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Research Article

Prometheus Unleashed: Bioethics, Environmental Responsibility and the Cosmic Imperative in Outer Space

Prometeusz uwolniony: bioetyka, odpowiedzialność środowiskowa oraz kosmiczny imperatyw w przestrzeni pozaziemskiej

Arthur Saniotis[1,2*], **Piper Hutson**[3]
[1] Cihan University-Erbil, Iraq
[2] Adelaide University, Australia
[3] Lindenwood University, St. Charles, USA
ORCID AS https://orcid.org/0000-0002-9708-6220; PH https://orcid.org/0000-0002-1787-6143
• arthur.saniotis@cihanuniversity.edu.iq
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Abstract

It has only been since the 1960s that humans have possessed the technology to venture beyond the earth. Over the succeeding decades, our knowledge of space and how humans respond to its adverse conditions has significantly increased. To date, over 700 astronauts have entered space in countless space missions, a remarkable achievement given the severe space environment and its inherent dangers. Given the adverse nature of human activities since the advent of the Neolithic period (circa 10,000 BCE), which have been marked by significant biodiversity loss, terrestrial degradation, and periodic crises mainly due to maladaptive socio-political-ideological systems, will our current zeitgeist be transported to future non-terrestrial settlements? Otherwise, will our future descendants manage to develop new kinds of ethical systems which privilege communion with the cosmos? Consequently, this paper argues for the necessity of future space colonists to develop an "ethically based cosmic imperative" for thriving in extra-terrestrial habitats. I define this ethical cosmic imperative as a human need for creating ethical systems/ideologies in response to the unique environmental and social conditions space colonists will experience. This argument supports recent developments in space governance and environmental ethics, which highlight the need for normative frameworks for reducing the possibility of political and ecological failures in extraterrestrial environments (Anker 2005; Billings 2006; Marino and Cheney 2023). However, this is a difficult task considering that humans have yet to colonise space.

Keywords

space ethics, bioethics, environmental ethics, space governance, space colonization, orbital debris, genetic engineering, extraterrestrial environments, extraterrestrial stewardship, human-nature relations, SDG 12 – Responsible Consumption and Production

Streszczenie

Dopiero od lat sześćdziesiątych XX wieku ludzkość dysponuje technologią umożliwiającą przekraczanie granic Ziemi i eksplorację przestrzeni kosmicznej. W kolejnych dekadach nastąpił znaczący wzrost wiedzy na temat kosmosu oraz sposobów, w jakie organizm ludzki reaguje na jego nieprzyjazne warunki. Dotychczas ponad 700 astronautów brało udział w niezliczonych misjach kosmicznych, co stanowi niezwykłe osiągnięcie, zważywszy na ekstremalny charakter środowiska kosmicznego i związane z nim zagrożenia. Biorąc pod uwagę negatywne konsekwencje działalności człowieka od czasu rewolucji neolitycznej (ok. 10 000 r. p.n.e.), obejmujące znaczącą utratę różnorodności biologicznej, degradację środowiska lądowego oraz nawracające kryzysy wynikające głównie z nieadekwatnych systemów społecznych, politycznych i ideologicznych, zasadne jest pytanie, czy współczesny duch epoki zostanie przeniesiony do przyszłych osiedli pozaziemskich. Alternatywnie, czy przyszłe pokolenia będą zdolne do wypracowania nowych systemów etycznych, które będą uprzywilejowywać harmonijną wspólnotę człowieka z kosmosem? W związku z tym w artykule wskazuje się na konieczność opracowania przez przyszłych kolonistów kosmicznych „etycznie ugruntowanego kosmicznego imperatywu", umożliwiającego trwały rozwój i funkcjonowanie w środowiskach pozaziemskich. Kosmiczny imperatyw etyczny definiowany jest jako potrzeba tworzenia systemów etycznych i ideowych odpowiadających szczególnym uwarunkowaniom środowiskowym i społecznym, których doświadczą społeczności zamieszkujące przestrzeń kosmiczną. Argumentacja ta wpisuje się w najnowsze kierunki badań nad zarządzaniem przestrzenią kosmiczną oraz etyką środowiskową, podkreślające potrzebę tworzenia ram normatywnych służących ograniczaniu ryzyka niepowodzeń politycznych i ekologicznych w środowiskach pozaziemskich (Anker 2005; Billings 2006; Marino i Cheney 2023). Jest to jednak zadanie szczególnie wymagające, ponieważ ludzkość nie dokonała jeszcze trwałej kolonizacji przestrzeni kosmicznej.

Słowa kluczowe

etyka przestrzeni kosmicznej, bioetyka, etyka środowiskowa, zarządzanie przestrzenią kosmiczną, kolonizacja przestrzeni kosmicznej, odpady orbitalne, inżynieria genetyczna, środowiska pozaziemskie, odpowiedzialna opieka nad środowiskiem pozaziemskim, relacje człowiek–natura, SDG 12 – Odpowiedzialna konsumpcja i produkcja

Introduction

To our knowledge, it was the Greeks who first contemplated the possibility of extra-terrestrial beings living in the cosmos. Epicurus (341 BCE–270 BCE) noted that there were limitless "*cosmoi*," each of them distinguishable from the other. This idea was informed by Democritus's earlier atomistic model, which stated that existence comprises infinite and indiscernible particles (*atomoi*) which had the ability to rearrange themselves. Thus, in a cosmos of infinite worlds, the probability of worlds similar to ours is not only possible but perhaps repeated continually.

It has only been since the 1960s that humans have possessed the technology to venture beyond the earth. Over the succeeding decades, our knowledge of space and how humans respond to microgravity has significantly increased. To date, over 700 astronauts have entered space in countless space missions, a remarkable achievement given the severe space environment and its inherent dangers. During this time, extensive amounts of scientific data have been collected and examined with the aim of understanding how humans function in space, as well as preparing for long-term space missions and the ultimate colonization of space. Colonization of the moon will be a necessary preparatory step for humans travelling to Mars. NASA is currently planning to launch the Dragonfly rotorcraft mission in 2028 to investigate the surface of Titan, Saturn's largest moon, which is rich in organic material. As extant humans are taking tentative steps towards creating the first space settlements in the next few decades, it is crucial that we discuss bioethical issues such as the kinds of societies future colonists will develop morally, intellectually, technologically, and spiritually. Given the adverse nature of human activities since the advent of the Neolithic period (circa 10,000 BCE), which have been marked by significant biodiversity loss, terrestrial degradation, and periodic crises mainly due to maladaptive socio-political-ideological systems, will our current zeitgeist be transported to future non-terrestrial settlements? Otherwise, will our future descendants manage to develop new kinds of ethical systems which privilege communion with the cosmos?

Consequently, this paper argues for the necessity of future space colonists to develop an "ethically based cosmic imperative" for thriving in extra-terrestrial habitats. I define this ethical cosmic imperative as a human need for creating ethical systems/ideologies in response to the unique environmental and social conditions space colonists will experience. This need becomes even more apparent when examined through current space debates which stress the inadequacies of existing ethical models and treaties for evaluating cultural, political and ecological issues in outer space.

1. Prometheus Chained: Recent Human Track Record in Space

The need for a cosmic imperative is in response to the past and current human track record in space. Hitherto, extant human behaviours in space have been less than satisfactory. I am mainly referring to large-scale human-induced space debris, colloquially known as "space junk" or "orbital debris." I will refer to the former. On October 4, 1957, the Soviet satellite Sputnik 1 was launched into space, heralding a new era in human space exploration and telecommunications. As of 2025, humans have sent thousands of rockets, satellites, and spacecraft into Earth's orbit. Space junk comprises a range of miscellaneous objects including collision fragments, discarded rocket stages, paint flecks, fuel releases, and space gear (i.e., gloves, tools) (Castronuovo 2011; Mane 2024; European Space Agency 2021). An official version of space junk has been provided by the European Space Agency (ESA) as follows: "Space debris is defined as all non-functional, man-made objects, including fragments and elements thereof, in Earth orbit or re-entering into Earth's atmosphere" (European Space Agency 2021). To this list, I would add numerous bags of human faeces that were disposed of by astronauts during various early space missions (i.e., Mercury and Gemini missions, Apollo lunar missions (1969–1972)). In the latter, astronauts discarded bags of human faeces on the lunar surface – the first extra-terrestrial toilet. According to the official testimony, this was done in order to lighten the spacecraft for the return journey. Notwithstanding the noxious nature of human waste, it is not explicitly included in the ESA definition of space debris (European Space Agency 2021).

Space junk is categorized according to its specific orbital region from the earth's surface: Low Earth Orbit (LEO) (~2,000 km / 1,200 miles from the Earth's surface); second, Geostationary Earth Orbit (GEO) (~35,786 km / 22,236.39 miles from the Earth's surface). This is the region where most of the telecommunication satellites orbit (Azcárate Ortega and Samson 2023). Current estimates of orbiting space junk range from ~22,000 to 36,000 detectable objects >10 cm (this includes 2,500 active and redundant satellites), while there are millions of fragments (Rethik 2024; Mane 2024) (Figure 1 – see appendix).

Furthermore, there is a phenomenon known as the "Kessler Effect," which stipulates that colliding space fragments create a positive feedback system, where each collision exponentially increases debris, thus making a specific region unfeasible for human/satellite activities (Kessler and Cour-Palais 1978). For instance, on February 10, 2009, an American commercial spacecraft was shattered after colliding with a non-operational Russian satellite, resulting in more than 2,300 fragments post-event (Rethik 2024).

In 1967, the Outer Space Treaty, created by the General Assembly (resolution 2222 (XXI)), was enforced—the first of many global treaties and legal frameworks which outlined how human activities in space should be constituted by sovereign nations. Although there were no references to space junk, it did specify for government and non-government actors to act responsibly and refrain from potential deleterious activities in space. Arguably, it was not until the 2000s that international agencies became more cognizant of increasing space junk and made attempts to mitigate it. Table A1 – see appendix) These included the:

1. "UN COPUOS Space Debris Mitigation Guidelines" (2007).
2. "IADC Space Debris Mitigation Guidelines" (2002; revised in 2007) (Inter-Agency Space Debris Coordination Committee 2007).
3. UN "Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space" (2019).
4. National licensing laws requiring that states mitigate space debris.

Additionally, the non-binding "Artemis Accords" (2020), which were jointly directed by the U.S. Department of State and NASA, and the Paris Peace Forum's "Net Zero Space" initiative, promote sustainable and responsible conduct in outer space (Smith et al. 2024). Given that there is no current legally binding global accord for the mitigation of space junk (Ansdell 2010; Chowdhury 2022), nor any global enforcement mechanism for ensuring a collective "clean up," we must ask ourselves whether this present mindset will inform future human activities once humans colonise extra-terrestrial worlds. This concern reaffirms a larger ethical critique in space environmental ethics, which argues that insufficient compulsory governance arrangements enables the continuation of ecological and anthropocentric adverse behaviours beyond Earth (Schwartz and Milligan 2016; Marino and Cheney 2023). In this context, Marino and Cheney (2023) note that protection clauses that were written in the Outer Space Treaty (OST) in 1967, that were sidelined in the initial treat draft, remain excluded to several governance mechanisms. This is precisely why Schwartz and Milligan (2016) highlight that outer space is not to be treated as the "new" frontier for unrestricted human activities. This perspective also resonates with the tradition of humanistic ecology, which understands environmental responsibility as arising from the ethical relationship between human beings and the broader community of life. Extending this relational understanding beyond Earth invites humanity to perceive extraterrestrial environments not merely as objects of exploration but as domains deserving moral consideration and responsible stewardship.

For now, it seems that the space environment is bedevilled by the same outlook that informs our polluting activities on Earth. Like the chained Prometheus, humanity is still bound to old conceptual frameworks that limit its ability to view space as a domain warranting respect and ethical observance. The current failure to implement a cosmic imperative underscores the lack of a united effort between countries for developing a feasible ethical framework regarding future space colonisation.

2. Prometheus Rewired: The Importance of Evolution and Its Consequences When Diverging from It

Human morality developed over evolutionary time as a result of increasing brain complexity in ancestral hominins. Moral systems would have had distinct fitness advantages as they enhanced cooperative behaviour, altruism, reduced reactive aggression, and fostered impulse control—necessary mechanisms for culturally programmed behaviours (de Waal 2006; Tomasello 2016). Although the roots of human moral behaviour evolved in our non-human ancestors, we can speculate that by the advent of *Homo* (circa 2 mya), nascent moral systems were undergoing intense selection via positive feedback mechanisms influencing morphological and behavioural traits: obligate bipedalism, changes in food procuring, symbolic communication, technology, cooperative breeding, extended parental investment, and ritualistic behaviour (Henneberg and Eckhardt 2022). A key feature in the evolution of ethical systems is that they do not represent a *telos*; that is, they are not an endpoint, but rather an ongoing process informed by time and the environment (Henneberg and Eckhardt 2022). This evolutionary dynamics is relevant when considering how moral systems will need to be reshaped by space colonists. On this point, Kearnes and van Dooren (2017) note extraterrestrial environments have their own unique value and significance that necessitates humans to develop feasible ethical frameworks. To this, Daly and Frodeman (2008) and Marshall (1993) question whether humans have obligations to extraterrestrial environments – the latter argues that such environments have intrinsic value. This is an important point for the development of a cosmic imperative, which will be discussed later on.

According to their neurochemical hypothesis of human cognition, Raghanti et al. (2018) postulate that neuro-hormonal organization in ancestral hominins changed, particularly in striatal serotonin levels, which were necessary for increasing pro-social behaviours and enhanced impulse control, necessary for group cohesion and fostering cultural complexity. Similarly, Previc (1999, 2009, 2025) argues that increasing dopamine regulation in *Homo* from the early Pleistocene Period was a crucial driver of cognitive abilities, religion, and exploratory and social behaviours. However, some scholars have proposed that changes in serotonergic and dopaminergic regulation may have been associated with increasing risk for psychiatric disorders such as schizophrenia and autism in human evolution (Crespi 2013; Brisch et al. 2014; Banerjee et al. 2018; Duński and Pękowska 2022). This is what has been referred to as an evolutionary tradeoff.

During the 20th century, increasing understanding of evolutionary forces enabled scientists to elaborate why human bodies were vulnerable to physical and psychiatric disorders. Thus, the discipline of evolutionary medicine was pioneered by Randolph Nesse and George Williams in the late 1980s in order to provide evolutionary reasons for this susceptibility in humans (Williams and Nesse 1991). An important idea proposed by them was “evolutionary mismatch,” which posits that the environmental conditions and lifestyles which extant humans experience differ radically from those to which ancestral humans were exposed (Nesse and

Williams 1998; Trevathan 2007). Second, long evolution favored traits in humans such as high PAL (i.e., persistence hunting), “thrifty” metabolism (i.e., fat deposition), energy-efficient reproductive strategies, and adaptive thermoregulatory mechanisms to multiple climates (Neel 1962; Saniotis and Henneberg 2011; Lieberman 2015).

In their recent paper, Saniotis et al. (2025) cite that evolutionary mismatch will be a real problem for long-term space travel due to continued relaxed selection. Although humans exhibit impressive adaptability, outer space will demand new adaptations (Saniotis et al. 2025). Indeed, space habitats significantly diverge from the terrestrial and social environments *Homo* had evolved in. The novel environments of outer space (whether long-term space flight or space colonies) may manifest various evolutionary mismatches, such as moral disengagement, weakened responses to potential hazards, and altered group dynamics, to name a few. These concerns correspond with a growing body of space governance literature warning that human behaviour in outer space environments may repeat terrestrial behaviours of ecological damage and resource exploitation (Anker 2005; Billings 2006; Klinger 2019; Marino and Cheney 2023). Thus, integrating evolutionary mismatch theory and space environmental ethics provides a broader understanding of future risks and challenges facing space colonists. For instance, how will future space colonists reduce the effects of reduced natural selection while maintaining cognitive and somatic integrity. This is still unclear. While I concur with Anker (2005) that space exploration is informed by cultural values and legal models, it is also shaped by evolutionary mechanisms regarding the limits of human biology in space and the consequences of artificial interventions.

3. Prometheus Altered: Genetic Engineering and The Promise of “Moral” Beings

For over a generation, transhumanists have repeatedly endorsed the enhancement of the human body via future biotechnologies. According to this school of thought, the human body is limited due to evolutionary constraints, which render it unfit for living in space colonies (Bostrom 2005, 2014; Young 2006; Saniotis 2012). Moreover, future enhancements will be necessary in order for humans to become post-human—humans endowed with superior physical and cognitive abilities (Saniotis 2012). These “enhanced” post-humans will eventually replace older “evolutionary” versions of humanity and propel the species to outer space, unalloyed by “evolutionary baggage.” Of course, this vision is unrealistic due to the limits of human technologies and understanding of the evolutionary substrates of the human brain (Saniotis et al. 2014). In the latter, science is profoundly lacking. This sentiment is noted in the following:

The daunting complexity of neurological processes which inform cognitive abilities, combined with a current lack of understanding, will likely confound any attempts at creating "smarter" minds. In fact, any attempt to circumvent the archaic substructures of the human brain may only serve to exacerbate the already existing maladaptive responses. For this reason, great caution must be adopted in approaching further attempts to go "messing with the mind" (Saniotis et al. 2014).

The idea that technology will come to the rescue during times of need is heavily ingrained in the Western psyche. Julian Huxley (1957) was an early advocate of transhumanism and foresaw a time when humans would shape their own evolution. Also, the Russian mathematician Konstantin Tsiolkovsky (1857–1935) foresaw humanity's eventual expansion into the universe. Currently, genetic engineering is the aspiring candidate that is anticipated to navigate humanity to its next evolutionary step. However, hitherto, genetic engineering has failed to fulfil the ambitions of transhumanists due to the sheer complexity of the human genome. In short, our knowledge of gene interactions during human ontogeny is elementary and will require decades of further research (Saniotis et al. 2025). For instance, gene pleiotropy refers to changing functions in the same genes in different periods of human life. Genes which regulate bone calcification during early adulthood may contribute to age-related atherosclerosis in later life. We are now beginning to understand that the entire body is regulated by ecological systems composed of genetic networks of exquisite intricacy, shaped by evolutionary forces.

Undeterred by potential pitfalls of genetic engineering, bioethicists Persson and Savulescu (2008) have pushed for genetically driven "moral bioenhancements" in order to reduce possible human annihilation. Their thesis is reminiscent of H. G. Wells' novel The Island of Doctor Moreau, which was made into a movie in 1997. In one scene, Moreau (played by Marlon Brando) states that his transgenic experiments are about creating the "perfect human" free from all vice. Like Moreau, Persson and Savulescu would have us believe that moral behaviour can be reduced to the tweaking of certain genes. Unfortunately, we have yet to find any "moral" genes just as science has yet to discover "intelligence" genes (Saniotis et al. 2014). As noted earlier, human moral behaviour evolved via amplification feedbacks, where certain traits were selected for their adaptive value and ultimately reified in symbolic language and behaviour (Henneberg and Eckhardt 2022). Natural selection and mutation were the drivers for this. Thus, no amount of artificial biomedical interventions can ever hope to emulate this kind of selection. This is evidenced by several studies which have shown possible epigenetic changes arising from assisted reproductive technologies (Saniotis and Henneberg 2021), such as alterations in DNA, chromatin structure (Mani et al. 2020; Kohan-Ghadr et al. 2016), cardiometric processes, and somatic composition (Ceelen et al. 2007, 2008), reduced DNA methylation in neonates (Estill et al. 2016), and significant disparities in methylation in TNP1, H19/IGFs, and C9orf3 regions (Castillo-Fernandez et al. 2017).

In his essay on whether humans should be genetically altered in future Mars colonies, Munévar (2020) supports this author's caveat by stating that both somatic and germline alterations may have devastating unforeseen consequences. Despite some improvements in neuro-prosthetic devices, any effort to sidestep the evolutionary substrates of the human brain may increase the emergence of deleterious alleles (Saniotis et al. 2014). Given the already significant "genetic load" afflicting Homo as a consequence of auto-domestication, resulting in relaxed natural selection (Saniotis et al. 2020; Bednarik et al. 2022), future genetic interventions to space colonists will probably exacerbate this trend. Moreover, thinkers such as Schwartz and Milligan (2016) remind us of the problems associated with relying on technological fixes. In short, altering human biology is fraught with several medical and moral challenges. Second, any genetic modifications to space colonists will need ethical safeguards which this author is sceptical of since any genetic tampering of the human genome flies in the face of selective forces. The fact is that natural selection is the biological default of all living organisms, and is, therefore, a necessary mechanism for reducing adverse alleles. Therefore, it is highly unlikely that genetic engineering will be a panacea for space colonists, as it is currently being promoted by various scholars, and may even increase human vulnerability to disorders in off-shore colonies.

4. Prometheus Reborn: The Need for a Cosmic Imperative

4.1. Human stewardship and the fall of geocentric models

The Neolithic advancement of civilisation during the Anthropocene Period (circa 11,700 kys–present) witnessed increasing codification of ethical systems. The rise of the great religions during the Bronze Age (circa 3500 BCE–1150 BCE) further established the central role of religion in guiding moral behaviour. Without exception, the great religions considered humans as the apex of creation, as signified by Protagoras's famous dictum "Man is the measure of all things" (Gr: Πάντων χρημάτων μέτρον ἐστὶν ἄνθρωπος). The Abrahamic religions not only gave humanity dominion over creation and the right to "subdue" it (Hebrew: kabash) (see Genesis 1:26), but also bestowed the self-same as nature's steward (Arabic: khalifah; Koine Greek: katakyrieusate). This contradictory role has always been a source of bioethical tension that has yet to be resolved. Interestingly, implicit to the word kabash is the transformation of the natural world into "productive land." The difficulty lies in whether humanity's stewardship extends to the "cosmic wilderness." On this point, the sacred scriptures remain silent. One reason for such scriptural reticence is because the firmament—the celestial sphere of the ancient Greeks—was the divine domain, and therefore excluded from human jurisdiction. It is also to this heavenly realm that Jesus (Acts 1:9–12), Elijah (2 Kings 2:11), Mary (according to Catholic tradition), and Muhammad (*mi'raj*: night journey) (Surah Al-Isra 17:1) had ascended. By this account, it can safely be determined that all human ethical systems are by default geo-centric, not cosmo-centric. They developed within certain historic periods within the terrestrial abode—the human world. Thus, the ordained title of "earthly stewards" seems anachronistic and irrelevant if it is projected unto the cosmos. Maybe also because human exceptionalism, implicit in the word "stewardship," has led to a separation rather than an interconnection with nature—a point elucidated by Gregory Bateson (1991). Although ethical systems on Earth have been found wanting at several levels, especially regarding ecological management, can such lapse or apatheia be tolerated in the high-risk environment of space, which demands persistent alertness? Due to this glaring mismatch between evolutionarily selected moral behaviour and current socio-technological changes challenging moral systems (Greene 2013), an honest interrogation is required before humans start colonising space.

Finally, who gives humans the right to colonise other worlds? What does this suggest about how we treat the extra-terrestrial domain? The fact remains that the act of colonisation, whether on Earth or elsewhere, denotes conquest. In the next few decades, humans will freely colonise extra-terrestrial domains in a similar vein as early colonial powers had colonised indigenous Australians on the pretext of Terra nullius. Is the presumption of the rule Terra nullius reasonable for the context of space colonisation if no intelligent beings will be directly oppressed? What if life forms, even simple ones, are eventually found? Are colonists beholden to protect such organisms, even if they pose a threat to colonists? After all, such life forms would have existed before the coming of Homo. On this point, Rolston (1986) has argued that human colonisation may interrupt the unique ecology of the domain. This is especially the case once human activities begin transforming the environment through extensive terraforming, mining, and building. For Rolston, such a mindset amounts to cosmic exploitation because it presumes that humans have an innate right to modify and misuse extra-terrestrial domains as they see fit.

As noted earlier, this critique resonates with recent space environmental concerns regarding space governance, as well as warnings against reproducing the same patterns of ecological destruction and human domination in extra-terrestrial worlds (Anker 2005; Billings 2006; Klinger 2019; Marino and Cheney 2023). This is precisely what the cosmic imperative seeks to address. Second, studies in environmental geopolitics have also critiqued the assumption that outer space represents a neutral and apolitical domain. This could not be further away from the truth. The prevalence of a long standing and ecologically destructive international satellite culture, as described in the first section, clearly indicates that nations are mutually disruptive and political in their engagement with outer space (Klinger 2019).

4.2. Mythos and the cosmos

In her recent book, Karen Armstrong (2023) notes that human history has been distinguished by two types of thinking—mythos and logos. Both were oppositional yet complementary modes of thought. Mythos dealt with the nature of existence and its connection with the timeless, with being and becoming (ontos), which gives rise to mythopoeisis. It is mythos that informs our imaginative engagement with the lifeworld, imbuing it with sacredness and awe, or what Rudolf Otto (1923) refers to as *mysterium et tremendum*. Mythos is the fabric of the unconscious mind and the architect of ritual genres. In contrast, logos is concerned with the rational mind, with empiricism, facts, and inventiveness. Whereas mythos reminds us of our beginnings, logos beckons us to move forward towards the unknown (Armstrong 2023, 22). As co-creators of the human psyche, it will be fascinating to see how mythos and logos will shape the mindsets of future space colonists. It could be argued that the sheer novelty of extraterrestrial environments will demand future space colonists develop a new mythos. How could a future cosmic mythos be constructed? Thomas Berry, a Catholic theologian, and cosmologist Brian Swimme offer unique insights on this intriguing question.

In their book, *The Universe Story: From the Primordial Flaring Forth to the Ecozoic Era—A Celebration of the Unfolding of the Cosmos* (1992), Swimme and Berry call for a radical shift in the way modern humans view the Earth. This idea is expressed as a "New Story" in which Homo can find a rapprochement between the human and non-human worlds. The need for a New Story is based largely on the radical discontinuity between Western scientific and religious traditions and the natural world. The authors stress the importance of recognizing nature as a community of subjects rather than a mere collection of objects. By promoting a deeper understanding of the intrinsic value of the natural world, Berry and Swimme aim to cultivate a sense of reverence and respect for the environment. This shift in perspective aligns with Martin Buber's notion of the "I-Thou" relationship (1937), emphasizing mutual recognition and appreciation between humans and nature. This contrasts sharply with Heidegger's concept of the "night world," where human technocratic systems have stripped the universe of its mystery (Dobson and Saniotis 2010). Thus, a future cosmic mythos could have the effect of re-enchanting the universe. The notion of re-enchantment is gaining recognition in space governance and humanities literature as a critical remedial step towards countermanding current anthropocentric driven space policy (Kearnes and van Dooren 2017).

An important way of developing and maintaining this bond with the cosmic other will be via the creation of new kinds of artistic/ritual genres. This is not far-fetched; Gregory Bateson argues that artistic activity enables a way for humans to restitute themselves with nature (Charlton 2008). Bateson considered art not merely as another artifact of human cognition but as a continuation of nature's indelible grasp within humans. Therefore, nature and art were akin, each composed of extraordinary complexity and diversity that are beyond the ability of the observer to comprehend. Similarly, Dissanayake (1992) proposes that art is a fundamental human behaviour that contributes to the reconciliation of culture and nature. Art reifies our desire to actively participate with those cosmic forces which enthuse corporeal life. As it has been in the nature of humans to create art and rituals, this predilection will no doubt continue in future space colonies. "Space art" will not only provide an emotional bridge for space colonists to experience their new environments but may become world-enchanting. Of course, the evolution of aesthetic activities will be largely informed by colonists' sensorial engagement with their extraterrestrial environments. The stark, desolate lunar sky and its pockmarked terrain may evoke a more melancholic response in colonists compared to the vibrant scenery of Titan, characterized by its methane oceans, lakes, and liquid methane rain, along with hazy orange skies, and the striking view of Saturn and its rings. Such environments would offer tantalisingly different appeals for mythopoesis. As humanity explores the vast expanses of space, its remarkable ability for mythmaking will give rise to new cosmic myths that may expand human consciousness across diverse space colonies, first within our solar system, and then into interstellar space of the Milky Way galaxy. This may well become the new cosmic imperative.

Thus, the cosmic imperative represents both an ethical framework and a cultural-spiritual vision that integrates environmental governance, aesthetics, and shared responsibility into a broader understanding of humanity's place in the cosmos.

4.3. How would the cosmic imperative be operationalised

So far, this paper has explained the reasons for developing a cosmic imperative. However, the implementation of the cosmic imperative will demand a substantial reshaping of our current value systems and behaviours in order to prevent off-world degradation. Importantly, how would the cosmic imperative work?

First, the cosmic imperative must function as an ethical constitution for directing human interaction with extra-terrestrial domains. However, to ensure this the cosmic imperative must be implemented through effective institutional, legal, and cultural frameworks that would be operative in every off-shore space colony. Therefore, each space colony would be bound by the constitutional tenets set down by the cosmic imperative. This could be fostered by establishing a more robust international governance body than the current United Nations Committee on the Peaceful Uses of Outer Space. This future governance body would function in enforcing environmental protection, facilitating equitable access to space environments, regulating resource management, ensuring environmentally responsible practices of space colonists and protection of "cosmic heritage zones." These examples would make a governance framework more applicable and mandatory rather than conceptual.

Second, developing sustainable technologies that harmonise with off-shore domains while limiting ecological degradation. This would manifest in the form of "ecological cities" grounded in recycling technologies and responsible environmental management. There are several candidates for ecological space habitats, such as the O'Neill Cylinder, Stanford Torus, and Mars Ice House concepts, which seek to reduce dependence on external resources through closed-loop life-support systems or the use of locally available materials (O'Neill 1977; Johnson and Holbrow 1977; Clouds Architecture Office and SEArch 2015). Another aspiring system is MELiSSA (Micro-Ecological Life Support System Alternative), a biological life-support system focusing on microorganism-based recycling processes and capable of converting human waste into water, gases, and nutrients (Hendrickx et al. 2006).

A more recent proposal is the Mars Dune Alpha that is constructed using 3D-printing technology that incorporates resource conservation methods. Mars Dune Alpha is a terrestrial analogue designed as a 3D-printed habitat for simulating long-duration human missions to Mars (Yashar et al. 2023). Its vision is to implement resource practices that are suitable to living on Mars. These afore mentioned designs manifest how off-shore habitats can embed the principles of the cosmic imperative.

Third, the principles of the cosmic imperative will demand the development of ethical training programs and conservational practices for fostering responsible stewardship of extraterrestrial environments. Such measures could be adapted for adults through collective conservationist-based rituals fostering humility and reverence for the cosmic environment. For instance, Thai Buddhist tree ordination (*Buat Pa*), where villagers ceremonially confer selected trees with sacred status, provides a suitable precedent for cultivating the desired ethical dispositions among space colonists. Rituals have played a central role in human collective behaviour since the Pleistocene. It is, therefore, important that ritual practices are transferred into the space environment, where they can continue to play a central role in the transmission of cultural knowledge, values, and social practices.

Fourth, perhaps the greatest challenge to implementing the cosmic imperative will not be governance or technology, but education. Future generations born or raised in space colonies will not simply inhabit a different physical environment; they will develop within conditions fundamentally unlike those that shaped human cognition over millions of years. Contemporary educational systems evolved on Earth under the assumptions of gravity, stable day-night cycles, terrestrial landscapes, and relatively predictable sensory experiences. They were also largely designed to prepare individuals for participation within geographically bounded societies. These assumptions may no longer be sufficient for children whose earliest experiences occur within artificial habitats, reduced gravity, confined ecosystems, and the psychological realities of viewing Earth as a distant object rather than an immediate home.

Consequently, the cosmic imperative should be understood not only as an ethical constitution but as an educational philosophy. Future curricula must move beyond disciplinary knowledge toward cultivating systems thinking, ecological responsibility, emotional self-awareness, intercultural understanding, and cosmological literacy. Children will require educational experiences that help them understand themselves as participants within interconnected biological, technological, ecological, and astronomical systems rather than isolated individuals. Such an approach would integrate evolutionary biology, environmental ethics, astronomy, psychology, philosophy, the arts, and contemplative practices that strengthen emotional regulation, adaptive reasoning, and cooperative behaviour under conditions of prolonged environmental stress.

Throughout human history, art, ritual, and symbolic systems have functioned as educational technologies that enabled societies to situate themselves within a larger cosmos. Future space education may similarly require new cultural practices that cultivate wonder, humility, and ethical responsibility alongside scientific literacy. Rather than preparing children merely to survive beyond Earth, the cosmic imperative should prepare them to perceive their dependence upon complex living systems, to recognise the ethical consequences of technological intervention, and to develop the psychological resilience necessary for environments that differ profoundly from those in which Homo sapiens evolved. In this sense, education becomes one of humanity's most important forms of preventive bioethics, ensuring that future generations inherit not only the technologies required to inhabit the cosmos, but also the wisdom required to do so responsibly.

Conclusion

In this paper, the author has posed certain bioethical issues which will need to be addressed by future space colonists. Firstly, the threat of maintaining outdated conceptual models, which have contributed to significant space pollution. It will simply be bringing "bad baggage" to new frontiers. Second, the notion of evolutionary mismatch and how novel space colonies may promote deleterious behavioural changes due to continued relaxed natural selection. Third, any genetic interventions with the intent of designing "moral" humans will probably have negative and unforeseen consequences as a result of artificial selection. Fourth, space colonisation may foster a possibility for re-enchanting the cosmos via the incorporation of a new mythos – the cosmic imperative. From the perspective of environmental ethics, the cosmic imperative extends human moral responsibility beyond terrestrial boundaries. Viewed in this way, the cosmic imperative can be understood as an ethical response to the Anthropocene, extending debates about ecological responsibility beyond the Earth and into future extraterrestrial environments where human activities may again transform fragile ecosystems. It requires future space societies to recognize extraterrestrial environments not merely as resources for human expansion, but as domains requiring respect, restraint, and responsible stewardship. In this sense, space exploration becomes not only a technological project but also an ethical test of humanity's relationship with the wider cosmos.

The history of space exploration has been prompted by our ancestral desire to travel to the stars, as well as providing a new way of understanding ourselves beyond the secure environs of Gaia. Human desire to commune with the cosmos is reminiscent of Gilgamesh's epic journey to find the meaning of human existence. In our search to return to the "home of the gods," we are beholden to ethically redefine ourselves. The ancient ideologies which have informed our socio-religious imaginations and behaviours for well over a million years seem strange and even irrelevant in the infinitude of the cosmos. Our geo-centric worldviews were never developed for guiding ethical behaviour outside the terrestrial realm. For this reason, the cosmic imperative offers future space colonists a way of transforming human ethical consciousness throughout the interstellar regions.

Statements

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Appendix

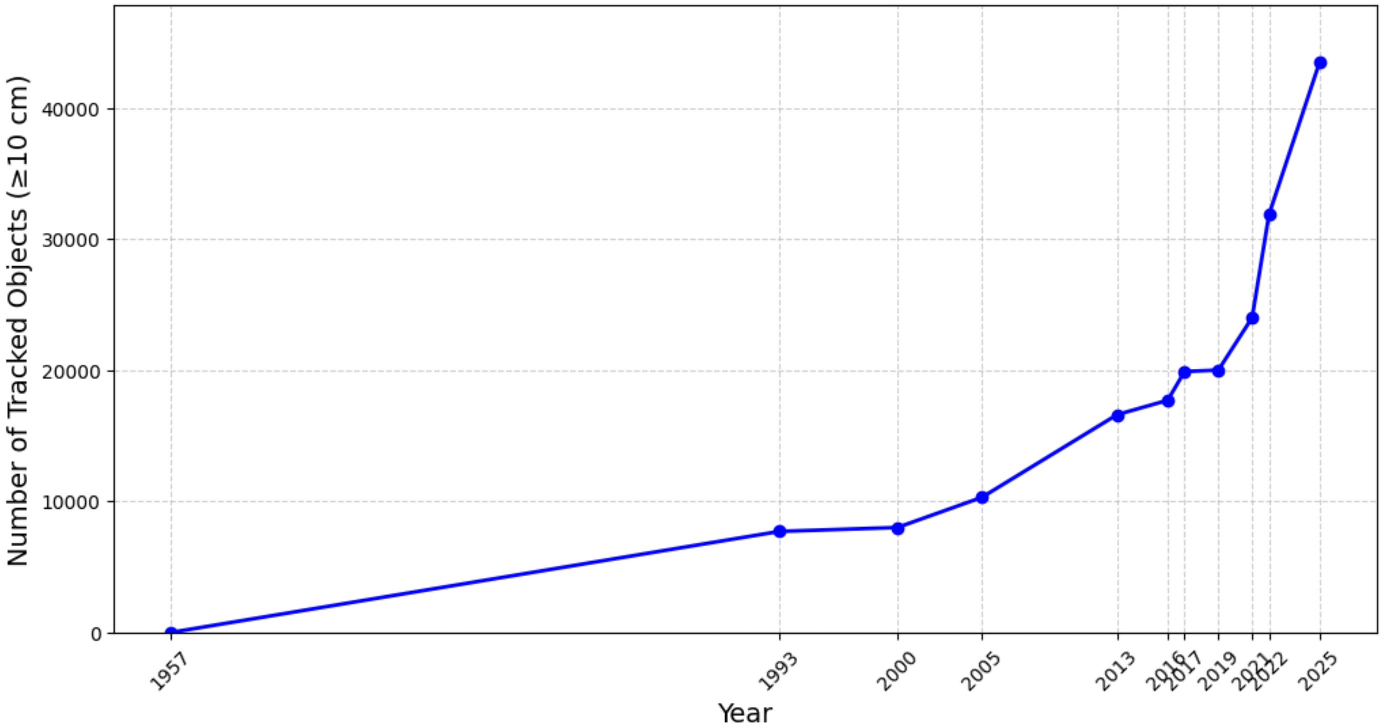

Figure 1. Growth of tracked space junk since 1957. Image generated using ChatGPT (GPT-5.2), OpenAI, 2025.

Table A1. International Legal and Policy Instruments Addressing Space Debris Mitigation
This table presents selected international legal and policy instruments addressing space debris mitigation. It compares their legal status, main actors, debris-related obligations, compliance mechanisms, and principal limitations, showing that most existing frameworks remain non-binding or lack effective enforcement.

Instrument / Effort	Legal Status	Primary Actors	Debris-Relevant Obligations / Norms	Compliance Mechanism	Principal Limitation
Outer Space Treaty (1967)	Binding Treaty	Launching States	State protection; obligation to avoid contamination.	UN	No explicit debris obligations.
Liability Convention (1972)	Binding Treaty	Launching States	Absolute liability on Earth; fault-based in space.	Diplomatic claims	No adjudicated debris obligations.
Registration Convention (1975)	Binding Treaty	Launching States	Registration and identification of space objects.	UN	No enforcement mechanism.
UN COPUOS Debris Mitigation Guidelines (2007)	Non-binding technical standard	UN COPUOS Members	Minimize debris generation; post-mission disposal.	UN	No enforcement mechanism.
IADC Mitigation Guidelines (2002/2007)	Non-binding technical standard	Spacefaring states	Passivation; 25-year disposal guidelines (LEO/GEO).	Voluntary	Not universal or legally binding.
UN LTS Guidelines (2019)	Non-binding technical standard	UN COPUOS Members	Space traffic management; data sharing and disposal.	UN	No enforcement mechanism.
National Licensing Regulations	Binding law	States Parties	Licensing, oversight, and end-of-life disposal.	National reporting to UN	Beyond major agencies.

Instrument / Effort	Legal Status	Primary Actors	Debris-Relevant Obligations / Norms	Compliance Mechanism	Principal Limitation
ASAT Test Moratoria	Political commitment	Spacefaring states	Prohibit purposeful debris-generating ASAT tests.	Political pressure	Not universal or legally binding.