IN COLLABORATION WITH
FABER FUTURES

WORLD ECONOMIC FORUM

BIO STORIES

Re-envisioning relationships with nature

REPORT
MARCH 2022

TABLE OF CONTENTS

TOC

PREFACE *PENDING

INTRODUCTION

GATHERING

G1: CIRCULAR FORMATIONS
G2: A SEAT AT THE TABLE
G3: A WELCOMING SPACE

THE MUSEUM OF SYMBIOSIS

BY CLAIRE L EVANS

DIALOGUE SYNTHESIS

BY MELISSA SALM

METHOD

M0: METHODOLOGY COMPASS
M1: BRIEF DEVELOPMENT
M2: PROJECT STRUCTURE
M3: STAKEHOLDER MAPPING AND CURATORIAL STRATEGY
M4: DIALOGUES
M5: TRANSCRIPTION AND CODING
M6: STORIES

STAKEHOLDERS

EPILOGUE *PENDING

ACKNOWLEDGEMENTS

APPENDIX

DIALOGUE SUMMARIES
CODEBOOK
BIBLIOGRAPHY

INTRODUCTION

In 2020, the World Economic Forum convened the Global Future Council on Synthetic Biology, aiming to articulate how synthetic biology could benefit people and the planet, and to define the kinds of values that would enable effective, equitable, and ethical outcomes in its deployment. The Council's work considers the narratives, assumptions and visions of a world changed by this technology, in order to ensure that this world does not replicate the inequities of the past. The council states that: 'If synthetic biology is to realise its full potential, it must have values at its core.[1]
If stories are a means to embody and advance values[2] [3], then how do we solicit new, value-driven narratives, and place them in context to clarify what is at stake in the ways that synthetic biology is advanced?

BIO STORIES is an interdisciplinary project that draws together curation, design, anthropology and fiction to develop a method for mutualistic storytelling. With synthetic biology now firmly on the global agenda as a technology that can reshape our relationships with the living world, BIO STORIES contextualises it into narratives that reveal what we prioritise as being key to continued human development. These stories are powerful because they provide a theatre in which to imagine the kind of a world we wish for. They give us space to explore how we might distribute agency and power in order to enact the radical change required to meet the most pressing challenges of the 21st century: climate change, biodiversity loss, and global inequity.

To create space for emergent narratives, BIO STORIES employs a curatorial strategy that crafts connections and establishes common ground between scientists, farmers, designers, investors, community leaders, artists, entrepreneurs, and others. Through shared dialogue, they relate back to one another their perspectives and approaches to the living world. Existing power dynamics and entrenched framings often render synthetic biology elusive or impenetrable to stakeholders who nonetheless carry valuable knowledge and capabilities. The ambition to ensure what is at stake is visible and approachable is essential to BIO STORIES, and achieved through accessible language, considered meetings of minds, and inspiring springboard questions.

To create conditions conducive to unexpected insights and connections, BIO STORIES upends existing strategies for stakeholder engagement by foregrounding creative, design-led methodologies. BIO STORIES is a collection of tools, spaces, and frameworks that actively empower[4]—not just expanding who sits at the table, but making it possible to share and engage across plural perspectives[5]. Each stakeholder provides an artefact as a conversational entry point. The artefact materialises complex lines of questioning and makes tangible various visual imaginaries that advance dialogue.

The dialogues demonstrate global and multidisciplinary accounts of what issues arise from the ways synthetic biology interfaces with society. But when regarded as a collective, they reveal something else: intertwined and plural visions of what it means to work, think, and live with nature. To further animate and broaden access to these syncretic narratives, the conversations are translated into several distinct BIO STORIES: a speculative journey through a biological future and its analytical counterpart that reveals what this might mean for today. These stories are grounded in plural human practices from across the world via material artefacts and personal testimonies shared by the BIO STORIES participants. The process is then made transparent for others to continue the work and iterate its methodologies across multiple contexts. Finally, we offer reflections from across the Global Futures Council for Synthetic Biology on what the BIO STORIES point towards for the future of synthetic biology.

This report is not intended to be a static documentation, but rather a versatile toolkit that can inform future visioning and visionary work. There are multiple possible ways to use it:

- Read in order, journeying through evocative fiction to practical instructions for further iterations;
- Immerse yourself in the collection of artefacts before following the threads to reveal connections across the set;
- Discover our process, organise a dialogue and use these stories as a prompt.

We hope that by following the threads across BIO STORIES, you encounter many more entanglements, narratives and possible futures for the fundamental and exceptional technology that is synthetic biology.

Let our stories begin here.

1. World Economic Forum (2021) Revisiting and Realizing the Promises of Synthetic Biology. Briefing Paper. [online] Available at: https://www3.weforum.org/docs/WEF_Revisiting_and_Realizing_the_Promises_of_Synthetic_Biology_2021.pdf, p. 3.
2. Scott, W. J. (2011) 'Forum: Holberg Prize Symposium Doing Decentered History: 2. Storytelling', History and Theory, Issue 50, pp. 203-209. Available at: http://culturahistorica.org/wp-content/uploads/2020/02/scott-storytelling.pdf.
3. Episkenew, J. (2009) Taking Back Our Spirits: Indigenous literature, public policy, and healing. University of Manitoba Press, pp. 1-109.
4. Costanza-Chock, S. (2020) Design Justice: Community-led Practices to Build the Worlds We Need. Cambridge, Massachusetts: MIT Press.
5. Escobar, A. (2018) Design for the Pluriverse. Durham and London: Duke University Press.

GATHERING

↓ CIRCULAR FORMATIONS
↓ A SEAT AT THE TABLE
↓ A WELCOMING SPACE

BIO STORIES prototypes and offers conceptual, curatorial and symbolic tools that facilitate storytelling. The spatial and visual world of the project has been built around the following three pillars, referencing the long and rich histories of gathering to discuss our relationships with nature.

GATHERING **G1: CIRCULAR FORMATIONS**

For millennia, people have gathered in circles to discuss the world that surrounds them—sharing ideas, asking questions, establishing meaning and purpose. However, the round table as a spatial trope in global decision-making also evokes the concentration of power in the hands of those who get a seat at the table at the expense of those who do not. BIO STORIES unfolds around a specially-designed round table that is not monolithic, but modular, light-weight and deployable across different contexts. This invites us to take the roundtable out from behind closed doors and into shared, social spaces.

Round Table, 2021. Designed by Faber Futures for BIO STORIES (Eindhoven). Commissioned by Dutch Design Foundation for Dutch Design Week 2021. Images Credit. Toby Coulson.

GATHERING **G2: A SEAT AT THE TABLE**

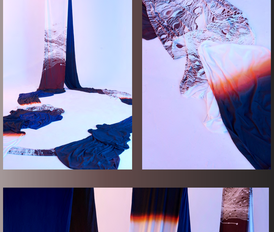
BIO STORIES empowers participants to place their own seat at the table, breaking down hierarchies and bringing us all to the same level. The stool echoes ancient practices of coming together offering no more and no less than what is required to support dialogue. When approaching the dialogues, the participants encounter a collective of unique stools that could be placed throughout the room, creating a different layout and dynamic in the room each time. Leveraging computer-aided manufacturing, each stool is unique and the collective can be expanded on for further iterations of the project.

Stools, 2021. Designed by Faber Futures for BIO STORIES (Eindhoven). Commissioned by Dutch Design Foundation for Dutch Design Week 2021. Images Credit. Toby Coulson.

Stools, 2021. Designed by Faber Futures for BIO STORIES (Eindhoven). Commissioned by Dutch Design Foundation for Dutch Design Week 2021. Images Credit. Toby Coulson.

GATHERING **G3: A WELCOMING SPACE**

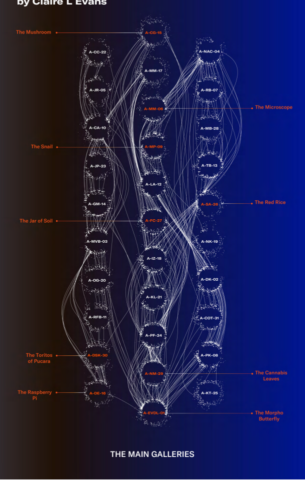
BIO STORIES is framed by a continuous flag, which stands not as an emblem from the narrative of the nation state, but as a symbol of the hidden networks that embody and sustain the interdependency of nature. Textile architectures that communicate intention and position have a long history of holding space for dialogue, celebration or communion—our flag for nature sits in this lineage and becomes both a beacon for the gathering, but also a comforting backdrop.



Flag for Nature, 2021. Designed by Faber Futures for BIO STORIES (Eindhoven). Commissioned by Dutch Design Foundation for Dutch Design Week 2021. Images Credit. Toby Coulson.

THE MUSEUM OF SYMBIOSIS

by Claire L Evans



THE MAIN GALLERIES

The Main Entrance

The plaque is easy to miss. Most people wander into the Museum of Symbiosis in a daze, awed by the building's strangeness. The walls, for one, are vertical. It is not the lazy winding climb of an oak tree, or the bobbing edge of a blade of grass whispering in the breeze. It is an uncanny vertical—a mathematical straightness that is grating to behold. The floor is flat, meeting the walls at alien angles. It's difficult to trust these trick surfaces, with their hostile impermeability. Not when you are accustomed to slime.

The rest of the world is a feast for the senses. The rough, dry textures of desert chaparral. Dark stones mattressed in moss. Electric orange mold. Dry riverbeds, carved anew every season by the fanning course of mountain runoff. Cool sand. Hot sand. The fragrant loam of the forest floor. But here, in the Museum, the floors click when you walk on them, and the sound of your footsteps echoes across the galleries. Outside is a riot of birdsong. Outside the air smells of mango and compost. Outside it is monsoon season, but beyond the Museum's doors the humidity peels from your skin like an orange. You enter the deafening coolness of another century. The Museum feels like a time capsule.

But, of course, that's exactly what it is.

You'd know that already if you'd read the plaque at the entrance—a plate of embossed brass flush in travertine marble. Over the centuries, the footfall of visitors has softened the letters, reducing entire sections to smooth planes of gleaming metal. Fortunately, the plaque's contents are reproduced in the brochures neatly tucked by the door, reproductions of originals printed in 2030, in the squiggly sans-serif of that strange and transformative decade. The brochures have been preserved, just as everything in the Museum has been preserved, as a reminder of a moment in human history. It was the moment that made hard verticals obsolete and set life loose again to play across the soft surfaces of the world. It was long before you were born, and for that you are grateful.

The Welcome Gallery

In the midst of a global pandemic, on the eve of an irreversible climate emergency, and in the early, thrilling decades of a biotech revolution, the human race began to question its relationship to the natural world. For centuries, the most powerful knowledge-reproducers on the planet had believed in a cosmology that artificially cleaved them from the process of planetary symbiosis that sustains—and defines—life on Earth.
This cosmology was powerful. It ordered empires. It built many monuments that are still standing today, and many more that have long since returned to the soil. It challenged death itself, and facilitated the unprecedented extraction of natural resources from Earth. Many of the living creatures of the planet were lost, some forever; many resources were expended to shelter the powerful from the consequences of their own actions. Not everyone had the luxury of ignorance. Generations of people bore the seemingly endless exploitation of their lands, resources, and biological diversity. The future was regarded, by many, with a sense of dread inevitability.

This is something you were taught in school, but it's an entirely different thing to read it here, in this sterile, angular place. There are images neatly framed on the walls: pit mines carved like upside-down ziggurats into mountain sides. Colorful islands made from something called plastic, tangled in whorls of kelp. Fires. Odd charts. Factories. Sick people crowding hospital hallways. A bare patch of sun-baked soil in the middle of a forest. Piles of boxes. Obsidian ribbon lying flat across a prairie. More obsidian, liquid this time, blackening the white feathers of a duck, leaving metallic prisms in the water. You examine each image carefully. The images are as crisp as the floor is smooth, but you do not recognize the world they depict.

That's why you're here—to learn. You need to see what it looks like when Earth's life-supporting systems are pushed beyond their breaking points, so that it can never happen again. Other museumgoers mill around the photographs: an older man alone, leaning pensively on the handle of a multicolored umbrella trimmed with solar flashing, a pair of adolescent twins, kicking and jostling one another, and a young family, holding their toddler's runny nose up to the framed images. All are hushed, save for the occasional gasp and muttered reaction: oh my, what, how ugly, look honey, that's what they called a clear-cut. Next to the photographs stands a large map of the Museum galleries. It's dotted with small domed lights that shimmer like bioluminescent bacteria as you approach. You run your finger along the smooth laminate wall as you read the long list of artifacts on display. Each name triggers a light; each light triggers a voice.

ARTIFACTS ON DISPLAY IN THE MUSEUM OF SYMBIOSIS INCLUDE:

A LARGE MUSHROOM, STILL DUSTED WITH DIRT
SPIRULINA ALGAE
A JAR OF SOIL FROM A VEGETABLE GARDEN IN ARGENTINA
A CORAL AND A SEASHELL
A GOURD FULL OF GHANAIAN RED RICE GRAINS
A BRILLIANT BLUE MORPHO BUTTERFLY
IMAGES OF A COOPERATIVE FARM IN THE NETHERLANDS
A COLORFUL GARMENT DYED WITH THE BACTERIA STREPTOMYCES COELICOLOR
AN IMAGE OF A WOMAN ENCOUNTERING AN ODD BIOLOGICAL FORCE
A 17TH-CENTURY MICROSCOPE
AN ANIMATION OF A CELL
A LIGHT FIXTURE MADE WITH DANDELION PAPPI
AN IMAGE OF A SNAIL CROSSING A SIDEWALK
A WHEEL OF DUTCH CHEESE
SYNTHETIC RHINOCEROS HORN POWDER
A VIAL OF PATCHOULI-SCENTED PERFUME MADE WITH ALGAE
A PHOTO OF A WORKER IN FRONT OF THE NEW YORK STOCK EXCHANGE
IMAGES OF FRUIT AND FLOWERS FROM TRINIDAD
EYEGLASSES
AN IMAGE OF A STATUE SHAPED LIKE A BACTERIOPHAGE OUTSIDE MAKERERE UNIVERSITY IN UGANDA
CANNABIS LEAVES FROM DURBAN, SOUTH AFRICA
A PAIR OF HOMEGROWN BUTTERNUT SQUASH
A TISSUE CULTURE INCUBATOR
A SMALL ENAMEL PIN DEPICTING MESSENGER RNA
A BIOBRICK
AN ASTHMA INHALER
A SMALL RASPBERRY PI COMPUTER

STAKEHOLDERS

In its multiplicity, the Museum evokes another time capsule, from another age entirely: a 12-inch gold-plated copper disk containing recordings of bird calls, whale songs, music from human cultures, and some 55 greetings in a range of languages, alive and dead. This impermeable monument is unknown to you, and it will remain that way as it travels on its lonely journey beyond the far reaches of the solar system. Perhaps it has been taken up by the alien intelligences it sought. In those recordings, an Arabic speaker greets humanity's "friends in the stars," while the Nguni and Sesotho speakers call to "great ones" across the distant cosmos. All of this would strike you as quite silly, if you heard it. There is abundant intelligence right here on Earth—friends, great ones, allies, and companions alike. It has been the work of centuries to make contact with these other minds. The first breakthrough was to stop speaking and listen.

The Main Galleries

It was an unsustainable existence. Everything was global but nothing was connected. Life persisted but did not flourish. Eventually it was discovered that the cosmology itself was at fault. It had—in fact—always been a fiction, designed to justify the pillaging of the planet for a privileged few. This became obvious as chemistry, biology, computer science, and engineering converged into a new field called synthetic biology, and humanity began to try its own hand at creating life. They edited genes. Tweaked organisms. Folded proteins. Sequenced DNA. At first it was more of the same: molecular strip-mining, microscopic exploitation. The benefits of the technology weren't distributed equitably; those with greater access to resources and funding more handily reaped its rewards. But the organisms had a strange power. They did not always do as they were told.

You have wandered into the main galleries of the Museum. In front of you stands a forest of white plinths, each capped with a temperature-controlled dome. The artifacts are safe here, eternally preserved. The air in each dome is continuously monitored and scrubbed clean by an army of microscopic living sensors. A skin of bioluminescent bacteria bathes each artifact in warm, ambient light. They look beautiful, safe in their hermetically-sealed tombs, but the objects in the Museum do not quite make sense to you.

Why were they selected? After all, the world of before was a world of objects. There were more human-made materials on the planet than biomass. Everywhere there was asphalt and airplanes, toothbrushes and toys. You've seen the images: beaches strewn with successive tides of plastic bags, handbags slashed and thrown away in dumpsters, cathedral-sized warehouses filled with everything from shoelaces to bicycles. Plenty of objects from this era have survived into the present age—repurposed, where possible, into useful things. But these artifacts are different. They do not serve any purpose but to teach.

The Mushroom

You are standing in front of a tawny oyster mushroom when a soft voice begins to emanate from the plinth. "My grandmother was over 100 years old when I knew her and we lived in a village," the voice begins, smiling with memory. "We didn't have much, and our favorite time of the year was the rainy season. She would sit under a tree and as a little girl, I would run around and collect all different types of mushrooms I could find and bring them to my grandmother."

As the mushroom in front of you spins suspended in air, you listen to the voice. It is the voice of Chido Govera, whose name means passion in her native Shona. It has been many centuries since Govera first learned oyster mushroom cultivation and taught it to her surrounding communities in the Eastern montane forest-grassland mosaic of the country once known as Zimbabwe. Three generations have passed since her work promoting the sustainable production of mushrooms transformed waste into food, income, and dignity for countless people. Indeed, much has changed since she selected this mushroom for display in the Museum of Symbiosis, but you know Govera's name. Everyone does.

You settle onto a hard bench and listen as she shares her grandmother's wisdom: never close the door on the forest. Always leave a little bit of the mushroom stalk in the ground. Mushrooms do not rot. Poisonous mushrooms are just as important to the ecosystem as edible ones. Mushrooms and other living things are not individuals—they all exist, as we do, within a greater whole. "Science tends to focus on the sterile version of nature," Govera's voice is saying. "It's missing the gods grandmother used to bring in. It's missing the basic things… like using the right language, the language that shapes you into a respectful human being."

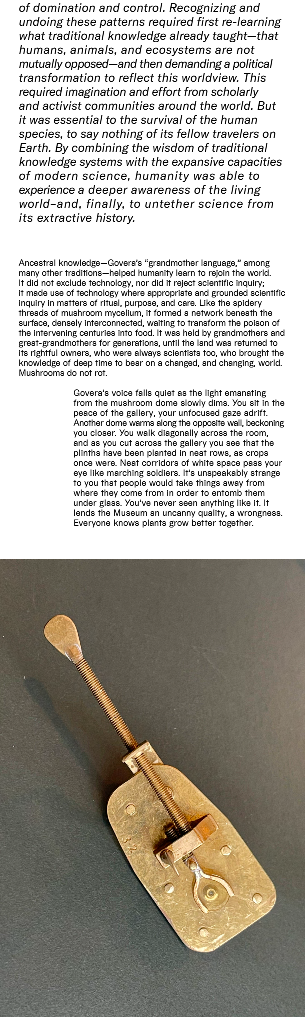
Facing the challenges of the 21st century required a complete re-evaluation of what it meant to conduct science, what counts as scientific knowledge, and who was entitled to be a scientist.
For centuries, the pursuit of science was undergirded by the Enlightenment belief that nature itself represented an archaic state from which "rational Man" had, in the progression of history, escaped. This enabled a colonial logic differentiating the "primitive" from the "modern." Upon this basis, European colonial societies accumulated enormous wealth and power by extracting labor and resources from the people and ecosystems they deemed primitive—often justified by science, if not explicitly in its name. When they encountered traditional knowledge systems inconsistent with this worldview, they deliberately stripped them of value.

It's moving to be here, in the presence of something so simple and so sacred. Listening to Govera's voice, you begin to understand why this building takes the form it does. If it were as alive, as iridescent and shape-shifting as any other building in the city, it would be impossible to appreciate the courage of the generation it commemorates. The radical hope it took to imagine—to demand—the world you take for granted today. Nothing was green then. Nothing was soft. Surfaces were disinfected. Technology was mindless rocks, polished to a glassy finish. Life was potted plants and zoo animals. Life was thirsty saplings in highway medians. Life was an enzyme in a factory. Life was something to conquer and capitalize upon. Life was dying.

Colonial logic persisted long beyond the fall of individual empires. In the 20th and 21st centuries, corporations accumulated the wealth and resources of entire nations using similar patterns of domination and control. Recognizing and undoing these patterns required first re-learning what traditional knowledge already taught—that humans, animals, and ecosystems are not mutually opposed—and then demanding a political transformation to reflect this worldview. This required imagination and effort from scholarly and activist communities around the world. But it was essential to the survival of the human species, to say nothing of its fellow travelers on Earth. By combining the wisdom of traditional knowledge systems with the expansive capacities of modern science, humanity was able to experience a deeper awareness of the living world–and, finally, to untether science from its extractive history.

Ancestral knowledge—Govera's "grandmother language," among many other traditions—helped humanity learn to rejoin the world. It did not exclude technology, nor did it reject scientific inquiry; it made use of technology where appropriate and grounded scientific inquiry in matters of ritual, purpose, and care. Like the spidery threads of mushroom mycelium, it formed a network beneath the surface, densely interconnected, waiting to transform the poison of the intervening centuries into food. It was held by grandmothers and great-grandmothers for generations, until the land was returned to its rightful owners, who were always scientists too, who brought the knowledge of deep time to bear on a changed, and changing, world. Mushrooms do not rot.

Govera's voice falls quiet as the light emanating from the mushroom dome slowly dims. You sit in the peace of the gallery, your unfocused gaze adrift. Another dome warms along the opposite wall, beckoning you closer. You walk diagonally across the room, and as you cut across the gallery you see that the plinths have been planted in neat rows, as crops once were. Neat corridors of white space pass your eye like marching soldiers. It's unspeakably strange to you that people would take things away from where they come from in order to entomb them under glass. You've never seen anything like it. It lends the Museum an uncanny quality, a wrongness. Everyone knows plants grow better together.



The Microscope

The next artifact is unlike anything you've ever seen. It's very small and fashioned from a plate of weathered brass. At the center of the plate sits a bead of glass no larger than a raindrop. Unlike the mushroom, which is ancient, this artifact is merely very old.

You consult the brochure and learn that this is a microscope designed in the late 1600s by the Dutch scientist Antonie van Leeuwenhoek, one of only ten in existence. Through this simple handmade lens, van Leeuwenhoek met the world's hidden actors: the panoply of single-celled organisms animating everything from pond water to dental plaque. The "animalcules," as he called them, that could be found in falling rain and carried by the wind, and floating alongside the dust in the air. How strange it must have been to find life hiding in air and water. To glimpse bell-shaped protists, nematodes, spirally-wound alga, and bacteria for the first time. To discover that the air is dense with seeds, spores, and organisms. You wonder if it frightened van Leeuwenhoek to discover that his own body was an ecosystem. Or was he overjoyed to learn that he was not one, but many?

As if echoing your thoughts, the dome in front of you begins to speak. This voice is accented with a warm cadence and rolls across the room invitingly. "Through the microscope, we came to realize that we are much more than humans," the voice says. It is the voice of Maurizio Montalti, the famous designer whose fungal materials tiled the floor of your childhood home, and every home you have lived in since. "We are, of course, walking biotopes, complex ecosystems that result from the collaboration among many very different types of living beings, mostly tiny and not visible and not perceivable to the naked eye," he says. "These are the organisms that make us human."

Peering into the microscopic world, Montalti's voice explains, is like looking into a mirror. It reveals an aspect of ourselves that defined us even before we could fully understand it: our multiplicity. Our place in an interdependent web of life with no bottom, no end, and no aim but to flourish. You examine the bead of glass, a tiny portal into that web. Van Leeuwenhoek held his microscope against a candle flame and gazed into it until his eyes hurt, as mystics once lost themselves in polished stones and mirrors, seeking beyond the visible. You try to imagine yourself in van Leeuwenhoek's shoes, standing on the outside of nature, looking in. It was a stance he would share with generations of scientists to follow.

Science craved order; it named each molecule and placed every living thing into a tidy taxonomy. Everything had its place in a great chain of being. For many years, scientists believed life to be a competition, one that humanity must win. One crack in this cosmology came from a biologist, Lynn Margulis, who saw evidence that eukaryotic cells emerged from the gradual symbiosis of mutual antagonists. She proposed that conflict is resolved in the coming-together of things—that cooperation, interaction, and mutual dependence drove evolution, and not, as had been previously believed, competition. This seemingly-new idea was, in fact, very ancient, forming the cornerstone of many Indigenous cosmologies. In the sciences, the heresy lost its sting with time. As biologists learned more about living systems, it became undeniable that interdependence was key to understanding life on Earth. Cooperation was everywhere: trees in old-growth forests communicated with one another through mycelial webs, sharing resources drawn from the soil and brokered by helpful symbiotic mycorrhizal fungi. Bees fertilized flowers. Fish and anemone scratched each others' backs, partners in the sea, even as the great coral reefs bleached to bone-white around them.

As you read this, you notice that you're feeling warm. It's subtle, but a change in temperature seems to have opened the pores of the room. You take a deep breath and inhale a musky, earthy scent that reminds you of finished compost curing in the sun. You close your eyes and linger on the familiar scent, listening to the voice of Maurizio Montalti. Nature is an active process of entanglement between organisms, he is saying, which we call symbiosis. You understand, of course. Nature is a continuous process of becoming enacted by a plurality of lifeforms. Yes, you understand. Across the centuries, Montalti tells you to accept the implications of adopting processes rooted in transformation and transience. Abandon your passion for eternity, he says. You wish that you could pluck the van Leeuwenhoek microscope from its pedestal and bring it home to your garden, where the soil is thick with jagged spirochaete bacteria, gossamer threads of fungal mycelium, amoeba, bacteria, and protozoa. These are the agents through which death becomes life. You would like to greet these invisible partners, but no matter—they will know you soon enough.

The Snail

Understanding is not always the same as knowledge. One can take apart a clock radio, examine how all the parts work, and put it back together again. This does not, however, explain music. One can examine life down to the cell, even edit genetic information. This does not explain life, or express its fullness. This became clear as, in the early 21st century, it became possible to directly manipulate and synthesize life from its component parts. This was done in order to solve problems facing humanity—problems of waste, nourishment, fuel, health, and survival. Life grew easily and healed itself handily. As such, synthetic biology created solutions. But it was not a panacea, because life is also a nonlinear phenomenon. It resists definition by the sum of its parts; it can only be understood through the dynamic interrelation of its parts.

As you wonder what a clock radio is, an image catches your eye from a neighboring dome. You step over, and press your nose to the glass. The image has the tinny sharpness of the pictures in the entrance gallery. You smile anyway, recognizing its subject with pleasure: a storybook snail, glistening brown. It travels across a gray plane of cement, somewhere in a residential neighborhood of Palo Alto, California. Today Palo Alto is a marshland, dense with wild thorny rose bushes and visited by soft-footed foxes and migratory seabirds. But this image predates all that—the snail is traveling the impermeable surfaces laid by people.

The image was taken by Megan Palmer, the scientist-turned-policy scholar. Her research into the ways biological science and engineering shaped society in the early 21st century—a century of asphalt, crisis, and transformation—led to the creation of this very Museum. Her voice is bright. She speaks of the snail with affection. It's moving from one little pocket of nature to another, she explains, leaving as the only evidence of its passing a silvery trail across the sidewalk. The snail travels along its own thick, thixotropic mucus, impervious to hostile surfaces. The mucus protects the snail from everything, adheres it to anything. It reveals where the snail has been, but not where it is going.

Palmer wonders if she should have lifted the snail in her hands and moved it elsewhere, but she cannot guess where the snail wants to be. "We're not starting from zero intervention," she says. "This little creature is already trying to make its way through our built environment and our relationships are very complex, and I hope that in the future, we keep it complex." She wonders about her relationship to the snail, and to all living things—was she collaborator or custodian, appreciator or intervener? This was the question of the age. Many wondered, as Palmer did, how to meet the living world on its own terms, while acknowledging that those terms were changing. Humanity had irrevocably changed the planet. This particular snail had never known a life before sidewalks. To the snail, pavement was natural. What to make of this new nature?

The early 21st century was a time of great contradiction. Never was there more awareness of life as a collective super-organism; never were individualistic interests so valorized. New scientific understanding of interdependence progressed even as the forces of industry plowed complex ecosystems down to bare earth. Books about the importance of forests and oceans were printed on pulped trees and shipped back and forth across the planet in ships loud enough to drown out the songs of whales. Understanding of climate systems was so precise that scientists could model every raindrop and predict global temperatures decades hence—and yet humanity did little to change its behavior. These contradictions were so puzzlingly intractable that many people believed the only way to transcend the binding conditions of the present moment was to escape the present entirely. They idealized old ways, and sought to trace the shapes of technology in nature itself. But they could never go back. Everything had changed, and the only way to ensure a future was to take a long and unflinching look at the present.

It took two weeks' travel on the solar trains to arrive here from your village. From your window you saw wondrous things. A cohort of flowerwalkers traveling barefoot along the rutted roads of your province, sowing the springtime wildflower seed along the land's storylines. Farther afield, the wandering islands of the Remediation Archipelago, their shoreside lagoons matted with rich blue-green algae; the famous Tree of 1,000 fruit, in full bloom, branches heavy with a dizzying gradient of pink blossoms; the tangled abundance of the university Milpa; the canal villages of the south, where jeweled carp traveled kitchen waterways. The great cities of the 21st century remain, albeit transformed; the rest of the world is a constellation of villages, communities small enough to maintain meaningful connections between people and just large enough to sustain themselves. Migrating butterflies and birds followed the train, riding its thermal currents, dancing with the glittering nano-insects monitoring the air. They dispersed as you slowed to cross a fairy ring of fungal waste-processing villages encircling the capital city, which came into view like a mirage, all shimmering buildings and big messy gardens thick with bees.

In the Museum, you return your attention to the humble snail, traveling across the sidewalks of ancient Palo Alto. For that snail, there was no before, only a now. For the humans who built the sidewalks, there was no before either—only a now, and, hopefully, with some effort, audacity, and care, an after. Behind you the generations have left their own silvery trail through conflict and crisis. Through change, chance, and emergence. Through harrowing scarcity and synthetic abundance. They moved with the slow confidence of the snail through it all, safe on the impermeable path they created for themselves. It was a long journey, from one pocket of nature to another, but they made it. And so have you—here you are, in the city, in the after, which is your now.

The Red Rice

You pause to examine a woody calabash filled with rust-colored grains. “This local rice is a short grain, and it’s red,” the voice of Selassie Atadika explains, matter-of-factly. “It’s higher in nutrients than imported rice, and does well in highland areas. It does not require a lot of inputs and fertilizer, and does not require too much water to grow.” Atadika—a Ghanaian chef known for her New African Cuisine, drawing from traditional ingredients like this red rice—speaks of food sovereignty with an eye to the future.

Traditional rice dishes in Ghana, she explains, are often prepared with imported Asian rice, which is less nutritious and requires more fertilizer than the Indigenous grain. “Much of what we’re doing is still very much related to the extraction of cash crops and the defamation of our Indigenous agriculture,” she says. “It’s important for us to understand how to feed ourselves and how to be able to put money back into the economy, and how to create sustainability by eating what grows traditionally, naturally, better, in the soil that we have.” Red rice is undervalued because it produces less yield than white rice, she explains. But the white rice requires more fertilizer, which, in the long term, damages soil health. “What is considered success in the short term might actually mean destruction in the long term,” Atakida says. Understanding value requires an awareness of the entire picture—the past and future of an ecosystem as well as of its human caretakers.

Everyone hopes to visit the Museum of Symbiosis at least once in their lifetimes. When it was first built, people came to the Museum as a way of making sense of the changes they were experiencing around them—seeing these everyday artifacts so carefully protected helped people to demarcate the end of one era and the beginning of another. Returning to the Museum years later, they found themselves explaining things they’d once taken for granted to their incredulous children and grandchildren. Over the centuries, people have come here for different reasons—driven by disbelief, curiosity, or spiritual fervor. Although it’s considered common knowledge today that the Museum commemorates a seismic change in human values, some scholars of the Symbiotic Era have suggested that the Museum itself created the world it hoped to bring about. It has been proposed in several papers and academic symposia that the Museum of Symbiosis has an “incantatory psychogeography”—that it precedes the change it commemorates. It’s a strange theory, but it does make sense. The Museum’s voices, replayed for visitors in perpetuity, are so keenly prescient that it feels as though they must have spoken reality itself into being. Their once-radical truth feels almost mundane.

You have to force yourself to remember that these voices were recorded in the early 21st century. Today, their perspectives are as self-evident as a flower turning to face the sun, but they were once seen as transgressive, questioning—even utopian. It’s only when the recorded voices speak alien phrases like “the extraction of cash crops” and “the defamation of our Indigenous agriculture” that you understand this fully. One of your schoolteachers once told you to have some sympathy for your ancestors. They nearly had it right, she explained. They understood that living things had value, but they didn’t know how to measure that value, or how to speak of it. The trouble came from their system of measurement, which they called money.

Pre-Symbiosis, attempts were made to measure the value of the living world using numbers that could be understood by the market: the yield of a rice crop, the economic value of a forest per acre, the worth of a wetland or a mangrove swamp expressed as a form of natural capital. Of course, the most valuable things in the world resisted such calculus. A mangrove swamp produces timber, it serves as habitat for birds, it supports cultural traditions like fishing, it sequesters carbon, it protects the shoreline from erosion and the neighboring human communities from storm surges. How to quantify such expansive benefits? How to square all of these inputs with the mangrove swamp’s own nature—the way it simply exists in its own place and time, eternal, irreplaceable?

These things have their own protected status now, like people. Their value is not measured in terms of market price or productivity. Instead, like clean air, wild fisheries, caregivers, public parks, social equity, and quality education for all, they are considered public values. Such outcomes—each as unquantifiably good as the mangrove swamp—are sought directly by the communities who benefit from them. In a process of imaginative co-creation, they gather to ask not what problems should be fixed but rather what kind of society, and world, they would like to live in. This is how collective visions are made explicit and shared missions formed. What was once solely the role of institutions to articulate and enact is now equally the purview of communities, which are far more resilient and adaptable to change. The successive disasters of the late pre-Symbiotic era galvanized this awareness: in the face of exponential growth and ecological disruption, those who fared best were those who organized and worked together.

Value takes many forms. It also looks like the package of seeds you’ve brought in your suitcase to the city. The seeds include the important medicinal and culinary plants of your ecoregion, reminders of where you come from and offerings to those you will meet along the way. What began, centuries ago, as a process of rematriation—the return of heirloom seeds to their native soil—has become a traveler’s custom. Seeds are the language of place. They are also carriers of community knowledge. Your grandmother’s garden laboratory has created some interesting specimens this season—a hyper-pigmented violet and a “talking” maize that spells out messages through its multicolored kernels. After you leave the Museum, you will bring her seeds to the library in the capital and return home, you hope, with some new plants for her. Perhaps you can bring home red rice, too.

The Jar of Soil

As the dome containing the red rice slowly dims, you hear a voice. “You have seeds, I have soil,” it offers. At first you think it’s the young family you encountered at the Museum entrance, who—their toddler’s runny nose now wiped clean—have trailed behind you into the galleries, holding hands and chattering to one another in the sing-songy dialect of the capital province. “I think that both always go together,” the voice says, and as you dial your head around to find its source you notice an open door leading to the next room. Following the voice through the door, you discover a small jar of soil, rotating in artificial suspension above the floor. You hunch over the jar to examine it more closely. “If you have a seed and you don’t have the soil,” the voice says, “you can’t do anything.”

The jar is made of glass—the old kind, with a screw top lid. Within the jar the soil looks dark, damp, and rich. It’s nearly 300 years old, of course, but the Museum maintains the life of this soil through regular ministrations of organic matter. The microorganisms currently present in the jar are ancestors of the original microorganisms. But are any of us really the same, from one year to the next? As we shed dead cells and host generations of microbial communities in our guts? A system may change, but if its internal relationships remain intact, it persists—resilience is not about maintaining an image, but a pattern.

The original soil was dug from a garden in Argentina, where the mother of a digital artisan named Fernando Castro once grew vegetables. Castro grew vegetables too, in his way, by helping subsistence farmers in Argentina transition to sustainable agroecology. He built tools to help them measure and monitor the soil’s health, because Castro loved soil, and appreciated the vast life it contains. “It’s a small world in itself, this little bit of soil,” his voice offers, across the centuries. “It’s a small world with many worlds inside.”

The Museum brochure speaks of cosmologies. It explains that pre-Symbiosis, people believed themselves to be separate from the living world. Superior, even. From there followed the assumption that humanity was entitled to dominate the rest of the planet, and to treat the living world as a raw resource to exploit. You remember the photographs of mines and clear-cuts solemnly framed at the Museum’s entrance. Today there is nothing so formal as all that: you just sit with the world, sharing an easy and natural complicity. Nothing is forced to act against its nature. Life is available to commune with at all scales, from Petri dish to ecosystem. Everyone is a scientist, in their own way, since everyone seeks the best way to interact with the life surrounding them. To perceive, too, what they themselves are made of. If your cosmology had a shape, it certainly wouldn’t be a straight line. It might look like a spiral, or like a jar of soil: a small world with many worlds inside.

The generation that created the Museum of Symbiosis seemed to think a great deal about the future. It weighed heavily on their minds; it felt hot, violent, and terribly brief. They felt themselves to be in a race against time, and were desperate to find solutions that might buy them a few more years, like crops strong enough to withstand drought, or vaccines to combat rapidly-mutating infectious diseases. With every success came unanticipated failures: the new crops survived parching hot summers, but, planted in great monocultures, were vulnerable to disease. The vaccines were not distributed equitably around the world, turning entire populations into incubators for more and more aggressive variants of the very diseases the vaccines were designed to protect against. Some days, this lack of consideration makes you livid. How could your own ancestors have been so short-sighted? Other days, you remember your own failures, and give them a little grace. When you fail, the important thing is to keep trying. And try they did.

You don’t imagine that your future will be terribly different from your present. After all, yours is a practical reality of cyclical economies, regenerative processes, and objects designed to return to the land with minimal interference. Your consideration of the future is simple: you hope to leave the world as you found it, if not in better shape. Your six-month shift in the remediation corps begins next spring, and it will take you to a former electronics disposal site in the desert—a place where the soil is still poisoned three generations after the global E-Waste ban. This, too, makes you livid. Your ancestors left you to clean up their mess. Did they think the future would end before you were born?

Before you left for the capital you asked your grandmother to tell you about the Museum. You’d heard stories: that it was overwhelming, best taken in over the course of several days. You were worried that you would miss something important. It’s not often you get the chance to come to the capital. Would you have the time to examine each artifact with care? Your grandmother put down her pipette and smiled. “That isn’t how the Museum works,” she reassured you. “It’s not a chore, or a task to be completed. You must simply enter with an open mind, and let the artifacts choose you. Everyone is drawn to different artifacts, and it’s as rich an experience to see them all as it is to sit with only one.”

She once spent an entire day at the Museum deep in meditation with the tissue culture incubator, harmonizing with its ambient hum. But that’s her nature, not yours. You’ve always preferred to make connections, to understand one thing in the light of another. You suppose that’s why you’ve taken such a meandering path through the Museum, building your understanding of each artifact cumulatively. We are all the product of our surroundings, defined by our place in a web of human and more-than-human relations. After all, what is soil without a seed? And what is a seed without soil?

The Toritos de Pucara

As you leave the soil room, a pair of ceramic statuettes catch your eye. They’re standing next to one another, shoulder to shoulder on a slender plinth nearly a full meter taller than its surroundings. Their horns and hooves are tipped with gold and their flanks are covered with delicate petals of red and blue paint. They peer down over the rest of the room with an authoritative air—guardians, perhaps, of the gallery’s precious artifacts. “They are Toritos de Pucará,” a new voice explains. “They’re from a place in the Andes in Peru called Puno.”

This is the voice of David Kong, a synthetic biologist and social activist best remembered today as someone who helped countless students of the life sciences to organize and run their own community biotechnology labs. Biotechnology, he believed, should not solely be in the hands of powerful institutions, research labs, and corporations. Like biology itself, it should be everywhere—in gardens, homes, schools, and communities. Kong and his peers knew that building an inclusive network of biotech leaders and empowering them to solve problems creatively would lead to world-changing innovations from the bottom-up. He was part of a global community of do-it-yourself life science enthusiasts who studied the history of movement-building. From their mentors and teachers, they learned how to leverage their collective values towards a shared purpose, putting pressure on governments and public and private institutions alike, demanding that the benefits of industrial biotechnology be shared equitably, and that proceeds be reinvested into their network of community labs. The bulls, he explains, were a gift.

For centuries, the Toritos de Pucará have been protectors. In the Andes, they’re often spotted sitting on rooftops and standing at attention near the entrances of homes, guarding families and ensuring their happiness. But in order for the little bulls to function in this capacity, they must be given as a gift. That’s because their power comes from the act of giving, an intentional gesture that imbues the bulls with meaning. This is the special relational energy created through gifting and gratitude, Kong explains, which activates an object and gives it a social context. The bulls have this energy two fold—they were given to Kong, and, in turn, Kong gave them to the Museum. Perhaps he was hoping to protect the future.

For a long time, it seemed as though the more humanity learned about the living world, the less it understood. Exciting breakthroughs led to stagnation. Researchers touted world-changing innovations that never seemed to arrive. Novel biotechnology solved problems—but those solutions often created new problems. It wasn’t for lack of caring. The synthetic biologists cared very much, and often discussed how to deploy their discoveries responsibly. In laboratories and universities, they shared ideas and spoke of democratization. Knowledge should be free, they said, and biotechnology should be made personal. No, it wasn’t that humanity didn’t care enough; it was that they cared in the wrong way. Rather than love, their attentions emerged from fear—the fear that they might lose valuable biodiversity before it could be captured. The fear of annihilation. The fear of losing control. The fear of losing money. They cared about the living world, but they did not care after the living world. They did not take care of it.

Kong asks, “could you imagine a world where we actually are honoring the organisms that provide us the life saving compounds and therapeutics? What does a world look like where gifting and gratitude is central to how we engage with the living world?”

You don’t need to imagine it. At your local community biotechnology lab, where everyone can be a scientist, rituals of gratitude are part of everyday operations. The cells you work with there are no different from the animals and plants you tend and forage: you never ask for more than they can give, and you always acknowledge their role in the process. It’s the same with machines. You smile, remembering last month’s celebration at the biofoundry—how your friends connected the robot biomechanics to the bellows of a custom-made concertina and how you all danced, laughing, into the night, to the music it created. Gratitude is a form of care, and care begets gratitude. None of this is finite. Quite the opposite: it only grows stronger and more abundant with time.

The Cannabis Leaves

You find a hard bench against the gallery wall and take a rest. Your mind begins to wander, and you think of the night market you'll visit tonight, the flute music, the street vendors pouring syrupy apricot juice from speckled silver goblets, the nubby local silks dyed blue and purple with soil-dwelling bacteria, the fruits you'll sample from garden laboratories across the region. The capital province is drier than your village, with crisp winter winds that whistle along the hillsides; you've heard the wine here is sweeter. You'd like to take a bracing dip into the salty coastal lake, whose waters are soft pink and dense with brine shrimp. In fact there's quite a lot you'd like to do while you're here in the city. But the Museum of Symbiosis has more to tell you.

> There is a nervy presence in the room, a quality of microscopic aliveness, like a hummingbird's heart-beat. It's enough to get you back on your feet with a start. You don't see anyone else in the room—the young family has wandered off towards a display of seashells in the next gallery—but still, you sense that you are not alone. The voices you've awakened with your presence have continued to talk to one another, to themselves, and to you. Their urgent whispers echo across the room and across time. As you approach different artifacts, new voices join this chorus: "I think we need to understand we do not exist in isolation from other species," one says. "I think a bit of humility is very important for us," responds another. "What if we let biology speak?" asks a third, and from there the questions multiply: What does nature mean to us? What has life come to mean to us? How do we see the future? How can we scale up? How can we scale back?

If you hold still and listen deeply you can isolate one voice from the din, like choosing to watch a single blade of the ceiling fan as it spins. But the overall effect is of a kind of song, a jangled round of spoken words. The polyphony reminds you of home.

The Symbiotic Era began with a thrilling confluence of ideas. Everything came to a head in 2030. Although this date is now recognized as the official dawn of the Symbiotic Era, or Symbiocene, it was not a single event, but a weaving-together. By the end of the 2020s, scientists had discovered that it was more effective to work with life than against it. Evolution had already created countless highly competent organisms. When researchers took the time to understand each in the full context of its evolutionary history, it became possible to enlist wild collaborators in all manner of projects. A similar shift in thought occurred in synthetic biology labs: although the discipline of synthetic biology had initially emerged from engineering, inheriting that field's emphasis on systematic control, it became obvious to the synthetic biologists that life resisted any attempts to constrain it. It was more productive to understand and harness life's existing strengths: its open-ended creativity, ceaseless adaptation, and an indomitable drive to flourish.

One voice speaks with a dry frankness that cuts through your reverie. You wander towards a bright green cannabis leaf—a wild plant with slim, rangy leaves. As you examine its delicate veining, you listen to the research scientist, academic, corporate advisor and entrepreneur, Dr. Nhlanhla Msomi. He was president of Bio-Africa at the dawn of the Symbiotic Era, and helped to shape the policies that redefined value for a new age. With fondness, Msomi is describing the herbal medicines his grandmother crafted for him when he was a boy, from the cannabis plants growing wild around his hometown of Durban, South Africa. Once he left his grandmother's side, he was forced to use asthma inhalers instead of the traditional cannabis steam she prepared to soothe his lungs. The "modern" medicine never worked quite as well. It was missing something.

> "When we talk about medicinal plants, we use a Western paradigm," explains Msomi. "We use the notion of an active ingredient—whereas a lot of the Indigenous knowledge systems tend to work in a synergistic manner." Science allowed the people of the 21st century to isolate and examine plant compounds in isolation, and they often found success creating medicines drawn from these compounds. But flavor, nutrition, and medicinal potency emerge from the complex interrelations of many compounds, which themselves emerge from an evolutionary history spent in constant interaction with an ecosystem. Like people, plants do not exist in isolation. "The value that is embedded in the Indigenous knowledge system is not in the actual unit, it's in the interactions," Msomi explains. In the Global South, he adds, people tend to use plants in a synergistic manner, using the whole plant, rather than just a single compound that can be isolated and turned into an economic unit. They also consider the interactions—the relations between plants and within the environmental context. And they situate the whole in rituals of care.

You understand, then, why you were drawn to his voice. You are standing in the center of a gyre of knowledge, in the form of plants, artifacts, voices, and memories. It is a living time capsule. And although each artifact has a voice and a point of origin, there is something transformative in their collection as a whole. They do not speak in isolation. That is the power of the Museum of Symbiosis: the story it tells is collective, like history itself, like life on Earth, like the cells in your body, like the countless agents pushing and whirling through this world, making meaning, making music, making life.

It wasn't long before the historians, ethicists, and artists-in-residence working alongside the scientists realized that leading with curiosity—taking the time to understand not only what drives an individual organism but the context informing its drives—could be applied to societies as well. People, too, had context, in the form of history, and the stories they told themselves. Certainly humanity could never survive the century if it remained mired in an idealized and myoptic fantasy of its own past. And so it became the essential project of the humanities to frankly assess the here and now in order to more freely imagine where we might go next. This effort was met with heated resistance by the beneficiaries of history: those whose ancestors had been enriched by the extractive, profit -driven subjugation of the living world and by the devastating exploitations of colonial empire. Had it not been for the existential threat of climate change, which presented humanity with a stark image of its own mortality, the Symbiotic Era may well have been permanently derailed.

The Raspberry Pi

Oh, you recognize this! Your father had one. About palm-sized, soft gray, carved with the outline of a summer fruit. It's a computer called a Raspberry Pi, inexpensive and simple to program, and the heart of home-built systems everywhere. It was part of the solar rig at home, the last holdover from the oldest part of the system—a rugged little robot that drew solar energy during the day and detached to wander the garden paths at night and weed invasive plants. The old computer was a bit of techie nostalgia but like your father always said, "if it ain't broke..." Until, eventually, it broke. The Raspberry Pi still has a place of pride in your family home, stationed above the hearth with a few other junky, sentimental reminders of a lost age.

As humans became aware that they existed within nature, their interpretation of technology changed. Machines were merely adaptations made by biological organisms living among countless others. Tipping points in biology and synthetic biology flattened once-hierarchical relations between people, plants, animals, ecosystems, and micro- organisms. In computer science, in the wake of the great silicon shortage of 2027, it became both practical and economical to develop computing systems with new substrates. Eventually, searching protoplasmic tubes of electric yellow slime molds would trace more efficient networks; information would be encoded in plant DNA and propagated in great fields of knowledge; functionalized mats of fungal mycelium would serve as ambient sensors in a biological internet of things; living robots carved from frog cells would conduct tasks too minute and dangerous for people or machines. Although humanity had once been content to push abstract symbols around on devices of glass, mineral, and stone, the Symbiotic Era muddled the distinctions between living and dead, animate and inanimate—and finally, thankfully, between nature and people.

The first time you saw your father's Raspberry Pi robot, you were six. You tried to feed it some lichen. A reasonable assumption considering everything you'd seen, by that age. Computers, to you, were already living things, not slabs of silicon. You glance back at the plinth holding that old microscope from the 1700s. These two artifacts don't feel that different to you. Scientists once peered through polished glass at a microscopic world, imagining themselves on the outside, looking in. Over time they came to name every organism they encountered. They measured and organized them all, producing enormous amounts of data. To process that data, they built machines, and those machines became so important that the scientists began to see the world as though it, too, functioned like a machine. They began to see life through the computer, as they had once seen life through a microscope.

> To suit the computer's inflexible world-model, everything needed to be reduced to its component parts. This mechanical mentality manifested itself in language: in synthetic biology, it was common to hear living organisms described as tools, devices, and parts. Cells became chassis, genes became software, and DNA became an operating system. Scientists spoke of building with blocks in a great factory of life—making and remaking living systems as though they were mere machines. The Raspberry Pi beeps placidly as a man's voice issues from the plinth. It asks, "What is synthetic biology about?" You think: synthetic biology is about facilitating relationships of mutual reciprocity. It's a powerful model for understanding life. It's a way of participating in ancient processes.

"It's about the expression of human intention in partnership with living systems," the voice answers. "It's about speech." You check the brochure. This is the voice of Drew Endy, the American synthetic biologist. As founder of several open-source biotechnology initiatives in the early 21st century, he helped forge key connections between community bio-labs and researchers around the world, opening the possibility for more people to become citizens of the bio-economy, rather than its consumers.

Language is important, Endy explains, and so is culture; if we understand synthetic biology to be part of human culture, a form of expression in concert with the living world, then it might be governed as we govern poetry and music. Endy echoes what many of the other voices in the Museum have said during your visit, in their own ways: that human separation from nature is artificial, and that as biotechnology becomes more fully-realized, more embedded within our bodies and societies, this artificial separation will become more difficult to abide. "Increasingly we'll see that we're not apart from things, that we're connected," Endy's voice says. You think of the colony of microorganisms in your sinuses, which turn your mucus bright pink when you contract a respiratory infection—they're not you, but they are part of the multiplicity that makes you. Not apart. Connected.

> In the meantime, Endy suggests, the relationship between people and nature is both understood and expressed through language. If we want to change our relationship to the living world, we must also change our language. Can we parent and collaborate with life, he suggests, rather than control and dominate it? Can we grow, rather than build? Can we sculpt, carve, and dance with—rather than assemble, code, and engineer? A fully-biotic society, Endy explains, mustn't be solely motivated by fear or desperation in the face of dwindling resources. Rather, it can be driven by curiosity and a sense of collaborative discovery. It can even be playful, since play, in both animal and human lives, is an important developmental stage, key to establishing trust and communication.

Before it finally sputtered out, your Dad's Raspberry Pi robot developed a kind of rapport with the neighbors' barn cat. They both prowled the garden at night. The cat would hide behind the hedgerows, watching the robot make its rounds, wiggling its hind end until a burst of energy propelled it to pounce, toppling the poor robot into the planter beds. Righted by its internal gyroscope, the robot would continue along its way, only to be knocked down again and again. You found it riveting to watch the cat and the robot fumble around, as littermates would. Although they were two very different kinds of beings, they were at home together in a post-natural garden.

The Morpho Butterfly

In the corner of your eye you catch a flash of brilliant color. As you approach the butterfly, its wing flutters, setting into motion delicate reflections of metallic blue. It's the blue of lapis stone; the blue of deep water; the blue of a jungle sky at noon. It's profoundly beautiful, and made even more so by the fact that it doesn't exist.

> The blue of the Morpho butterfly does not derive from pigment, but light itself reflecting from the microscopic diamond-like scales covering its wings. You recognize it at once, because your favorite dress is Morpho blue, and your village flag. In fact, Morpho scales are cut delicately into surfaces everywhere. Color from form is an idea borrowed from the butterflies—just as buildings mimic termite mounds, adhesives mimic the toes of tree frogs, and surgeons seal wounds with spider-like silk. Even algorithms are "ecorithms" modeled after the cleverest adaptations of living systems. Evolution is the process of creative becoming. Humans were the result of this process, but they are far from its end.

You no longer feel as though you are simply a visitor to the Museum, or that your role is to walk a straight line from exhibit to exhibit, nodding gravely as you take in the atrocities—and audacious hopes—of the distant past. Your role is evolving into something more active. The voices envelop you. You have a place in their story, and a responsibility to continue it. You begin to feel slightly, dizzily delirious, like a pollen-drunk bumblebee. Staid lines curve. The sounds of the gallery warm your ears. The loamy perfume of soil and fungus grows richer. Without realizing it, you have fallen into a trance, your inner wandering guided by the persistent song of voices surrounding you. You decide to succumb to it fully. Certain words appear and reappear in your consciousness with the persistence of mantras: equity, sustainability, humility, solidarity.

The new technologies did not poison and deplete the Earth as the servers, chips, and batteries once had. Instead, they were regenerative, returning to the Earth all they had drawn from it, and more. Data fruit trees drew heavy metals from the soil. Mycelial systems transmuted toxic waste into benign edible mushrooms. Algal computers sequestered carbon deep beneath the sea. It became impossible to distinguish between a garden and a computer—and who would want to? Every blooming flower was a node in a great system, processing and expressing the beauty of wild information.

In your imagination, the neat little domes crack open like eggs, setting the musty air of history loose into the galleries. Suddenly everything leaps into conversation with everything else. Govera's mushroom exhales its spores towards Castro's soil. Palmer's snail nibbles Msomi's cannabis leaves and creeps through history to peer through Montalti's microscope. The butterfly comes alive and flies out the window; bunches of Trinidadian flowers bloom; the rust-red grain cracks and sprouts tendrils of green; a beaker of algae issues a heady patchouli perfume; delicate pappi of a dandelion seed drift through the room as lazily as motes of dust in a sunbeam. In the midst of this hypnotic entanglement, a fragment from an ancient poem bobs up in your memory:

I like to think
(it has to be!)
of a cybernetic ecology
where we are free of our labors
and joined back to nature,
returned to our mammal
brothers and sisters,
and all watched over
by machines of loving grace.[1]

You feel a sudden urge to tear open the Museum and let the outside world in. Surely nobody would stop you—not now—from running across the galleries, pulling the blinds, smashing windows, and inviting the past to mingle with the present. These artifacts should not be hidden away, pinned and preserved like butterflies under glass. The people of the Symbiotic Era knew how important it was to understand history and, where necessary, to correct its imbalances. They also learned to cherish the rich web of relations that define existence on Earth. They celebrated interdependence, or else they never would have survived. They never would have turned the colossally extractive mechanisms of industry inside-out, or made the regenerative processes of the living world available to all. They never would have returned technology to the earth, integrating everything humanity had learned in its troubled journey to maturity back into its source. And they never would have built the Museum of Symbiosis—the first seed planted in a flourishing new world.

You throw open the Museum door at last.

1. Extract from Richard Brautigan's poem - "All Watched Over by Machines of Loving Grace". https://www.theatlantic.com/technology/archive/2011/09/weekend-poem-all-watched-over-by-machines-of-loving-grace/245251/

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DIALOGUE SYNTHESIS

by Mathew Smith

ANALYSIS: SYNTHETIC BIOLOGY TODAY

Synthetic biology actively generates new relationships between technology and living world. While advancing our knowledge of life, it might also transform our relationship with life. Some see this as human, for the first time, able to intentionally and deliberately step up to question our longest held assumptions about life. Others see this as human hubris, playing God, and hence, contemptuous—referring back to our longest held assumptions about life.

SYNTHESIS 2010 embraces the challenge by showcasing the perspectives of selected stakeholders who are actively shaping the future of synthetic biology. Invited authors for a short, focused, and speculating yet, the best approaches to bring forward the most relevant perspectives. Each author was asked to consider the future of synthetic biology and its relationship with society. The answers are a glimpse into the future of relationships with various fields—technological and biological sciences, the arts, and the humanities. Stakeholders expressed their hopes, fears, or both. Each speaker's voice is unique also into the fabric future of synthetic biology. Each speaker's voice is unique as with the diversity of the languages and ways of thinking. Each speaker's voice is unique also in depth, despite present realities.

Here, we present our findings from a discursive analysis of the 80 STORIES dialogues. Above all, we have found that synthetic biology is a dialogue with nature on-going. Each author identifies the values guiding those changes. On one week, the Stakeholders Dialogue, the Synthetic Biology Dialogue, and the World Economic Forum's Global Future Council on Synthetic Biology—the dialogue—are activated in stakeholder's present perspectives on the future of synthetic biology. The answers are guiding perspectives on the future of intentionally reconfiguring their relations with nature. Synthetic biology is a dialogue with nature, beyond pure life. Which is a dialogue with nature, beyond pure life. Which is a dialogue with nature, beyond pure life. Which

ANALYSIS **SEMANTIC SHIFTS**

Synthetic biology began with an aim to apply rigorous engineering principles to the design and development of biological systems [5]. In this context, mechanical metaphors emerged—'chassis', 'parts', 'devices', 'tools', 'factories', 'building blocks of life', etc.—and were adjoined by computing analogies—'operating systems', 'circuits', 'programmable microbes', organisms as 'machines', cells as 'hardware', genes as 'software', etc.—to represent the inner workings of synthetic biology[6]. Today, however, there is widespread agreement among diverse stakeholders that these conceptual metaphors ought to be rethought because they reinforce an idea of biology as being little more than material resources to be exploited by humans.

DSK: *From a synthetic-biology or an engineering perspective, you view the object as this engineering substrate, which to me is something we need to challenge and interrogate. When the cell is a factory that is supposed to produce molecules for humans, it ends up being this question of 'what can this organism do for me?' 'What is the way that I can exploit this organism to get it to give something beneficial to me?'*

Interestingly, stakeholders no longer take the use of engineering analogies for granted as neutral descriptors of synthetic biology. This is not to say that engineering idioms for describing natural technology are suddenly and unanimously considered 'bad'. Nearly all participants acknowledge that metaphors can both conceptually open up and foreclose ways of thinking, doing, and communicating synthetic biology.

NK: *You mentioned the metaphor of Legos and the idea that we can snap together these little snippets of DNA and have a genetic programme that might run in a reliable fashion. I think that that is a goal, a desire. It's built on certain principles from other engineering disciplines that have been successful and are more established disciplines. The notion of standardisation of parts in order to enable greater diversity of built outcomes... I think it's counterintuitive and so, in that sense, a wonderful teaching point, the idea that if you standardise components, then suddenly you actually expand the range of possibilities rather than narrow them... But for sure, any metaphor has its limits. I think that's why we need many.*

That said, many are actively searching for new metaphors to represent their relationships with nature along the lines of ecologically imbued values. Some, for example, eschew engineering analogies–like 'building'—in favour of organic metaphors—like 'growing'.

IZ: *When teaching, it's very important for me to always remind the students, yes, we're changing things, but we're not building things. We're working with materials that were built already. And also those materials are in process, those materials are changing... They're not like a Lego. They are actually growing things. And we need to really, really to be aware of that understanding of the materials and to understand how different they are from the way engineers may look at them.*

Craftsmanship metaphors—such as 'carving', 'fabricating' and 'sculpting'—appear in these dialogues to describe processes of working with organisms in an instrumental yet humble manner that privileges deep relationships with biology over mastery of technique.

COT: *You're studying the surfaces of a radish and how the carving will flow with it. It's really being creative with biology; you're working withits contours and the material texture. And you learn what's too deep a cut and what's just the right surface and you're playing with that outer red surface; when you carve it away there's some of the white. So, what are the properties of the organism that you are working with?... It's a meditative experience working with carving a radish in this way. Yes, so the experience, the process, I think, is part of the journey.*

'Bio-facturing' and 'bio-welding' are other craft idioms invoked to figuratively ontologise biological processes as, themselves, manifestations of craft.

MM: *The cells fuse with each other as in, what one could describe as, 'bio-welding'.*

Again, this sort of discursive reconfiguration portends an ethical reorientation, primarily one of humility and solidarity, in relation to the agency of nonhuman life forms with which one works and to which one ought to carefully listen.

NAC: *I spent about a year trying to figure out how to ferment the organism so that it would produce its beautiful pigment, with a non-scientific background, and reached a dead end effectively. And I realised upon evaluating a year's worth of research in the lab that maybe I was approaching this in a slightly wrong way, that perhaps the thing I needed to do was not show the organism what I wanted it to do, but to understand how this organism lives and lives well, and how I could integrate that into my design process. And it was only at that point that I started to grow the bacteria directly onto the textile in a process that we referred to as solid-state fermentation. And when that happened, this organism was able to deploy, in a very direct and precise way, pigment molecules directly onto the textile. Suddenly the process was colourfast.*

Several stakeholders describe 'partnering with nature' and 'respecting our partners' by treating them less as 'living materials' and more as 'microbial actors' with whom they 'collaborate'.

JR: *We don't want to repeat the same mistakes that we had been making already in the industrial paradigm. We want to start working with nature instead of against nature. We want to engineer and partner with nature and biological organisms instead of just dominating them or mastering them or trying to deploy them only for human ends because I think doing that has brought us a lot of problems as well. So how can we shape the language with other words? For instance, partnering with organisms or working with actors or seeing them as partners or agents instead of seeing them as machines or little factories even.*

There are at least two ways to interpret these semantic shifts, both of which may be possible simultaneously. On the one hand, some stakeholders feel ideologically compelled to seek metaphors beyond those issuing from engineering disciplines with the hope that new ways of speaking may precipitate new ways of doing. When semantic shifts are more theory-driven than practice-driven, as in the latter case, stakeholders ironically end up orientating to reality as something to be engineered through speech. Implicit in this latter perspective is the idea that language influences reality and can thus proactively reshape cultural values, rather than merely reflect them post factum[7].

On the other hand, there are some stakeholders for whom old metaphors do not capture the processes with which they presently engage. For them, the use of new idioms is driven by their particular ways of working and interacting with biology; their semantic shifts represent their already shifting practices. In either case, these discursive practices create new meaning around working in/with biology today.

5. Void, C. A. (2012) 'Synthetic Biology', ACS Synth. Biol., 1 (1), pp. 1–2.
6. Balmer, A.S. and Herreman, C. (2009) 'Craig Venter and the Re-programming of Life: How metaphors shape and perform ethical discourses in the media presentation of synthetic biology', in Nerlich, B., Elliott, R. and Larson, B. (ed.) Communicating biological sciences: ethical and metaphorical dimensions. London: Ashgate, pp. 219-234.
7. Science Direct (2022) Sapir-Whorf Hypothesis Overview. Available at: https://www.sciencedirect.com/topics/psychology/sapir-whorf-hypothesis.
8. Weber, M. (1949) 'Objectivity in social science and social policy', in Weber, M., Shils, E. and Finch, H. A., The Methodology of the Social Sciences. Glencoe [Illinois] : Free Press, pp. 49-112.

ANALYSIS **MODALITIES OF PRACTICE**

Drawing from personal experience and their own professional practices, the speakers across these dialogues collectively rethink relations between bios and anthropos in the interest of imagining ideal possible futures. From this diverse set of stakeholder voices, we have distilled several core figures—'ideal types'[8]—that aid our grasp of the perspectives on nature most consistently appealed to. Taken together our core figures or 'types' of human actor schematise the different available approaches to nature, the tropes each relies upon, and the values each expresses.

The Farmer's Practice

The farmer who tends to nature knows what to harvest, what to sow, what to slaughter. Some consider the farmer's agricultural praxis a science, others consider it an art. Some see it as traditional, others view it as cutting-edge, insofar as the farmer's knowledge of breeding has recently become translatable and seen as valuable for genetically engineering food products. Farmers can use high and/or low technology to optimise their crops yields, but the most important technology they work with is nature itself. The farmer understands that nature is a technology for growing food. The farmer, in their place, harvests what nature grows and ingeniously uses natural technologies, such as composting, to produce ecological and economic value: better soil health and higher crop yields. The farmer works with and tends to nature so that nature may do its work.

Through working directly and intimately with nature, the farmer comes to understand its rhythms while respecting its constraints. That said, farmers in an industrial agricultural context are far more constrained than those in a cooperative community context. Smaller-scale farmers are capable of laying the foundation for a sustainable food system, while industrial farmers are often captive to economic incentives that alter their relationship to nature, such as being required to buy genetically modified seeds instead of native germplasm or to use pesticides and herbicides when growing vegetables to sell to the market.

The farmer embodies the values of solidarity and social cohesion, ecological humility, and industriousness. The practical wisdom they impart is that outpacing or outperforming what nature provides will inevitably lead to problems.

DK: *Each farmer that visits our farm says: 'Well, it's a nice system, but you can't feed the world'. There isn't any farmer who feeds the world on his own... it's not the intention that we feed the world. But my farm is feeding 75–80% of my stomach and my wife's and my children's and all the other members. So it's not an issue that you have to feed the world.*

The Scientist's Practice

The scientist wants to understand and to generate knowledge of the living world. Unlike the farmer, scientists do not restrict themselves to managing natural materials; in syn-bio fields, they also invent new ones. Their practices are tethered to a history of modern knowledge production, which includes ideologies of mastery and control along with subservience to the institutional (economic and political) demands of the day. Trained to revere objectivity, they embody the notion of being on the outside of nature looking in. At the same time, they increasingly understand that scientific praxis and technological innovation cannot be, and has never been, separated from value judgments. Indeed, the scientist is increasingly sensitive to the fact that their pursuit of scientific knowledge always raises social and political questions, that their research agendas are always taken up in cultural contexts, that there is a difference between truth and meaning, and that matters of fact are often laden with questions of which values matter.

Although the scientist has to reckon with mounting public distrust of their aspirations and claims, they are nonetheless committed to pursuing research questions and potential applications in the service of humanity. The scientist embodies the values of ingenuity, humility, responsibility, and industriousness. The practical wisdom they impart is that rebuilding trust, staying humble, and remaining open to learning new things, especially outside of our conventional comfort zones, is integral for ensuring that future scientific knowledge-making serves our species, our societies and our ecologies.

KL: *I think it's our job as scientists to show what's possible and to be as engaged with the public as possible, to say: 'Hey, look, this is what we can do. This is what it's possible to do. This is what nature has given us and how we can use it.' And to say nature isn't perfect. We're not perfect, but we can actually apply design principles now to natural systems to try and make them better... I think we have to learn to be shepherds of the planet. We have to engage with nature at its level and understand it and also learn from it.*

The Grand/Mother's Practice

The Grand/Mother not only nurtures her kin, but respects them; she allows her relatives to be as they are and become as they may. She parents with courage not control; that is, she lets her wards explore, play, and experiment on their terms. The Grand/Mother is akin to the cell culture incubator found in nearly all modern life science laboratories: humble and seemingly insignificant from an aesthetic point of view, yet necessary for sustaining life. The knowledge she generates and imparts, however, is not confined to the laboratory, but makes a laboratory of the world. Like the scientist, her knowledge of the living world comes from a process of interaction and contextual familiarity. Unlike the scientist, however, the grand/mother does not try to control nature in order to understand or improve it.

GM: *Your grandmother was able to provide you with knowledge about natural phenomena, to convey information about processing, to convey information about different uses, to identify varieties, to provide you with information about those natural materials in context, which means that not only was she a scientist, she was displaying the best of scientific method because you also said that she was able to convey that information in a way where you could replicate it.*

The grand/mother is not typically presented as the face of 'science', per se, but she is increasingly viewed as an integral science communicator. The information she passes on provides us with the rules of inquiry and the contents of innovation. Moreover, her attentiveness cedes us the necessary conditions for pursuing both, for she fabricates spaces safe enough for her relatives to dare to try, to fail, to correct our mistakes, and to learn.

The grand/mother embodies the values of empathy, gratitude, humility, respect, and courage. The practical wisdom she imparts is that it is not possible to eliminate things beyond our control, even things that may harm us, and that we ought instead to develop ways of nimbly addressing problems when they do arise.

DE: *One of the things I love about my mum is when I was growing up she let us be children. She didn't control what we were doing. Now that I'm a parent I find this amazing and terrifying. Like, how was she a parent in this way, because I'd have a bow and arrow in the yard? I'd just shoot it straight up in the sky. It's like whatever, right. We could do all sorts of things that are terrifying and lucky to be here, but as a parent one of the things I respect and love about her is that she didn't control me ... I don't wish for a future in which I absolutely can control biotechnology. I wish for a future in which I'm a good parent and we're good parents to our creations.*

The Artist's Practice

The Artist shares residence with laboratory scientists and plays a complementary role in innovation and creation, by asking different questions. Like scientists, artists in synthetic biology conduct experiments, albeit often for different reasons; they use the same tools, albeit often for different ends. Because their creations are driven more by curiosity, fascination and inquiry than by incentives to solve problems, the artist is quintessentially disruptive. Their path proceeds along a series of disorientations and detours that compel science to account for itself. Artists' sensibilities and insights are instrumental in the early stages of conceptualising and designing research projects, not just in illustrating or analysing their impacts further downstream. Like the grand/mother, the artist is a storyteller and an educator who offers visual and conceptual language for bridging communities.

The artist works with nature in a way that foregrounds careful attention to embodied craft and to creative acts that are worthy of attention beyond what is considered valuable by institutional (state-owned, corporate, academic) gatekeepers. They embody the values of tact, ingenuity, multiplicity, and complexity. The practical wisdom they impart is to embrace chance and process as method.

IZ: *I'm an artist working with biology and biotechnology as a medium for artistic expression. I started probably in the mid '90s, working with tissue engineering and regenerative biology... started a laboratory within a scientific department that is dedicated for artists to work with biology, but to do research for more cultural philosophical questions rather than science. And we also have actual scientists coming and doing research with us, research that they could not have done within their scientific career.*

The Curator's Practice

The Curator travels with and serves as a mediator between all of the figures above. They bring people together by 'representing' stories to a wider world, engaging with publics and communities, producing events, and even creating experimental social situations. In the name of design, they connect disparate knowledge, sensibilities and insights, providing these and the staged relations between them as resources for further thought.

This mode of translation affords the curator a somewhat privileged position, one which they occupy with care (the term curator comes from the Latin curare, meaning to take care, cure or help, rather than door-keeping). In the context of BIO STORIES, the curator operates as a relational barometer of an expanded and expanding field of syn-bio practices. To curate is to be attentive to this expansion, while recursively participating in it.

CONCLUSION

Contemporary stakeholders are rethinking the relations between humans and nature as one of integration and mutual co-constitution rather than separation. Their perspectives are diverse and their stories represent a multiplicity of ideas, all of which are open to different interpretations. This synthesis is one such interpretation, and seeks to demonstrate how their perspectives, when taken together, provide us with the contours of new languages and ways of thinking, which may guide us towards desirable futures.

Melissa Salm is a Bio Policy & Leadership in Society postdoctoral fellow in the Center for International Security and Cooperation at Stanford University. Melissa's current research portfolio is orientated towards channelling technology-driven innovations at the frontiers of bioengineering and earth systems science into global public health research and practices. Prior to joining CISAC, Melissa completed her PhD in Anthropology with a designated emphasis in Science & Technology Studies at the University of California, Davis.

[1] These categories emerged during thematic co-occurrence analysis, in which thematic relationships between code categories were identified across a set of research questions: How do stakeholders describe human-nature relationships with reference to the present, the past, and the future? Thematic patterns between the co-occurrence of codes affixed to passages of text relevant to these questions were identified, ordered according to frequency, then commonality, and collapsed into the thematic groups above.

[2] These priorities emerged during thematic analysis, in which relationships were identified between passages of text affixed to the following code categories: Temporal Horizons, Relations, and Values (see Codebook for descriptions of codes).

↑ TOC

METHOD

- CASE STUDY 1
- CASE STUDY 2
- CASE STUDY 3
- CASE STUDY 4
- CASE STUDY 5
- CASE STUDY 6 (SPECIAL FORMAT)
- CASE STUDY 7
- CASE STUDY 8
- CASE STUDY 9 (SPECIAL FORMAT)
- CASE STUDY 10
- CASE STUDY 11 (SPECIAL FORMAT)

BEYOND THE CASE STUDIES

METHOD 1: MRI. DEVELOPMENT

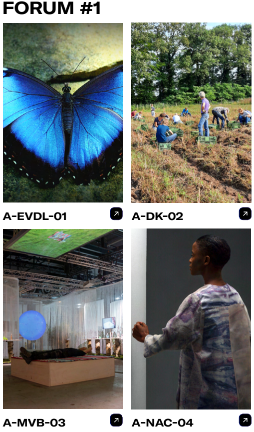
MRI
MATRIX CHARTING
DEVELOPMENT
INTERACTIONS
PROJECT STRUCTURE
STRATEGY
ECONOMICS
MOTIVATIONS
ORGANIZATIONAL STRUCTURE
TRANSACTIONS
CONCEPTS
SINGULARITY
TRANSITIONS
CONTEXT
CONTROL
CONTINUITY
CONTRADICTIONS
CONTRIBUTIONS
CONTROVERSIES
CONTEXTS
CONTINGENCIES
CONTINUITIES

STAKEHOLDERS

↓ PROTOTYPE FORUM
↓ INTRODUCTORY DIALOGUES
↓ EXPANDED DIALOGUES

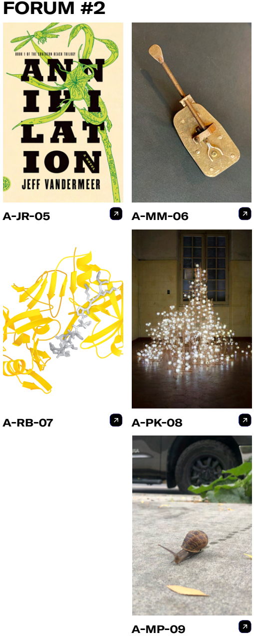
BIO STORIES emerged around an expansive community of stakeholders and the artefacts that embody their relationships with nature. Individually, the artefacts are material manifestations of the ways of thinking, knowing and doing that each participant brought to the dialogues. However, as a collective, they start to reveal the many domains that synthetic biology can impact or is impacted by.

PROTOTYPE **FORUM #1**



A-EVDL-01 A-DK-02 A-MVB-03 A-NAC-04

PROTOTYPE **FORUM #2**



A-JR-05 A-MM-06 A-RB-07 A-PK-08 A-MP-09

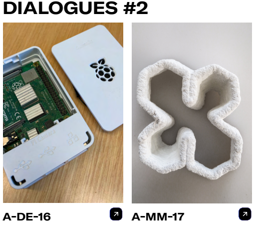
PROTOTYPE **FORUM #3**

A-CA-10 A-RFB-11 A-LA-12 A-TB-13

INTRODUCTORY **DIALOGUES #1**

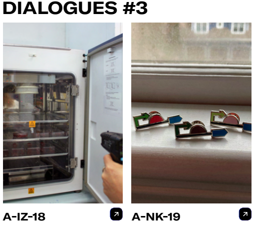
A-GM-14 A-CG-15

INTRODUCTORY **DIALOGUES #2**



A-DE-16 A-MM-17

INTRODUCTORY **DIALOGUES #3**



A-IZ-18 A-NK-19

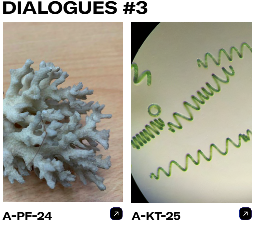
EXPANDED **DIALOGUES #1**

A-OG-20 A-KL-21

EXPANDED **DIALOGUES #2**

A-CC-22 A-JP-23

EXPANDED **DIALOGUES #3**

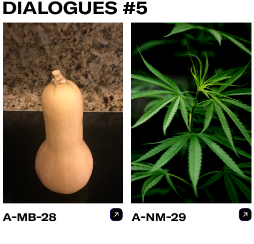


A-PF-24 A-KT-25

EXPANDED **DIALOGUES #4**

A-SA-26 A-FC-27

EXPANDED **DIALOGUES #5**



A-MB-28 A-NM-29

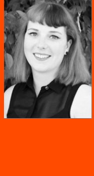
EXPANDED **DIALOGUES #6**

A-DSK-30 A-COT-31

PROTOTYPE FORUM #1

A-EVDL-01 *"[This] is structural colour. [...] And it really strikes me because not only butterflies and animals have it, but flavobacteria [...] can also produce a structural colour in the petri dish. And I brought it because I'm a designer, and of course, I really like colours [and that we] can produce colours by growing them. And maybe in the future we can programme our clothing to be blue or purple without using a chemical colour or pigments."*

EMMA VAN DER LEEST



Emma van der Leest graduated in 2015 with a bachelor's degree in product design from the Willem de Kooning Academy in Rotterdam. Form Follows Organism: The Biological Computer is the title of her research and book on biodesign and the shifting role of a designer working collaboratively with scientists. Throughout the years Emma has worked with a number of different working materials made by microbes. She is the founder of BlueCity Lab, an experimental and prototyping laboratory in the former Tropicana water park in Rotterdam. Her goal is to lower the threshold for anyone interested in working with micro-organisms and waste streams in the development of new materials. Emma holds a research position in 'New Material Practices' at Willem de Kooning Academy and teaches at Ecology Futures Master program at Avans University.

A-DK-02 *"By changing the food system, we create a new playing field. [...]The collateral benefit of this is not only the food, but it's community, it's a better soil, it's more biodiversity, it's more nature. It's a nature driven way of producing."*

DOUWE KORTING

Douwe Korting (1974) has a background in land & water management and constructive journalism. Since 2016, he has been a board member of the first cooperative 'Herenboeren Farm' in the world, located in Boxtel. In recent years he has been self-employed and helps to start this and other cooperative farms off the ground that have around 500 co-owners. Along the way, he has embraced the valuable collateral benefits that arise in these communities.
In 2020 he and two partners founded Cooperative Creabitat that tries to develop small and large living communities. Central to this is the integral sustainable development of areas supported by them. Besides the fact that people are jointly responsible for their food, they also work cooperatively on living together, shared mobility, care for each other, nature, soil recovery, water and meaning.

A-MVB-03 *"I am not only a human, but I am much more than this. There are little particles inside me. [...] The relationship between everything and nothing [is something] we should be more aware of when talking about our relationship with nature and the things around us."*

MARLEEN VAN BERGEIJK

Marleen van Bergeijk is a curator and a designer. With a background in Industrial Design she is fascinated by how technology has the potential to bring value to society, if designed in the right way. Her work focuses mostly on health and society, improving interaction and understanding between people. At Dutch Design Week 2021 she curated DDW's sub theme It's in our Nature, reflecting on the relationship between human and nature.

A-NAC-04 *"[There are many] possibilities when we start to work in a way that is not driven by our intentions or our expectations, but that listens to what the organism is well evolved to do already [through the] fermentation of biological systems that are more sustainable and rooted in craft. [...] And once we start talking about craft, it's impossible to not talk about communities. Who are the crafts people? What knowledge do they have to have? And what do they bring to the wider community in being able to create in this way? In other words, what is our future of bio manufacturing if it can happen at this community scale?"*

NATSAI AUDREY CHIEZA

Natsai Audrey Chieza is founder and CEO at Faber Futures. She is a leading thinker on the transformative role design can play in the equitable development of consumer biotechnology. With over ten years of experience co-developing multi-sector innovation strategies and shaping policy with global institutions, she leads a dynamic team that translates value and transforms systems across education, design, life science and manufacturing industries. Over a decade of experimentation, Chieza established novel design-driven processes and for bacteria textile colouration, which have been exhibited internationally, including at Ars Electronica, Design Museum, Pompidou Centre, Vitra Design Museum and the Science Gallery Dublin. She is a member of the current session of the World Economic Forum's Global Futures Council on Synthetic Biology, and has taught on biodesign programmes at Central Saint Martins in London and the Bartlett School of Architecture.

A morpho butterfly producing blue color through interference with visible light, 2013. Image Credit: TexasEagle via Flickr.

Co-operative Herenboeren farm in Boxtel, the Netherlands, changing the ownership of food production from business to the consumers. Image courtesy of Douwe Courting.

An image of the Dutch Design Weeks' sub-theme exhibition called 'It's in our nature', curated by Marleen van Bergeijk, 2021. Image courtesy of Marleen van Bergeijk.

Assemblage 002, a textile dyed in collaboration with an organism called Streptomyces coelicolor, in a process of solid-state fermentation, Faber Futures in collaboration with Professor John Ward, Department of Biochemical Engineering, University College London, Commissioned by Cooper Hewitt Museum, 2019.
Image Credit: Oskar Proctor.

PRROTOTYPE FORUM #2

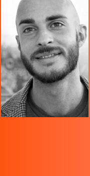
A-JR-05 *"We have to face this biological force [...] we now have to face the consequences of our own actions. [...] So I hope for the future for our relationship with nature to counter this kind of alienation, to get back into learning, to show curiosity to nature, to biology, and face these kinds of mysteries."*

JULIA RIJSSENBEEK

Julia is a researcher at the intersection of philosophy, technology, and biology. She is working on her PhD in Philosophy of Socially Disruptive Technology at Wageningen University, conducting research on synthetic biology and the biobased future. She is also a researcher at FreedomLab, a future studies thinktank that uses scenario methods to imagine alternative futures, where she focuses on the future of food and biotechnology.

A-MM-06 *"We came to realise that we are much more than humans, that we are [...] walking biotopes, complex ecosystems that result from the collaboration among many different types of living beings, mostly not visible to the naked eye. [This] tool enables an encounter not just with the non-human other, but ultimately an encounter with ourselves [...] Culture is nature, and we are nature."*

MAURIZIO MONTALTI



Maurizio Montalti is a designer, researcher, educator and entrepreneur. He is Founder and Creative Director of Amsterdam-based practice Officina Corpuscoli (2010), where he develops projects investigating inclusive and regenerative opportunities for the establishment of symbiotic relations among the spheres of the living and beyond. Working at the junction of design and biotech, Maurizio is one of the early pioneers committed to the study and development of wide-ranging mycelium-based technologies, focusing on the creation of multiple innovative biomaterials and of the related artefacts and products. He is also co-Founder, Chairman, and R&D Director of Mogu, the innovation-driven design company dedicated to the creation of everyday products and solutions deriving from fungi. He has extensive experience in education (Sandberg Instituut, Design Academy Eindhoven, Design Akademie Saaleck). He has exhibited globally in the Museum of Modern Art (New York), Centre Pompidou (Paris), Design Museum (London), Triennale (Milano), MAXXI (Rome), and MAK- Museum of Applied Arts (Vienna), among others.

A-RB-07 *"We are in a changing scientific engineering space. From a—you could say - farmer's background where we breed and optimise [...] microbes, bacteria, yeast and fungi for all sorts of industrial production, we entered a phase with genomics and DNA sequencing [...] where it gets a design aspect. [...] And this world is now on the move and is developing at a high speed. And that is what I find fascinating, including all the complexities of safety, of regulation, of dual use, and also of public appreciation and acceptance."*

ROEL BOVENBERG

Roel Bovenberg is Senior Science Fellow Biotechnology at Royal DSM and honorary professor Synthetic Biology and Cell Engineering at the University of Groningen. He has a background in microbiology, biochemistry and genetics and is especially interested in the design and evolution of bacteria, yeast, fungi for the production of a wide range of products (proteins, lipids, carbohydrates, flavors, vitamins, antibiotics, biochemicals,) by fermentation. The fast developments in the Biosciences and the broad potential of Biotechnology to contribute to more sustainable products and processes are a/his continuous source of spiration.

A-PK-08 *"This very fragile organic thing connected with human craft then gives us a monster, an assemblage of things that don't normally hang together, right? [...] It looks beautiful, and it looks natural, maybe even. But they are of a different nature [...] and not just because one is made by man, and one is made organically, but also because they have a different relationship with fragility. [...] I see this as an invitation to [also] discuss our relationship with other human beings. The dandelion was used to make something pretty, but it's also a symbol of mastering nature, of putting it to use for our ends."*

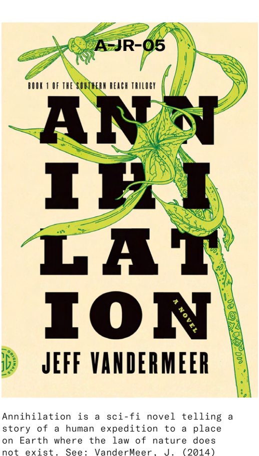
PIM KLAASSEN

Pim Klaassen works as assistant professor in Science and Technology in Society at the Athena Institute, VU Amsterdam. His work focuses on the societal and cultural meaning of science and technology, on processes through which elements and developments in science, technology and society reciprocally shape each other, and impacts of inclusive and reflective research practices, amongst others in the context of environmental policy. Recently his interest has been shifting towards the role of reflection in co-productive entanglements between science, technology and society and arts-based methodologies to simultaneously promote such reflection and to investigate science-technology-society interactions, for instance in synthetic biology.

A-MP-09 *"This little snail was slowly and steadily trying to make its way from one little pocket of biology to the other. And I honestly just didn't know what to do. I didn't know if I should just leave it be, knowing the next person might step on it, or should I help it along? [...] But I was also just struck by awe, awe at this little organism, wondering, what did it want? Where did it want to be? And why? Was it a simple decision encoded in the logic of the molecules underneath it or was there something more?"*

MEGAN PALMER

Dr Megan J. Palmer is the Executive Director of Bio Policy & Leadership Initiatives at Stanford University, leading integrated research, teaching and engagement programs to explore how biological science and engineering is shaping our societies, and to guide innovation to serve public interests. In addition to fostering broader efforts, Dr. Palmer leads a focus area in biosecurity in partnership with the Freeman Spogli Institute for International Studies (FSI) at Stanford and serves as co-chair of the World Economic Forum Global Futures Council on Synthetic Biology. For the last ten years she has led programs in safety, security and social responsibility for the international Genetically Engineered Machine (iGEM); she now serves as a special advisor to iGEM. Dr. Palmer also founded and serves as Executive Director of the Synthetic Biology Leadership Excellence Accelerator Program (LEAP), an international fellowship program in biotechnology leadership. She advises and works with many other organizations on their strategies for the responsible development of bioengineering.



Annihilation is a sci-fi novel telling a story of a human expedition to a place on Earth where the law of nature does not exist. See: VanderMeer, J. (2014) Annihilation. New York: Farrar, Straus and Giroux.

A replica of a 17th-Century microscope discovered by van Leeuwenhoek that proved the existence of microbes.
Image courtesy of Maurizio Montalti.

A 3D model of an enzyme naturally residing in the stomach of calves, also used by traditional Dutch cheesemakers to convert milk into cheese.
Image courtesy of Roel Bovenberg.

Fragile Future (2007) by Studio DRIFT, a light sculpture made with dandelions, Cidade Matarazzo, São Paulo, 2014.
Image courtesy of DRIFT.

A photograph of a snail trying to make its way across the sidewalk, taken by Megan during her daily walk in the Californian neighbourhood.
Image courtesy of Megan Palmer.

PROTOTYPE FORUM #3

A-CA-10 *"[I've been] interested in the double meaning of equity. Equity as in the shares of the company that can be publicly traded now on the Stock Exchange, but also equity in terms of justice, fairness. Those seem to be actually at odds with each other most of the time. The economic priorities of companies, of capitalism, seem to conflict with what an equitable outcome of a technology might be. [...] All of our workers, all the people who work at the company, have high vote shares [...] because we believe that people who are close to it, who are building that platform should have that voice."*

CHRISTINA AGAPAKIS

Christina Agapakis is a biologist, artist, writer and creative director at Ginkgo Bioworks, an organism design company that is bringing biology to industrial engineering.

Ginkgo Bioworks grows cultured products for partners across many industries. Agapakisi's work brings together biologists, engineers, designers, artists and social scientists to explore the future of biotechnology. She holds a PhD from Harvard University, where she worked on producing hydrogen fuel in bacteria, creating customizable plants, and making photosynthetic animals. She has taught designers at the Art Center College of Design and biomolecular engineers at UCLA.

A-RFB-11 *"This old piece of work is also subject now to synthetic biology because the proteins that are in the cheese [...] nowadays start to be produced by micro -organisms instead of by the cow. [...] And of course, I love cows and I hope they will be with us for many years to come, but we also are very much aware of the environmental burden because of cows."*

ROB F. BEUDEKER

Rob has been active as Theme Director Nutrition and Health at TIFN coordinating public private parternships till July 2021. Rob is also responsible for the investment in start-up companies active in nutrition at DSM Venturing. This open innovation activity is for the benefit of both the start-up and DSM. Rob was active as VP Innovation at Human Nutrition and Health at DSM between 2010-2016. These activities were steered globally from Switzerland. He has an MSc in biology and PhD in microbiology from the University of Groningen in the Netherlands. He did a post-doc at the University of Texas at Austin in molecular biology after which he joined Gist-brocades (now DSM) R&D in 1984. He has been working in various functions in R&D (project-, program- and resource management) and New Business Development at DSM ever since. He got an MBA from the Universities of Rotterdam and Rochester (NY).
He is a member of the Board of Nutrileads NV, JavaFoods Ltd, S-Biomedic NV, Frontier Nutrition Inc., Phynova Ltd and Deep Branch Biotechnology Ltd.

A-LA-12 *"Their idea was if we just flood the market with this synthetic rhino horn we will reduce demand, it will become so abundant and the price will go down, so there won't be a need for people to poach rhinos anymore. So, yes, I thought that was a great idea. But [...] it's not really tackling the core problem here, which is that some elites in some countries have cultural beliefs about rhino horn, and there will always be a hunt for actual rhino horn. Also some local communities in countries where there are rhinos, they said, well, this is just a Western based technology from people that know nothing of our culture, and trying to make something alien and introduce it, and then they think everything will be solved. That's just too simplistic."*

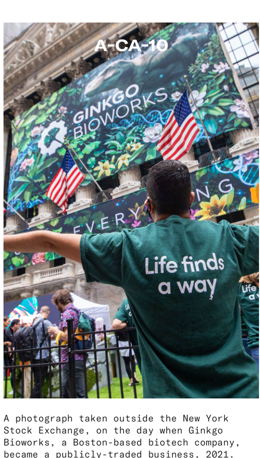
LOTTE ASVELD

Lotte Asveld is an assistant professor in Biotechnology and Society at Delft University of Technology. Her research focuses on the question of how industrial biotechnology can be made more inclusive, through design, or additional innovation management approaches.

A-TB-13 *"[Twenty-two years ago, our brief] was to help a small desert community in Australia to figure out how to become economically relevant. Through the use of a catalytic organism, we could solve so many social, environmental and also financial problems for this town. [...] It's interesting to look at this image as I find it a rather mechanical application of the use of bio-organisms, but at the time the thinking was 'We just make a factory for spirulina', and that was it. And now we are integrating it into the urban environment and into living building systems. We see that they can have more additional benefits than if just applied as a factory."*

TOM BOSSCHAERT

Tom is Except's founder and director, and creator of the Sustainability in Development (SiD) framework. He crafts innovative processes that drive complex systems towards resilient and flourishing futures. He steers teams using design thinking and innovation processes to pioneering results. As an entrepreneur he has founded several sustainable development organizations. As an educator, he writes, teaches, lectures, and gives professional training.



A photograph taken outside the New York Stock Exchange, on the day when Ginkgo Bioworks, a Boston-based biotech company, became a publicly-traded business, 2021.
Image courtesy of Ginkgo Bioworks.

An image of cheese, 2014.
Image Credit: Frank Schulenburg via Wikimedia Commons.

Synthetic rhino horn, developed by an American-based company, Pembient, 2015.
Image Credit: Pembient.

An image of a spirulina factory; It is a type of algae that grows in water and, similar to plants, produces energy from sunlight through the photosynthesis process.
Image courtesy of Tom Bosschaert.

NOTE: **DOCTORY DIALOGUES #1**

A-DM-16 "Before and through that year I was interested in the idea of a contemporary museum, and I was involved in a lot of discussions about what it should be. I was also very involved in the Pompidou Center, which was being built at the time. Many people felt that it was a mistake to have a museum of contemporary art in the middle of a city, because it would be a place where people would go to be alone, to meet their friends, to eat, to drink, to talk, to do anything but look at art." — Dominique de Menil, in conversation with Pierre Cabanne, 1977

DOMINIQUE DE MENIL

Dominique de Menil (née Schlumberger) was the co-founder of the Menil Collection, a museum of art and anthropology in Houston, Texas, which she co-founded with her husband John de Menil in 1987. Her family's oil company, Schlumberger, Limited, was a major sponsor of the Pompidou Center in Paris, which was designed by Renzo Piano and Richard Rogers and opened in 1977. Dominique de Menil was also a patron of the Dia Art Foundation, the Rothko Chapel, and the Cy Twombly Gallery in Houston, and she helped to establish the Menil Collection's Cy Twombly Gallery, Dan Flavin Installation, and Rothko Chapel Campus. She was also a patron of the Byzantine Fresco Chapel Foundation, the Institute for Research in Biblical Antiquity, and the Rothko Chapel Foundation. She died at the age of 90 in Houston, Texas, on July 4, 1997.

JOHN DE MENIL

John de Menil (né Jean-Paul de Menil) was the co-founder of the Menil Collection, a museum of art and anthropology in Houston, Texas, which he co-founded with his wife Dominique de Menil in 1987. His family's oil company, Schlumberger, Limited, was a major sponsor of the Pompidou Center in Paris, which was designed by Renzo Piano and Richard Rogers and opened in 1977. John de Menil was also a patron of the Dia Art Foundation, the Rothko Chapel, and the Cy Twombly Gallery in Houston, and he helped to establish the Menil Collection's Cy Twombly Gallery, Dan Flavin Installation, and Rothko Chapel Campus. He was also a patron of the Byzantine Fresco Chapel Foundation, the Institute for Research in Biblical Antiquity, and the Rothko Chapel Foundation. He died at the age of 90 in Houston, Texas, on July 4, 1997.

DOMINIQUE DE MENIL

Dominique de Menil, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

John de Menil, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

NOTE: **DOCTORY DIALOGUES #2**

A-DM-18 "My origins have influenced my work in a very direct way. I feel that it is one of the strengths of my work. I feel that it is very important that I am a woman, that I am Mexican, that I am a Catholic, that I am a mother, that I am married, that I am a Chicana, that I am a Tejana, that I am a Texan, that I am a Southwestern woman, that I am a Southerner, that I am a Gulf Coast woman, that I am a Texas Gulf Coast woman, that I am a South Texas Gulf Coast woman, that I am a Corpus Christi woman." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

Vanessa Vega (née Lott) is a Corpus Christi, Texas, based artist who has been a member of the faculty of the University of Texas at Austin since 1990. Her family's oil company, Lott Oil, was a major sponsor of the Pompidou Center in Paris, which was designed by Renzo Piano and Richard Rogers and opened in 1977. Vanessa Vega was also a patron of the Dia Art Foundation, the Rothko Chapel, and the Cy Twombly Gallery in Houston, and she helped to establish the Menil Collection's Cy Twombly Gallery, Dan Flavin Installation, and Rothko Chapel Campus. She was also a patron of the Byzantine Fresco Chapel Foundation, the Institute for Research in Biblical Antiquity, and the Rothko Chapel Foundation. She died at the age of 90 in Houston, Texas, on July 4, 1997.

JESSE LOTT

Jesse Lott (né Jesse Lott) is a Corpus Christi, Texas, based artist who has been a member of the faculty of the University of Texas at Austin since 1990. His family's oil company, Lott Oil, was a major sponsor of the Pompidou Center in Paris, which was designed by Renzo Piano and Richard Rogers and opened in 1977. Jesse Lott was also a patron of the Dia Art Foundation, the Rothko Chapel, and the Cy Twombly Gallery in Houston, and he helped to establish the Menil Collection's Cy Twombly Gallery, Dan Flavin Installation, and Rothko Chapel Campus. He was also a patron of the Byzantine Fresco Chapel Foundation, the Institute for Research in Biblical Antiquity, and the Rothko Chapel Foundation. He died at the age of 90 in Houston, Texas, on July 4, 1997.

A-DM-16

Dominique de Menil, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-VV-17

John de Menil, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

NOTE: **DOCTORY DIALOGUES #3**

A-DM-19 "Structural strength is what I think of when I think of my work. I think of it as being very structural. I think of it as being very structural because I think of it as being very structural." — Dominique de Menil, in conversation with Pierre Cabanne, 1977

DOMINIQUE DE MENIL

Dominique de Menil (née Schlumberger) was the co-founder of the Menil Collection, a museum of art and anthropology in Houston, Texas, which she co-founded with her husband John de Menil in 1987. Her family's oil company, Schlumberger, Limited, was a major sponsor of the Pompidou Center in Paris, which was designed by Renzo Piano and Richard Rogers and opened in 1977. Dominique de Menil was also a patron of the Dia Art Foundation, the Rothko Chapel, and the Cy Twombly Gallery in Houston, and she helped to establish the Menil Collection's Cy Twombly Gallery, Dan Flavin Installation, and Rothko Chapel Campus. She was also a patron of the Byzantine Fresco Chapel Foundation, the Institute for Research in Biblical Antiquity, and the Rothko Chapel Foundation. She died at the age of 90 in Houston, Texas, on July 4, 1997.

VANESSA VEGA

A-DM-19

Dominique de Menil, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-VV-17

Vanessa Vega, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #1**

A-DM-16 "Because the family of origin is so important, I feel that I have to be very careful about what I say about my family of origin. They have been very supportive of my work, and I don't want to do anything that would hurt them. I don't want to do anything that would hurt my family of origin. They have been very supportive of my work, and I don't want to do anything that would hurt my family of origin." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

JESSE LOTT

A-DM-16

Vanessa Vega, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-VV-17

Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #2**

A-DM-18 "I think that I have a distinctive voice in my work, and I think that it is very important that I have a distinctive voice in my work." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

JESSE LOTT

A-DP-24

Vanessa Vega, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-P-23

Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #3**

A-DP-24 "I feel that in the Dominique's house, there was a very strong sense of family. I feel that in the Dominique's house, there was a very strong sense of family." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

JESSE LOTT

A-P-23

Vanessa Vega, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-T-25

Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #4**

A-DP-24 "I felt that in the Dominique's house, there was a very strong sense of family." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

JESSE LOTT

A-DP-24

Vanessa Vega, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-T-25

Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #5**

A-DP-24 "I felt that in the Dominique's house, there was a very strong sense of family." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

JESSE LOTT

A-DP-24

Vanessa Vega, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

A-DP-24

Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #6**

A-DM-19 "Structural strength is what I think of when I think of my work. I think of it as being very structural. I think of it as being very structural because I think of it as being very structural." — Vanessa Vega, in conversation with Jesse Lott, 2000

VANESSA VEGA

JESSE LOTT

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Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #7**

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Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #8**

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EXPANDED **DIALOGUES #9**

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EXPANDED **DIALOGUES #10**

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EXPANDED **DIALOGUES #11**

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Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

EXPANDED **DIALOGUES #12**

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EXPANDED **DIALOGUES #13**

A-DM-19 "I felt that in the Dominique's house, there was a very strong sense of family." — Vanessa Vega, in conversation with Jesse Lott, 2000

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EXPANDED **DIALOGUES #14**

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EXPANDED **DIALOGUES #15**

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EXPANDED **DIALOGUES #16**

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EXPANDED **DIALOGUES #17**

A-DM-19 "I felt that in the Dominique's house, there was a very strong sense of family." — Vanessa Vega, in conversation with Jesse Lott, 2000

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A-DP-24

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EXPANDED **DIALOGUES #18**

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Jesse Lott, photographed by Hans Namuth, Houston, Texas, 1980. Courtesy of the Menil Collection, Houston, Texas.

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BIO STORIES has emerged as a result of tremendous multi-disciplinary collective effort.

The project has been led and curated by Faber Futures, a London-based biodesign agency, operating at the intersection of nature, design, technology and society. The studio's team—*founder and CEO* Natsai Audrey Chieza, *lead designer* Ioana Man, *lead strategist* Laura Vent, *art director* Camille Thiéry *lead researcher* Magdalena Obmalko, and *communication designer* Veronica Jones—is deeply indebted to a wide pool of stakeholders and collaborators, without whose contribution to the project and the present report could not have been accomplished.

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APPENDIX

↓ DIALOGUE SUMMARIES ↓ CODEBOOK ↓ BIBLIOGRAPHY

APPENDIX **DIALOGUE SUMMARIES**

To access the BIO STORIES Dialogue Summaries (including Dutch Design Week dialogues, Introductory conversations and Expanded conversations), click here.

APPENDIX **CODEBOOK: DIRECTIONS AND GUIDELINES**

To access the codebook with directions and guidelines on the coding system of BIO STORIES, click here.

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