-of-eclipse- _ ok8uv2l2gi

LHS 1140 b: LHS 1140 b is an Earth-sized planet located in the constellation Cetus, about 40 light-years away. It orbits within its star's habitable zone and is thought to have a rocky surface. Its size and mass suggest that it may have an atmosphere capable of supporting life, and it has been studied extensively by astronomers to assess its potential for habitability.

TRAPPIST-1 System: The TRAPPIST-1 system, located about 39 light-years away, contains seven Earth-sized exoplanets, three of which are in the habitable zone of their ultra-cool dwarf star. This discovery was groundbreaking because it highlighted the possibility of multiple planets in one system that could potentially support life. The TRAPPIST-1 planets are a key focus of research, with ongoing studies to determine their atmospheres and suitability for life.

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6. the role of telescopes in exoplanet exploration

Telescopes play an essential role in the search for and study of exoplanets, those mysterious worlds beyond our solar system. Thanks to advancements in telescope technology, scientists have been able to detect thousands of exoplanets, unravelling the diverse nature of planetary systems across the galaxy.

Ground-Based Telescopes: The First Step in Exoplanet Discovery Many of the early exoplanet discoveries were made using ground-based telescopes, which remain crucial for ongoing research. Instruments like the Keck Observatory in Hawaii and the European Southern Observatory's Very Large Telescope (VLT) in Chile have been instrumental in detecting exoplanets using methods such as radial velocity and direct imaging.

delalande, s (december 26, 2020)

unsplash. https://unsplash.com/photos/white-and-black-satellite-dish-on-brown-field-during-night-time-otj8oauiiq8

7. the future of exoplanet exploration

As more advanced telescopes are developed, our ability to detect and study exoplanets will only improve. New methods, such as gravitational microlensing, will enable astronomers to discover planets far from their stars, while direct imaging will help us observe planets that are too faint or distant to be detected by other means. Together, these telescopes will continue to provide us with a deeper understanding of the universe and the many diverse worlds it contains.

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mars: the red planet

julia de guzman

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introduction

Mars – the Red Planet and the fourth planet from the Sun – has captivated humans for thousands of years. It is easy to see in the night sky due to its distinctive red colouring, caused by the abundance of iron oxide on its surface. In the seventeenth century, Galileo studied Mars through his telescope and catalogued its moons, Phobos and Deimos, and since then we have studied Mars perhaps more than any other planet in the solar system, particularly because of its theorized capacity for supporting life.

natural history of mars

Mars' history is broken up into three periods: the Noachian, Hesperian, and Amazonian periods. Over these periods, scientists have catalogued a change in Mars' environment from being wet and watery to dry and arid. For example, the Noachian period, during which Tharsis– a volcanically rich region of Mars– formed, was likely characterized by warm and wet conditions due to the valley formation during this period and the presence of clay minerals called phyllosilicates, and the Hesperian period was characterized by groundwater eruptions that formed outflow channels. Theories for Mars' early warm climate include the presence of large amounts of greenhouse gases and consistent volcanic activity during the Noachian period, but ultimately much is still unknown. The Amazonian period, which started 2.9 billion years ago and is Mars' present period, is characterized by less overall geologic activity as well as a dry, arid climate – although this has most likely varied over thousands of years due to Mars' rotation and axial position. It is also known for the formation of the ice caps at Mars' poles, which seem to have accumulated during this period (Carr & Head).

natural features of mars

Compared to Earth's atmosphere, Mars' atmosphere is very thin with low average surface pressure. The terrain of Mars is characterized by volcanoes, valleys, canyons, and craters. Some interesting features of Mars include:

Surface: At the beginning of its formation, Mars' small size and weak gravitational field compared to Earth led to the escaping of hydrogen atoms into space and the abundance of oxygen atoms. These atoms reacted with the iron on Mars' surface, causing iron oxidation and Mars' red colouring (Marsden).

Polar ice caps: Located at Mars' northern and southern poles, these are shaped by Mars' four distinct seasons.

Atmosphere: Along with its surface, Mars' atmosphere also appears coloured red to the human eye due to the absorption of sunlight. Storms on Mars tend to be less violent than on Earth due to the thin atmosphere.
Volcanoes: Most of the volcanoes on Mars are shield volcanoes, like Olympus Mons. These volcanoes are most like the volcanoes on the Big Island of Hawaii, although Olympus Mons is almost three times larger than the entire island.

Vallis Maneris: Vallis Maneris is the largest canyon in the solar system at 4,000 km (2,500 mi) long, and nothing on Earth compares to it. Evidence pointing to lakes has been found in the canyon, but the interconnected canyon system is thought to have been formed by immense geological activity from Tharsis (MarsEd).

olucci. d, (march 5, 2021)

niaid. (2024, january 30). national institute of allergy and infectious diseases

Mars is generally arid, but scientists are interested in whether Mars could have supported life in the past. Features like outflows and valleys suggest water in the past and a wetter climate, but scientists believe most of Mars' water is below the surface, sealed by the cryosphere, a layer of permanently frozen ground. However, in 2015 the Reconnaissance Orbiter provided compelling photographic evidence that water currently flows on Mars, showing dark streaks called recurring slope lineae, also called RSL, in which hydrated salts were detected, leading scientists to believe that water contributed to their formation. However, a report published by NASA in 2017 refutes this, saying that RSL was caused by granular flows, in which sand and dust travel downhill, which supports the dry characterization of Mars in the present day (NASA).

exploration of mars

Mars is the most explored planet in our solar system and is the only planet where robots are the prime residents. Starting in the 1960s, there have been many flybys, orbiters, and landed rovers on Mars; in 1976 the Viking 1 was the first craft to land on Mars and took the first photograph of Mars' surface.

However, these missions are not without their failures; around half of the missions to Mars in the last sixty years have failed. Famously, in 1999 NASA "lost" the Mars Climate Orbiter, later finding that it burned up upon entering orbit in Mars' atmosphere, due to a misunderstanding concerning unit conversions. The team at JPL used metric units for their launch calculations, while the manufacturers at Lockheed Martin used Imperial units. This misunderstanding had wide-reaching consequences; it cost nine months of labour and 125 million dollars, and embarrassment over such a simple mistake (Hotz, NASA).

But even with these failures, we have still made significant discoveries about Mars that deepen our understanding of our neighbouring planet. As stated previously, NASA's Reconnaissance rover photographed RSL, which deepened our understanding of the water presently on Mars, and the InSight lander provided valuable findings about Mars' atmosphere and recorded the sounds of wind on Mars, enriching scientific studies (Banfield et al.). In the present day, the NASA rover Perseverance looks for ancient signs of microbial life in the Jezero Crater, along with the ExoMars rover, which gathers evidence towards past life on Mars. Outside of NASA, China's Zuhrong rover studies the geologic features of the Utopia impact basin (Changela et al.).

human missions to mars and the ethics of colonization

We have sent many robots to Mars, but we have not sent any humans. Mars poses a great danger to the human body; its atmosphere is composed of 95% carbon dioxide. Other dangers include space radiation and the physiological and psychological toll space travel takes on the body. Additionally, there are still many unknown variables surrounding human missions, like shelter, cost, and the procuring of food and water.

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Although Mars is unsuitable for human life, researchers found that Mars' surface can support the growth of cyanobacteria, and they also could be genetically modified to survive. They could help support plant and food growth, be used as food during Mars missions, and produce oxygen for humans on Mars thanks to their properties of nitrogen fixation and photosynthesis. However, this plan is only hypothetical; it is still uncertain if cyanobacteria will be used in a future life-support plan for Mars thanks to how rapidly the field of bioengineering is progressing, and discoveries about Mars could change the plan significantly (Vereseux et al.).

That does not mean we have completely abandoned the idea of humans to Mars. While human missions are for scientific advancement, some have presented the idea of humans settling or colonizing Mars, like Elon Musk's company SpaceX. However, the colonization of Mars also has moral and ethical concerns. As Cristian van Eijk argues, it would be a violation of space law– in particular, the Outer Space Treaty Article II, which states that "Outer space [...] [is] not subject to natural appropriation by claims of sovereignty, utilizing use or occupation, by any other means." (Eijk). Although SpaceX is a privately owned company, it is still trying to impose sovereignty on Mars, which could reflect badly on the United States in foreign affairs. Additionally, the word "colonization" calls back to European and American conquest of Africa and Asia, and the mirroring of those beliefs. It could lead to the spread of totalitarian ideals (Pumaala et al.). In its current form, it also mainly benefits the rich and those in power, as they are the ones sponsoring these ideas, and act in their self-interest, not humanity's as a whole (Eijk). The exploration and colonization of Mars is touted as potentially revolutionary that could save humanity, but it also falls into danger of perpetuating the colonialist and classist beliefs rampant on Earth.

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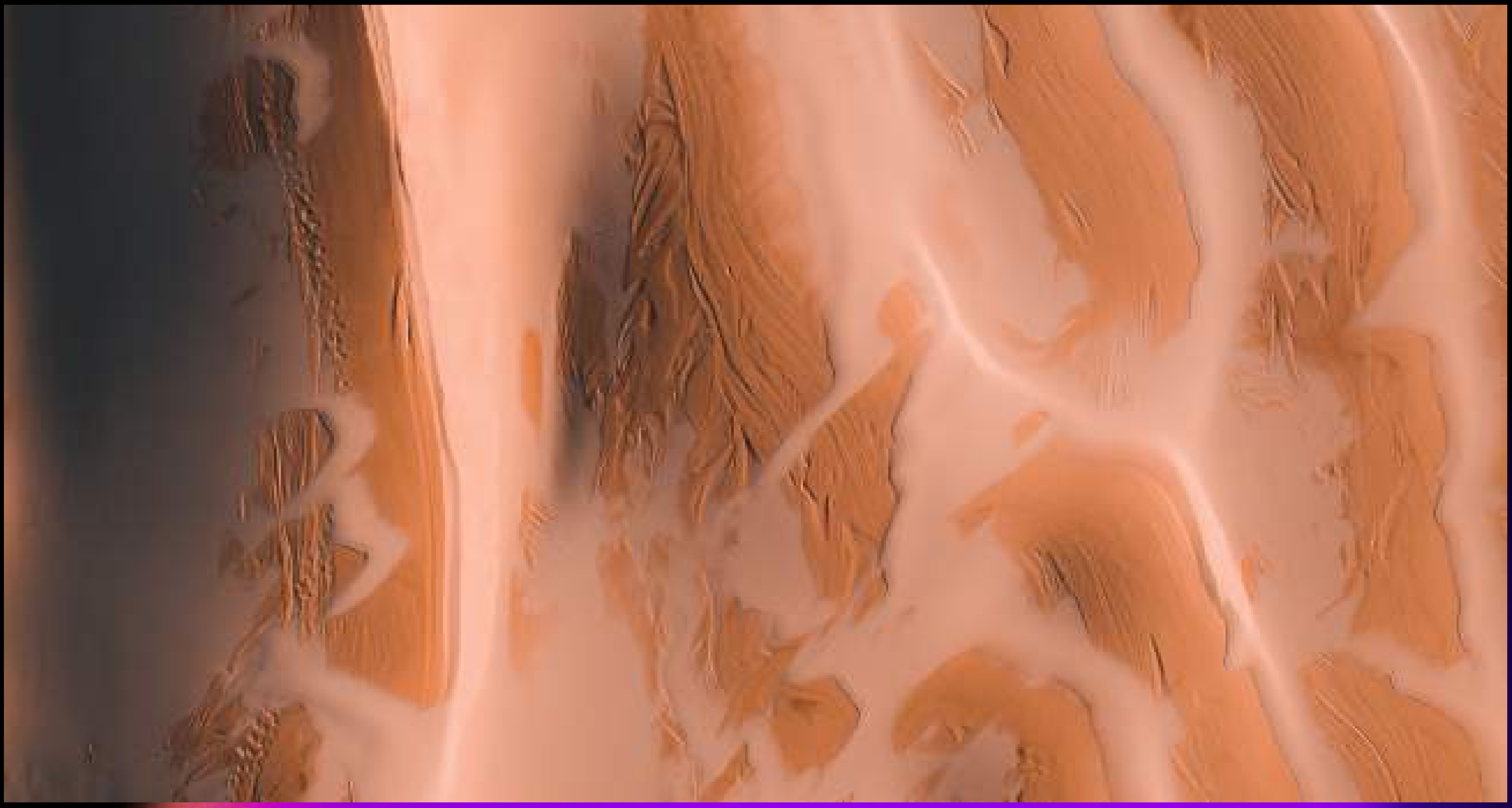

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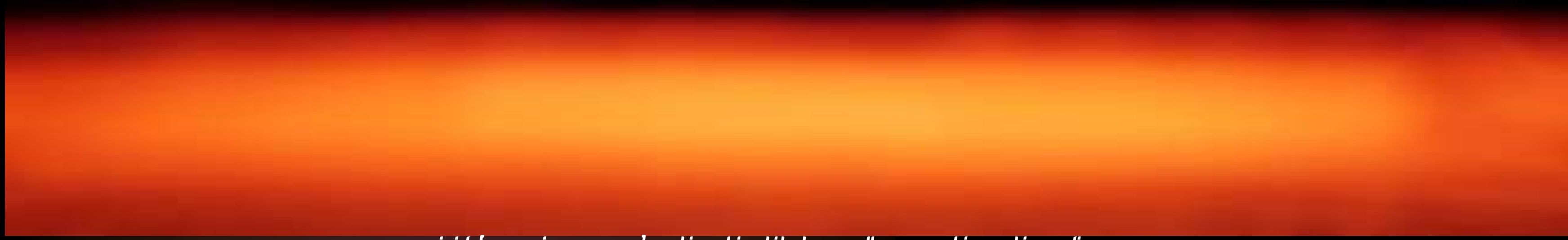

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is space slowly killing us?

Combating Space's Impact on the Human Body with Technology

stemed competiton winner hanna abe

Figure 1. This image is a photo of the Serpent nebula from James Webbs space telescope.
Image Credit: NASA, ESA, CSA, STScI, Klaus Pontoppidan (NASA-JPL), Joel Green (STScI)

introduction

A long time ago in a galaxy far, far away, while Jedi knights like Luke Skywalker may have been able to avoid the harsh reality of hopping between different planets in space, modern astronauts today face challenges against evil that is even more deadly: space.

Recently, medical data from the private Inspiration4 mission in 2021 showed temporary mental and physical changes in 4 astronauts. A simple 3-day trip in space has caused a visible decline in their conditions from cognitive to genetic cells.

The lack of warning regarding the side effects highlights the lack of knowledge about the interaction of the body and space. Unlike other space explorations, Inspiration4 invited people who weren't professional astronauts: Jared Isaacman, Hayley Arceneaux, Sian Proctor, and Christopher Sembroski.

During their expedition, medical samples were collected, known as the Space Omics and Medical Atlas. The SOMA includes data from the conditions of people who have visited space, to provide a guide to treatments after missions. However, it is not enough. While SOMA is extending our knowledge on the intersection of health and space, further innovation is necessary if space exploration wants to establish longer missions. This article explores the dangers of space on human health and how technological advancements are helping solve the issue.

causes and effects of space on the body

Space's environment has abnormal conditions that no human can withstand unless you're an alien. For example, unlike Earth, space consists of characteristics of extreme temperature, Ionizing radiation, acoustic noise, and microgravity. Regardless, mitigation measures help avoid these harmful conditions. So, how exactly do astronauts still get affected by space? Well, the NASA Human Research program has found various impacts on the human body in space.

nasa, (november 5, 2015)

unsplash. https://unsplash.com/photos/satellite-flying-on-space-ahJKagnzyea

The ionizing radiation has been found to have a long-term risk of cancer due to exposure, and acoustic noise can lead to hearing loss. According to Nasa, "weight-bearing bones lose an average of 1% to 1.5% of mineral density per month" (Axpe et al., 2020). Additionally, SOMA has found changes in genetics. They observed how human cells exposed to space have undergone genetic changes due to epigenetic factors, impacting gene regulation. Due to the barrier between us and space, scientists today are still in the process of understanding the unknowns of the limitations of how far we can go. Medical challenges such as radiation, pressure, and the availability of medicine in space all contribute to space advancement.

Kjell Lindgren, a medical physician, states that despite NASA's predictors, measuring the extent of humans' limits is difficult. Not only does space have psychological effects on the body, but it can also put a risk for behavioural conditions. Factors like isolation, fatigue, and environment are heavy on psychiatric risk. Therefore, the relationship between space and medicine is crucial, to successfully advance the medical system's design for future space missions.

technology paves the way

However, despite these challenges, scientists have utilized technology to counter the hostility of space to the body, like biotic technologies, and brain-computer interfaces. NASA has also been focusing on advancing space-based medical technology. In the future, unlike the ISS, astronauts may not be able to go back to Earth as easily. Researchers are working on space-based surgery; a study from the University of Louisville has worked to facilitate surgery in space. Their SFMS works to create bursts of microgravity; it includes a dome that creates a seal to provide points for surgical instruments with the main goal of helping prevent contamination by blood from wounds. The WetLab-2 is also used to help monitor health, which processes gene expression and tissue data on board.

Furthermore, astronauts have found ways to counteract the side effects even without the use of technology. Though microgravity in space can greatly affect bone and muscle, by forcing the tissues to reshape and slow down the cells that sustain building new bones. It has been found that with consistent exercises, they can maintain their shape. Astronauts have used ARED to help them stimulate a weighted-workout. Without a routine, they can end up with weakened muscles, called atrophy. The progress toward understanding how to maintain a healthy body in space can help NASA's plans.

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conclusion

In conclusion, while astronauts can't withstand the evil of the hostile environment of space, it is not over yet. From conditions varying from radiation to microgravity, we still have a long way to go. However, through new research, we are uncovering the human body vs. space. After all, Luke Skywalker may have the Force, but we have the power to move beyond the unknown.

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an introduction to astronomy

niharika koduru

So you may...what is the history behind the study of astronomy? In fact, astronomy traces far back in history and one of the earliest observations was the Nebra sky disk from Northern Europe. This disk was a representation of the sun. This disk could also be seen as a religious symbol. The earliest history was found by Babylonians in about 1600 B.C. as they closely monitored evidence from specific patterns noticed such as positions of planets. This made astronomy the first science that observations were recorded for.

schuler, b, (november 23, 2020)

unsplash. https://unsplash.com/photos/black-and-brown-starry-night-9d2wuvst9 _ i

About 1,000 years later, the Ancient Greeks obtained these records from the Babylonians and their discoveries. Thales was a significant contributor to the identification of ellipses due to his well-versed knowledge of math and Babylonian records. Due to these findings, orbits were known as perfect circles which created the belief that all things in Heaven had no flaws. But, later, Aristarchus came up with an alternative approach to the Solar System which contrasted with Thales' discoveries. He mentioned that the Sun was at the centre of the Solar System while the Earth and the planets orbit around it. This alternative approach became known as the heliocentric model which was also supported by another European astronomer named Nicholas Copernicus. Contrastingly, another approach to the Solar System whas also developed the geocentric model. This approach was proposed by an Egyptian astronomer named Claudius Ptolemy. This approach believed that Earth is at the centre of the universe while the planets and other bodies in the solar system would orbit around it. The heliocentric model became more widely accepted and as a result, in modern-day society, astronomers and people believe that the sub is at the centre of all planets.

Now that we have gone over the history of astronomy, you may ask...so what actually is astronomy? According to Merriam-Webster, astronomy is defined as "the study of objects and matter outside the earth's atmosphere and of their physical and chemical properties." Astronomy combines various fields of study like mathematics, physics, and chemistry in order to closely examine celestial objects. Astronomy is also a very wide field of study but it cannot be divided into four types. In fact, it has multiple subfields within the study of astronomy like observational astronomy, astrophysics, and cosmology. If you might be interested in learning more about astronomy, astronomers typically focus on the origin of the universe such as the stars, planets, and black holes. Astronomers also focus on answering questions about the universe through observing unique phenomena.

Finally, do not confuse astrology with astronomy. Astrology is considered a field of science that explains how the position of celestial objects (i.e. planets) affect people who reside on Earth. On the other side, astronomy is the study of the universe using mathematics, physics, and chemistry.

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cosmic medicine: the challenges of treating astronauts in microgravity

adil mukhi

Space—it's the final frontier, but it's also a weird and wild place for the human body. Even while space travel offers amazing opportunities for investigation and learning, there are particular difficulties in maintaining astronauts' health. The absence of gravity while they are floating around in microgravity affects every part of their body, not just how they move. Let's examine how we address these health issues of the space era.

1. the bone dilemma: "gravity, where are you? what's happening?

Similar to osteoporosis on Earth, astronauts lose bone density at a rate of 1% to 2% every month when gravity is not pushing on their bones (Smith et al., 1999). Because of this, bones become more brittle and prone to breaking. Without gravity, there would be no regular movement to build bones, which might have major long-term health consequences. Why does it matter? The long-term implications are huge. If astronauts are going to explore other planets, like Mars, they need bones that can handle the stress of both space and Earth's gravity when they return. The solution? To combat this, astronauts use resistance exercise devices to try to mimic the effects of weight-bearing activities like walking or running. But it's a tough battle—gravity is a powerful force to counteract.

2. muscle weakness: "where did my strength go?" what's happening?

Muscle atrophy or deterioration occurs due to the absence of gravity. Since astronauts do not need to exert as much effort to maintain their bodies, their muscles become weaker and shrink (Convertino, 2024). It's like indulging in a couch potato lifestyle while in space. Why does it matter? Muscle weakness isn't just a nuisance—it affects mobility, and strength, and can make returning to Earth's gravity extremely difficult. The solution? Exercise, exercise, exercise! Astronauts do resistance training to maintain their muscle mass. However, even with regular workouts, they still face challenges and ongoing research is focused on finding better ways to preserve muscle function in space.

3. the heart of the matter: "floating fluid"

What's happening? Fluid shift. Under microgravity, physiological fluids flow from the lower to the upper body (Mahmood et al., 2024). The outcome? Alterations in vision, head swelling, and even elevated ocular pressure. Additionally, because the heart is not forced to pump blood upward against gravity, which might impair circulation, it must work harder.

Why does it matter? These fluid shifts can cause cardiovascular problems like orthostatic intolerance (difficulty standing up after sitting or lying down), making it tough to function and work properly in space. Not ideal if you're trying to do complex tasks on a space station! The solution? Astronauts engage in daily cardiovascular exercises and carefully monitor fluid levels to keep things in balance. But, given the complexity, scientists are exploring new ways to prevent these fluid shifts from causing health problems.

vellanki. m, (may 5, 2017)

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conclusion: ready for blast-off?

Although space flight is exciting, the human body does not enjoy it. Treating astronauts in microgravity is a challenging task because of their delicate bones and floating fluids. However, we are discovering answers via ingenuity, inventiveness, and a great deal of exercise. Who knows? Life on Earth may become healthier as a result of the medical advancements we make for space travel!

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space elevators: engineering the future of low-cost space travel

adil mukhi

jelen. b, (february 11, 20180)

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Imagine a giant elevator reaching from Earth to space—sounds like something out of a sci-fi movie, right? But this idea, known as the space elevator, is more than a cool concept. It could revolutionize space travel by making it cheaper, safer, and more efficient. So, how exactly does this sky-high idea work, and what stands in the way of making it a reality?

what is a space elevator?

Simply put, a space elevator is a huge structure built to carry payloads from the Earth's surface to space, such as satellites, goods, or even passengers. Anchored at the equator, the elevator would reach geostationary orbit, which is around 35,786 kilometres above the ground and is essentially where communication satellites hang out.

why it matters: cheaper and safer

Rockets are expensive, but space elevators could reduce the cost of space travel by up to 90% (Yazici, 2020). This opens the door to industries like asteroid mining and space tourism.
Safer and Faster: Rockets require huge amounts of fuel and have safety risks. A space elevator would offer continuous, fuel-free transport, reducing the risk of accidents and delays.

engineering hurdles: a long way to go

The tether must be extremely strong to withstand forces. Current materials like steel are not up to the task. Scientists are exploring carbon nanotubes or graphene for the job (Johnson, 2023). The elevator must cope with environmental factors like space debris and wind. Advanced models are needed to ensure the tether and climbers remain stable (Kuzuno et al., 2021).

economic and geopolitical considerations

The potential rewards of building a space elevator are enormous, but the cost is high. Once it is operational, it might significantly reduce the cost of launching items into orbit. International cooperation would be necessary during construction to resolve security, ownership, and military issues (Johnson, 2023).

the road ahead: a long journey to lift-off

Although space elevators might revolutionize space travel, their implementation is still a long way off. International cooperation, engineering, and materials science advancements are essential. Who knows as technology develops? A space elevator might be the physical doorway to the stars in the future!

In conclusion, although space elevators may seem like a pipe dream, the concept has scientific foundations. They could hold the secret to opening up the next phase of reasonably priced space travel if we can get beyond the technical and financial obstacles. Who knows? You could be taking an elevator directly into space in the not-too-distant future!

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understanding the impact of space travel on the human mind

tiya joby

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understanding the impact of space travel on the human mind

Space exploration has always fascinated humanity, representing both the pinnacle of technological achievement and a daunting challenge for human endurance. While the outer space environment presents physical hazards, its effects on the human mind are equally profound. As space agencies, such as NASA and ESA, and private companies like SpaceX prepare for longer missions, including possible voyages to Mars, understanding the changes in cognition and behavior for astronauts is becoming a pressing area of research. Indeed, the unique challenges associated with traveling through space greatly test their physical, mental, and psychological fitness (Smith 45).

the space environment and its influence on the brain

Space is an implacable environment that has a deep impact on the human body. The absence of gravity, or simply microgravity, makes fluids shift around inside the body differently, and it eventually weakens muscles and bones over time (Johnson 67). On the other hand, perhaps more important than this physical consequence, is the psychological toll of being in space: isolated, confined, and cut off from Earth. The very first steps of research into the cognitive and behavioral effects of space travel started with the dawn of human spaceflight. For instance, astronauts during early manned space flights, such as in the Apollo program, reported distorted senses and disorientation (Adams 23). In recent times, other studies, including those conducted on ISS-bound astronauts, have come up with clear evidence that prolonged exposure to space results in drastic changes in cognitive functions, regulation of emotions, and social behaviors (Lee 89).

cognitive changes: memory, attention, and decision making

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One of the most studied aspects of space travel on the human mind is its influence on cognitive function. Different changes have been recorded in memory, attention, and decision-making, especially during long-duration flights (Harris and Nguyen 112). Microgravity might affect the brain's ability to process sensory information, which would eventually weaken memory retention and spatial awareness (Martin 76). Often, astronauts express a general feeling of mental fatigue that negatively impacts the performance of tasks requiring attention and concentration (Lee 91).
Besides, the factor of being in space disturbs the normal circadian rhythm that governs sleep and wakefulness. The ISS orbits Earth in 90 minutes, meaning the astronauts encounter multiple sunrises and sunsets within a day (Brown 134). Such unending variation in light might interfere with sleep, thereby causing sleep deprivation, which, in turn, accelerates the process of cognitive decline and emotional stress (Carter 56). For these reasons, astronauts are specifically trained to overcome cognitive impairments by learning various coping mechanisms and techniques to remain mentally keen (Harris and Nguyen 115). However, the accumulated impact of disrupted sleep patterns coupled with the psychological isolation during space missions can ultimately dampen their mental acuity over time (Smith 47).

behavioral changes: stress, anxiety, and mood disorders

The potential for behavioral changes is another concern for the scientists in space explorers. Though extensive psychological checkups are performed on all the astronauts, isolated continuous stay amidst space may lead to various adversities like stress, anxiety, and even mood disorder problems among astronauts (Taylor 102). Long-term confinement without privacy and the inability to flee from some situations might result in irritability, interpersonal conflict, and heightened levels of stress (Adams 28). In long-duration missions, like those in the ISS where astronauts stay for months or even years away from Earth, psychological features of space travel are a specific concern (Johnson 71). Absence of natural environmental cues, like changes in weather or changes in sunlight on the skin, can give way to feelings of isolation and disconnection. Thus, astronauts feel sad or depressed, which has popularly been termed "space blues" (Brown 137).

Other factors that can impact the mental health of astronauts include social dynamics onboard spacecraft. Whereas the small crew size allows for a tight-knit team, the absence of privacy and constant proximity of other crew members can also be a source of tension and emotional stress (Carter 59). Astronauts report that conflict does occur, although rare, due to mission stressors and confined living quarters (Taylor 106).

isolation: the social and emotional impacts

Of all the psychological effects of space travel, isolation is perhaps the deepest. Besides the physical distance from Earth, astronauts are also isolated from the greater human experience. The inability to regularly communicate with loved ones, the absence of familiar cultural references, and the inability to immediately access Earth-based support systems can lead to a feeling of loneliness (Harris and Nguyen 120). For astronauts on missions beyond low Earth orbit, such as those to the Moon or Mars, the distance will create even greater communication delays, making real-time interactions with mission control or family members almost impossible (Martin 79).

Studies of isolation in extreme environments on Earth, such as those conducted in polar stations or submarines, provide valuable insights into the psychological challenges faced by astronauts (Smith 49). Prolonged isolation causes symptoms of anxiety, depression, and a feeling of helplessness (Brown 140). To handle this, space agencies prepare astronauts with psychological support systems, like regular communication with loved ones, team-building exercises, and mental health resources (Lee 93). However, the unknown factor of deep-space travel, especially missions going up to many years, poses new questions that demand fresh answers (Adams 31).

the future of space travel and mental health

As humanity pushes toward the next frontier in space exploration—manned missions to Mars and beyond—determining the cognitive and behavioural effects of space travel becomes all the more important (Johnson 75). The length, isolation, and environmental complexity of future missions will increase. Astronauts' mental health will become even more of an issue than now, as the likelihood of psychological damage increases with mission duration and distance from Earth (Carter 62). Addressing these factors, space agencies are looking into advanced technologies and ideas. For example, VR might immerse the astronauts into Earth-like experiences, while simultaneously allowing them to "travel" to be with families and friends (Harris and Nguyen 125). Artificial intelligence systems may offer real psychological support soon through personalized coping strategies, monitoring, and responding to their emotional statuses during space travel (Taylor 110).

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utilizing crispr technology in microgravity for silencing htert to mitigate risks of cancer

stemed competition winner saanvi arun

Although space exploration is extremely fascinating and can lead to numerous breakthroughs for long-term missions in the future and better life here on Earth, astronauts in space are constantly exposed to conditions that are harmful to their health. Just a few examples are constant physiological stress, changes in their sleep cycle, loss of muscle mass, and visual impairments. But perhaps the most detrimental risk they face in the microgravity environment is their increased risk of developing cancer. This increased risk is primarily due to space radiation exposure, specifically from particles known as galactic cosmic rays and solar particle events (Why Space Radiation Matters 2017). The constant exposure to this harmful radiation is when the lengthening of telomeres happens. When telomeres are lengthened, cancer cells proliferate increasingly, casting doubt on the safety and feasibility of long term space missions.

Telomeres are protective caps at the ends of chromosomes. They serve as molecular drivers of ageing and their length is a cumulative product of various genetic and lifestyle factors (Mason et al. 2024). Unusually long telomeres have been associated with increased risks of certain cancers such as lymphoid and breast cancers (Mason et al. 2024). Previous research has shown that telomerase- an enzyme found in cancer cells that adds length to telomeres- gets switched on in space (Becker 2018). The activation of this enzyme therefore means that telomeres get lengthened in space, causing astronauts to develop an increased risk for cancer when exposed to space radiation for long periods. To be able to sustain long-term missions, this risk has to be mitigated somehow.

In the past, CRISPR-R technology has been used in space only once before. CRISPR, which stands for clustered regularly interspaced short palindromic repeats, is a technology that allows scientists to modify genomic DNA. In a past experiment done by NASA, CRISPR technology was used to successfully generate breaks in the DNA of a common yeast, allow these breaks to repair, and sequence the patched-up DNA to determine whether its order was restored (Gaskill 2024). This experiment serves to prove the extent of potential applications CRISPR can have in microgravity. Since telomere length is a major risk for astronauts staying in microgravity environments for extended periods, using CRISPR technology to silence the enzyme for telomerase could potentially reduce telomere lengthening in space and therefore reduce the risks astronauts face for cancer.

figure 1. astronaut christina koch working on a crispr experiment to analyze breaks in dna for a common yeast (gaskill 2024).

To add on to this idea, additional research has shown that cancer stem cells in space have tripled in size in just ten days due to the gene ADAR1 being overexpressed (Sanford Stem Cell Institute 2023). ADAR1 is a gene responsible for providing instructions to create the ADAR1 protein that controls immune response for foreign invaders (ADAR Gene 2024). Researchers have hypothesized that due to the stress of microgravity, the immune response is greater and thus causes the gene to be overexpressed (Sanford Stem Cell Institute 2023). Henceforth, the combined overexpression of this gene along with hTERT- the subunit of telomerase responsible for telomere lengthening- can lead to increased proliferation of cancer cells (Ma et al. 2020). Therefore, telomere lengthening due to space radiation exposure and ADAR1 gene overexpression due to microgravity stress could serve as a potential explanation for increased cancer stem cell growth. However, the problem with lengthening telomeres has not been efficiently addressed, which is where CRISPR comes in.

A previous study used the CRISPR tool to sense hTERT in bladder cancer cells and results showed that it suppressed cell proliferation, migration, and invasion and also induced cancer cell death without affecting healthy cells (Zhuang et al. 2021). Therefore, a similar experiment can be tested in microgravity to prevent cancer stem cell proliferation. CRISPR-R technology can be an effective tool in mitigating cancer risks for astronauts and therefore able to help them sustain future long-term missions. Cancer cell growth is primarily due to radiation exposure. The long-term exposure of this causes stress to the ADAR1 gene and accelerates immune response. The hTERT protein is also overexpressed due to the stress of microgravity and hence causes the lengthening of telomeres. While experiments have been tested on Earth on both CRISPR and ADAR1, a lack of studies done in space on telomeres exists. This is where CRISPR technology can bridge the gap for cancer research on telomeres in microgravity.

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are we ready to move onto mars? the future of human colonization

tiya joby

Humans have dreamt of visiting and perhaps even inhabiting other worlds for years, and Mars has remained right at the centre of their ambitions. Due to many similarities to Earth, day length, seasons, and the likelihood of water, Mars is said to be the best candidate for human settling. Recent advances in space technology, coupled with the ambitions of organizations like NASA, SpaceX, and other private space exploration companies, have brought this dream closer to reality. However, with human colonization of Mars no longer mere science fiction but a tangible possibility, questions of readiness will increasingly be put to humans who will embark on this project.

the vision of martian colonization

The concept of humans inhabiting Mars had, until recently, been strictly speculative: the subject of science fiction novels and the musings of a few visionary scientists. Now, the concept of colonizing Mars has passed from the realm of science fiction into that of scientific fact-finding. Mars offers an appealing alternative to Earth due to its proximity, geological similarities, and resources that could potentially support life. Companies like SpaceX, under the leadership of Elon Musk, have set ambitious goals for Mars, including Musk's vision for sending the first crewed mission to the planet as early as 2026, with the long-term goal of establishing a self-sustaining human colony.

One of the most attractive features of Mars is its potential to harbour resources necessary for survival. Liquid water, found in ice deposits at the poles and in the Martian soil, is the most crucial resource for human survival. The atmosphere, although thin, contains carbon dioxide, which could be converted into oxygen using technology already in development. This process, known as In-Situ Resource Utilization (ISRU), would enable astronauts to produce essential resources from the Martian environment itself, reducing reliance on Earth-based supplies (Stoker and Bullock, 100).

Despite these possibilities, a myriad of obstacles remain. Getting to Mars, surviving on its surface, and establishing a long-term, sustainable colony are profound challenges. Mars is, in its current state, inhospitable to human life, and every element of colonization, from transportation to human health, will have to be carefully considered and technologically innovated upon.

the technological challenges

The venture of sending humans to Mars is by no means an easy task. Technological challenges associated with such a trip are huge. A Mars mission would not only need a spacecraft that could safely carry astronauts through the vast distance between Earth and Mars but also systems to shield them from radiation, microgravity, and psychological stresses related to deep space travelling. The most significant of these challenges is the time it takes for the journey. The journey to Mars is six to nine months long, depending on the specific positions of the planets involved in such an alignment. Unlike Earth, which is protected by a magnetic field and atmosphere, Mars offers no such shield, meaning that astronauts would be at risk of radiation-induced cancer, cognitive decline, and other health complications (Cucinotta, 125). Therefore, spacecraft and habitats for Martian colonists would need to be equipped with shielding systems to mitigate radiation exposure. Furthermore, while on Mars, astronauts will be exposed to microgravity and low atmospheric pressure, both of which are very harmful to human health. Long-term exposure to microgravity causes muscle atrophy and loss of bone density, while the thin atmosphere on Mars presents a risk of asphyxiation and hypothermia. In such scenarios, special suits, habitats, and life-support systems would be necessary. Another challenge is the resupply of a colony on Mars. With Earth millions of miles away, resupply missions would be slow and costly. A Martian colony would have to be highly self-sufficient in producing food, water, and oxygen. Current research into hydroponics, bio-regenerative systems, and closed-loop life-support systems is promising, but they remain in the early stages of development and far from operational testing and refinement (Miele et al., 98).Psychological and Social Considerations

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While the technological and physical challenges are big, the psychological and social implications of living on Mars may prove to be just as daunting. The isolation and confinement associated with long-term space travel and Martian residency could take a severe toll on the mental health of astronauts and colonists. Astronauts aboard the International Space Station (ISS) have reported feelings of loneliness, anxiety, and stress due to isolation and limited social interaction (Smith 230). On Mars, these feelings would be intensified by the distance from Earth and the small, tight-knit nature of the colony.

The journey to Mars could take up to nine months, with astronauts living in close quarters and facing limited social contact. On Mars, the small colony size could easily lead to interpersonal conflicts, social tensions, and feelings of isolation. Mental health support would be crucial, and already there are solutions in the pipeline, such as virtual reality systems, to help combat the psychological effects of isolation. (Sonnenberg 47). Furthermore, it would be required that the astronauts and colonists go through comprehensive psychological training to enable them to bear the stresses of extreme confinement and isolation.

Then again, the colonization of Mars would bring in ethical issues: the protection of the environment, contamination of Mars with Earth-based microorganisms, and the ethical considerations of changing a pristine planet. Furthermore, the formation of a new society on Mars and our role within the universe will be some of the important questions that shape the debate on Martian colonization. The severe moral and ecological questions related to terraforming or settlement building raise questions about causing permanent alteration to the Mars ecosystem.

are we ready?

Although significant technological, physical, and psychological challenges remain, the rapid advancement of space technology suggests that a manned mission to Mars is getting more feasible. But are we ready to colonize the Red Planet? As experts agree, while technological developments are underway, the structure that will support human life on Mars is still in its infancy. More to the point, however, is the question of whether humanity is ready for such a fundamental shift in perspective that colonizing another planet would entail. Going to Mars is not about sending astronauts;

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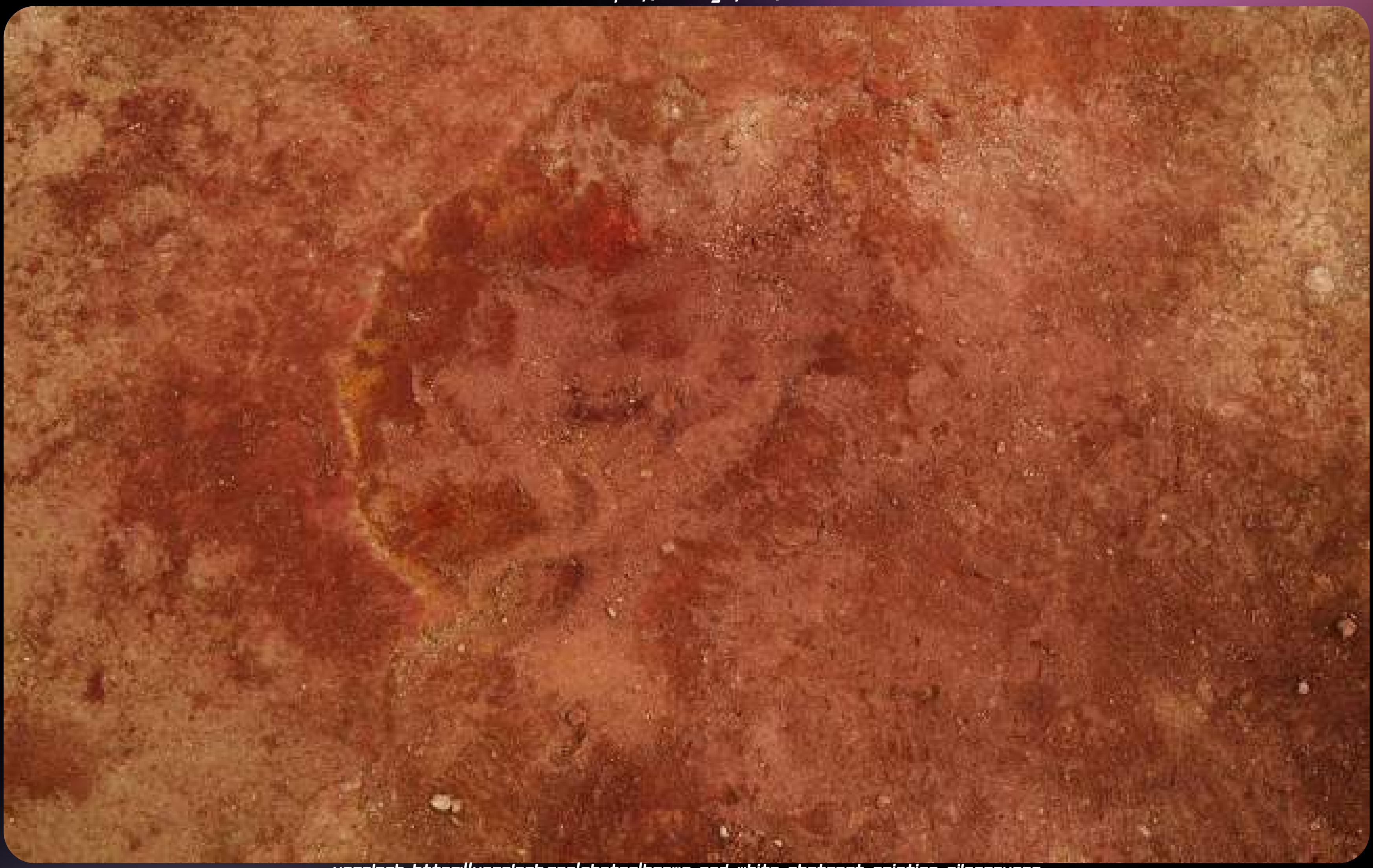
unsplash. https://unsplash.com/photos/a-rock-in-the-middle-of-a-red-desert-pomo-gmufvo it's about how human society will adapt to completely new conditions. The next few decades will, most likely, reveal whether we are really prepared for such a mega step. While Mars might reach our grasp, to make a home there both in ecological and ethical ways remains one of the most daunting tasks humanity ever faces. As we stand literally at the threshold of interplanetary colonization, the immensity of the responsibility to reach beyond our home planet comes into view. Mars may hold a key to humanity's future, but only if these challenges of the journey, of the Martian environment, and perhaps most importantly of ourselves, can be met

delp. k, (january 7, 2021)



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