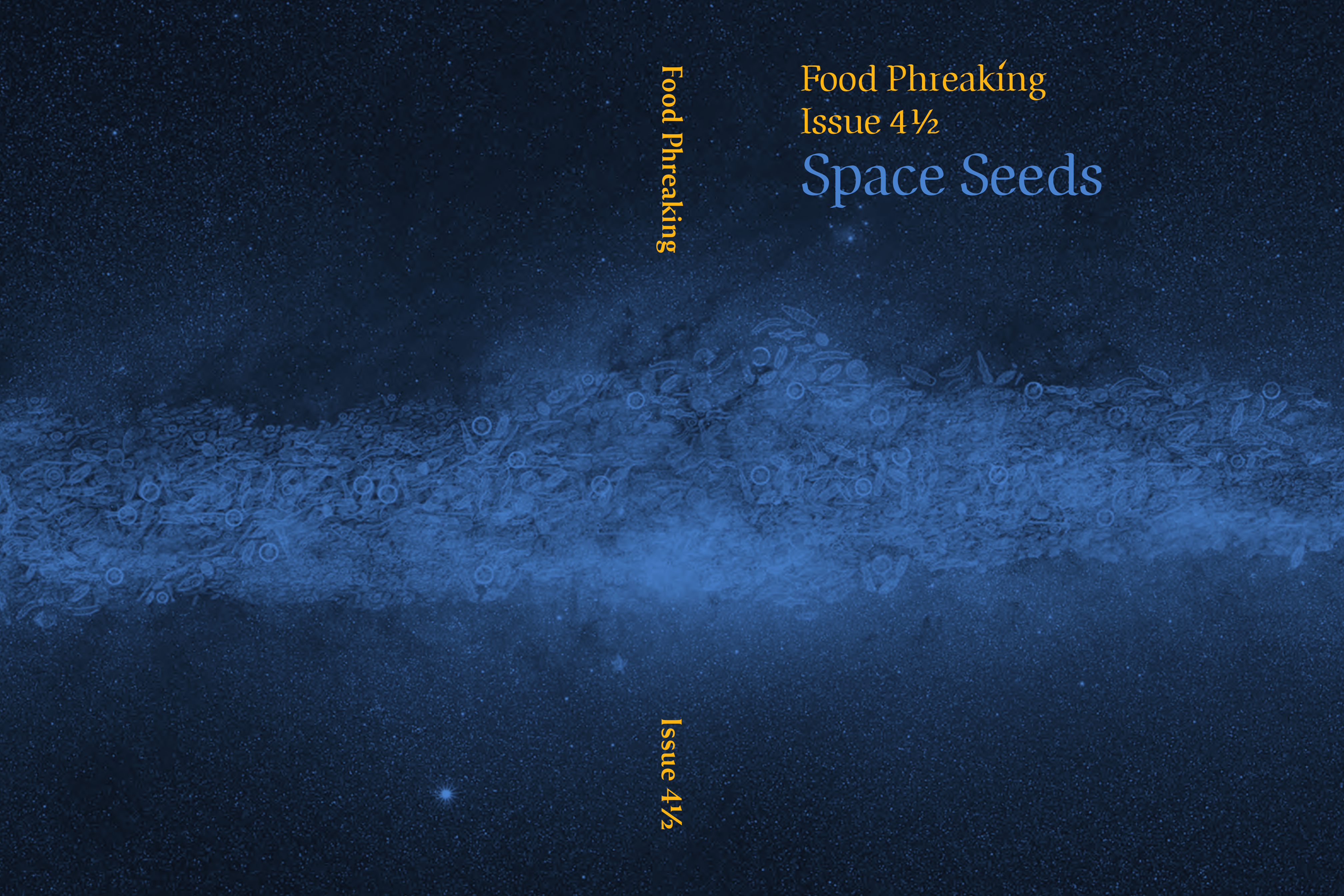


Food Phreaking

Issue 4½

Space Seeds

Food Phreaking
Issue 4½

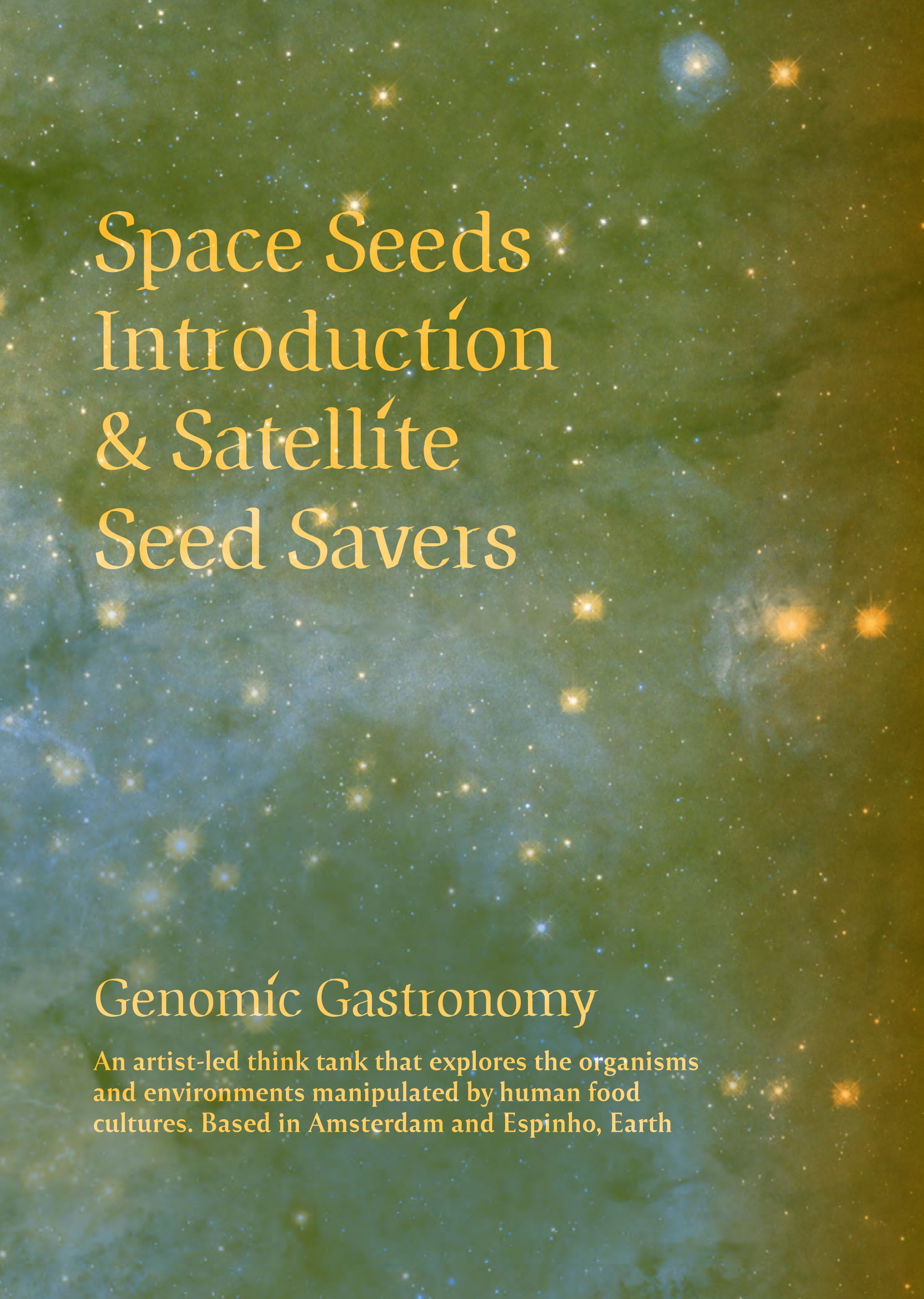
FOOD PHREAKING
issue 4½

Space Seeds

Genomic Gastronomy

_____ / 300

Food Phreaking is where food, technology and open culture meet. Each issue of the journal contains stories about experiments, exploits and explorations of human food systems. Food Phreaking Issue 04 (2019), our previous issue, was all about SEEDS. In Food Phreaking Issue 4½ (2023) we zoom in on SPACE SEEDS: the seeds of edible plant varieties that have been cultivated for—or traveled to—outer space. SPACE SEEDS focuses on the peculiar botanical space travelers that have been bred, nourished, grown, eaten, and in some cases even brought back to Earth to repopulate our soils.



Space Seeds Introduction & Satellite Seed Savers

Genomic Gastronomy

An artist-led think tank that explores the organisms and environments manipulated by human food cultures. Based in Amsterdam and Espinho, Earth

Space seeds are agronomic astronauts. Some space seeds derive from plants that are trained for potential space travel but never reach their destination. Others come from plants that have made the off-planet trip and returned to Terra Firma, where their seeds, possibly mutated, are collected in the hopes of finding new breeds. Other space seeds are only ever propagated in synthetic growth mediums in satellite grow labs, generations of plants living and dying without ever touching down on Earth or being embraced in its soil. These are truly extra-terrestrial beings.

At the Center for Genomic Gastronomy we are particularly interested in the biotechnologies and biodiversity of human food systems. SPACE SEEDS collects stories and seeds of plant varieties that carry with them the genetic interventions—and the cultural imaginaries and longings—of humans who want to farm or eat plants in space.

For this issue we have commissioned a range of essays that provide context for these interventions and journeys, widening the view on the rather niche topic of agriculture in space.

OPEN SPACE CULTURE & TECHNOLOGY OR NOT AT ALL

In the early 2000s the signals that an open space culture was viable were on the rise. Texts and images from groups like the Association of Autonomous Astronauts (AAA), Arts Catalyst and MakroLab circulated on our webzines, in art journals and at the edges of classrooms. Conversations and meetings with researchers at the Indian Space Research Organization (ISRO) in 2007 opened us up to the possibility that even national space agencies could resist describing their mission statement in terms of military and economic might, and could rhetorically frame themselves as creating and deploying space technology to improve the lives of non-elites and non-humans that reside here on Earth. On the other hand, the lyrics of Gil Scott-Heron and the writing of Masanobu Fukuoka gave us pause.

"The scientists who rejoiced when rocks were brought back from the moon have less grasp of the moon than the children who sing out, "How old are you, Mr. Moon?" Basho could apprehend the wonder of nature by watching the reflection of the full moon in the tranquility of a pond."

What would prevent human activities in space from replicating the extractivist ideologies and practices that are here on Earth? With the explosion of commercial space activities funded by technology billionaires in the 2010's we turned our attention elsewhere for a decade. This book is our initial step back towards a critical examination of off planet imaginaries and dreams for an open space culture, starting with food, plants and seeds.

SATELLITE SEED SAVERS

There are many local and national seed saving programs that preserve the agricultural biodiversity of a place, but what happens when the place is space? Who will assemble, maintain and propagate plant varieties that have been grown in—or cultivated for—outer space?

Throughout 2023 the Center for Genomic Gastronomy hosted *Satellite Seed Savers* swap events* at various sites around the world. These pop-up exchanges were intended to foster a network of gardeners who grow, interpret, and preserve the seeds of edible plants that have been cultivated or eaten in outer space.

We hoped that each Satellite Seed Saver would create their own garden—be it on a whole field, small plot, raised bed, or window sill. These gardens would be sites for assembling and distributing off-planet agricultural biodiversity and directing the visitors' gaze upwards—connecting the plants in the garden to multi-species activities in the sky—asking questions about environmental stewardship in outer space and here on Earth.

Although many stories about agriculture in space involve proprietary technology, national space programs, and closed forms of knowledge, *Satellite Seed Savers* moves the focus away from the systems or people, and towards the plants.

In the summer and fall of 2023, a number of Satellite Seed Saver growers harvested and ate their own space plants. A few reported back that they saved seeds and shared them onward. You can find out more about the four seeds featured in year one of the program later in this book.

Satellite Seed Savers badge

**Satellite Seed Savers* workshops took place in Cēsis (Latvia), Kilkenny and Dublin (Ireland), Santa Cruz (USA) and Porto (Portugal). They took on slightly different forms in the various locations. We held a seed savers exchange in Dublin, Kilkenny, Porto and Santa Cruz, a *Satellite Seed Savers* banner making workshop at Butler Gallery in Kilkenney and a Space food inventing workshop for kids in Cēsis as part of the project "Art+Food+Next Generation." Thanks to all the organizations and participants who helped make this happen.

Satellite Seed Savers banner

Satellite Seed Savers seed packet

NCAD FIELD site, one of the locations that hosted Satellite Seed Savers

Plant List

An incomplete list of potentially edible plants grown in or for space

1971 **Moon trees (Pine, Douglas Fir, etc.)**
Apollo 14
Seeds irradiated in space to create new breeds, and to market space exploration

1975 **Scallions**
Salyut 4 Space Station
Grown for research and consumption (first space-grown crop eaten in space)

1982 **Thale cress**
Salyut 7 Space Station
Grown as a model organism for research (not consumed, though edible)

1984 **Rutgers California Supreme tomato**
Space Shuttle Challenger
Seeds irradiated in space to create new breeds, and to market space exploration

1995 **Super-Dwarf wheat**
Space Station Mir
Grown in order to test the root module and other growing instruments in space

2012 **Zucchini**
International Space Station
Grown as a DIY experiment in a ziplock bag and for companionship

2020 **Radish**
International Space Station
Grown, packaged, and shipped back to Earth for research and analysis

2020 **Lunar rice**
Chang'e-5 lunar probe
Seeds irradiated in space (the moon) to create new breeds for better grain production in China

2021 **Española Improved chile pepper**
International Space Station
Grown and eaten on tacos in space

20__ **Whole-Body Edible and Elite Plant**
Not yet deployed in space
A proposal by Chinese scientists for low-input, high-nutrient/yield, biotech-modified space crops

MIZUNA

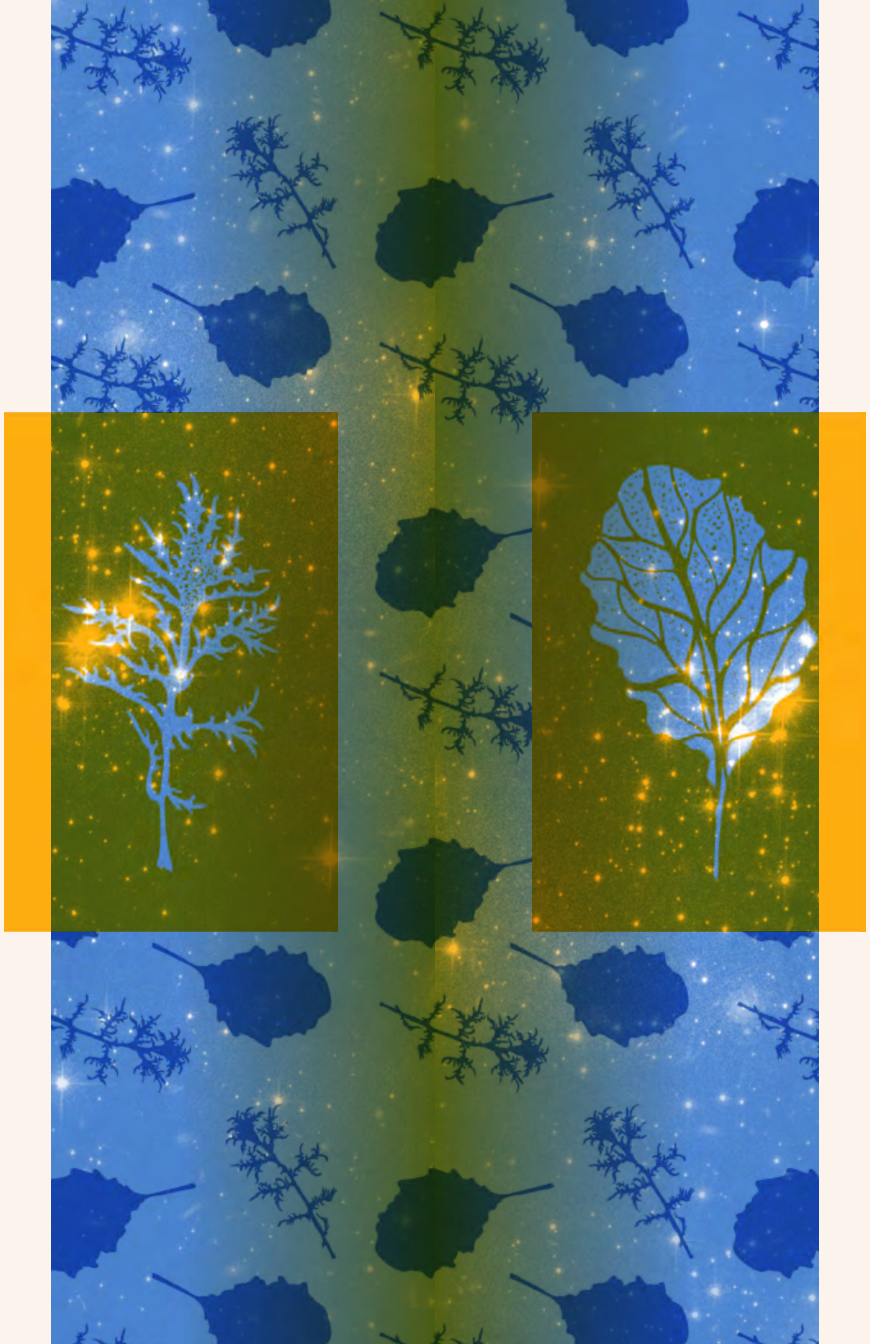
Brassica rapa var. japonica

Grown on the International Space Station in 2019 to demonstrate the potential of space agriculture, test the impact of various growing lights and conditions in the Veggie system, and to provide fresh greens for astronauts to eat.

GROWING & SAVING ON EARTH

Ready in ~40 days or baby greens can be harvested sooner. Sow outdoors from early spring to late summer. Succession sow every 2-4 weeks. Sow 5 mm deep in spring (1 cm in summer). Ideal germination temp is 24°C (7-28°C is OK). Sow seeds 2.5 cm apart in rows 45 cm apart. Thin to 15 cm apart. Seeds germinate in 4-7 days. Full sun to part shade. Loose, well-drained soil.

Flowering plants will form green pods. Let the pods brown and dry on the plant. Cut the plants and continue to dry the pods in a warm, well-ventilated room. Remove the seeds from the pods by banging the dried plants against a flat surface over a tarp. Place the seeds in a shallow dish and blow away the chaff (extra plant material). Store seeds in an airtight, dry, clean, labeled bag or jar. Keep in a cool, dark, dry location.



TOKYO BEKANA

Brassica rapa var. chinensis

Tokyo Bekana (aka "Space Cabbage") was trialed and grown on the International Space Station in 2017 as part of the VEG-03 experiment.

GROWING & SAVING ON EARTH

Sow indoors before March. Sow outdoors in March-October. Seed spacing between the row: 15-20 cm. Seed spacing in the row: 10-15 cm. Sowing depth: 1-2 cm.

Let the plant go to seed, forming pods that dry on the plant. Cut the pods when they are dry and brittle. Place the pods in a small cardboard box and hit them with a wooden spoon to release the seeds. Shake the box so the seeds settle at the bottom, then remove the chaff by hand or by blowing it away. Store in a dry, sealed bag or jar.

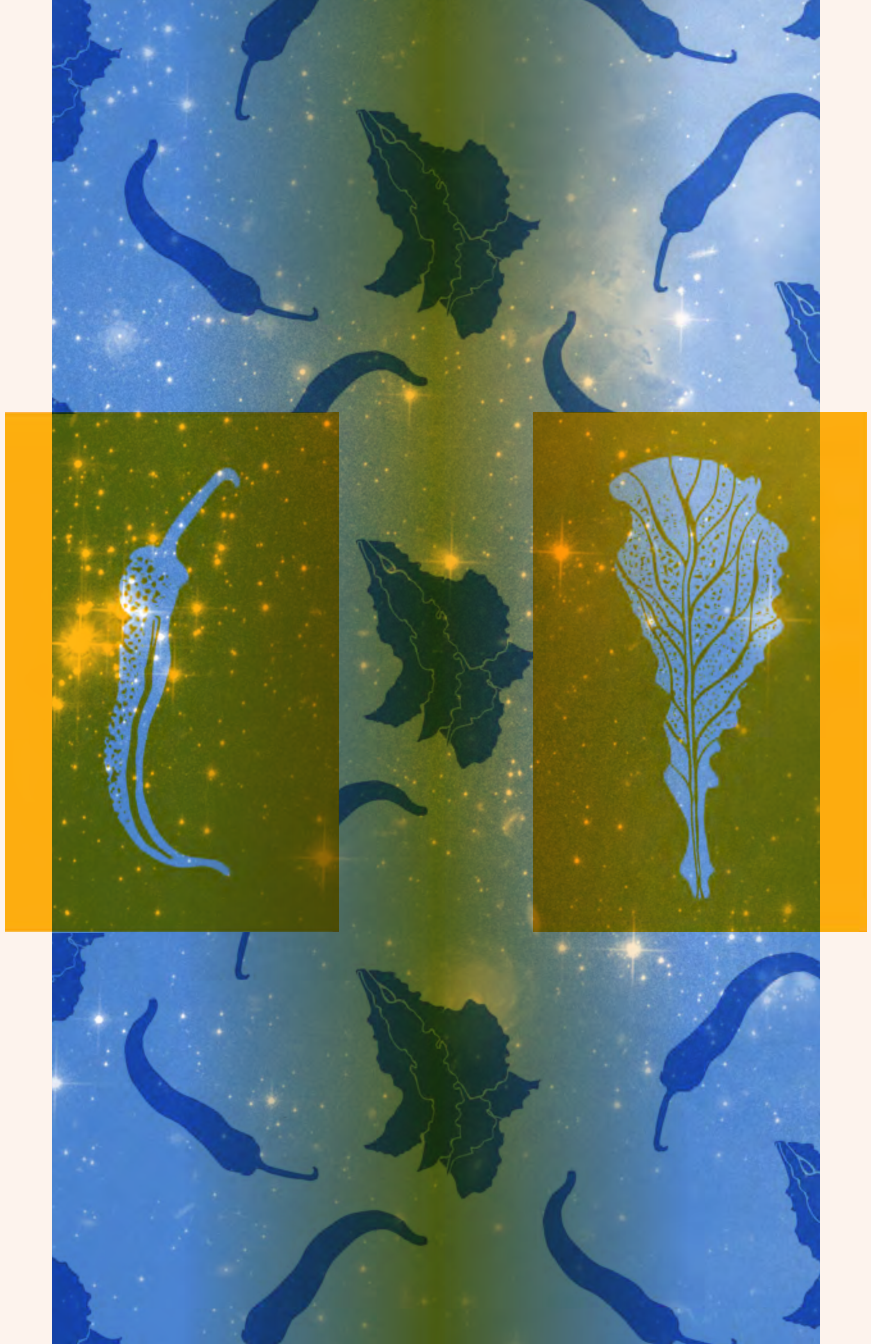
HANGJIAO SPACE PEPPERS
Capsicum annuum

In 1987, a Chinese space project was developed to send seeds into orbit on satellites in order to induce mutations via space radiation. There are 10 Hangjiao pepper varieties bred this way. We have collected 8: Corona, Solar Flare, Comet's Tail, Helix Nebula, Pulsar, Super Nova, Big Bang, and After Glow.

GROWING & SAVING ON EARTH

Start seeds 6-8 weeks before planting outside. Spread the seeds across starter mix and cover with a soil layer. Mist or water lightly until soil feels damp all the way through. Cover with a humidity dome. Place in a warm location (21-28°C) to germinate. Check daily for moisture levels and seedlings. Germination takes 7-14 days. Remove the plastic cover when seedlings appear.

To save, harvest a ripe, healthy pepper. Expose the seeds by cutting the pepper down the center. Scrape the seeds out with the knife onto a clean surface and let them dry for about 2 weeks (until hard). Store in well-sealed dry, clean, labeled jars or bags. Keep in a cool, dark place for up to 3 years.



OUTREDGEOUS LETTUCE
Lactuca sativa

NASA selected Outredgeous Lettuce to be the first grown and eaten by their astronauts in space. It has a red colour, bitter taste and low microbial growth.

GROWING & SAVING ON EARTH

50-55 days. 4-8 hours of Sun. Sprouts in 7-10 days. Ideal Temperature: 15-28°C. Seed Depth: 5 mm. Plant Spacing: 20 cm. Frost Hardy. Sow in thick bands for baby greens or space farther apart for head lettuce. Best grown as a spring or fall crop in most areas.

Once the plant bolts and the seed heads are dry and fluffy, cut the flower stalk, place the head in a paper bag, and shake it until the seeds come loose and fall into the bag. Place the seeds in a shallow dish and lightly blow away the chaff. Seal the seeds in a dry, clean, labeled bag or jar, and store in a cool, dry place for up to 5 years.

Diary of an Earth-Bound Astronaut

Mission Report from Cēsis Summer 2023

By Cathrine Kramer, Genomic Gastronomy

Saving seeds and growing edible plants is a core life skill every human should have. While you can "teach a man to fish," you might be better off teaching a person to grow plants, and I want you to teach me! As someone who has grown up in an urban context, this is not a skill I have innate at my fingertips. No green thumb here.

The part where you put the seed in the ground is pretty straight forward, but where I seem to fail more often than not is the part where you nurture and maintain a plant for long enough that the plant has a chance to grow strong and healthy - at least until I have a chance to eat it! Instead, my fickle brain forgets, neglects, over- or under-waters. Despite many attempts over the years, I have never had much luck with growing plants. But I don't think it is down to luck. It takes time, skill, dedication and focus. If I were to rely on my own growing skills to survive, I worry I wouldn't live very long. In many ways I live on planet Earth the way astronauts live in space. I rely on someone else to prepare and provide my food, shipping it long distances until it ends up on my plate. My food sometimes comes highly processed in plastic packaging, and I don't even know how to calculate the amount of energy it took for it to end up in my mouth. I am an Earth-bound astronaut. Many of us are.

I was talking to a Dutch science journalist who had a very healthy perspective on the fantasy of humans living off-planet. She said, "imagine the harshest place on planet Earth and what it would be like to live there. Then imagine you have no oxygen." While we can fantasize about traveling to outer space, I am not sure you want to live there. The view might be expansive, but I get the impression that life off-planet feels claustrophobic.

While some people believe that leaving planet Earth is the only long-term solution for human survival, I am under no illusions that long-term space occupancy is desirable, joyful or attainable. We might as well focus our energies on surviving and thriving here on this spaceship Earth we seem determined on trashing. So why, you might wonder, am I involved with the *Satellite Seed Savers* project? If astronauts can grow these plants in outer space, perhaps I have a chance at being a successful grower too. It turns out there have been a lot of seeds in space! Some in the name of research, others in the name of storytelling. There is something poetic and beautiful about growing a plant whose relatives have been in space. And while trying to uncover which plants have been there and why, we start to map the underlying assumptions and stories they carry with them.

Mízuna, Tokyo Bekana and Outredgeous Lettuce going to seed in a raised bed

Hangjíao Peppers, growing in a greenhouse / film screening structure

Seed Saver location:
Rucka Art Foundation, Cēsís, Latvía

Earth-bound astronauts vísíting and taste-testing the Satellíte Seed Savers garden

In addition to plants, another key element to human life on Earth that is often omitted from current space-faring realities and fantasies is the presence of children. Space shuttles and the International Space Station (ISS) are not designed for children to inhabit. A temper tantrum on the ISS could result in dire consequences. So, in the summer of 2023, I brought space down to Earth, creating a spaceship within Rucka Art Foundation in Cēsis, Latvia, enlisting some unofficial astronauts-in-training (aged 8-15) to imagine what life in space would look like for them. First they had to customize their space suits, infusing them with individuality and exuberance. Then they had to get on with the important task of creating space foods that would appeal to children in space.

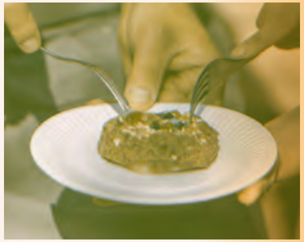
We started by discussing what foods they could not live without, their favourite dishes and flavours, and the current constraints of eating in space. Besides the few plant experiments which offer a bit of fresh garnishing (and water that is recycled from urine) all food eaten by humans in space is currently shipped from Earth. Our resident space expert, Angelina Bekasova, informed us that the current price for sending things to the ISS is about 3,000 euros per kilo. The kids invented new dishes inspired by their favourite foods, which ranged from chocolate to sushi. Their inventions were chopped, blended, and packaged in tubes and vacuum sealed bags, to be taste-tested by a panel of experts.* The inventions ranged from vacuum sealed cream cake to french fries in a tube, to be squeezed with ketchup and garnished with fresh Outredgeous Lettuce leaves, grown onsite.

Space exploration to this date has been made possible by a hyper-rationalist mindset, which aims to have complete control over every last detail and where efficiency reigns supreme. When you start to add children, biodiversity and the chaos of everyday life into the techno-utopian narratives of living off-planet, you start to get a lot more interesting and complex stories, even if they remain pure speculation and fantasy for now. If you are reading this and think “impossible - space exploration needs to be founded on rational thinking,” ask yourself: is that a place you would like to live? We might be able to survive, but to thrive we need a little bit of unpredictability and playfulness.

So, while I hope that those imagining and designing life off-planet expand their horizons and invent systems that include children, biodiversity and play (not just aging billionaires), for now I will focus my energies on becoming less of an astronaut on planet Earth. I will concentrate on appreciating and understanding the systems that we rely on for our continued survival, from the trees that breath our carbon to the soils and waterways that nourish us.

*The tasting panel consisted of Angelina Bekasova (from Innovation and space policy at the Ministry of Economics of the Republic of Latvia), Zane Cerpia (curator and initiator of the Art+Food+Next Generation residency) and Ēriks Dreibants (chef from the restaurant “Pavāru Māja”).

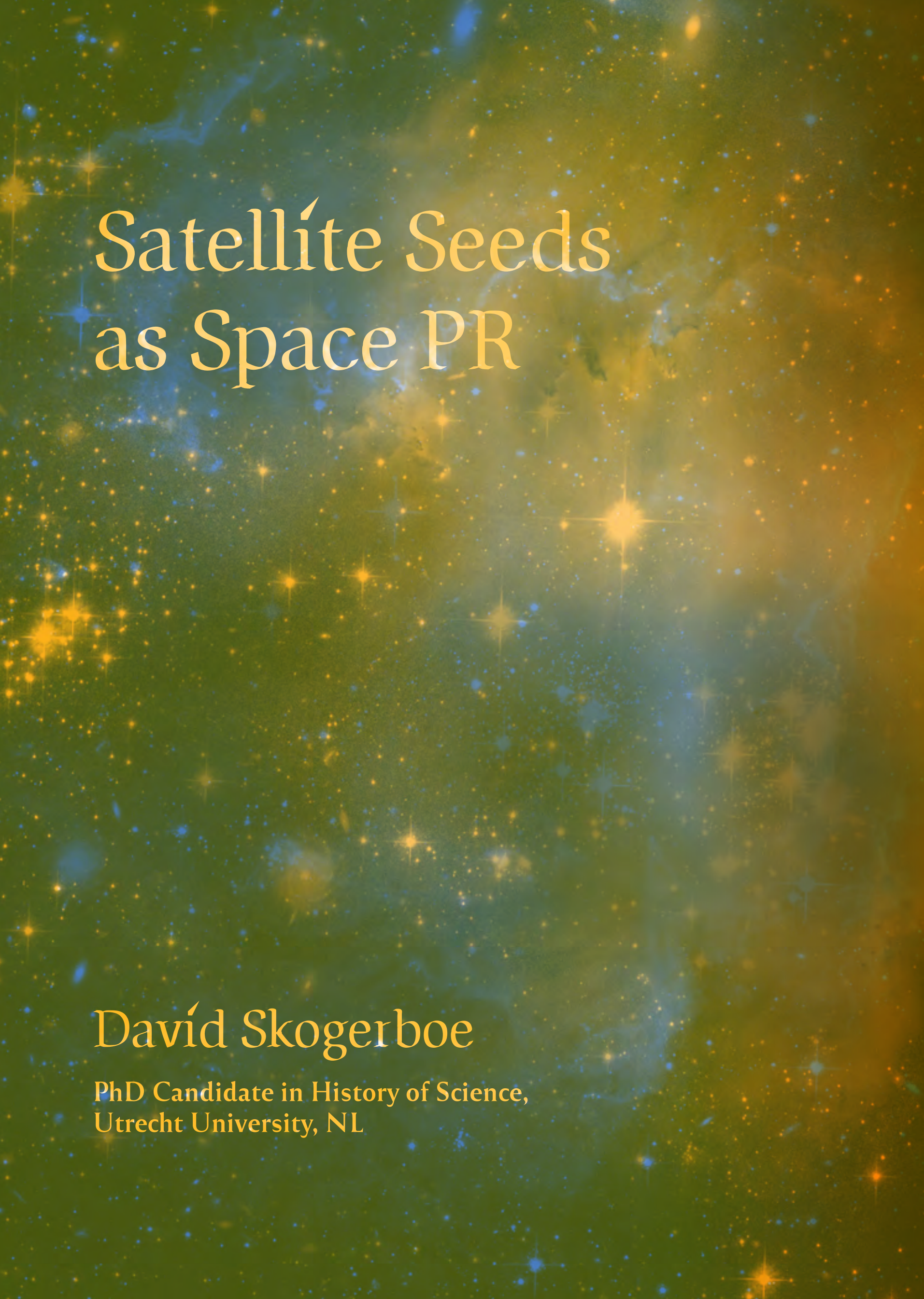
Cookie in a tube:
Oreo blended with
fresh strawberries



Chocolate Sushi Powerbar

The making of a vacuum-sealed cream cake

Sublimated (freeze dried) ice cream and fruits provided
by space food company "Cryogenic and Vacuum Systems"
and prepared by Chef Ēriks Dreibants



Satellite Seeds as Space PR

David Skogerboe

PhD Candidate in History of Science,
Utrecht University, NL

Long before both satellites and humans orbited the planet, such endeavors were feats of the imagination. The first known imagining of both an artificial satellite, and a space station, can be found in American author Edward Everett Hale's short story *The Brick Moon*, published across several installments in *The Atlantic Monthly* in 1869. The story depicts the creation and launch of a 60 meter (200 foot) artificial Moon, made of bricks, that would orbit the planet as a navigational beacon for mariners. When the Moon was completed and sent into orbit, it unknowingly had people on board who created a tiny society that farmed food (Fig. 1). From the first imaginings of travelling to, and living in space, the necessity of food has meant that seeds have implicitly come along.

While today satellites and space stations are no longer relegated to fiction, reliable food production in orbit remains elusive. And any far future imagining of a long-term/long-distance human existence in space nearly always features a life support system that includes plants, grown from seeds, providing a food source, essential nutrients, oxygen, and, it could be argued, psychological well-being. As former NASA administrator Thomas Paine argued at the 1984 Case for Mars conference, "when space navigation and closed-ecology life support technologies have been mastered, Mars will be settled."[1] Now consider the 2015 film The Martian, and the vital role potatoes played in (botanist!) Mark Watney's survival within "The Hab"

(Mars Lander Habitat), and the necessity of plants in space seems to be a collectively shared imaginary. It thus makes sense why nearly every space agency across the planet, from NASA to JAXA, has invested in researching the effects of the space environment on seeds and plant growth. The mission patch for the 2006 TROPI experiment–which studied the effect of microgravity on seedling root growth aboard the International Space Station (ISS)–represents this internationally recognized reality (Fig. 2).[2]

Aside from the clear scientific prerogative, however, it can be argued that such seed experiments serve a greater purpose for the many publicly funded space programs–they provide inexpensive yet effective Public Relations (PR). Many space programs, with NASA as the clearest example, are funded through ever shifting percentages of tax payer resources.

As a result of such an arrangement, space programs must constantly communicate their value with the public. Grand media spectacles like the Apollo Moon landings went a long way in this respect, but they were proven to be unsustainably costly. Enter seeds: lightweight, and thus inexpensive to launch, and bring back; tangible, and able to physically connect the public to endeavors in space; and inspiring, a way to encourage future generations to pursue space science. Oh, and scientifically pertinent to boot.

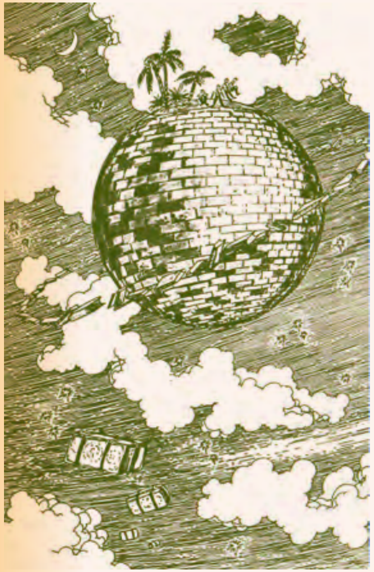


Fig. 1: Image of The Brick Moon from the NASA archive

Fig. 2: TROPI Mission Patch

Space seeds entered into the public consciousness during the Apollo missions of the early 1970s. In an effort to find new ways to engage the American public with NASA's endeavors, Apollo 14 Command Module pilot Stuart Roosa brought a metal canister with hundreds of Pine, Sycamore, Sweetgum, Redwood, and Douglas Fir seeds into lunar orbit. Upon returning to Earth, the seeds were germinated and strategically dispersed throughout the US (with several reaching Brazil, Switzerland, and Japan, among others). These seedlings became the "Moon Trees."

Many are alive to this day, and most have an accompanying plaque that reminds shade seekers that the tree was grown from seeds that traveled to the Moon (Fig. 3).[3] NASA is again repeating this PR exercise, producing a new set of Moon Trees grown from seeds that orbited the Moon on the recent Artemis I mission in late 2022. In NASA Administrator Bill Nelson's words, "...this new generation of Moon Trees will plant the spirit of exploration across our communities and inspire the next generation of explorers."[4]

Seeds as space PR has remained a recurring theme. In April 1984, the Space Shuttle Challenger deployed the Long Duration Exposure Facility (LDEF)–a satellite that carried 57 experiments on the effects of the space environment. This included SEEDS, or Space Exposed Experiment Developed for Students. Done in partnership with the Park Seed Company of South Carolina, 12.5 million Rutgers

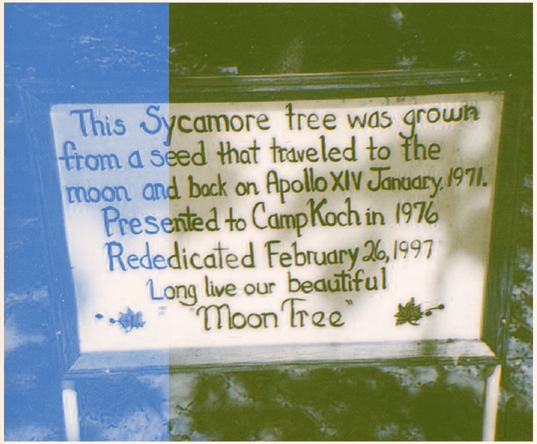


Fig. 3: Signage under the Moon Tree at the Koch Girl Scout Camp in Cannelton, Indiana.

tomato seeds were sealed in five metal canisters aboard the satellite (with an equivalent number of control seeds kept on Earth).[5] The goal was twofold: To determine the effects of an extended time in space on germination, growth, and mutation rates, and "to generate interest in science and to provide students with experimental opportunities using materials flown in space."[6] In January 1990, after 69 months in orbit, the LDEF was picked up by the Space Shuttle Columbia and returned to Earth. Shortly thereafter, NASA distributed 132,000 SEEDS kits to over 40 thousand classrooms housing over 3 million students ranging from kindergarten to university (Fig. 4). This is quite a significant footprint on Earth for such a small payload in orbit.

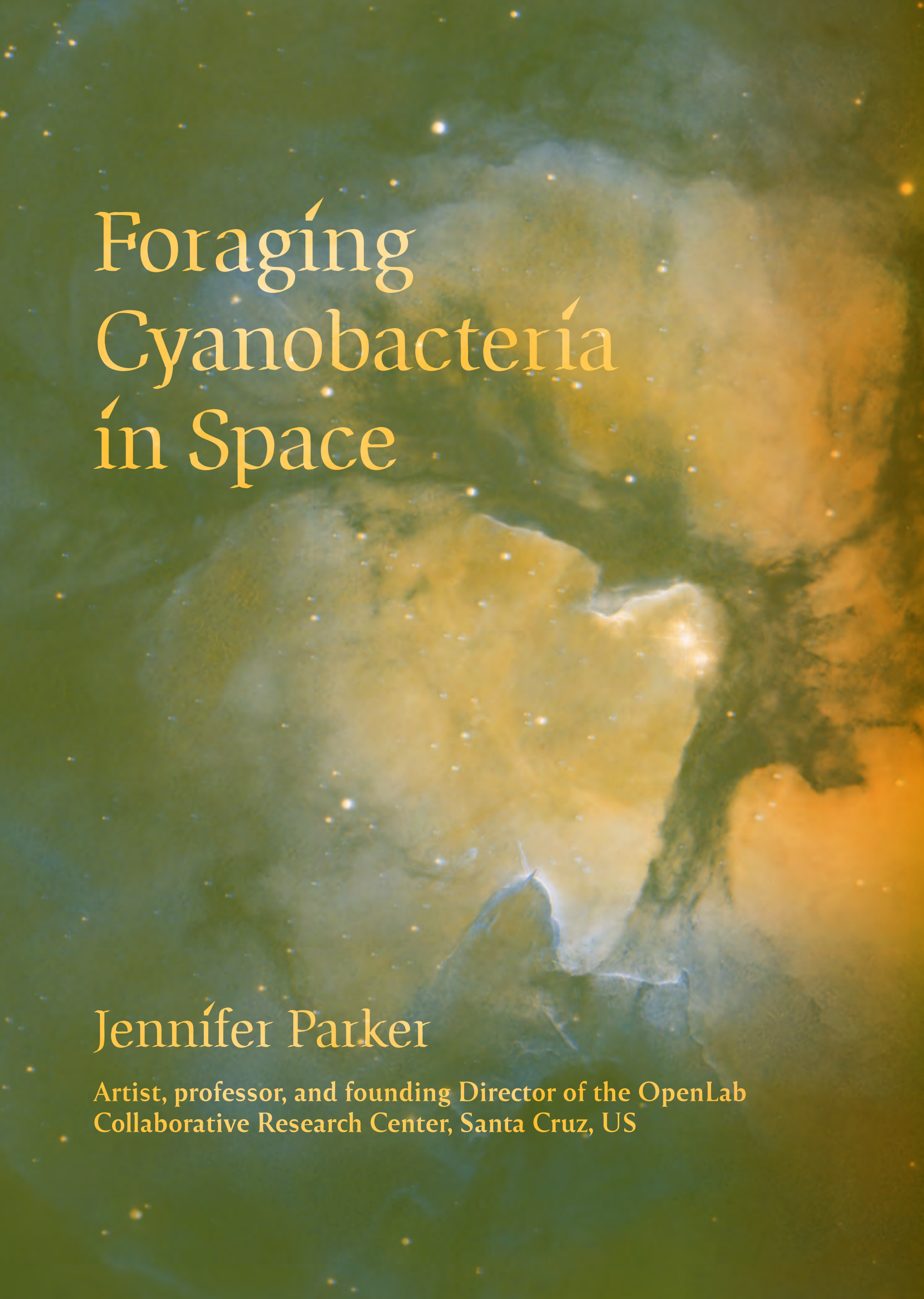
SEEDS provided a fruitful blueprint for combining space research with PR – one that the emerging space nations have emulated. For one example, the "Space Seed for Asian Future" program is a collaboration between Japan, Indonesia, Korea, Malaysia, Thailand, and Vietnam with a vision similar to its predecessors–most notably to bring seeds housed in the ISS back to Earth, and disperse them to students of all ages to conduct experiments and inspire future space scientists (Fig.5).[7]

All told, from the earliest imaginings of leaving Earth to the creation of space seed projects, there is a collective cultural and scientific understanding that plants are an essential element in any human future in space. But the

reality is that such a future, if possible at all, is still likely generations away. For those invested in maintaining forward progress toward such a future, life-support systems must be perfected, tax payers must be appeased, and future space scientists must be recruited. Seeds have become a valuable tool in addressing all three.

Fig. 4: Park Seed Kit

Fig. 5: Mission Patch for Space Seed for Asian Future by MYSA and JAXA



Foraging Cyanobacteria in Space

Jennifer Parker

Artist, professor, and founding Director of the OpenLab Collaborative Research Center, Santa Cruz, US

The possibility of life beyond Earth has been tantalizing for centuries, and recent scientific discoveries have rekindled our curiosity. One of the most intriguing findings is the presence of microfossils resembling cyanobacteria on the inner surfaces of certain meteorites. This revelation has profound implications for our understanding of the origins of life and the potential for life elsewhere in the universe. Cyanobacteria, a photosynthetic bacteria on Earth for approximately 3.5 billion years, have been pivotal in shaping our planet's atmosphere.

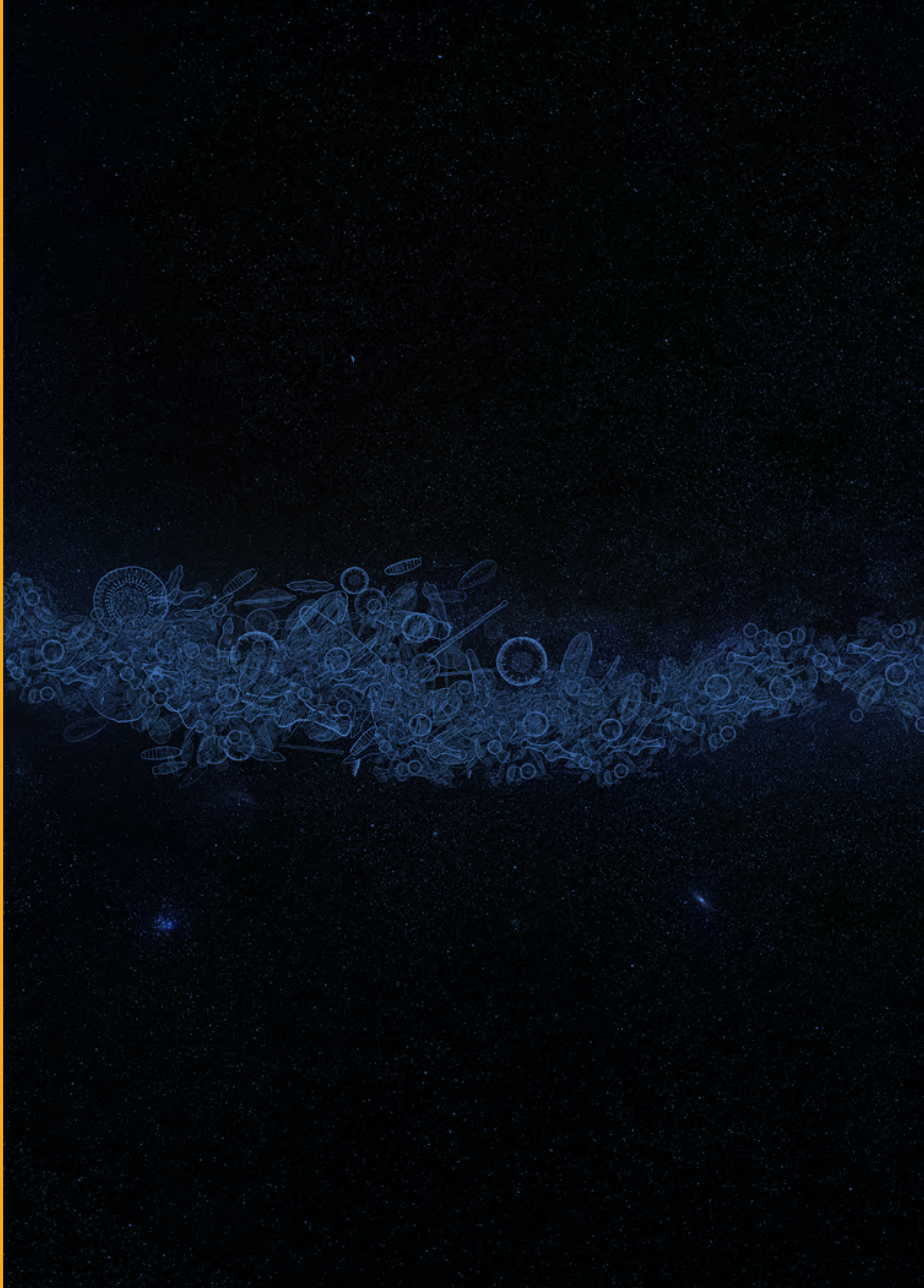
Cyanobacteria are ancient organisms with an incredible legacy. They are Earth's oldest known oxygen-evolving organisms, responsible for transforming our planet's primitive atmosphere into the oxygen-rich environment we know today. Over billions of years, these remarkable microorganisms have contributed to the development of complex life forms by introducing oxygen into the atmosphere, which was essential for the evolution of aerobic organisms. This process, known as oxygenic photosynthesis, remains one of the most significant events in the history of life on Earth.

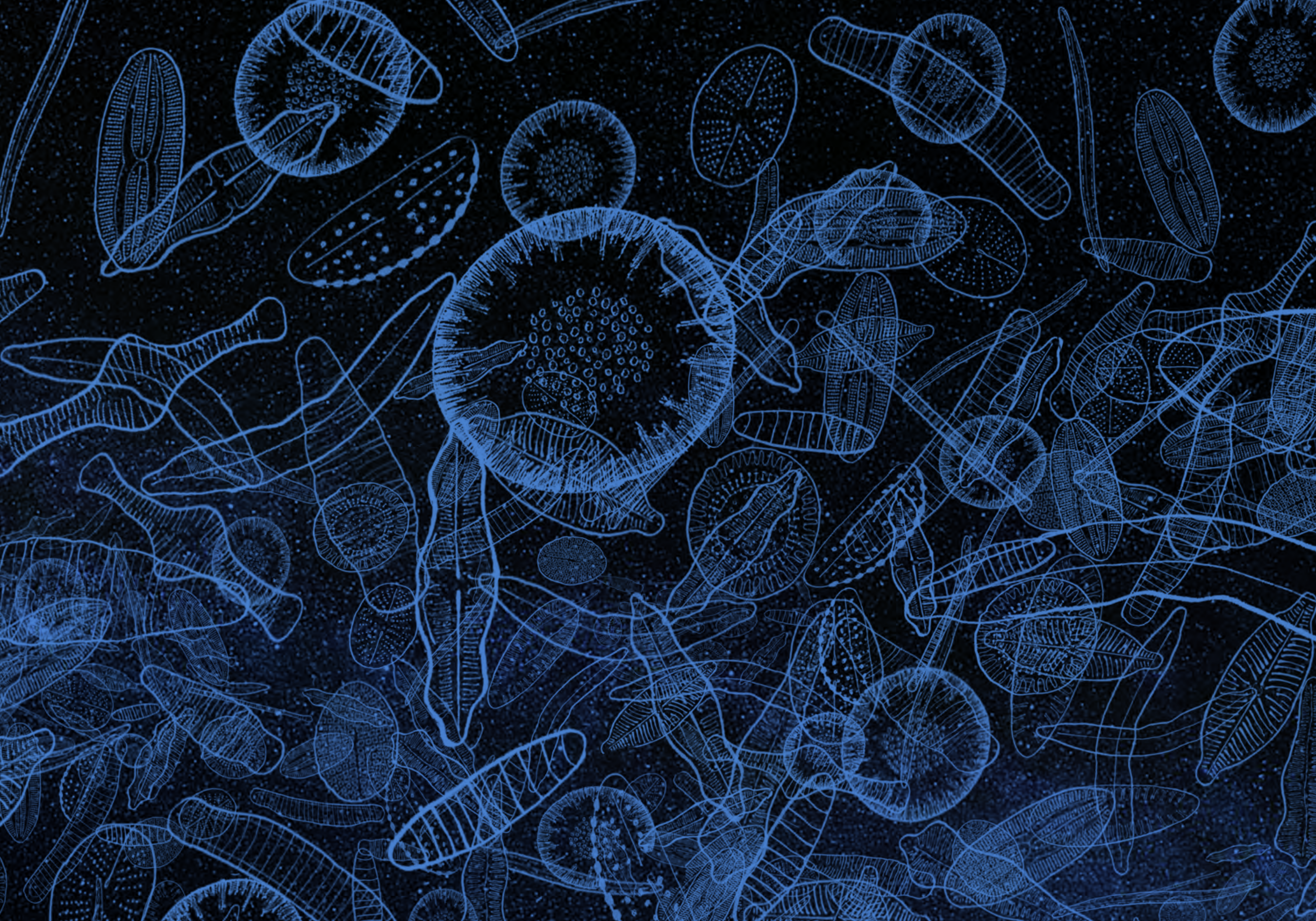
The discovery of microfossils resembling cyanobacteria on the surfaces of meteorites has ignited the imaginations of scientists and space enthusiasts alike, raising the possibility that life may not be confined to Earth. If these microfossils are of biological origin, they could represent the first concrete evidence of extraterrestrial life. However, the debate over the authenticity of these microfossils continues, with some scientists suggesting alternative explanations for their formation. Studies are ongoing, and further research is necessary to confirm their origin definitively.

The connection between cyanobacteria and space exploration extends beyond the mere discovery of microfossils. It leads us to contemplate the broader context of soil microbial communities, and their role in existing space imaginaries such as "sustainable space colonization" and "space permaculture."* In the context of space exploration, maintaining a sustainable environment for extended missions or colonization of other celestial bodies is a formidable challenge. Many questions about sustainability shift when one's perspective drifts off-planet. What is being sustained, for whom, and for how long? Is there a difference between the terms "sustainable" and "regenerative" when it comes to farming in space? How do we "sustain" or "regenerate" when the off-planet biological systems to nurture, maintain or exploit are unknown? If off-planet cyanobacteria exist, will humans act as good stewards as we introduce other biological processes and systems?

Would-be space farmers aim to develop self-sustaining ecosystems in space by harnessing the principles of ecology and biology. Soil microbial communities, including

*One description for establishing permanent off-planet agricultural systems that are regenerative (and cultivated with human eaters in mind) could be "Space Permaculture." Space Permaculture is a concept developed and debated by Genomic Gastronomy during their Planetary Indigestion artist-residency hosted by OpenLab and supported by the Genomics Institute at the University of Santa Cruz 2021-2022.





Artwork description

Habitable Zones: We Live in the Milky Way #1-5 2023

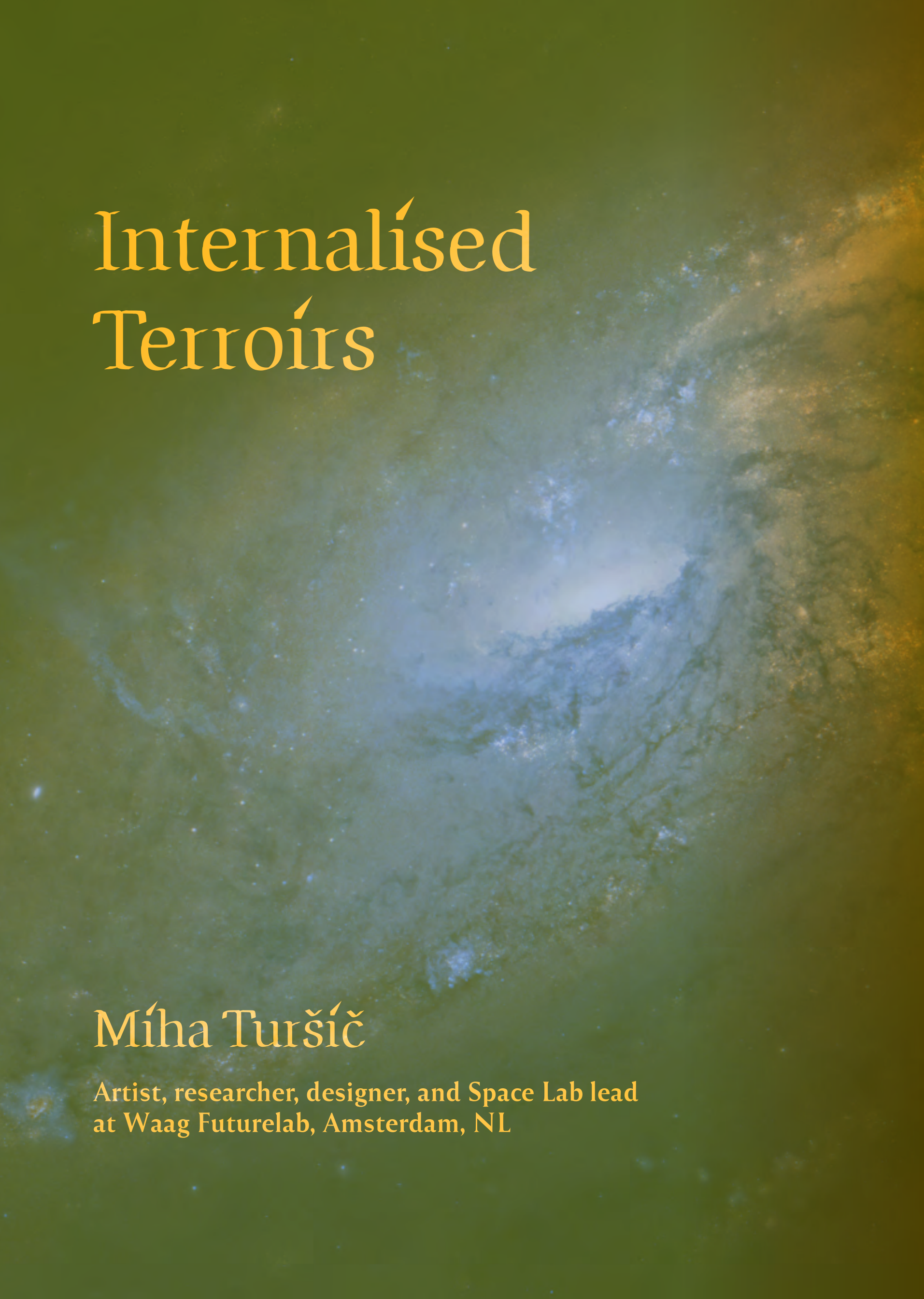
An artwork symbolizing the union of micro-organisms on earth with the vastness of the Milky Way, suggesting the presence of algal remnants in space.

24 x 48 inch print created with a live feed of pictures, taken by an Imaging FlowCybot (IFCB)* of diatoms and dinoflagellates in the Pacific Ocean, collaged onto a 360º Panorama of the Milky Way by ESO/S. Brunier GigaGalaxy Zoom project, to imagine silica remnants of an algal bloom in space.

***The Imaging FlowCytobot is an in-situ automated submersible imaging flow cytometer that generates images of particles in flow from the aquatic environment. Parker used the IFCB in Professor Kudela's Lab to create drawings based on dinoflagellates found in the Eastern Pacific Ocean coastal region—special thanks to Karina Molina, OpenLab intern, for outlining the image data set.**

cyanobacteria, are essential to these ecosystems. They are crucial in nutrient cycling, carbon decomposition, and maintaining the soil's overall health. In particular, roundworms, the most abundant soil invertebrates, contribute significantly to these processes through their interactions with bacterial communities. Understanding and harnessing the potential of these microorganisms in space environments as future habitable zones raises critical ethical concerns related to extractive practices of resources on Earth. These practices include the withdrawal of materials from the environment for human use, such as fossil fuels, rocks, minerals, biomass, and water, leading to unsustainable practices that have radically altered the planet and the climate. The effects of these resource extractions include decreasing soil quality, increased erosion, reduced nutrient levels in terrestrial ecosystems, the destruction of habitats, and increased pollutants and waste released into the environment.

One can easily envision a hypothetical future of foraging bacteria in space. Cyanobacteria and other soil microbes could be engineered to thrive in extra-terrestrial environments, providing essential nutrients and oxygen while serving as a food source for future space colonists. Such a concept aligns with the principles of sustainability and self-sufficiency, which are crucial for the success of space missions and colonization, but do they align with principles of regeneration or good extra-terrestrial stewardship?



Internalised Terroirs

Miha Turšič

Artist, researcher, designer, and Space Lab lead at Waag Futurelab, Amsterdam, NL

10 years ago, I visited Krasnoyarsk, the second largest city in Siberia. It was December, with temperatures reaching 25°C below zero. After a lecture on space culturalisation that I gave to the students of astronautics, my host said he had a surprise for me. We got in the car and drove for about 15 minutes to finally stop at one of those generic research office buildings from the 1960s. After a short wait, we were met by an employee who took us to the basement.

Hidden there, unassumingly, was one of the iconic projects that I had read about while studying my favourite topic, space ecology. It was the BIOS-3 enclosed environmental system from the early 1970s. The person who gave us the tour was none other than Dr. Alexander Tikhomirov, a leading expert on closed ecological systems and the director of the facility.

The whole experience was of course uniquely exhilarating, but what struck me most was a piece of information Alexander shared. Based on their experiments carried out in the 1970s and all the modelling that followed, he said that we still don't have the knowledge required to construct a closed life support system that could include humans in the long run. Even the International Space Station, which resembles an enclosed living system, receives most of its resources from Earth.

Not long after, I invited Dr. Christophe Lasseour for a talk at the "Earth Without Humans" conference in Slovenia. He is a good friend of Alexander and one of the leading researchers of the European MELiSSA project, which develops regenerative life support systems for long term space missions. The day after the conference, we went for a trip to the Škocjan karst caves, an example of a unique ecosystem "closed off" from surface life.

Naturally, we discussed possible settlements in outer space, where his main concern was not life support in these remote, hazardous or even deadly environments, but more the opposite—*the contamination* of outer space with terrestrial microorganisms. With just a few people on the Moon or Mars, peoples' companion species would quickly leak. "Life finds a way" via unexpected paths; like the *Tardigrades* which spilled on the Moon surface after the Israeli Beresheet lunar lander crash, or the *Tersicoccus phoenicis* bacteria found only in clean rooms in space labs.

It was insights like these that led me to work with Antti Tenetz, a bioartist from Oulu, Finland. At Waag,* and in collaboration with the European Space Agency (ESA), we organised the Supre:organism art-residency during which he developed an artwork on imagining bacterial life travelling and settling the Moon. There are organisms that do not require technology to survive in outer space conditions with extreme temperatures and radiation.

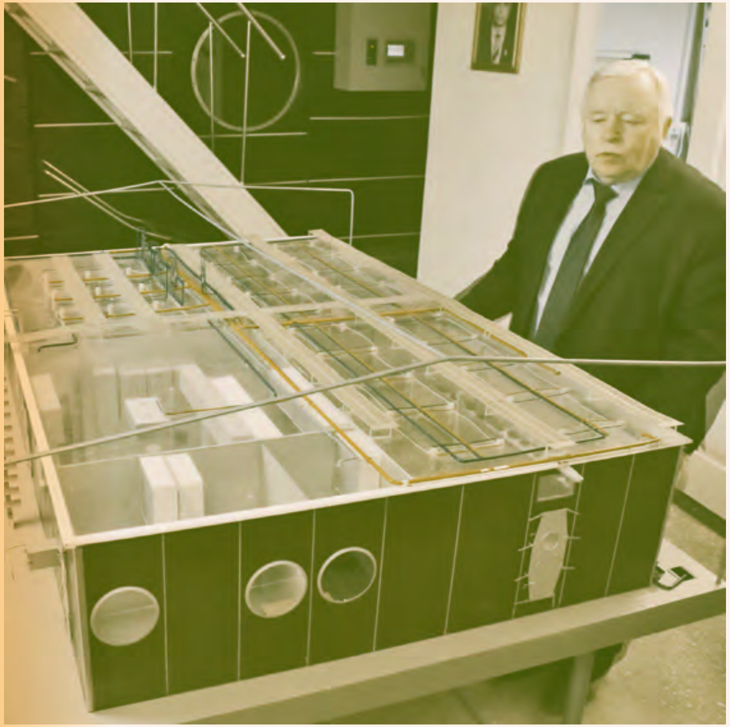


Photo taken by Míha Turšíč on vísít to BIOS-3

* Waag is a futurelab for technology and society based in Amsterdam.

He proposed that metal-digesting bacteria settle on the Moon as a pioneer species and built a prototype of their speculative habitation that was displayed at the exhibition.

It's through these experiences that I contemplate the concept of the *outer space terroir*. Article IX of the planetary protection policy, which is part of the Outer Space Treaty from 1967, addresses the necessity to lower the probability of contaminating outer space with terrestrial life and, vice versa, of the Earth by possible alien life. Such regulation fundamentally conditions any attempt of outer space food production as contained, controlled, sterile and free of external environmental influences. All space plant and food growing experiments run in sealed environments and, as such, very much relate to controlled food production landscapes in Dutch Westland or Spanish Almería. Peter Sloterdijk describes these growing environments as the *Weltinnenraum* (world interior), encapsulating both nature and culture into a planetary-scale glasshouse.[1] In this context *outer space terroir* becomes a sterile *internalised terroir*.

Internalised worlds like the former Crystal Palace in London or Biosphere 2 in Arizona appeared mainly as *membrane architecture*. Bruno Latour observes such internalisation through the anthropological study of life science laboratory practices,[2] which claim to study nature, yet all the observed processes are taken out of the context of their environments.

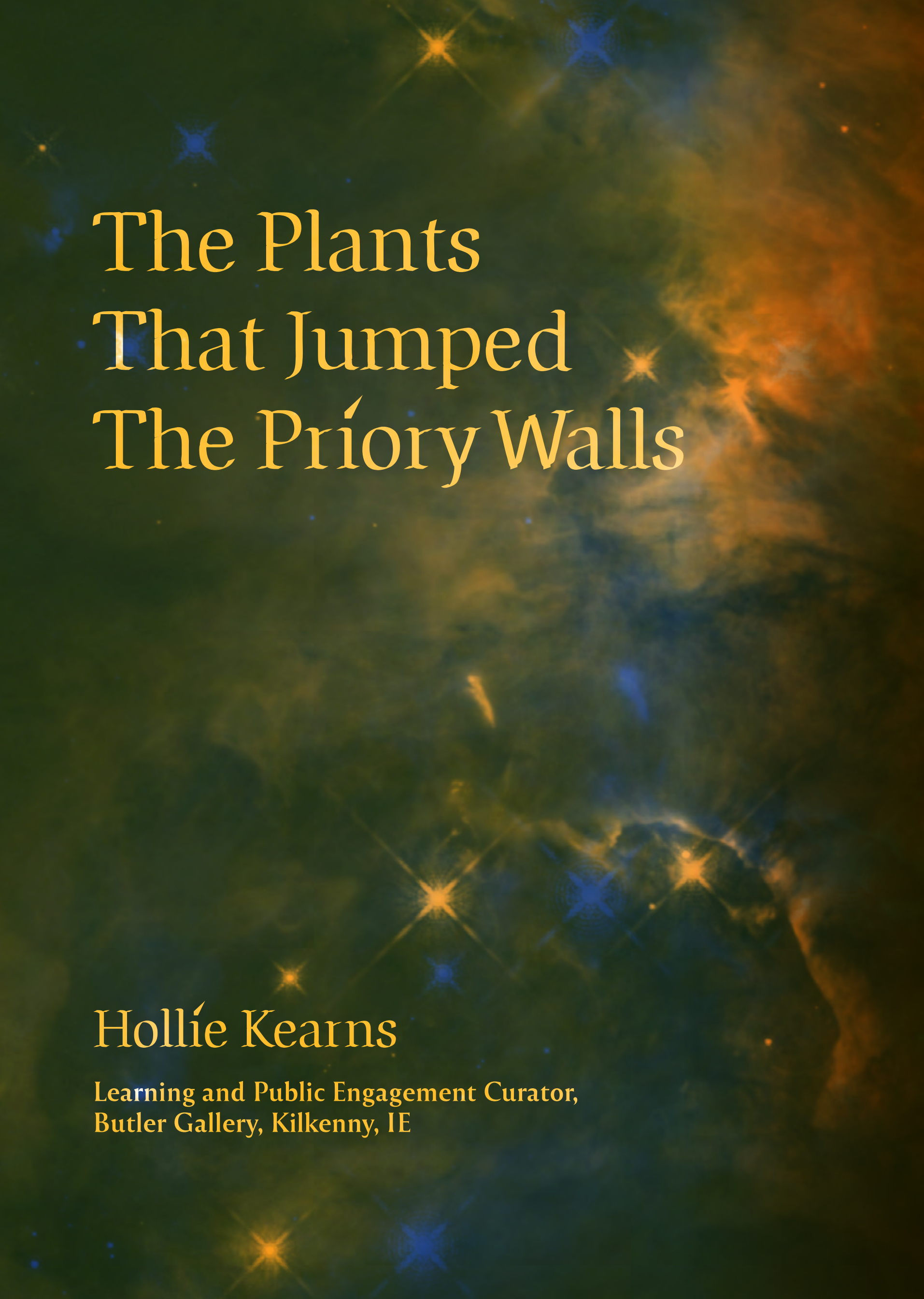
Photo taken by Miha Turšič on visit to BIOS-3

Today's containment of life has transitioned into another level of internalisation: the *digital twins* of our worlds on the scale of planet computation, smart cities, pixel fields, and other complex adaptive systems.

If we expected the *outer space terroirs* to be a type of *xeno*-wilderness as portrayed in the early Georges Méliès film *Le voyage dans la lune*, we find them reduced to utterly limited technoscientific imaginaries. Plants in space research are robbed of their agencies and reduced to model plants or useful resources. Some are even genetically designed to be part of these closed model systems and would not survive outside of them. These *internalised terroirs* not only alienate plants from their surroundings but also make them alien by their internal design. They are more an analogue of speculative Martian or Lunar settlements on Earth than of Earth's environment in outer space.

The dominant space community's narrative claims "Space for Earth" benefits humanity, yet it reduces the understanding of liveable environments to something contained, sterile, and controllable. Although planetary protection supposedly protects Earth from external contamination, it nevertheless leaks interests that are alien to existing terrestrial life. Internalised terroirs, both those in outer space and those on Earth, are a case of such alienation. With plants subjected to the control of scientific methods and commercial productivity, terroirs are transitioning from being defined by ecological conditions to being defined by scientific and market interdependencies.

From this perspective outer space terroirs do not appear as fancy *xeno*-gardens, but utterly controlled environments with capacities defined by interests alien to the actual messiness of life.[3] If we would seek more Earth-like terroirs in outer space, then they would have to be designed through contamination and not containment.



The Plants That Jumped The Priory Walls

Hollie Kearns

Learning and Public Engagement Curator, Butler Gallery, Kilkenny, IE

Like many other cultural phenomena, the plants that we cultivate and eat hold up a mirror to our society. When I first invited the artist group Genomic Gastronomy to work with Butler Gallery as part of *The Soil Project* commission, the story of “Satellite Seed Savers” led us to discuss another story, about another society which is significant to Butler Gallery. In 2020, Butler Gallery relocated to Evans’ Home by the river Nore in Kilkenny, a site that was established as an Augustinian Priory by Norman lord Sir William Marshal in 1240. It hasn’t been in private ownership since, and Butler Gallery is proud to be able to tell the stories of this site through contemporary visual art.

As we moved to the new site, *The Soil Project* emerged as a compelling annual commission and part of the Learning and Public Engagement programme. The soil, we’ve found, is a catalyst for contemporary storytelling as both a physical receptacle for our past and the rich substance of our existence on Earth. What a brilliant counter-reflection to the international and extra terrestrial practices of the International Space Station growing programme.

So, let’s set the scene: in the 1100s, Ireland was a feudal society of Gaelic Kingdoms and Celtic Christianity. The practices and culture of the people intertwined an understanding of the landscape; its flora and fauna, with both Christian principles and epic folklore. The people had an understanding of which native and indigenous plants nourished and healed. Plants were very important in ancient Irish laws and the Brehon laws described penalties for cutting certain trees or bushes, or for foraging on someone else's land, although urgent medical uses were allowed. Whilst the records we have don't mention herbs by name, they do mention wild plants that can provide food, especially fruits.

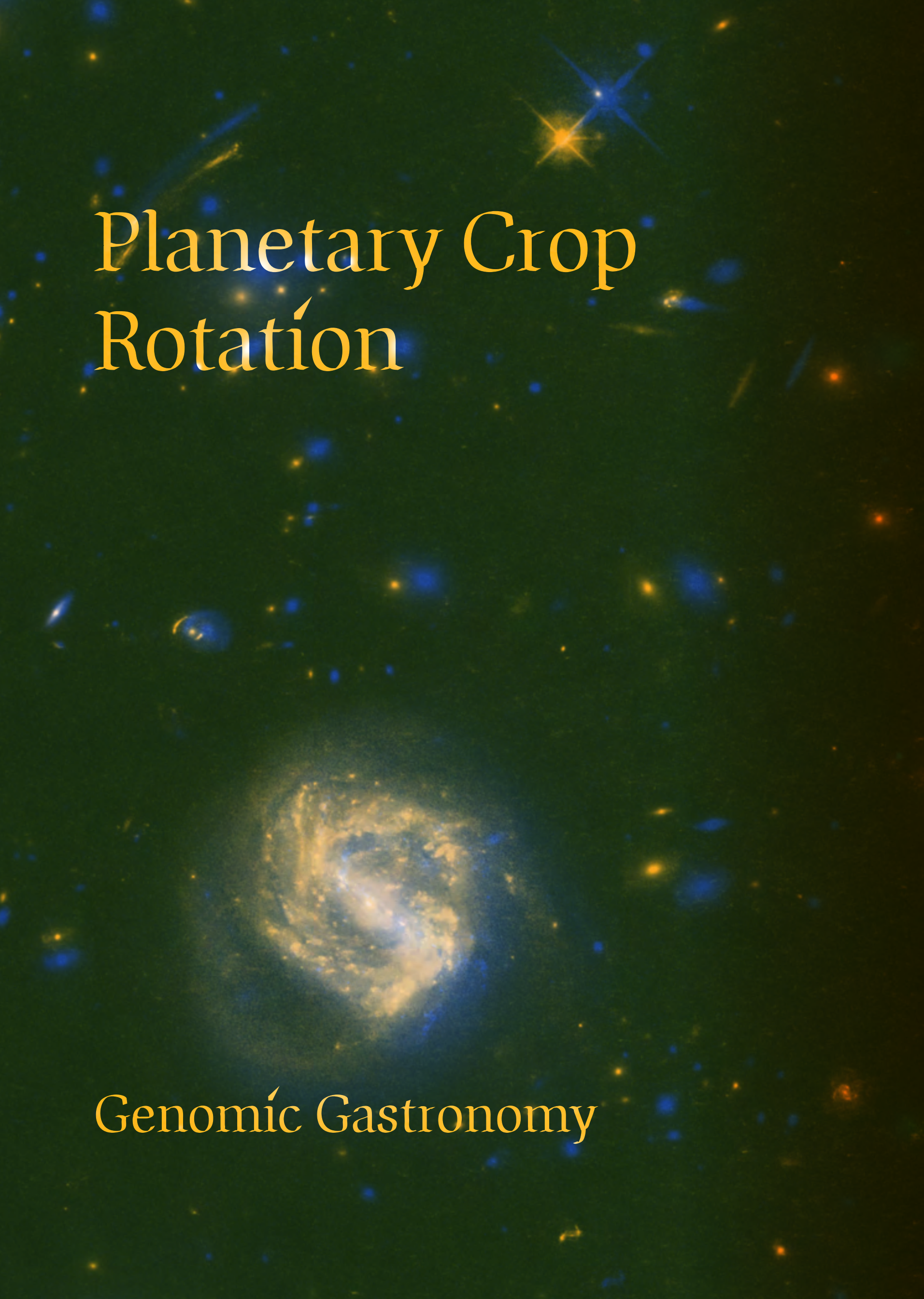
Dian Cecht was the pre-Christian Irish god of medicine. Legend says that he killed his son Miach and out of his grave grew 365 herbs, each one related to a part of the body (365 was a common division of parts in the old Irish understanding of the body). During this same battle Dian Cecht is said to have gathered every herb grown in Ireland and put it into a healing well. All the dead soldiers were put into the well and emerged alive the next morning. Herbal baths were frequently mentioned in Irish mythology. By the medieval period, medical practices treated the 'humours' (cold, hot, moist, and dry), and also looked to superstition, astrological, religious and folkloric conceptions of plants.

The Christian orders employed indigenous wisdom to cultivate gardens that were useful in their mendicant practices of tending to and caring for their communities. The earliest historical references relate to the 'lubgort' or enclosed herb garden. The lubgortoir was the gardener and one of the seven offices of the church in early Christian

monasteries. Monasteries and old Irish texts promote the use of salads and vegetables as well as herbs for health.

During this time, Latin medical texts from Europe travelled to Ireland and disrupted this local knowledge of local herbs. Monasteries mainly used the book 'Materia Medica,' a 1st century book written in Greek by physician Dioscorides who described the properties of over 500 herbs. This emphasis on Greek and Roman texts led to an emphasis on Mediterranean herbs and plants over indigenous – separating the hierarchies of knowledge between the folk traditions and formal cultivation. Plants like nettle, fat hen and good King Henry went out of use in favour of plants like parsley, sage, rosemary and thyme, and began to be seen as garden weeds.

The Augustian Priory closed in 1642 after the order of the dissolution of the monasteries. Part of the disruptive story of our nation's history is that we have no continuous tradition of cultivation or medical practices, so there is a task in relearning from the land. What we have been learning through the activities of *The Soil Project* over the last four years is the microbial value of the soil with its own set of cultural and philosophical implications of non-binarism and entanglement. In a critique of our post-modern, post-global society, Bruno Latour has argued that beyond the Global and the Local we must now think of, and connect to, the 'Terrestrial'. We must "land somewhere" with the entanglement of soil but without the nationalistic implications of 'blood and soil'.[1] It's a way to think through not just the environmental, but also the societal impacts of the current climate crisis. In this vane, this summer, in my own kitchen, I fermented re-terrestrialised Hangjiao 3 Solar Flare Space Peppers into a jar of hot sauce, rich in the microbial activity of my own backyard soil.



Planetary Crop Rotation

Genomic Gastronomy

Tonight as you look to the stars, perhaps amidst the Big Dipper or Cassiopeia you'll see the dim string of the Starlink Satellite Train coasting through the sky. The chain of 22 recently launched satellites has become part of the Starlink mega-constellation—as of today, about 5,000 small satellites in low Earth orbit, theoretically providing high-speed internet to every remote corner of the world.[1]

Starlink is a project by SpaceX, the private aerospace company owned by Elon Musk. Aside from satellites, launch services, and government R&D contracts, SpaceX has a grander ambition of “making life multiplanetary.” In addition to rural broadband internet, the SpaceX website ambiguously offers human space flight missions that bring customers into orbit, or to the Space Station, Moon, or Mars.[2] Obviously, these rides to Mars aren’t available (yet), but SpaceX’s speculative galactic cruises—and multiplanetary living—are vivid imaginaries, shaping the future of space exploration.

SpaceX isn’t unique. Today some of the loudest visions of space exploration come from private space corporations, often founded by tech billionaires and based on consumption and colonization narratives, dominated by an engineering approach and extraction mindset. Jeff Bezos, owner of the aerospace company Blue Origin is interested in moving all heavy industry off Earth, leaving Earth as a conservation space,[3] while Musk notes, “Over time terraforming Mars...

[will make] it really a nice place to be"[4]... "It is a little cold, but we can warm it up."[5] The Starlink project itself creates intense light pollution and space junk—experts are already raising concerns about "big light" (the light pollution equivalent of "big oil"), satellite collisions, and the danger of long term space debris.[6] SpaceX intends to send 37,000 more satellites into orbit before the project is complete.[1]

As the privatized space industry takes notable steps towards the colonization of the moon and Mars, it seems like the opportunity for space-related collective decision-making has passed. If multiplanetary living is bound to happen, is it possible to do it right?

Among the various techno-utopian visions and deeply cynical scenarios, could we imagine a bizarre story of Earthly maintenance where our planet (and subsequent human-inhabited planets) are cared for through a practice of planetary crop rotation? Could humanity move from planet to planet, letting each one rest and rejuvenate like fallow land? Is it possible to imagine a responsible space perma(nent)culture?

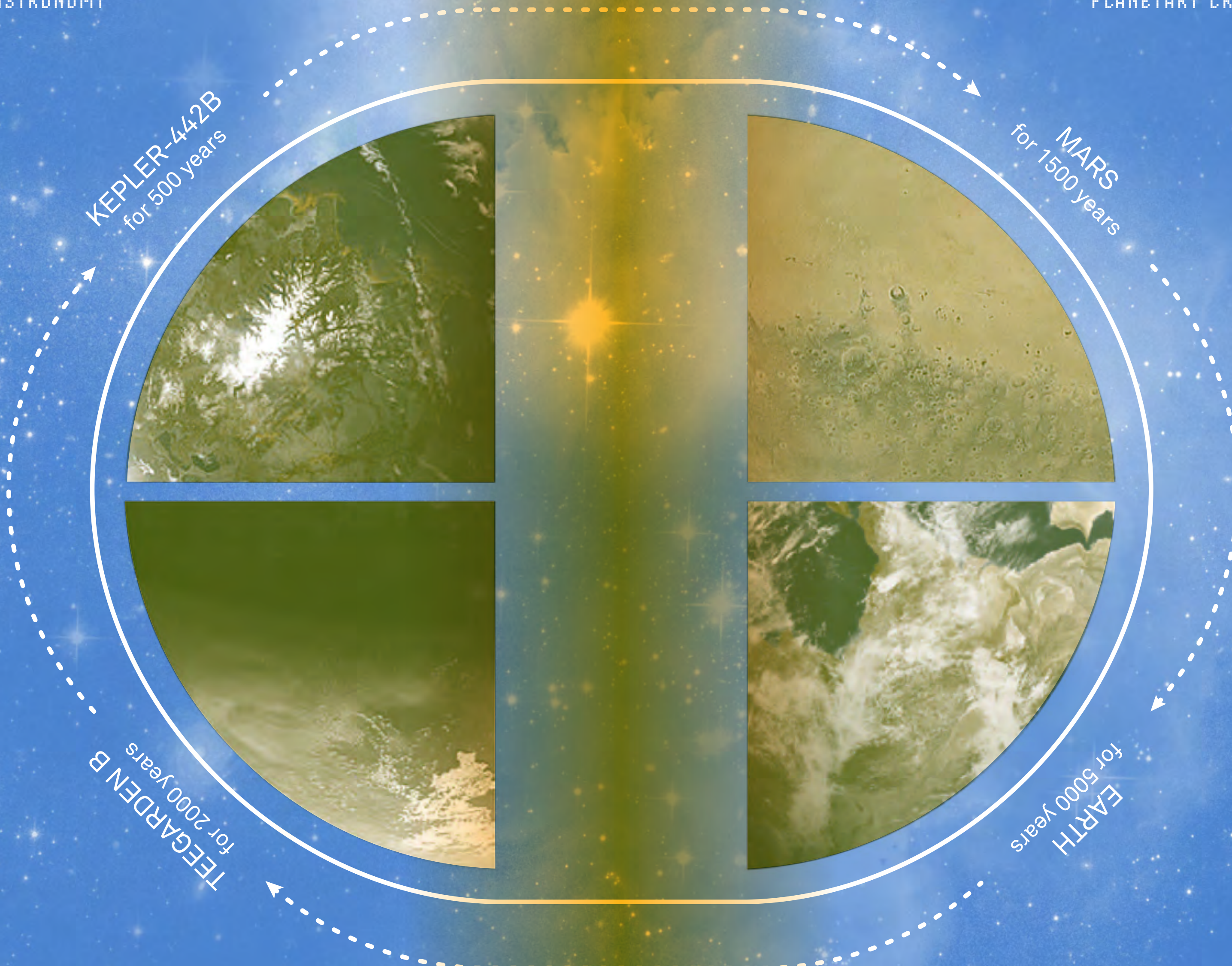
"The Rotation Effect" is a term used by agronomists to describe benefits to agricultural production due to the rotation of crops and/or the resting of lands between growing seasons.[7] Could we employ a system of Planetary Crop Rotation that uses "The Rotation Effect" and other

principles from regenerative agriculture and rewilding work to create new narratives for human-space relationships, bringing care and maintenance to the forefront of space exploration?

The following text *Planetary Crop Rotation Script* reimagines and diversifies our relationships with space by remixing space exploration with concepts, practices, language and belief systems from a variety of agricultural philosophies.*

What can we learn from regenerative farming practices? When does a farmer switch from conventional farming to regenerative farming and why? What are the trade-offs, barriers, and discomforts of adopting new systems? What does it take to balance care, maintenance and stewardship mindsets with approaches from engineering, science and design at multiple scales? If a farmer can take the leap, can those in space exploration do the same?

*(organic farming, cover cropping, intercropping, crop rotation, ancient crop rotation, indigenous farming techniques, permaculture design principles, whole farm systems, biodynamic farming, and rewilding projects)


KEPLER-442B
for 500 years
MARS
for 1500 years
EARTH
for 5000 years
TEEGARDEN B
for 2000 years

Planetary Crop Rotation Script

The following text was a script created for "Planetary Crop Rotation," a video artwork that reimagines humanity as a responsible spacefaring civilization. To create the work, audio extracts from regenerative agriculture and rewilding Creative Commons videos, as well as interviews with SpaceX founder Elon Musk, were transcribed and remixed. The script was then recorded using a "deepfake" artificial intelligence Elon Musk voice.

KEY

Regenerative agriculture and rewilding extracts
Elon Musk extracts
Artists' additions

ON LIFE IN SPACE

You can't manage the climate—it's something that it takes millions of years to change and it is much more permanent, as opposed to soil. So, soil is easier to adjust on our site as opposed to the climate. These timescales seem very long, but on an evolutionary timescale they are very short. A million years on evolutionary timescale, is really not much and the Earth has been around for four and a half billion years. We need to be looking intergenerationally, and saying, "how do we leave deeper soil, more suited to produce food in the future, rather than less? How do we leave cleaner water and in this very specific moment in time, how do we leave this peak of our access to energy in the best legacy possible?

So you got to figure out sort of, okay how can we get the atoms in the right shape much more efficiently? Yeah, and so, how can we work alongside all of those players down to the microbes as all super important players to make a healthy planetary system. That's our journey.

So, to manage good universal health, a sound planetary crop rotation is of great importance. We might bring together certain plant teams, or planet teams, or certain partners, combinations of plants and planets, whereby one is facilitating the growth of the other. I want to journey to that place just to form in myself an imagination. I have to form an inner imagination. So, I came to the conclusion that something like that could work and would be practical.

Not that I'm pessimistic about life on Earth, but much more important is the thinking behind how we create relationships between the parts of a system and looking, in fact, to ecology as the model for how these relationships are mutually beneficial.

I think we're either extinct or on a lot of planets, but, only Nature is the given. You can modify it, but you can't create it. We're trying, but all we can do is take pieces of it and replicate it.

What this means is that it is necessary to make a connection between the macro and the micro, between the farthest out possibilities and the minutiae of the world. Then you would be able to communicate to anyone instantly and have access to all of humanity's knowledge. I wasn't sure if success was one of the possible outcomes.

Funny, you know, if you think, like, what is education? Like you're basically downloading data and algorithms into your brain, and it's actually performed best when established early in the season and is mostly used in a mixture with other cover crops.

We have a model where we basically let nature take care of itself if at all possible. There are circumstances where you'll need to kick-start that. For instance with planetary regeneration there are many places where there are no seed sources for species, and so you might want to kickstart that through government satellites that do scientific missions, earth-based or space-based missions, or improving the technology to the point where we can make full regeneration work.

I would say try and leave that bubble where you're completely blinded and numbed by technology and just try and go back to nature wherever you can find it. But there's an even better step beyond that, which is to make space regenerative, so the farm is able to produce its own fertility.

ON FARMING

Space permaculture is really just a sensible order of the design approach, so we start off with the most important thing and before you even start with this we need to know what our goals and objectives are: not to compete, but rather to advance the course of balanced ecological systems so the universe is able to produce its own fertility.

Like absolutely, I mean, something bad is bound to happen. If you give it enough time, and civilization has been around for such a very short period of time, we need to always be thinking about how to design systems that are more resilient so we can maintain reasonable production and the health of the environment. We need to be able to irrigate the gardens, the orchards, and the pastures of our food sources.

So I thought, oh well, you know this would make it better: a diversified regenerative space program focused on diversity, collaboration, and engaging community in many ways through food, art experiences, music, care, and care for the land, animals, plants, and planets.

Generally when you want to embark on something, it's desirable to figure out a sound crop rotation, adapted to the local conditions.

I didn't expect the growth rate of social and ecological stewardship to be what it was, yeah, so, that actually created major cycles of health and sustainability.

In fact, the first three harvests failed, so it wasn't as though it was, like, you know, spot-on. But we all recognize and forgive our part in the equation and then we actively work towards embracing our humanity, reaching out to each other and recognizing that we are all part of the same vision of ecological regeneration.

ON MARS

If a sort of interconnected tapestry results in us going to Mars, that would be a pretty good outcome.

I discovered, actually, that NASA had no plans to send people to Mars or even really back to the moon to create the kind of habitats and connectivity that allows species to disperse, as they have to move because of climate change.

And we have sufficient scale and sophistication to be able to take people to Mars. But what this means is that it is necessary to make a connection between the macro and the micro, between the farthest out possibilities and the minutiae of the world.

It was quite depressing because we're very good at the minutiae of the world and also very good at, you know, the Hubble Space Telescope, but not very good at bringing those two together.

But if you'd asked people in 1969 what would 2013 look like they would have said there'll be a base on the moon, we would have at least had some people to Mars and maybe there'd even be a biodynamic farm base on Mars, there'd be, like, orbiting space fertility.

So, I was trying to figure out why we'd not sent any people to Mars, because really, the combinations of plants that you can bring together in <u>space</u> is limited only by your imagination.

Then I said, okay, well, I need to work on the way I understand energetic relationships.

I really want to do something that's action-oriented and transformative. It's just a very small percentage of mental energies, and if we're gonna take a <u>planet</u> and we're gonna pull it out of its wild condition, because every farm is not wild, and we're gonna remove it from the natural system, we better make sure that we're using that <u>planet</u> appropriately so that we are maintaining the health and fertility to get the crops that we need, for the effort we put in, and for the mouths we need to feed. Ideally you want to try to bracket it and say success is in the envelope of outcomes. The actual path is going to be some sort of zigzagging thing in that direction. We'll try not to deviate too far from the path that we want to be on, but we're gonna have to do that to some degree.

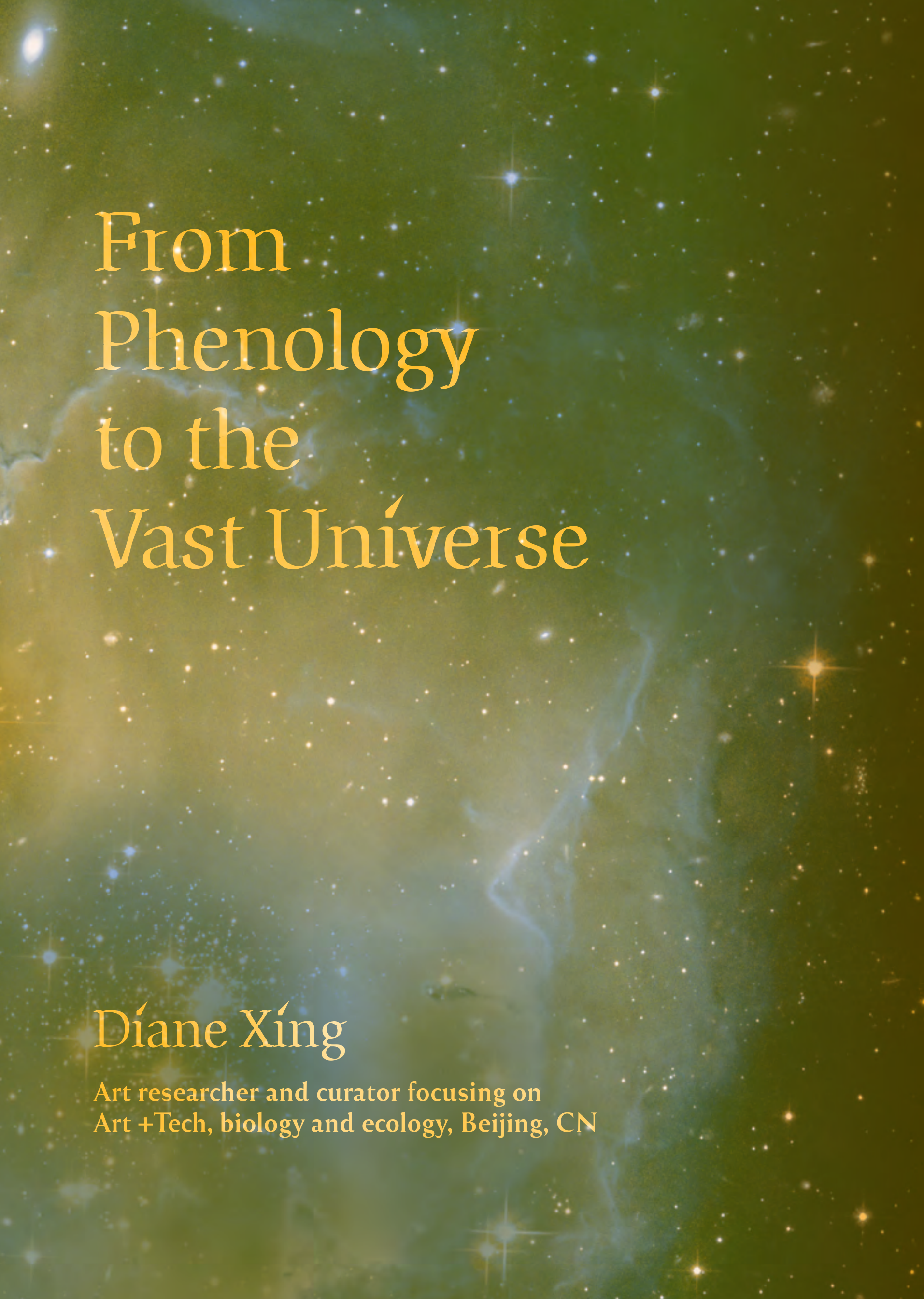
But, if we can build back this soil rather than just mining it in a quasi infinite cycle and calendar life, then you would have an awesome solution for energy storage. You know, feed the soil, not the plant.

You could have all this diversity of plants going on that are cycling, living and dying, and cycling at different times to create a balance, or something called Mars Oasis, which is a small greenhouse with seeds in dehydrated gel, and upon landing you rehydrate the gel. You have green plants on a red background. A rocket fuel for biodiversity. I think that makes you very aware of your environment and what you're bringing in, and what you're putting out, so I think learning to grow organically is vital.

I was wrong about my first premise, that there was a lack of will. In fact I think that there's a tremendous amount of will in the United States for <u>planetary</u> crop rotation because it is essentially a nation of farmers. I mean, it's a distillation of the human spirit of my family. We used to cultivate, and we used to plant, and it was communal. It was huge! Practically the whole community came to plant these enormous fields. We practiced crop rotating, everything. So of course it was quite silly of me to think that people lacked motivation.

I think if you can explain that you have to start seeing space as a whole, that makes a huge difference to people's motivation, you know, then they understand there has to be a balance. So, there's not a scalable solution, but we could build organic matter and create an environment that you know is balanced: the nutrient cycle, the water cycle and then add plant diversity in the crop rotation. If you wish to do this work, you have to meditate. You have to meditate the world.

Stills from the Planetary Crop Rotation video



From Phenology to the Vast Universe

Diane Xing

Art researcher and curator focusing on Art +Tech, biology and ecology, Beijing, CN

"Red sky at night, sailor's delight. Red sky in the morning, sailors take warning" ("朝霞不出门，晚霞行千里"). My mother knew all sorts of proverbs, and when I was a child I would always be forced to go out with my umbrella on clear mornings with the sunrise, and at noon or in the afternoon the rainfall clouds moved eastward from the west, and it really did rain. This periodically occurring biological phenomenon, in which the weather and even the climate are based on subtle changes in life—color of the sky, alignment of the stars, migration of specific birds—is often called "phenology."

During their long-term stargazing, the ancient Chinese discovered that the orientation of the stars in the sky had a fixed correspondence with the seasons and the change of weather on the ground. Building on this knowledge, they created a system of star positioning and stargazing to guide agricultural practices and various social activities on Earth.

For example, the Big Dipper (the most well-known configuration of stars in the northern celestial sky) is an asterism consisting of seven of the brightest stars of the constellation. Three stars form the "handle" part of the Big Dipper, and the other four stars form the "spoon" part. The Big Dipper changes as it rotates counterclockwise around the north celestial pole from season to season. In ancient China, there was a "spoon handle pointing to the season" method of timing ("斗柄指季"授时方法): "spoon handle eastward, the world is spring; spoon handle southward, the world is summer; spoon handle westward, the world is autumn; spoon handle northward, the world is winter."

"Xia Xiaozheng" was the earliest Chinese weather calendar, which summarized the weather, celestial phenomena and corresponding agricultural activities for each month. "Taichu Calendar" of Han Dynasty, gradually formed a more complete weather calendar, reaching its peak in the form of the "Zhushi Calendar" of Yuan Dynasty. In each period, people were trying to interpret "the language of nature," known as phenology. During the Yin and Shang dynasties, the ancients began to study astronomical phenomena and even set up special roles in society: people to observe the stars and set the seasons.

The ancient sextant calendar of the Warring States period also included the concept of "solar terms." Solar terms were created by dividing the sun's annual circular motion into 24 segments. Each segment has associated weather and agricultural characteristics.

We are still using the twenty-four solar terms to predict the weather today. As I write these words, it is the "Major Heat" in solar terms, the hottest time of the year, when the weather is scorching hot in most parts of the country.

In the changing nature of the stars, people also define their own position in the universe, and the operation of

the celestial bodies and the cosmic images have become an artistic way of interfacing with the unknown and mysterious world. The vastness of the starry sky gives people unlimited space for imagination. This topic has become increasingly important in contemporary art.

In the work *Stellar Axis: Antarctica* (2006), Artist Lita Albuquerque aligned 99 blue spheres on the ground in the Antarctic with the position of the stars on the summer solstice—a day when no stars are visible at the Earth's pole.

Stellar Axis: Antarctica delineates the cosmic relationship between the stars and humans on the ground. As the planet rotates along its orbit, the displacement between the original positions of the stars and the blue spheres forms an invisible helix of the earth's rotational movement. This magnificent artwork is a source of imagination for the "unknown" and the "mysterious."

The theme of the 23rd Triennale di Milano is *Unknown Unknowns: An Introduction to Mysteries*. It highlights the fact that human beings know very little about the universe, the oceans, the land on which they live, and that in recent years the impact of their actions on the planet has become more and more significant. The exhibition attempts to explore what we "don't know we don't know" in various fields: from the origins of our consciousness to the evolution of cities, from the surges of the seafloor

Image of Gaía's Stellar motíons
for the next 400 thousand years
from ESA/Gaía/DPAC.

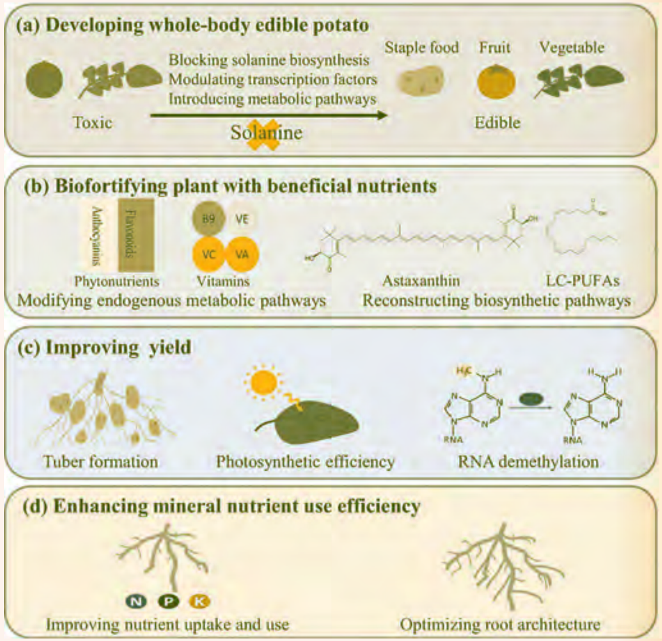
to astrophysics. It's a tribute to the unknown parts of the micro-and macro-universe, to the unknowns we have always feared. These topics become fertile ground for the encounter between art and technology.

The universe has always been the greatest unknown, and the starry sky has always carried our infinite imagination and aesthetic experience. Hanging from the ceiling of the *Unknown Unknowns* exhibition is Gaia EDR3, a spacecraft launched by the European Space Agency (ESA) in 2013. Gaia's mission is to create a three-dimensional map of objects throughout the Milky Way and to follow the traces of stars as they traverse the heavens, mapping their motions, luminosities, temperatures, and compositions.

This vast "stellar census" will provide the data needed to address a host of important questions about the origin, structure and evolutionary history of our galaxy. These stellar trajectories are woven into a giant cocoon of life-imagery in the map, where the infinity and chaos of the universe are interwoven into a picture of life. The presentation of these trajectories is not just a reproduction of the data, but here a new aesthetic image is created, intertwining data and cosmic life.

From the perspective of the history of the universe, humans are a tiny fragment in geologic time. We are sandwiched between the very small things and the giant things, and can feel a sense of oppression between the complex time and space scales. It is precisely because of this sense of oppression that we want to establish a link with the things around us and to look at the power of non-human life to re-establish a connection.

In ancient farming practices, human cultivation and the stars were inextricably linked. Nowadays, in addition to looking up at the stars, mankind can use the power of science and technology to travel there. Humans are even experimenting with farming in space. In 1982, *Arabidopsis Thaliana* demonstrated the possibility of cultivating plant life outside of Earth by successfully completing a full life cycle of growth from seed-plant-seed in space and re-germinating after returning to Earth.



Biotechnological generation of
WBEEP-potato and its applications

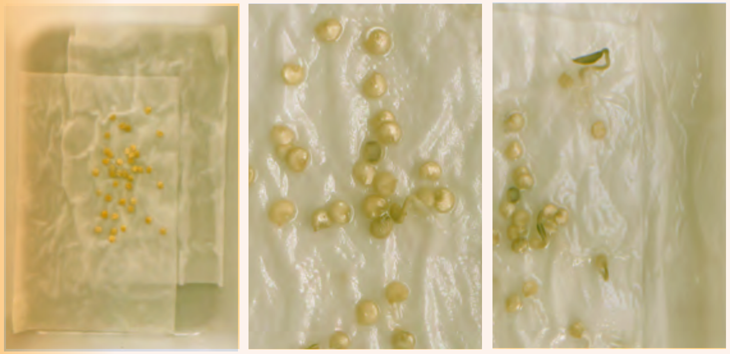
Human beings have continued their attempts at off-planet cultivation, expanding the new field of research with space mutation breeding (exposing seeds to radiation in space to create new crop varieties) and space cultivation (growing edible plants in space).

Now, the Institute of Urban Agriculture, Chinese Academy of Agricultural Sciences has proposed an innovative strategy of “Whole-Body Edible and Elite Plants” for crop improvement for space farms. Currently, the International Space Station has only leafy greens such as lettuce and kale. If humans are to conduct long-term space missions and colonization, an effective space agriculture system will have to be established. However, the existing crops are relatively expensive and low in production. Therefore, Maozhi Ren’s team proposes the strategy of Whole-Body Edible and Elite Plant (WBEEP), using biotechnology to create a plant with various desirable characteristics for growing and consuming in space.

There is a long relationship between the stars and human agriculture. The ancients looked to the stars to better understand and develop their agricultural practices. Today, we work towards understanding space through the act of growing and cultivating plants beyond the boundaries of planet Earth. As we explore the unknown, what can we learn from the past to inform our relationship to the universe? Can agriculture in space be a creative process that considers and understands the cosmos in a new aesthetic way?

Hangjiao planting diary

I planted Hangjiao Pepper 3 and recorded the whole process from germination to fruiting. Hangjiao Pepper 3's chili fruits are much larger and more numerous than those of regular chili peppers. The space pepper tree continues to grow, and I will collect new seeds when the fruits are ripe.



Tissue paper germination

Sprouting

Chili grower Lucas Stafford, product design student

Satellite Seed Savers plants grown at NCAD FIELD

NCAD FIELD

In March 2023 Genomic Gastronomy held the inaugural Satellite Seed Saver events in Ireland—exchanging seeds with community garden activists, home growers and farmers. *Satellite Seed Savers* was hosted by the FIELD at the National College of Art & Design (NCAD) in Dublin and as part of the *Soil Project Residency* at Butler Gallery in Kilkenny. Artist and lecturer Gareth Kennedy, the course leader from NCAD FIELD, reported that many of the plants were producing by the end of June. FIELD growers even had luck with the Comet's Tail and Solar Flare space pepper varieties in the greenhouse. The seeds were saved and disseminated in October, and the Solar Flare has become part of the Art School's permanent collection.

Seeds saved from Hangjiao 3 pepper grown in 2023

Exit Strategy

Genomic Gastronomy

This issue of Food Phreaking starts small (with seeds) and heads towards infinity (the universe)—mirroring the overall trajectory of the Food Phreaking journal. We began publishing a decade ago with issue 00: choosing that number in order to acknowledge the time before anything existed, the time when things were just in formation. We have already begun plotting our next and final issue (Food Phreaking: Infinity) in order to conclude Genomic Gastronomy's Food Phreaking publishing project—while leaving open the Food Phreaking multiverse—making room for unbounded imaginings about the topics and issues not quite covered in our time together as readers and writers.[1]

Down here in the more mundane world of publishing-an-actual-bounded-issue we have decided to number this issue four-and-a-half because it is both an extension and supplement to the previous issue, and to highlight the cracks that exist within and amongst what we consider to be solid objects. We wanted to give ourselves a moment to reflect on the areas and moments that are in-between.

0, 1, 2, 3, 4, 4½, ∞: that is a counting system that implies a certain escape velocity. What are we trying to escape? Why has our artist-led think tank turned its attention towards the sky, away from our usual soil and Earth-bound inclinations?

[1] If all goes well look for Food Phreaking Issue ∞ sometime before 2030!

For various reasons:

a. We are getting older and closer to death and wonder about the cycles of life and our place in the universe. Space is a place where our mind can wander freely, outside of human-time.

b. We are living through a moment of intense Planetary Indigestion.[2] We worry about the future of our fellow terrestrial inhabitants.

c. We have begun to utilize remote-sensing data and satellite imagery in some of our projects, making us aware of the not-yet space junk that provides this information and putting us in contact with the good, bad and ugly of hi-tech outerspace imaginaries.[3]

Meeting space science enthusiasts, commercial space ideologues and terraforming evangelists makes us wonder: who wants to live in outer space anyway? We hear the food is terrible and the portions are tiny. As we research the organisms and environments manipulated by human food cultures (in space) we ask ourselves: what is the purpose of imagining and prototyping a permanent human culture

[2] The self-regulating cycles of the super-organism we inhabit are out of whack. Could the sixth extinction you are experiencing be diagnosed as a case of digestive trouble? Time to slow things down and take a bit of a rest. Choose degrowth or prepare for more explosive Planetary Indigestion.

[3] Many strains of today's techno libertarianism are embedded in Timothy Leary's conception of S.M.I².L.E. "Space Migration, Increased Intelligence, [and] Life Extension."

in space?[4] And if we are working towards some kind of Space Permaculture[5] could it include essential but non-edible organisms we have co-evolved with, especially trees[6] and decomposers?[7] How far will we go to create perfect living conditions elsewhere—in an attempt to replicate the home we have here on planet Earth? We are already living on spaceship Earth, orbiting the sun, with some of the best dining options anywhere in the universe.

Thinking about human activities in outer space—while holding the seeds of a plant that has traveled there—is also a chance to look down at the Earth from far away with a renewed sense of wonder, awe, humility and curiosity.

[4] We are reminded of a quote from *One Straw Revolution* by Masanobu Fukuoka: "All the scientists did when they went off into space and stomped around in their space boots was to tarnish a bit of the moon's splendour for millions of lovers and children on the earth. How is it that people think science is beneficial to humanity?"

[5] Space Permaculture is about directing our gaze up towards the heavens and down towards the soil, and making connections between the two.

[6] It was fascinating for us to see that the illustration accompanying *The Brick Moon* (reproduced earlier in this issue) included trees growing on the artificial moon that hosted a tiny society.

[7] Many human cultures have embraced agriculture, but many of these have lost or never fully developed a robust decompiculture. See: *Planetary Crop Rotation* an artwork that attempts to reimagine humanity as a responsible spacefaring civilization by considering the application of practices from regenerative agriculture and rewilding to space exploration. What if leaving Earth was a step in the cycle of planetary (crop) rotation rather than an emergency evacuation from Landfill Earth?

References

In order of appearance, as cited by contributors

Whitey on the Moon Lyrics

Scott-Heron, Gil. "Whitey on the Moon." Small Talk at 125th and Lenox, Flying Dutchman / Ace Records, 1970.

Plant List

Plant list generated from following sources and contributor suggestions

"Astrobotany.com." Astrobotany: Let's grow plants in space. | astrobotany.com, https://astrobotany.com/. Accessed 27 October 2023.

Wikipedia contributors. "Plants in space." Wikipedia, 1 October 2023, https://en.wikipedia.org/wiki/Plants_in_space. Accessed 27 October 2023.

NASA.gov, https://www.nasa.gov/. Accessed 27 October 2023.

Satellite Seeds as Space PR

1 Munns, D.P.D, and Nickelsen K. Far Beyond the Moon: A History of Life Support Systems in the Space Age. Pittsburgh: University of Pittsburgh Press, 2021, p. 90.

2 EMCS stands for the European Modular Cultivation System, which could alter the gravity exerted upon the seedlings between 0g and 2g in 60 seconds.

3 Williams, D.R. "The Moon Trees." NASA Goddard Space Flight Center. 15 Sept 2023. https://nssdc.gsfc.nasa.gov/planetary/lunar/moon_tree.html.

4 Brown, K., and NASA. "NASA, Forest Service to Share Moon Tree Seedlings, Promote STEM." Release 23-093. 23 Aug 2023. https://www.nasa.gov/press-release/nasa-forest-service-to-share-moon-tree-seedlings-promote-stem.

5 Ehrlich, N. and Grigsby, D. "Space Exposed Experiment Developed for Students." Paper presented at LDEF–69 Months in Space: First Post-Retrieval Symposium. Kissimmee, Florida. 2-8 June 1991. NASA Conference Publication 3134. pp. 1635-1636. https://ntrs.nasa.gov/api/citations/19920017840/downloads/19920017840.pdf.

6 Ibid. p. 1635.

7 JAXA Japan Aerospace Exploration Agency. "Space Seeds for Asian Future 2010-2011." 12 February 2019. https://iss.jaxa.jp/en/kuoa/ssaf/2010.html

Internalised Terroirs

1 Peter Sloterdijk, In the World Interior of Capital, Polity, 2013

2 Latour, Bruno, and Steve Woolgar. *Laboratory Life: The Construction of Scientific Facts.* Princeton University Press, 1986. https://doi.org/10.2307/j.ctt32bbxc.

3 Jaque, A., Verzier, M.O., Pietroiusti, L., *More-than-Human,* Het Nieuw Instituut, 2020

Plants That Jumped the Priory Walls

1 Latour Bruno and Catherine Porter. *Down to Earth : Politics in the New Climatic Regime.* English ed. Polity Press 2018.

Planetary Crop Rotation

1 Wikipedia contributors. 2023. "Starlink." Wikipedia. Retrieved October 14, 2023 from https://en.wikipedia.org/wiki/Starlink.

2 Human Spaceflight. SpaceX. Retrieved October 14, 2023 from https://www.spacex.com/humanspaceflight/

3 About Blue. Blue Origin. Retrieved October 14, 2023 from https://www.blueorigin.com/about-blue

4 Elon Musk. 2017. Making Life Multiplanetary. Adelaide, Australia. Retrieved October 14, 2023 from https://www.spacex.com/media/making_life_multiplanetary_transcript_2017.pdf

5 Mars & Beyond. SpaceX. Retrieved October 14, 2023 from https://www.spacex.com/humanspaceflight/mars

6 Davis, Nicola. 2023. "Calls for ban on light-polluting mass satellite groups like Elon Musk's Starlink." The Guardian. https://www.theguardian.com/science/2023/mar/20/light-polluting-mass-satellite-groups-must-be-regulated-say-scientists.

7 Richard Smith, Katherine Gross, and G Philip Robertson. 2008. Effects of Crop Diversity on Agroecosystem Function: Crop Yield Response. Ecosystems 11, (August 2008), 355–366. DOI:https://doi.org/10.1007/s10021-008-9124-5

Planetary Crop Rotation Script

"Best4Soil: Crop rotation – Practical Information." 2020. YouTube. https://www.youtube.com/watch?v=3-xjgCWMEDo.

Dirksen, Kirsten. 2020. "Rewilding as a biodiversity engine." YouTube. https://www.youtube.com/watch?v=4Pbgiu8aM4w.

"Elon Musk | Khan Academy - Tesla Motors ve SpaceX'in CEO'su ile Söyleşi (Girişimcilik)." 2018. YouTube. https://www.youtube.com/watch?v=BbS8eAyhe3Y.

Else, Marianne. 2015. "Dennis Klocek 1 at the Biodynamic Conference Louisville KY Nov 2014." YouTube. https://www.youtube.com/watch?v=2X4X3vdEWHE.

"Farmer Training Program: Farming Practices panel." 2018. YouTube. https://www.youtube.com/watch?v=6TA46GgJGhg.

Greenfield, Robin. 2020. "Indigenous-led Permaculture Brings Resilience And Food Sovereignty to Pine Ridge Reservation." YouTube. https://www.youtube.com/watch?v=uZk8j1Lhi6I.

Hafferty, Stephanie. 2020. "Best4Soil: Green Manures & Cover Crops – Practical Information." YouTube. https://www.youtube.com/watch?v=Zk_SPAtCd8g.

Judy, Greg. 2021. "Short Term Perennial Pasture Within a Cropping Rotation with Josh Lloyd & Keith Thompson." YouTube. https://www.youtube.com/watch?v=mOFIQm8YoEg.

"Keyline Design Permanence." 2019. YouTube. https://www.youtube.com/watch?v=4jHol4wqe7E.

"Organic Farming Through Biodynamic Methods." 2019. YouTube. https://www.youtube.com/watch?v=_9p10C3OpSM.

Williams, Joel. 2019. "Intercropping." Intercropping. https://www.youtube.com/watch?v=Lt3ceKjdKOw.

Image Credits

All images below are creative commons licensed or exist in the public domain unless otherwise stated.

Cover Artwork

Title: Habitable Zones: We Live in the Milky Way
Author: © Jenifer Parker

Space Seeds Introduction & Satellite Seed Savers

Title: Tarantula Nebula
Credit: ESA/Hubble & NASA, C. Murray, E. Sabbi; Acknowledgment: Y. -H. Chu

Title: Satellite Seed Savers badge
Author: Genomic Gastronomy

Title: Satellite Seed Savers banner
Author: Genomic Gastronomy

Title: Satellite Seed Savers seed packet
Author: Genomic Gastronomy

Title: NCAD FIELD site
Author: Gareth Kennedy

Featured Satellite Seeds

Title: NGC602.jpg
Author: NASA, ESA, and the Hubble Heritage Team
Source: Wikimedia Commons

Title: Satellite Seed Plant Illustration
Author: Eileen Reiner for Genomic Gastronomy

Diary of an Earth-Bound Astronaut

Title: Rucka Space Plant Images
Author: Genomic Gastronomy

Title: Space food workshop images
Author: © Sintija Cerpina, Art+Food+Next Generation, 2003

Satellite Seeds as Space PR

Title: NGC602.jpg
Author: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration
Source: Wikimedia Common

Title: The Brick Moon
Author: Unknown author
Source: from NASA archive via Wikimedia Commons

Title: TROPI Mission Patch
Author: NASA Ames Research Center
Source: Wikimedia Commons

Title: Moon Trees
Author: Unknown
Source: Nasa.gov

Title: Park Seeds Kit
Author: unknown
Source: Herald sun (heraldsun.com)

Title: Logo designed by The National Space Agency of Malaysia (ANGKASA)
Author: MYSA and JAXA
Source: https://humans-in-space.jaxa.jp

Foraging Cyanobacteria in Space

Title: Nébuleuse Trifide
Author: Subaru Telescope (NAOJ), Hubble Space Telescope, Martin Pugh;
Processing: Robert Gendler
Source: Wikimedia Commons

Title: Habitable Zones: We Live in the Milky Way
Author: © Jenifer Parker

Internalised Terroirs

Title: Hubble view of M 106 (8450543502).jpg
Author: NASA, ESA, the Hubble Heritage Team (STScI/AURA), and R. Gendler (for the Hubble Heritage Team). Acknowledgment: J. GaBany
Source: Wikimedia Commons

Title: Images of visit to Bios-3
Author: © Miha Turšič

Plants That Jumped the Priory Walls

Title: Hubble Sees Cosmic Flapping 'Bat Shadow' - Flickr - NASA Goddard Photo and Video.png
Author: NASA Goddard Space Flight Center from Greenbelt, MD, USA
Source: Wikimedia Commons

Title: Herb Man
Author: Genomic Gastronomy
Source Image: British Herbal Plate 52. (John Hill)

Planetary Crop Rotation

Title: Between Local and Laniakea SDSS J0333+0651.jpg
Author: ESA/Hubble & NASA
Source: Wikimedia Commons

Title: NGC602.jpg
Author: NASA, ESA, and the Hubble Heritage Team
Source: Wikimedia Commons

Title: Planetary Crop Rotation Diagram
Author: Emma Conley for Genomic Gastronomy
Source Images: Wikimedia Commons: Kepler442b(comp).jpg (Pho3nix1986), Mars (white background).jpg (Allice Hunter), Earth Eastern Hemisphere.jpg (NASA), Artist's impression of the planet Ross 128 b.jpg (ESO/M. Kornmesser)

Planetary Crop Rotation Script

Title: Stills from Planetary Crop Rotation Video
Author: Emma Conley for Genomic Gastronomy

From Phenology to the Vast Universe

Title: NGC602.jpg
Author: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration
Source: Wikimedia Commons

Title: Gaia's stellar motion for the next 400 thousand years ESA22358019.png
Author: ESA/Gaia/DPAC.
Acknowledgment: A. Brown, S. Jordan, T. Roegiers, X. Luri, E. Masana, T. Prusti and A. Moitinho., CC BY-SA IGO 3.0
Source: Wikimedia Commons

Title: Biotechnological generation of WBEEP-potato and its applications
Authors: Liu, Y., Xie, G., Yang, Q. et al.
Source: Biotechnological development of plants for space agriculture. Nat Commun 12, 5998 (2021). https://doi.org/10.1038/s41467-021-26238-3

Growers' Update: China and Ireland

Title: Images in Growers' Update: China
Author: Diane Xing

Title: Images in Growers' Update: Ireland
Author: Gareth Kennedy

Exit Strategy

Title: Crab Nebula - Flickr - NASA Goddard Photo and Video.jpg
Author: NASA Goddard Space Flight Center from Greenbelt, MD, USA
Source: Wikimedia Commons

Final Note

Every effort has been made to contact copyright holders of content which has been reproduced in this book. We would be pleased to rectify any omissions in subsequent editions should they be drawn to our attention.

WITH THANKS

Support for the printing of this book has come from OpenLab Research Center and The Genomics Institute at UC Santa Cruz. Special thanks to Jennifer Parker for her advocacy and enthusiasm.

Thank you to our contributors and to those who supported both the Satellite Seed Savers initiative and the production of this issue of Food Phreaking.

We'd like to give a special thanks to our Satellite Seed Savers hosting sites: OpenLab Research Center and The Genomics Institute at UCSC in Santa Cruz, US, Rucka Art Foundation, Zane Cerpina and the Art+Food+Next Generation, 2023 team (including all the kids who brought the space food workshop to life) in Cēsis, LV, Butler Gallery in Kilkenny, IE, National College of Art and Design in Dublin, IE, and Mármol in Porto, PT.

We'd also like to acknowledge and thank all of the growers and seed savers who enthusiastically participated in this project, and who continue to do the care work of nourishing the seeds and plants that make the Satellite Seed Savers project possible.

Finally, thank you to Oliver, Luca and the next generation, for whom all seed saving work is truly for.

Zack, Cat, Emma
The Center for Genomic Gastronomy

ISSN 2372-6504

Produced and published by
Genomic Gastronomy

November 2023

EDITORS
Emma Conley, Zack Denfeld, Cathrine Kramer

DESIGN
Cathrine Kramer, Eileen Reiner,
Emma Conley, Eirin Koehler Breivik

COPY EDITING & PROOFING
Eileen Reiner, Camille Pelissou, Jennifer Parker

FONTS
Reforma 1918 by PampaType
Unibody 8 Pro by Underware
Autopia by Antoine Gelgon

PRINT
Printed by Chute Studio in Oakland, California

www.foodphreaking.com
info@genomicgastronomy.com