

BioQuantum Record: Exploring otherness through extremophilic microorganisms

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ABSTRACT: The art-science collaboration BioQuantum Record aims to bridge scientific inquiry and artistic narrative using an astrobiological lens to explore fundamental questions regarding life, otherness, and the human perspective. We propose to move away from an anthropocentric view and send extremophilic archaea, "microbial astronauts", to potentially establish first contact with extra-terrestrial microorganisms. This parallels the search for life in astrobiology, which mainly focuses on the search for microbial life. This transdisciplinary approach merges art and science by maintaining a liminal state of uncertainty and openness to new forms of knowledge. We derived experimental methodological approaches from anthropological concepts to support a research stance in which the artist acts as a catalytic figure, enabling a transdisciplinary practice that unfolds collaboratively and opens new avenues for exploring anthropological concepts in art-science collaborations. This culminated in an art-science performance and exhibition that fused scientific protocols with artistic exploration to create science-fiction-inspired encounters. We conclude that astrobiology can be used as a means to explore otherness, with transdisciplinarity creating a shared space for encountering uncertainty and generating new inquiries.

Keywords: AstroBioArt, astrobiology, panspermia, sci-fi narrative, chirality, liminality

Introduction

"The chances of this happening might be one in infinity. Put it this way: the chance that there being intelligent alien life are, for me, infinitely higher than the chance there being a creator god." —Comedian Tim Minchin when asked if he thought the universe was full of life (Minchin 2009).

BioQuantum Record is the title of an evolving body of work emerging from an art-science collaboration rooted in astrobiology. It encompasses the development of exhibition and performance concepts, the presentation of the project in talks, and a meta-level exploration of the nature of transdisciplinarity in relation to the concept of otherness. The core principle of transdisciplinary work is seen as encounter: scientist and artist meet in uncertainty. The artist engages with scientific material not as subject matter but as a material, and the scientist approaches artistic inquiry not as an illustration but as method, allowing space for the unknown to act. This paper focuses on the transdisciplinary methodology emerging from art-science collaboration.

BioQuantum Record revolves around a hypothetical new edition of the Golden Record. Framed by this speculative sci-fi gesture, the project opens ontological and epistemological inquiries central to astrobiology, such as how we define and perceive life. Unlike the Golden Record sent aboard Voyager 1 and 2 to potentially contact extra-terrestrial intelligence (NASA 2025), this transdisciplinary project proposes a biological connection based on molecular chirality. The "handedness" of molecules serves as both a poetic and scientific framework to explore how life might recognize and interact with something fundamentally "other". While life on Earth almost exclusively uses left-handed (L-)amino acids and right-handed (D-)sugars as essential building blocks, extra-terrestrial organisms might use molecules with reversed chirality or a mixture of both elsewhere in the cosmos, forming a mirrored version of life as we know it.

The project proposes sending an artistic vessel prototype hosting biochemical materials and "a crew" of prokaryotes into space to initiate a chiral handshake with their extra-terrestrial siblings. The crew candidates are extremophiles from the Archaea domain, microorganisms that could potentially thrive in environments such as Mars or other planetary bodies. The conception of the vessel draws on panspermia theory (Kawaguchi 2019), the idea that life can travel between planets on space debris, echoing life's potential as a cosmic traveler, resilient, adaptive, and capable of seeding worlds.

What happens when we send not only a message but life itself into the unknown?

66 *Post Voyager*

67 The BioQuantum Record is a post-Voyager concept that critically engages with the
68 implications of scientific progress and contemporary cultural-, societal-, and
69 philosophical thought, particularly the growing awareness of our pervasive
70 anthropocentric worldview alongside an emerging recognition of the interconnected
71 principle of life.

72 If we were to send another Golden Record into space today, what might the new
73 record look like? Based on the premise that microbial collectives may be the first
74 form of extra-terrestrial life that we will come into contact with, how might we
75 establish contact with them? Given the limitations of human sensory perception and
76 scale, how can we meaningfully engage with microorganisms, whether terrestrial or
77 extra-terrestrial? Despite technological advances, our understanding remains
78 fundamentally constrained by human experience.

79 Could we send microorganisms as intermediaries to make contact with their extra-
80 terrestrial kin? Although inevitably a gesture steeped in anthropocentric longing, the
81 narrative¹ framework playfully exposes the futility of transcending the limits of human
82 perspective. It becomes a narrative boomerang, which necessarily returns to us,
83 asking Michael Ende's question: "*What is mirrored in a mirror that is mirrored in a*
84 *mirror?*" (Ende 1984). Here, the paradox transforms into a potential opening: a koan.

85 *Microbial Astronauts*

86 Our astronomical candidates are the extremophilic archaeal species *Metallosphaera*
87 *sedula* and *Halobacterium salinarum*. *M. sedula* is a tough organism, growing
88 optimally in hot, acidic, metal-rich environments (Huber et al. 1989). It can be
89 cultured on meteorite breccia and Mars regolith (Milojevic et al. 2021), even when
90 adapting to heavy metals such as As, Cu, Zn, Cd, and Ni (Dopson et al. 2003), and is
91 able to survive desiccation (Kölbl et al. 2020). *H. salinarum* has evolved to live in
92 high-salinity environments (Eichler 2023), conditions that are not only found on Earth
93 but are also widespread throughout the solar system. Enceladus and Europa appear
94 to have salty oceans beneath their ice crusts (Lunine 2017), and Mars allows for the
95 formation of salt crystals (Pasteris et al. 2006; Davila et al. 2010), which can provide
96 shelter for potential microorganisms by serving as shields against harmful radiation
97 (Leuko et al. 2015).

¹ Here, "narrative" is used in the artist's sense as a reflective device rather than linear storytelling or plot. It may serve as an anchor point for the audience to enter the work, a lens to explore concepts, or a kaleidoscopic frame that fractures perception. In practice, the artist works with pre- and post-narrative structures, allowing for both framing and deconstruction of ideas.

99 Our proposal to enable contact between terrestrial microbial astronauts and
100 hypothetical extra-terrestrial microbial life is based on chirality. The term *chirality*
101 comes from the ancient Greek word χείρ (*cheir*), meaning "hand," as it refers to the
102 concept of "handedness." Chirality is a fundamental geometric property at the atomic
103 level that is extremely significant in chemistry and has important implications in life
104 sciences. Molecules with opposite chirality share the same atomic composition and
105 connectivity but cannot be perfectly overlaid in space, similar to the left and right
106 hand.

107 Instead of using both enantiomers, life on Earth has evolved using almost exclusively
108 L-amino acids and D-sugars (Barron 2008). This preference for one enantiomer over
109 another in living organisms is referred to as "biological homochirality", a phenomenon
110 that could serve as a potential signature for carbon-based life on other planets
111 (Glavin et al. 2020). Louis Pasteur wrote in 1874: "*The universe is asymmetric and I*
112 *am persuaded that life, as it is known to us, is a direct result of the asymmetry of the*
113 *universe or of its indirect consequences*". Inspired by this quote, and contrary to
114 Louis Pasteur, we can imagine that if the reason why life is asymmetric depends on
115 external bias factors, these can result in opposite outcomes if life were to emerge in
116 other places in the universe (Ozturk and Sassellov 2022). Under these premises, we
117 can imagine a carbon-based extra-terrestrial life that is a mirror version of life on
118 Earth.

119 Although enantiomers share the same chemical composition and atom connectivity,
120 they can behave very differently in biological systems; one enantiomer may be
121 curative, whereas the other may be ineffective or even harmful. The myth of Tantalus
122 from Greek mythology springs to mind: just as Tantalus was surrounded by food and
123 water, which he could never reach, we might encounter molecules that appear similar
124 but are fundamentally inaccessible or unhelpful to our life processes because of their
125 chirality. On a planet where life is a mirror version of our life, we could eat and still die
126 of hunger because our body simply could not utilize the molecules. The
127 "handedness" of molecules is not only a scientific concept but also a philosophical
128 framework that invites us to consider what happens when life recognizes and
129 interacts with something "fundamentally other": a possible mirror image of ourselves.

130 Stepping back from the poetic lens, it is with the rigors of science that a final point
131 deserves attention: while mirror-image biomolecules hold promising scientific and
132 therapeutic potential, the scientific community has recently undertaken a collective
133 effort to raise awareness of the risks associated with creating "mirror-image" life on
134 Earth (Adamala et al. 2024). BioQuantum Record plays with the concept of chirality,
135 imagining a metabolic chiral gift carried by the microbial extremophilic space
136 travelers within the vessel: L-glucose, the mirror form of glucose that terrestrial
137 organisms cannot metabolize, as an offering to their hypothetical extra-terrestrial
138 mirror-life kin.

Art, Space, and Astrobiology

The use of microorganisms as a medium in artistic practice has paved the way for projects at the intersection of art and the life sciences. Early experiments, such as those of Alexander Fleming, the father of penicillin, who created drawings using different strains of bacteria (Dunn 2010), anticipated contemporary practice. Since then, the use of microorganisms in art has gained increasing recognition, both as a distinct artistic medium (Hauser 2020) and as a pedagogical tool for public science communication (Yarzabal Rodríguez and Batista-García 2025). A prominent example of biological art (BioArt) using microorganisms is Anna Dumitriu who fuses fine art, performance and BioArt techniques in art and science collaborations (Fawcett and Dumitriu 2018; Dumitriu 2024) including investigations of human-microbiome relations (Greenhough et al. 2020). Meanwhile, Space Art has engaged with the space environment for decades. An example is Inner Telescope by Eduardo Kac, created with astronaut Thomas Pesquet aboard the International Space Station (Kac 2017). Despite these precedents, art explicitly addressing astrobiology remains rare. Suzanne Anker's installation "Astroculture (Shelf Life)" (Anker 2009-on going) is a notable exception, cultivating plants under spectral lights and connecting this work to NASA research on life-support systems.

BioQuantum Record builds on these precedents but approaches the intersection of art and astrobiology from a distinct perspective: it merges a focus on microbial life with extra-terrestrial motifs through extremophilic archaea, conceptualized as microbial astronauts. Unlike previous projects that focused on plants or human perception in space, the BioQuantum Record uniquely engages with extremophilic archaea as active agents, inviting speculation on the possibilities of life beyond Earth while merging artistic exploration and scientific investigation—and highlighting encounters with forms radically different from our own. To the best of our knowledge, no other project has worked with extremophilic archaea in a space-art context, making this approach pioneering.

Results and Discussion

Point Zero: Entering the Lab

The artist arrives at the laboratory with ideas, sketches, and questions. Despite all prior preparations, stepping into the lab means undergoing Ritual Zero²: a deliberate un-knowing. Ritual Zero creates a space of open-ended inquiry, where the goal is not to narrow a field but to expand a perspective. This methodological divergence creates productive friction between the artist and the scientific partner, whose training is to define variables, control conditions, and focus on specific, testable truths. The artist's expansive "what if" meets the scientist's precise "how".

The artist begins as an intruder in the lab. They do not know the language and do not belong; they require attention, which cuts into research time. Routine procedures are disrupted. This causes irritation. But this irritation is not a flaw. It is the mechanism of the practice. The artist, inhabiting the role of otherness, operates as a deliberate agent of uncertainty. This position of liminality is an active, extended field that interrupts habitual practice, evokes latent possibilities, and activates a fundamental shift in perspective, inviting collaborators into a space where their certainties are displaced.

Arnold van Gennep first introduced the concept of liminality in 1909 in his study of rites of passage (Van Gennep et al. 2019). The term "liminal" comes from the Latin word *limen*, meaning threshold or boundary. Van Gennep described liminality as the middle phase in a three-part process: separation, liminality, and incorporation. In the context of rituals, the liminal phase is the stage in which individuals have left their previous status but have not yet assumed a new one; a state of ambiguity, suspension, and openness. Victor Turner later expanded this idea, emphasizing liminality as a period of profound potential, where structure and anti-structure coexist (Turner and Abrahams 2017). In these "betwixt and between" states transformation becomes possible. In the BioQuantum Record project, the liminal state is not only a phase but also a method: a deliberate opening toward not knowing, allowing encounters, and the emergence of new forms of knowing.

² The concept of Ritual Zero was derived from the methods that Sergey Kovalevich, a theatre director, student of Vladimir Klimenko (Klim), and art director of the International Theatre Resource Song of Songs, applied within the group. The artist was a member of this group, associated with the Jerzy Grotowski International Institute in Wrocław, Poland, from 2006 to 2008. Ritual Zero was an integral part of both the methodology and training, functioning as an energetic practice of attunement.

Immersion and Liminal Persona

We propose immersion as a method for deliberately sustaining the liminal state. By engaging in hands-on experiments, materials, and scientific practices without seeking immediate mastery or closure, the artist remains in the space between certainty and uncertainty. Immersion begins with attuning: observing how people move through the lab, how scientific knowledge is organized, and how the space itself structures attention.

At the heart of this approach is the collaborative work itself. Working alongside scientific partners, not only to understand the theoretical framework but, crucially, to engage in the tactile and material dimensions of the work. Handling protocols, tools, and substances becomes a way of thinking through doing, in which insight emerges from direct encounters rather than detached observations. Sensory involvement—touch, texture, and proximity—acts as a portal for a different kind of knowing. This mirrors the resonance described by anthropologist Lisa Messeri in her ethnography of planetary scientists: a felt connection through which abstract concepts become tangible via embodied, affective interactions with materials and processes (Messeri 2016).

Through sustained immersion, a new persona gradually takes shape: the lab shapes the artist's liminal identity. This persona is twofold: it is both a mode for engagement grounded in the quality of encounter and a trickster-like role, an agent whose disruption opens space for alternative ways of thinking (Plant 2010).

When Science meets Art

The core principle of transdisciplinarity is humility: the willingness to recognize one's ignorance against the backdrop of the other. Everything begins with finding and establishing a common language; a certain word linked to a specific task may not have the same meaning in art and science. The scientist, though guided by rational boundaries, is invited to open their imagination within the collaboration (**Figure 1**).



Figure 1. Artist and scientist meet in the laboratory. Artist Anna Steward and scientist Sebastian Gfellner together in front of a bioreactor of *M. sedula* culture grown on mineral pyrite in the laboratory of the host institution.

Artists and scientists have different ways of conducting their work. The artist works iteratively, with each cycle building on what emerged from the last—not toward a fixed goal, but deeper into the questions the work itself raises. They own the right to define when the work is completed. In contrast, scientists typically have no access to experiments once they are initiated. Any changes during the experiment tend to introduce errors. Therefore, it is crucial to carefully plan an experiment beforehand, accounting for potential errors, because once it has started, scientists can no longer intervene. Additionally, once an experiment is formalized in a scientific publication, the peer review process leads to a never-ending “specimen” that could also be proven wrong by future observations. The way of science is built upon continuous improvement and discovery, imperfections that must be explained by others while opening new gaps of knowledge: a never-ending story.

Where science is rooted in the empirical soil, artistic narratives can grow from it into speculative air. The artist has the freedom to imaginatively reinterpret physical laws, play with them, or inhabit frameworks that suspend them—all in the context of an artwork. This is something a scientist, by the nature of their discipline, cannot and would not aim to do. This divergence is complementary: where science seeks to explain, art speculates, evokes, or reframes. Working within the context of artistic imagination can enrich scientists' vision, potentially opening new research questions that enhance scientific curiosity.

Art can serve as a vessel for the parts of a scientist's psyche that resist rational frameworks, those impulses drawn to the beauty of the unknown or the enigma of existence. It offers a medium through which scientists can momentarily detach from logical paradigms and touch the parts of themselves that first fell in love with the unknown, the part that method could never fully contain.

From Art to Experiment: Stimulating the Scientific Process

Among sugars, glucose ($C_6H_{12}O_6$) is one of the most crucial sources of energy for all organisms on Earth, and exclusively the right-handed chiral form D-glucose is the substrate for enzymatic reactions. Thus, we speculated that an extra-terrestrial form of life could also use glucose as an energy source. However, what if they would use the chiral mirror version L-glucose instead? Could we design an experiment to determine whether Earth microorganisms can carry L-glucose as a chiral gift to their potential extra-terrestrial kin? This hypothetical question stimulated scientific inquiry. The materials and methods of the conducted experiment, as well as an in-depth discussion of the experimental setup, can be found in the **Supplementary Materials**.

Astrobiology and Anthropology as Transdisciplinary Allies

Astrobiology is a relatively young discipline that has developed rapidly since the advent of space exploration and the discovery of exoplanets (Cockell 2001). In 1975, NASA launched the Viking program to search for signs of life on Mars, and in 1984, the Search for Extra-Terrestrial Intelligence (SETI) Institute was founded. Astrobiology explores the potential and origins of life in the universe, bridging scales from the molecular realm of chemistry through the microscopic world of microbiology to the macroscopic domain of planets and galaxies. In this sense, it resonates with Feynman's spirit, connecting the extremely small with the extremely large (Anniversary of a Myth 2009) and envisioning a new field of research. Astrobiology also forces a confrontation with our deepest conceptual assumptions, unsettling anthropocentric, terra-centric, and even life-centric assumptions, as we recognize that what we seek may lie beyond our present imagination.

This movement between extremes and scale, perspective, and meaning creates a liminal space in which categories dissolve and new connections emerge, echoing patterns of anthropological inquiry, such as Victor Turner's notion of communitas (Turner and Abrahams 2017), an intense experience of connection that arises in

liminal phases, temporarily dissolves hierarchy, and fosters collective bonds. While Turner's original focus was on human participants, subsequent posthuman interpretations have expanded such concepts to include non-human agents, materials, and processes, evoking a more-than-human field of shared becoming in which diverse forms of knowing are entangled (Haraway 2016). Astrobiology, in its own liminal search, echoes these patterns of entangled knowing, opening toward an encounter with cosmic alterity.

We propose both anthropology and astrobiology as key allies in transdisciplinary collaborations. Anthropology has the tools to examine how different domains construct meaning and knowledge; more than a mode of observation, it enables a situated, relational way of knowing, which is especially valuable when disciplinary boundaries are in flux. It helps track how concepts shift between fields and how language shapes perceptions. Rather than seeking synthesis or consensus, it provides space for tension, ambiguity, and multiplicity. When brought into dialogue with astrobiology, anthropology finds unexpected resonance. Both disciplines operate in liminal epistemic zones, where categories are destabilized and understanding must be renegotiated. Just as anthropology asks what it means to be human across diverse life worlds, astrobiology asks what it might mean to be alive beyond Earth. In this shared space of speculation and uncertain categories, anthropology reflects on the assumptions embedded within each field, while astrobiology, stretching the scope beyond human and terrestrial references, holds the possibility of an encounter with otherness.

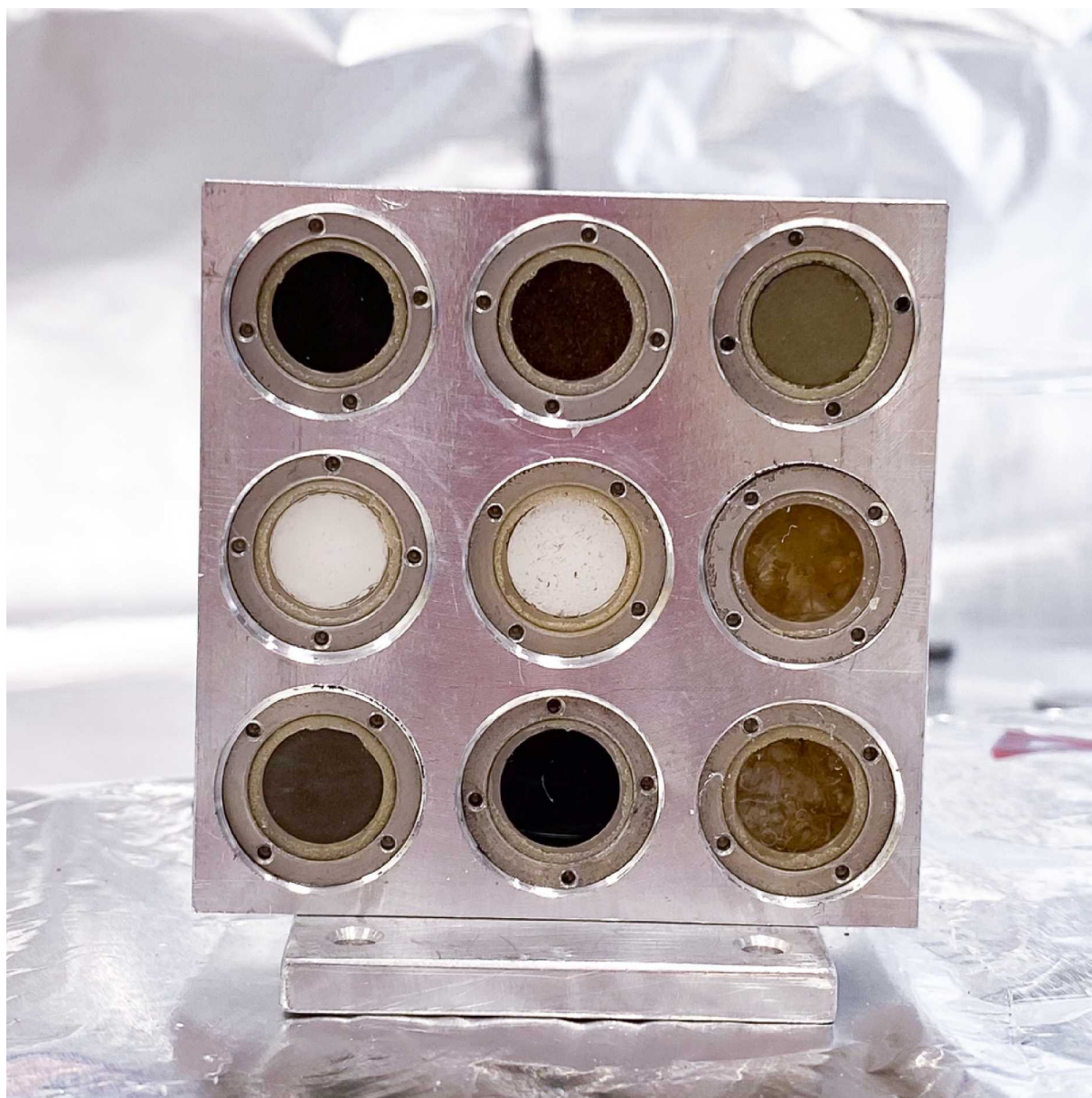
From Ping-Pong to Pattern: Idea Emergence Between Systems

The collaborative process itself became the generative ground for the artistic work, as initial ideas for a vessel designed to make contact with potential extra-terrestrial microbial life began to take shape. Co-author Marie Catherine Sfora remarked on the toughness of *M. sedula*, sparking the image of extremophiles as astronauts—survivors, travelers, and cosmic emissaries. Conversations with geologist Frances Westall while exploring and examining the International Space Analogue Rockstore (ISAR)³ collection further expanded the concept: the vessel gradually took on the form of an asteroid, moving away from conventional engineering logic and inviting alternative ways of thinking about spacefaring objects.

Building on this, a discussion with co-author Sebastian Gfellner introduced the idea of the vessel as a generation ship—or “arkship”—carrying life across cosmic distances. This progression—from envisioning resilient microorganisms as astronauts, to the vessel echoing asteroid geology, to conceptualizing it as a microbial arkship—traces the project's collaborative evolution. This collaborative progression marks the beginning of what we term the ping-pong phase. While learning and doing intersect, the idea is shaped through quick exchanges, such as

³ <http://www.isar.cnrs-orleans.fr/isar/>

318 hitting a ball made of wet clay back and forth. This is the stage where the artist, while
319 still trying to understand the concept of chirality by making molecular models from
320 plasticine, is already following laboratory protocols to cultivate microorganisms. The
321 pendulum swings from the lab to the studio, from protocol to improvisation, from fact
322 to intuition. This dual movement between scientific inquiry and artistic speculation
323 shapes the emerging narrative gesture (**Figure 2**).



324
325 **Figure 2. From science to art.** Microorganisms grown on various mineral substrates
326 embedded in a space exposure well taken out of the scientific context become an artistic
327 object detached from its original purpose.

328 *Finding Analogies: Making Connections*

329 The artist follows lab procedures as far as possible. This deep engagement with both
330 physical substances and theoretical concepts is not about replication; it serves as a
331 method to evoke the emergence of ideas—moments when synapses connect
332 previously unrelated elements, placing them in experimental relation. Within this
333 methodical space, perceptual shifts occur. The act of counting cells under a
334 microscope becomes a moment of emergence: Is it a cell or a mineral fleck? The
335 rhythmic behaviors of magnetic stirrers each at their own frequency become music.
336 The line blurs. This moment of uncertainty, in which data and perception intertwine,
337 fuels an artistic process in which the red “Martian” soil from the host institute
338 basement merges with extremophile cultures and minerals, coalescing into a visual
339 essay. These moments of unexpected synthesis mark a shift from scientific
340 observation to artistic play. This is where freedom enters: when the artist stops
341 absorbing and begins transforming and creating meaning, and not simply mirroring it.

342 *Beyond Representation: Experimenting and Intervention*

343 At one point, co-author Carlo Pifferi said, “Ah, so you really want to do something, an
344 experiment? I thought this would be more of a representation”. This shift from
345 representation to intervention marks the point at which art and science begin to
346 actively shape one another, no longer running in parallel but becoming entangled.
347 The speculative narrative of extremophiles as interstellar travelers has become a
348 trigger for real scientific inquiry. This is no longer a mere exchange but a fusion: the
349 artist enters the scientific process to contribute, provoke, and open new pathways.
350 Questions arising from artistic inquiry can seed experiments that would otherwise not
351 occur. This is the unique role of the artist in science: to ask questions that no scientist
352 would ask, to propose impossible ideas that, through collaboration, become
353 experiments, objects, and new forms of knowledge (**Figure 3**).



Figure 3. Exhibition “BioQuantum Record”. Left: Tent installation of vessels displayed on laboratory clamps. Right: 3D-printed ceramic vessel by Anna Steward. *Credits: Louise Cotte and ESAD Orléans.*

Exhibition and Performance

The first series of vessels was presented in an immersive installation envisioned as a deserted, possibly posthuman, laboratory tent. Suspended in the act of being filled with mineral powders, biopolymer substrates, and microbial samples, sculptures function as speculative objects—quasi-laboratory artifacts bridging scientific inquiry and artistic imagination. The surrounding elements, including minerals, microbial cultures, and reference materials, provided context, framing the installation as a space for sensory encounters with speculative astrobiological questions. A glossary offered an accessible scientific background, further supporting visitor engagement. Building on this initial presentation, a second exhibition is being developed in which chirality plays a central role, extending the project’s exploration of asymmetry and mirrored forms in the context of life beyond Earth.

The exhibition opening was accompanied by the performance “Alien in the Closet”, a collaborative work between researcher and artist (**Figure 4**). Lasting approximately 45 min and set to a live electronic score, the piece choreographs laboratory techniques to narrate the story of microbial explorers from stasis to speculative deployment across the cosmos. In the performance, scientist Sebastian Gfellner enacted the improved extraction protocol developed during previous research (Gfellner et al. 2025a), merging scientific precision with performative presence. Artist

Anna Steward prepared the chiral metabolic “gift” by pouring biopolymer infused with minerals into Petri dishes, representing the L-glucose offering. In parallel, the microbial astronauts were placed in cryogenic hibernation, poised for their voyage aboard the arkship. The materials used included Mars-analog material and leftover cell-mineral mixtures from the cell counts of an exposure experiment conducted in a Mars simulation chamber (Gfellner et al. 2025b).

This reciprocal entry—the scientist into the artistic world and the artist into the scientific world—is a foundational aspect of this work. It signifies not only a shift from scientific protocol to a science-fiction narrative but also a profound methodological fusion in which roles became interchangeable. Through this entanglement, performance moves beyond conventional collaboration, proposing a new model for transdisciplinary creation.



Figure 4. Impressions from the performance “Alien in the Closet”. Left: Artist Anna Steward preparing a speculative arkship. Right: Scientist Sebastian Gfellner preparing the microbial astronauts for takeoff.

Conclusion

Astrobiology is not primarily about extra-terrestrial life; it is about the nature of otherness itself. This mirrors the authors' artistic practice of discovering strangeness in the familiar, kinship in otherness, and familiarity with the weird. We propose that this orientation toward otherness, whether cosmic, microbial, material, or symbolic, is the underlying principle of transdisciplinary research. Transdisciplinarity is not simply the merging of fields; it is the holding of a shared in-between space in which artists and scientists encounter uncertainty and ambiguity. In this liminal zone—between the empirical and the speculative, the methodical and the intuitive—new inquiries take form. It is a field shaped as much by myth as by method, where knowledge is co-created through encounters, relations, and transformations.

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Author Contributions

A.S., S.V.G., and M.R. conceptualized the project. A.S., S.V.G., C.P., and V.A. designed the experiments, and A.S., S.V.G., and M.C.S. cultivated the microorganisms used in this study. A.S. designed and manufactured the artistic objects and conducted the art exhibition. A.S. and S.V.G. designed and implemented the art-science performance. A.S. and S.V.G. designed the manuscript. All authors contributed to the editing and discussion of the manuscript.

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