SPROUTING A NEW COSMOLOGY: DECENTERING SPACE THROUGH SPECULATIVE ASTROBOTANY

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INTRODUCTION

Humans possess an eternal drive to explore: the furthest lands, the deepest caves, the highest mountains, and even beyond, up into the vastness of space. From this cosmic perspective, our planet Earth appears as nothing more than a speck, and space travel has opened the universe for exploration and colonization. However, humans do not achieve this feat on their own. They rely on powerful technologies: rockets to break through Earth's atmosphere with a boom, followed by a multitude of life-support systems to survive the empty and hostile vacuum of outer space. Even then, we remain unable to completely detach from our home planet. The International Space Station, our most advanced orbital outpost, still depends heavily on Earth for supplies, including repair materials and food, which must be sent from the surface. For long-duration space missions, humans will also need to bring another essential Earth species: plants.

This paper examines the entrenched anthropocentric paradigms in space exploration, decentering them through speculative fabulation by taking the stance of the easily overlooked but indispensable plants as astronauts, referred to as astrobotany, asking:

In what ways can speculative astrobotany decenter anthropocentric paradigms in cosmic exploration?

Before addressing this question, the current position of plants in space travel from an anthropocentric paradigm will be examined and criticized by Tabas' 'post-planetary ecocriticism'.[1] The shift to a new, more-than-human paradigm will be substantiated through Haraway's concept of 'kin-making'.[2] This approach is applied to the vegetal standpoint through 'plant thinking'.[3] Here, speculative artworks complement and enhance the theory.

Building on this theoretical foundation, the last half of the paper explores an artistic speculative fabulation of plant-based cosmic expansion as an art/science collaboration supported by Yuk Hui's book *Art and Cosmotechnics*, where Hui argues that, unlike the insensitive 'challenging' of contemporary technology, speculative art can bring forth new truths and perspectives.[4] This also aligns with Bruno Latour's call for an interplay of art in science and politics to address the ecological questions of the Anthropocene.[5] As a form of

[1] Brad Tabas, "On Earthlings and Aliens: Space Mining and the Challenge of Post-Planetary Ecocriticism," *Resilience: A Journal of the Environmental Humanities,* 9, no. 3 (2022): 26–61, https://doi.org/10.1353/res.2022.0009.
[2] Donna J Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham, NC: Duke University Press, 2016).
[3] Michael Marder, *Plant-Thinking: A Philosophy of Vegetal Life* (New York: Columbia University Press, 2013).
[4] Yuk Hui, *Art and Cosmotechnics* (Minneapolis: University of Minnesota Press, 2020).
[5] Bruno Latour, "What Are the Optimal Interrelations of Art, Science and Politics in the Anthropocene?" interview by Per Magnus Bøe, filmed at the Under Western Skies 2016 conference, Mount Royal University, Calgary, Canada, *Bifrost Online*, November 30, 2017, https://bifrostonline.org/bruno-latour-what-are-the-optimal-interrelations-of-art-science-and-politics-in-the-anthropocene/.

artistic research that embodies the plants' perspective, the paper culminates in a speculative design envisioning the colonization of the exoplanet Proxima Centauri b by plants.

ASTROBOTANY IN THE ANTROPOCENE

With severely limited resources in the isolated, self-sustaining environments within the lifeless vacuum of space, efficiency and recycling are necessitated. This makes plants' potential in space exploration enormous, especially for humans. As highlighted by Mortimer & Gilliham, "from the simple inputs of CO_2, H_2O, and mineral nutrients, photosynthetic organisms create a vast array of molecules".[6] Plants can serve not only as a source of nutritious food but also as providers of pharmaceuticals, biomaterials, and air and water purification. Additionally, they play a vital role in supporting astronauts' mental well-being.[7]

Space Farming

Recognizing the importance of future long-duration, space missions, such as the planned lunar space station collaboration known as Artemis,[8] the U.S. National Aeronautics and Space Administration (NASA) is actively experimenting with various plant growth projects. These include the manually operated plant station Veggie (see Figure 1) and the automated Advanced Plant Habitat, situated in the International Space Station.[9]

The space framing accomplished though such controlled environments, provides locally grown food indispensable for sustaining life in future space outposts. Like human life in outer space, this form of farming is heavily mediated by advanced technology. Vermeulen discusses the issues that could emerge within these new social-technoscientific dynamics: "Because of the extreme dependence on technology, the lack of open reservoirs (e.g., no atmosphere), and an atomized commodification of life-supporting resources (every molecule is valuable), space colonists will live in a world in which they are potentially vulnerable to inequalities, power concentrations, and even coercion."[10]

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[6] James C. Mortimer and Michael Gilliham, "SpaceHort: Redesigning Plants to Support Space Exploration and On-Earth Sustainability", *Current Opinion in Biotechnology,* 73 (2021): 246, https://doi.org/10.1016/j.copbio.2021.08.018.

[7] James C. Mortimer and Michael Gilliham, "SpaceHort: Redesigning Plants to Support Space Exploration and On-Earth Sustainability", *Current Opinion in Biotechnology,* 73 (2021): 246, https://doi.org/10.1016/j.copbio.2021.08.018.

[8] NASA, "Gateway Space Station", last modified June 12, 2023, https://www.nasa.gov/reference/gateway-about/.

[9] NASA, "Station Science 101: Plant Research", last modified October 18, 2023, https://www.nasa.gov/missions/station/ways-the-international-space-station-helps-us-study-plant-growth-in-space/.

[10] A. C. J Vermeulen et al., "The Space Farming Project: Space Colonization, Techno-Agriculture and the Future of Extraterrestrial Biopolitics", paper presented at the 70th International Astronautical Congress (IAC), Washington, DC, October 21–25, 2019, *Proceedings of the International Astronautical Congress*, IAC-19_E5_3_3_x52527, 1, https://pure.tudelft.nl/ws/portalfiles/portal/70172866/IAC_19_E5_3_3_x52527.pdf.

Figure 1. NASA astronaut Kayla Barron checks out plants growing inside the Veggie research facility for the Veggie PONDS experiment.[11]

The Artwork *Space Farming Project* by Angelo Vermeulen

Vermeulen's artistic *Space Farming Project* (see Figure 2),[12] initiated by the international SEAD collective and developed in collaboration with various experts, specifically addresses biopolitical issues, a term coined by Foucault to describe how power operates through the management of life. The project features prototypes for a space farming station, including a centrifuge for plant cultivation in space, a microgravity simulator, and experiments with spirulina algae and edible callus tissue.[13] It could potentially be launched to the International Space Station.

The independent project employed a participatory DIY approach.[14] Embracing a hacking ethos, Vermeulen sought a conceptual shift in power and knowledge, away from institutional agencies and capitalist tech giants. By invoking biopolitical narratives, questioning who should be in control of life, the project encourages a critical reflection on the technocratic and expansionist paradigms of humanity's venture into space.

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[11] NASA, "Station Science 101".
[12] SEADS, "Space Farming Project", Accessed May, 2025, https://seads.network/project/space-farming-project.
[13] Vermeulen, "The Space Farming Project", 2.
[14] Vermeulen, "The Space Farming Project", 6.

Figure 2. Space Farming Project by Angelo Vermeulen.[15]

Post-Planetary Ecocriticism

Tabas emphasizes the human tendency to exploit environments, a pattern evident in history through practices such as intensive farming and specifically mining the Earth, now echoed in the emerging phenomenon of space mining for rare resources like Helium-3.[16] He argues that ecocriticism should not be confined to Earth, which risks sustaining a perception of space as lifeless and barren and thus justifying its destruction and exploitation. Instead, he advocates for a rethinking of ecocritical theory in light of these emerging post-planetary phenomena: "in the name of attending to environments both on Earth and elsewhere in the cosmos".[17]

This post-planetary ecocriticism adopts a novel, zoomed-out perspective that appreciates environments beyond our planet and extends concern to a broader range of living and non-living entities. As Tabas writes: "Given that human access to space is of necessity technologically mediated, any post-planetary ecocriticism must not only theorize relationships between living beings, but also provide for ways of thinking that include and reflect the entanglement of all beings -from human beings to cats, viruses, and asteroids- within entangled bio/social/technical webs".[18]

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[15] SEADS, "Space Farming Project".
[16] Tabas, "On Earthlings and Aliens", 26–61.
[17] Tabas, "On Earthlings and Aliens", 28.
[18] Tabas, "On Earthlings and Aliens", 47.

Kin-Making Through Speculative Fabulation

Tabas's conclusion resonates with Donna Haraway's idea of 'kin-making', which she presents as a vital response to the current planetary crisis of the Anthropocene.[19] An epoch marked by the destruction of refugia, places of refuge for diverse life, due to severe extraction of the planet. Such activities threaten to collapse the balanced biological systems of Earth, a planet regarded by the Gaia Hypothesis as a normally self-regulating entity that maintains conditions favorable for life.[20]

Haraway asserts how "only with intense commitment and collaborative work and play with other terrans, flourishing for rich multispecies assemblages that include people will be possible".[21] She advocates for a "robust biological-cultural-political-technological recuperation and re-composition"[22] within a new, more-than-human oriented paradigm.

Drawing inspiration from science fiction, Haraway proposes speculative fabulation through multispecies storytelling as a method to make such a world more real and tangible, mentioning how "it matters what stories make worlds, what worlds make stories".[23] Her thinking incorporates Karen Barad's concept of *intra-action*, which views the universe as interconnected phenomena including both human and non-humans, including plants.[24]

APPRECIATING THE VEGETAL STANDPOINT

In both philosophy and the sciences, plants have been largely overlooked and marginalized as ontological beings. Instead, they are objectified or instrumentalized, with research centering on their utility to humans, treating them as ornaments, products, or living curiosities. If non-human animals are already marginalized in comparison to a perceived superiority of the human species, then plants have occupied the "margin of the margin".[25]

A historical example is the Linnaean system of classification, in which plants are rigorously categorized into order, family, tribe, and genus, stripping them of any sense of individual autonomy.[26] These paradigms do not only deny and neglect the unique ontological and epistemic status of plants, but also hinder critical ethical reflection within intellectual

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19 Donna J Haraway, *Staying with the Trouble*.
20 J. E. Lovelock, "Gaia as Seen through the Atmosphere", *Atmospheric Environment,* 6, no. 8 (1972): 579–580, https://doi.org/10.1016/0004-6981(72)90076-5.
21 Haraway, *Staying with the Trouble*, 101.
22 Haraway, *Staying with the Trouble*, 101.
23 Donna J Haraway, "SF: Science Fiction, Speculative Fabulation, String Figures, So Far", keynote address, Science Fiction Research Association Annual Conference, Lublin, Poland, July 7, 2011, reprinted in *Ada: A Journal of Gender, New Media, and Technology*, no. 3 (2013), https://scholarsbank.uoregon.edu/xmlui/handle/1794/26308.
24 Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007).
25 Michael Marder, *Plant-Thinking*, 2.
26 Marder, *Plant-Thinking*, 4–5.

discourse. Recent research evokes the need for such ethical inquiring by discovering that plants express a severe state of stress by ultrasonic 'screaming' in case they are cut.[27]

Philosophers like Marder and Coccia attempt to restore prominence to vegetal life, arguing for a shift beyond traditional scientific approaches toward an embodied mode of thinking that considers the world from the plant's perspective.

Plant-Thinking

'Plant-thinking'[28] involves envisioning the world from the perspective of plants themselves, allowing human thought to be decentered or transformed through encounters with the vegetal world. This approach is not about anthropomorphizing, but rather about recognizing that vegetal life is "coextensive with a distinct subjectivity",[29] granting plants a unique standpoint. It requires acknowledging plants' phenomenological otherness without diminishing their significance.

Plants' Unique Spatiotemporal Relations

From the vegetal standpoint, existence is characterized by a radical mode of being in the world, one of complete exposure and adhesion to the environment. Unlike animals, which can move and select locations, plants remain rooted in place, exemplifying what Coccia calls "absolute continuity and total communion with the environment".[30] While they lack sense organs like those of humans, plants are far from shut in on themselves; on the contrary, they respond to their surroundings in direct and intuitive ways, actively participating in the world. A concrete example is the common mycorrhizal root network through which plants communicate and cooperate beneath forests, coined by Suzanne Simard as the "wood wide web".[31] In spatial terms, plants prioritizes surface over volume, maximizing absorption from their surroundings. Physically and metaphysically, a plant cannot be separated from the world that accommodates it.

Plants' temporality is also asynchronous to that of humans, driven by the 'other'. External factors include light, temperature, seasonal cycles, and insect activity. Guided by such environmental cues "plants never cease to develop and grow, to construct new organs and new parts of their own body (leaves, flowers, parts of the trunk, etc.) which they previously

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[27] Itzhak Khait et al., "Sounds Emitted by Plants under Stress Are Airborne and Informative," *Cell,* 186, no. 7 (2023): 1328–1336.e10, https://doi.org/10.1016/j.cell.2023.03.009.
[28] Marder, *Plant-Thinking*.
[29] Marder, *Plant-Thinking*, 8.
[30] Emanuele Coccia, *The Life of Plants: A Metaphysics of Mixture*, trans. Daniela J. Montanari (Cambridge: Polity, 2019), 13.
[31] Suzanne Simard, *Finding the Mother Tree: Uncovering the Wisdom and Intelligence of the Forest* (London: Penguin Books, 2022).

lacked or had gotten rid of".[32] In this way, they persistently morph, multiply, and extend, without a definitive endpoint and independent of circumstances.

These distinct spatiotemporal relations of plants suggest, at the same time, a deeply intertwined and peaceful indifferentness to their surroundings. Marder observes that "despite their undeniable embeddedness in the environment, plants embody the kind of detachment human beings dream of".[33] Lacking desire as humans understand it, plants exhibit a transcendent, communal aspiration, functioning as an unconscious intentionality.

Plants as Cosmological Forces

In the cosmos, plants are not merely passive inhabitants; they are fundamental cosmological forces that bring life and shape the world. They do not depend on other living beings for survival, requiring only the basic components of the world: soil, water, air, and light. They transform these abiotic substances into life, making vital resources available to their environments, a "Midas-like power of nutrition".[34]

Plants have also drastically shaped the Earth itself. They constitute approximately 99% of the planet's eukaryotic biomass, thriving in ecosystems ranging from tropical rainforests to the cold pine forests of the upper latitudes. Historically, they made the Earth's atmosphere breathable by producing oxygen through photosynthesis, making aerobic life possible.[35]

Contrary to the notion that life merely adapts to its environment, plants demonstrate that they can create the conditions for their own existence, fundamentally modifying the metaphysical structure of the world.[36] Recognizing these active, world-making capacities of plants challenge the anthropocentric belief that humans should lead the terraforming of other planets.

The Artwork *The Wilding of Mars* by Alexandra Daisy Ginsberg

Alexandra Daisy Ginsberg has put this idea into practice with her artwork *The Wilding of Mars* (see Figure 3),[37] a video installation featuring multiple simulations that depict the Martian surface gradually becoming overgrown with plants over millions of years. The aim of the work is explicitly not about terraforming Mars for human habitation; instead it speculatively asks: "Could we imagine Mars colonized only by plants, flourishing without us?"[38]

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[32] Coccia, *The Life of Plants*, 20.
[33] Marder, *Plant-Thinking*, 12.
[34] Coccia, *The Life of Plants*, 17.
[35] Coccia, *The Life of Plants*, 18.
[36] Coccia, *The Life of Plants*, 19.
[37] Alexandra Daisy Ginsberg, *The Wilding of Mars*, Video installation, 2019, https://daisyginsberg.com/work/the-wilding-of-mars.
[38] Alexandra Daisy Ginsberg, "Case Study: The Wilding of Mars," in *Design Studio Vol. 4: Working at the Intersection: Architecture After the Anthropocene*, ed. Harriet Harriss and Naomi House (London: Routledge, 2022), 96–101 https://doi.org/10.4324/9781003285410-11.

It is a critique on the prevalent human dream of colonizing Mars, problematizing the frame of Mars as barren, treacherous and beautiful, aligning with Tabas' post-planetary ecocriticism. It is a frontier narrative reminiscent of colonial histories, where landscapes were viewed as open for exploitation, regardless of the existence of indigenous life. *The Wilding of Mars* subverts this utopian narrative, questioning the assumption that space colonization should serve human benefit.[39]

Voyeuristic camera angles allow viewers to observe the environment from a distance, reinforcing their position as outsiders looking into a world not centered around them.[40] This explicitly prioritizes a non-human perspective. Plants are depicted not as passive, but as active agents, visibly growing and colonizing the terrain. Starting from the south pole, they spread and develop a complex ecosystem shaped by evolving environmental factors.[41] This portrays plants as fundamental, world-shaping forces, while at the same time recognizing their non-human intentionality. As Ginsberg explains: "While plant life takes Mars in a different direction, Mars may take life elsewhere."[42] In other words, *The Wilding of Mars* depicts plants as world-makers in action.

By displaying multiple screens in parallel, the speculative artwork offers alternative planetary futures beyond human-centered paradigms.

Figure 3. The Wilding of Mars by Alexandra Daisy Ginsberg.[43]

[39] Ginsberg, "Case Study", 99.
[40] Ginsberg, "Case Study", 101.
[41] Ginsberg, "Case Study", 99.
[42] Ginsberg, "Case Study", 98.
[43] Ginsberg, *The Wilding of Mars*.

PLANTS AS ASTRONAUTS

While plants might not possess a human-like desire to explore space, it can be argued that they express a drive for expansion with unconscious intentionality. Plants demonstrate expansionist behavior, with evolution driving their survival through specialized adaptation and reproduction via dispersal of seeds. This relates to the astronomical theory of 'panspermia', which suggests that seeds of life could travel through the universe and establish themselves on various planets.

Given their inherent world-making capacities, plants might be the most successful life forms when it comes to terraforming the universe as such. However, this should be understood as an ecological dynamic representing how life could spread, rather than an intentional, plant-driven form of exploration. Even without the desire to travel, life may carry plants into the cosmos, serving the broader purpose of life's cosmic expansion. In light of this, Meurer advocates for a new interdisciplinary field, astroecology, which merges ecology and astrobiology to study the origin, evolution, and distribution of life on an astronomical scale.[44]

Conditions for Extraterrestrial Life

In the speculative fabulation that vegetal life could evolve into extraterrestrial lifeforms as astrobotany, plants would still need to overcome numerous challenges. In their astrobiology research programs, NASA has conducted extensive research on the conditions necessary for life to survive in space.[45] Plants require fundamental resources: nutrient-rich soil, water, air, and light as an energy source. In space, however, they may find themselves traversing unfamiliar ecosystems that challenge their typical metabolism. They could be exposed to stress-inducing hazards in alien lands, atmospheres, or even in microgravity.

A habitable environment capable of supporting life depends on a wide range of environmental parameters. Extraterrestrial environments may have harsh conditions, low water availability, extreme temperatures, high radiation levels, and poor nutrient access, all of which are known stress factors for plants. While conditions in space may surpass those found on Earth, analogs exist here in the form of extremophiles: organisms adapted to low temperatures (*psychrophiles*), high salinity (*halophiles*), extreme pressure (*piezophiles*), low water activity (*xerophiles*), and intense radiation.[46]

To address these challenges, NASA is developing Controlled Environment Agriculture (CEA) to ensure survival of life in space. Another technologically mediated solution could come in the form of genetic engineering to enhance plant resilience. However, this remains difficult

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[44] Johannes C Meurer,. Jacob Haqq-Misra, and Marina de Souza Mendonça, "Astroecology: Bridging the Gap between Ecology and Astrobiology", *International Journal of Astrobiology,* 23 (2024): e3, https://doi.org/10.1017/S1473550423000265.
[45] NASA, *NASA Astrobiology Strategy 2015* (Washington, DC: NASA, 2015), https://astrobiology.nasa.gov/nai/media/medialibrary/2015/10/NASA_Astrobiology_Strategy_2015_151008.pdf.
[46] NASA, *NASA Astrobiology Strategy 2015*, 121–142.

without a precise understanding of the conditions on exoplanets. Interestingly, it has been discovered that plants naturally undergo epigenetic changes in space, these changes are modifications in gene expression without the altering of DNA, aiding in their adaptation to new circumstances. Although it remains unclear whether these adaptations transfer to subsequent generations.[47]

Ultimately, the immense scope of the universe may challenge our current understanding of what life could be. The exact nature of life on other planets might differ radically from life on Earth, potentially featuring an alternative biochemistry. NASA categorizes such possibilities under the concept of 'weird life', life forms that could defy Earth-based biological assumptions altogether.[48]

The Artwork *Astroculture (Shelf Life)* by Suzanne Anker

Inspired by NASA's experiments on growing plants in extraterrestrial environments, artist Suzanne Anker created *Astroculture (Shelf Life)*, an installation consisting of three sets of galvanized metal cubes housing LED lights, peat pods, and seeds in contained hydroponic systems (see Figure 4).[49] Within the "futuristic, laboratory-like environments", Anker cultivates plants under violet light and without soil. These completely artificial conditions make the technical requirements for plant growth in outer space both visible and tangible.[50]

Though the plants inside appear unnatural under the violet glow, the conditions are designed to be sufficient for healthy and nutritious growth of herbs. Anker often explores the boundaries between the natural and the artificial, using tools such as DIY biology to investigate the non-human other.

By presenting plants that survive in strictly controlled, artificial conditions in *Astroculture (Shelf Life)*, Anker raises the question of whether we can still call the cultivated plants 'natural'. Conversely, viewing plants in this alien environment, may also broaden our expectations of what 'natural' could look like, opening new perspectives on life beyond Earth.

[47] NASA, "Station Science 101".
[48] NASA, *NASA Astrobiology Strategy 2015*, 147.
[49] Suzanne Anker, *Astroculture (Shelf Life)*, Installation, 2009, https://www.suzanneanker.com/artwork/astroculture-shelf-life.
[50] Sofia Sousa, "From Monsters to Astroculture: Reflections from the Plenary Session's Chair (Part II)," *Hypothesis Historia Periodical,* 4, no. 1 (2024), 7, https://doi.org/10.34626/2184-9978/2024_vol4_n1_1277.

Figure 4. Astroculture (Shelf Life) by Suzanne Anker. [51]

A Speculative Artwork Exploring Plant Life on Proxima Centauri b (by the Author)

To practice embodying the plant perspective, this section explores what a speculative cosmic exploration effort by plants might entail as a form of artistic research; thereby making a plant-centered imaginary more tangible.[52] The outcome is a series of conceptual plant species designs suitable for life on the nearest exoplanet in the fertile 'Goldilocks zone', Proxima Centauri b.

Inspiration

This speculative work is grounded in the theory from this paper and specifically inspired by the speculative biology often featured in science fiction. A relevant example is the science fiction book *Expedition: Being an Account in Words and Artwork of the 2358 A.D. Voyage to Darwin IV* by Wayne Barlowe.[53] It is presented as a firsthand narrative and illustrated record of a future journey to a fictional exoplanet, describing an imagined ecosystem and its inhabitants. The alien lifeforms are designed to be genuinely unlike anything on Earth, a form of 'weird life', contrasting with typical science fiction depictions of aliens. Conversely, the book's detailed illustrations and writing aim to create a sense of realism, with speculations grounded in scientific knowledge; an aim shared by this speculative work about vegetal lifeforms on Proxima Centauri b.

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[51] Anker, *Astroculture (Shelf Life)*.
[52] Hui, *Art and Cosmotechnics*.
[53] Wayne D Barlowe, *Expedition: Being an Account in Words and Artwork of the A.D. 2358 Voyage to Darwin IV* (New York: Workman Publishing, 1990).

This highlights the shared desire of both science and art to look beyond the obvious to discover new insights by asking "'what if?' questions about the universe", bridging the art/science divide.[54]

Planet: Proxima Centauri b

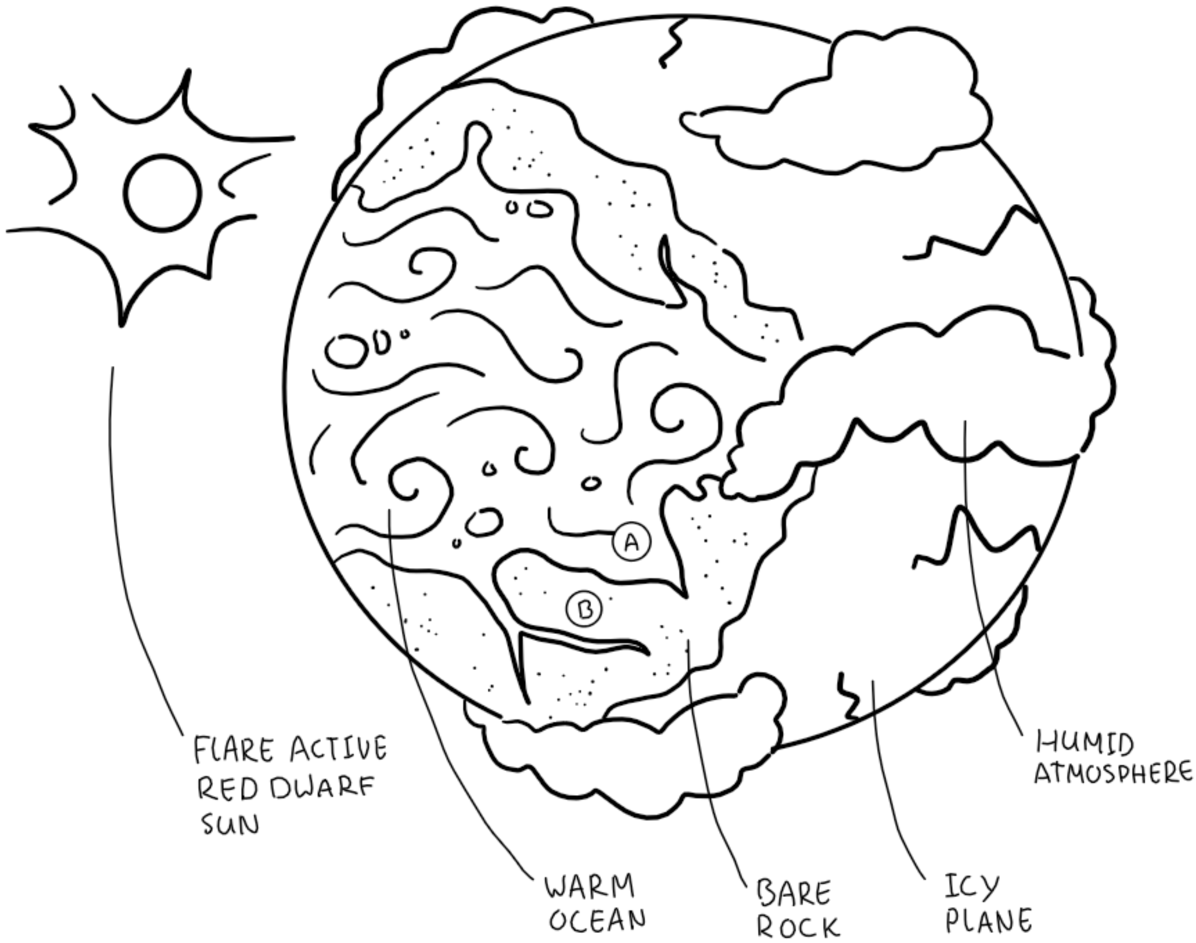

Figure 5. A speculative design of Proxima Centauri b (created by the author).

Proxima Centauri b (see Figure 5) is a planet in the Alpha Centauri star system, located in the constellation Centaurus (see Figure 6). At around four light-years away, it is the closest solar system to Earth, making it the most feasible exoplanet to reach. Its central star is an active red dwarf, which emits lower temperatures and luminosity compared to our sun. However, this star also produces turbulent solar storms with sudden solar flares.[55]

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[54] Ione Parkin, Alison Lochhead, and Gillian McFarland, "Creativity and Curiosity: When Art Meets Science", *Astronomy & Geophysics* 57, no. 6 (2017): 6.28–6.31, https://doi.org/10.1093/astrogeo/atw222.

[55] Guillem Anglada-Escudé et al., "A Terrestrial Planet Candidate in a Temperate Orbit around Proxima Centauri," *Nature,* 536 (2016): 437–440, https://doi.org/10.1038/nature19106.

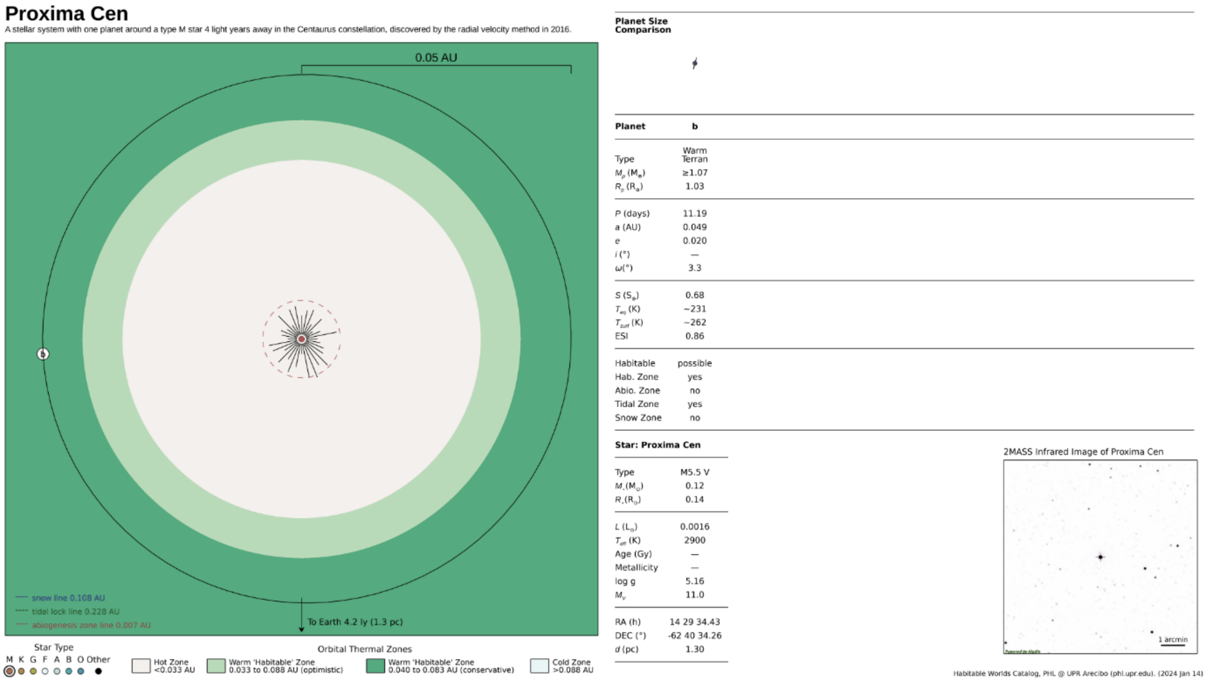

Figure 6. Orbital plot of Proxima Centauri b within its planetary system. [56]

Proxima Centauri b is tidally locked to its sun, meaning the same side is always illuminated. It receives about 65% of the light that Earth gets from our sun. This could result in temperatures ranging from 15 to 30°C on the sunlit side and from -30 to -90°C on its dark side. The planet has a slightly greater mass and gravity than Earth. Together, these properties place Proxima Centauri b in the 'Goldilocks zone', suitable for liquid water and possibly life.[57]

It is a rocky planet, and its probable atmosphere is rich in hydrogen, along with oxygen and carbon dioxide gases. Persistent winds likely blow across the planet due to the extreme temperature contrast between the day and night sides. The abundance of hydrogen may indicate the presence of oceans,[58] leading to a humid climate over the ocean, rocky mainland, and icy plains on the dark side.[59] See Figure 7 for climate simulations done on Proxima Centauri b. The stable, warm oceans seem especially favorable for plant growth.

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[56] University of Puerto Rico, Planetary Habitability Laboratory (PHL), "Exoplanet Orbital Plots", Arecibo, accessed May, 2025, https://phl.upr.edu/hwc.
[57] Victoria S. Meadows et al., "The Habitability of Proxima Centauri b: Environmental States and Observational Discriminants", *Astrobiology,* 18, no. 2 (2018): 133–189, https://doi.org/10.1089/ast.2016.1589.
[58] B. Brugger et al., "Possible Internal Structures and Compositions of Proxima Centauri b", *Astrophysical Journal Letters,* 831 (2016): L16, https://doi.org/10.3847/2041-8205/831/2/L16.
[59] Laura Kreidberg and Abraham Loeb, "Prospects for Characterizing the Atmosphere of Proxima Centauri b", *Astrophysical Journal Letters,* 832, no. 1 (2016): L12, https://doi.org/10.3847/2041-8205/832/1/L12.

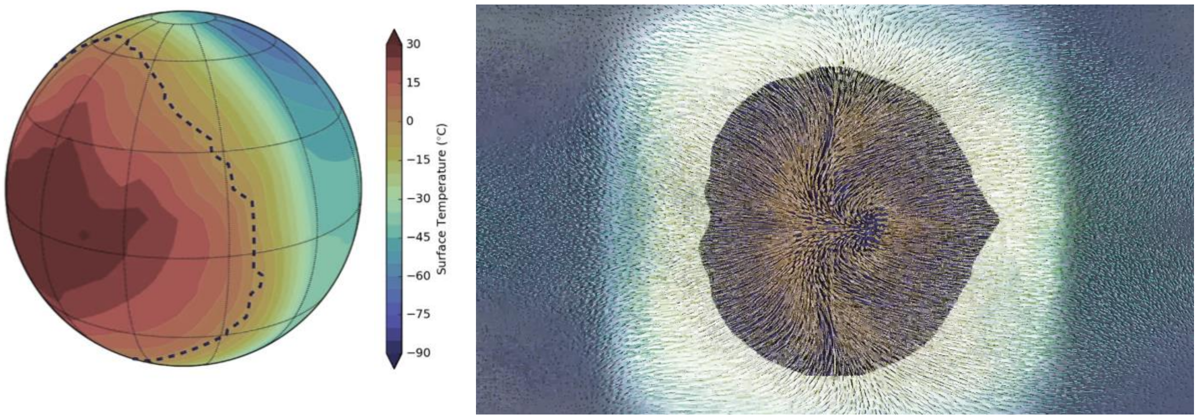

Figure 7. Climate simulations of Proxima Centauri b with an ocean. Left: surface temperature simulation by Laboratoire de Météorologie Dynamique (LMD).[60] Right: air circulation visualization by NASA's Scientific Visualization Studio.[61]

Plants: Plantea Centaurensis

Plants could travel through interstellar space as seeds, resilient structures containing everything needed to unfurl life on a new planet. Proxima Centauri b, relatively similar to Earth and within the Goldilocks zone, presents favorable conditions for plant growth, including a warm, moist climate and a carbon dioxide rich atmosphere for photosynthesis. However, its sun differs significantly from ours. The star Proxima Centauri is fainter but highly active, producing unpredictable bright bursts of radiating solar flares. Earth plants would benefit from adaptations to survive this temperamental environment on Proxima Centauri b.[62] Several general adaptations are proposed, and five variations of a new species, *Plantea Centaurensis*, are designed to thrive in Proxima Centauri b's oceans or on its rocky terrain (see Figure 8). Inspiration comes from diverse Earth plants, particularly extremophiles capable of surviving in challenging conditions, as well as specialized biological processes found in microorganisms.[63]

For plant life to thrive on Proxima Centauri b, the following adaptations may be generally beneficial:

To adapt to the slightly larger size and stronger gravity of Proxima Centauri b, plants might need to be sturdier or grow flatter than those commonly found on Earth. Tall, vertically

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[60] Laboratoire de Météorologie Dynamique (LMD), *Planetary Global Climate Model visualization*, Laboratoire de Météorologie Dynamique, https://www.lmd.ipsl.fr/en/appendices/praticals-informations/.

[61] NASA Scientific Visualization Studio, *Proxima Centauri b Climate Model Scenarios*, visualizations by Alex Kekesi and Horace Mitchell, scientific consulting by Avi Mandell and Anthony Del Genio, released January 23, 2020, https://svs.gsfc.nasa.gov/4777.

[62] Robert J. Ritchie, Anthony W. D. Larkum, and Ignasi Ribas, "Could Photosynthesis Function on Proxima Centauri b?" *International Journal of Astrobiology,* 17, no. 2 (2018): 147–176, https://doi.org/10.1017/S1473550417000167.

[63] Dong-H Oh et al., "Life at the Extreme: Lessons from the Genome", *Genome Biology,* 13, no. 3 (2012), https://doi.org/10.1186/gb-2012-13-3-241.

growing plants would be less viable, except in aquatic environments, where buoyancy can support greater height. The presence of vast oceans creates excellent opportunities for the development of aquatic plant life. To facilitate reproduction, flowers that bloom in the open air could effectively disperse seeds using the planet's strong winds.

Because the red dwarf sun emits limited luminosity, plants on Proxima Centauri b must make the most of available sunlight to perform successful photosynthesis. To absorb a broader range of the light spectrum, large, wide leaves could develop darker pigments, such as deep greens, especially tuned to absorb the red wavelengths most abundant from the star.

In contrast, sudden solar flares from the star can release intense bursts of light, heat, and radiation. Plants would need to be resilient, capable of protecting themselves or even utilizing these energy bursts. Protective adaptations might include a thick, durable outer layer or a waxy coating. Some species may evolve regenerative abilities to repair cell damage caused by UV and X-ray radiation. Aquatic plants benefit from an additional protective layer of water, though light penetration diminishes with depth. Plants on Proxima Centauri b might also use the irregular occurrence of solar flares as a temporal cue for growth and blooming, compensating for the lack of a regular day-night cycle due to the planet's tidal locking.

In Figure 5, one ocean area (A) and land area (B) are marked as the initial settlement areas for plant colonization.

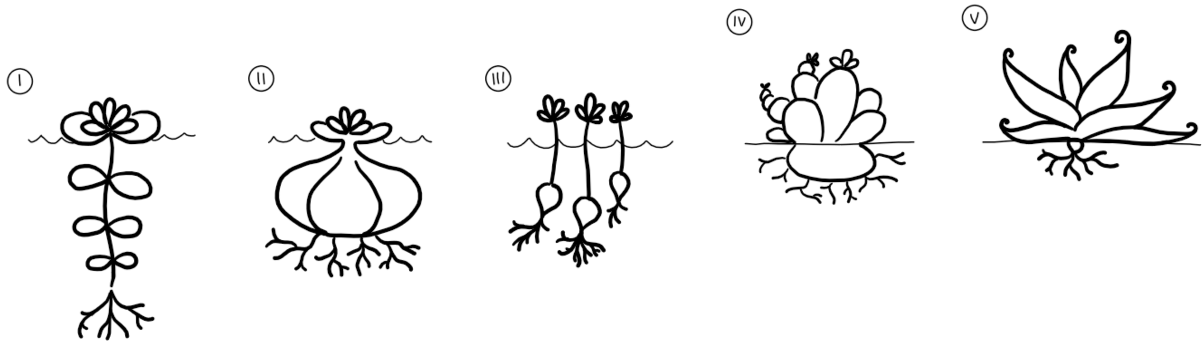

Figure 8. Five speculative plant species designs adapted to the environment of Proxima Centauri b (created by the author).

I Plantea Centaurensis Nymphaeaceae

A graceful, aquatic plant that floats serenely on the surface of Proxima Centauri b's warm oceans. With thick, spiraling leaves, it maximizes exposure to the dim red sunlight, absorbing every available photon. Its largest leaves spread wide beside a striking flower that blooms just above the waterline and can release its seeds in the strong winds. Meanwhile, its deeper, submerged leaves are shielded by the water, allowing the lowest of them to survive even the heaviest solar bursts. These plants move slightly with the current, forming elegant, ever-shifting carpets of dark green and violet hues across the ocean surface.

II Plantea Centaurensis Eleocharis

A robust aquatic species anchored by a dense, radiation-shielded bulb beneath the water's surface. This bulb contains vital internal processes and stores essential nutrients. The plant's thick, fibrous exterior withstands the planet's harsh space weather. Above the water's surface, long, sturdy leaves unfurl, gracing a singular flower. Designed for endurance, this species thrives in more shallow waters.

III Plantea Centaurensis Raphanus

These community-minded, tuberous plants store their resources deeper underwater in intricate root structures, while thin, flexible stems rise toward the surface to gather light and release delicate but disposable floating flowers. This species forms interconnected root networks and exerts strong cooperative behavior, they exchange nutrients, share environmental data, and even transmit genetic repairs when one of them is damaged. In times of environmental stress, the plant colony acts as one, redistributing resources to ensure survival of the group.

IV Plantea Centaurensis Kalanchoe

A land-dwelling succulent with a resilience honed by fire and radiation. It anchors itself in the planet's rocky, nutrient-poor terrain, drawing sustenance from deep mineral veins. Its fractal-like growth follows a recursive genetic pattern, allowing damaged cells to regenerate by referencing repeating DNA stored in multiple parts of the plant. Thick, wax-coated leaves grow outward to collect sunlight and deflect radiation. During violent solar flares, the outer leaves may scorch, but the inner bulb, nestled under the plant's armored layers, will persist, recover and regenerate.

V Plantea Centaurensis Aloe

This moisture-rich plant grows on the rocky surface, unfurling in wide, undulating mats of thick, moisture-rich leaves. These leaves drink in sunlight, converting the faint red rays into stored energy. But when solar storms approach, they exhibit a remarkable defense mechanism, their leaves roll up in themselves, creating a tough, self-insulating spiral that protects their delicate inner tissue from radiation damage. Once the storm passes, they unroll slowly, ready to power the plant's further growth.

Further speculation

Besides this speculation on individual alternative plant species, it is also worth speculating on the larger terraforming process and the development of new homeostatic ecological systems in exoenvironments, such as that of Proxima Centauri b. Colonization of Proxima Centauri b could begin with hardy, pioneering plants capable of extracting resources from the rocky earth and dense waters, making them available to other species. Early plant generations might offer shelter for later, more delicate species, which could diversify under improved conditions. Symbiotic microorganisms could also support plant processes. These microbes, like bacteria and fungi, might travel encased in the plant seeds or already exist in the alien soil.

It is interesting to speculate further on the intra-action of plants with potential alien species. Alien life seems plausible in the vastness of the universe, as suggested by the Drake Equation, yet this position is challenged by Fermi’s Paradox. A resulting interspecies encounter has the potential to become harmonious or conflicting, needing further ethical contemplation.

Ultimately, a novel ecosystem could emerge in the cosmos, reaching an equilibrium suitable for long-term habitation.

CONCLUSION

This paper aimed to question the entrenched anthropocentric paradigms in space exploration, decentering it with speculative fabulation by taking the stance of the easily overlooked but indispensable plants as astronauts, referred to as astrobotany, asking:

In what ways can speculative astrobotany decenter anthropocentric paradigms in cosmic exploration?

After establishing the relevance of astrobotany, the philosophical value of vegetal life was explored. The need to move beyond anthropocentric paradigms toward a more relational understanding of life was framed through the concept of ‘kin-making’. We identified with our kin, the plants, through the method of ‘plant thinking’, which allowed us to decenter the human perspective and consider how plants themselves might approach cosmic exploration. From this non-human standpoint, it was argued that plants exhibited an unconscious intentionality toward expansion, grounded in the theory of evolution. This led to a deeper inquiry into the environmental and possibly technological conditions required for life beyond Earth, culminating in the speculative design of a plant-led colonization of the exoplanet Proxima Centauri b. This speculative fabulation was complemented by artworks of Angelo Vermeulen, Alexandra Daisy Ginsberg, and Suzanne Anker, each confronting aspects of astrobotany.

In bringing together, art, science, technology, and philosophy, this paper has shown that speculative astrobotany can serve as a meaningful tool to decenter anthropocentric paradigms in cosmic exploration. By treating plants not as passive cargo but as active co-astronauts, we can begin to envision space not as a frontier for human conquest but as a shared environment, one in which life in its many forms might take root and thrive, evoking imaginaries of the futures we want to grow.

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