BIOTECHNE:
INTERTHINKING ART, SCIENCE AND DESIGN

EDITED BY

JANE PROPHET & HELEN V. PRITCHARD

PLANTS BY NUMBERS

ART, COMPUTATION, AND QUEER FEMINIST TECHNOSCIENCE

BLOOMSBURY

Plants by Numbers

Biotechne: Interthinking Art, Science and Design

Series Editors

Biotechne: Interthinking Art, Science and Design publishes books about the history, theory and practice of art and design as they comingle with the natural sciences. The series title reclaims the Greek meanings of the roots bios, conveying life, the living, or citizen-life, and techne, conveying art, skill, or craft. Biotechne thus names the folding of "art" and "science" into complex and hybrid practices that transcend a human-centered "engineering" worldview. "Interthinking," a neologism invented by art and science visionary György Kepes, describes knowledge informed by ecological, systemic, and cybernetic connections, defining the active engagement among fields central to the Biotechne series. This engagement is the source of the cultural creativity and resourcefulness necessary to thrive in the rapidly changing world conditions of the Anthropocene. Biotechne welcomes proposals treating art and design subjects from any time period, antiquity to the present, which speak directly to these contemporary concerns. We seek inventive, cross-pollinating works about the arts and their engagement with sciences from astrobiology to zoology, wherever that engagement occurs, in art or design studios, scientific laboratories, natural habitats, the museum and gallery worlds, performance spaces, medical practices, and the political realm. By identifying significant intersections of art, humanities, and science, and tracking rigorous paths through the cross-disciplinary information jungle, Biotechne serves audiences of both experts and lay readers while substantiating the role of aesthetic insight within the natural sciences.

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Plants by Numbers

Art, Computation, and Queer Feminist Technoscience

Edited by Jane Prophet and Helen V. Pritchard

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BLOOMSBURY VISUAL ARTS
Bloomsbury Publishing Plc
50 Bedford Square, London, WC1B 3DP, UK
1385 Broadway, New York, NY 10018, USA
29 Earlsfort Terrace, Dublin 2, Ireland

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First published in Great Britain 2023

Cover design: Elena Durey
Cover image: *Flower Fire: a collaboration with* Arabidopsis thaliana. Video projections onto lasercut seed paper. Work in progress by Jane Prophet. All rights reserved.

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A catalogue record for this book is available from the British Library.

Library of Congress Cataloging-in-Publication Data
Names: Pritchard, Helen V., editor. | Prophet, Jane, 1964- editor.
Title: Plants by numbers : art, computation and queer feminist technoscience /
edited by Helen V. Pritchard and Jane Prophet.
Description: London : Bloomsbury Visual Arts, 2023. |
Series: Biotechne: interthinking art, science and design |
Includes bibliographical references and index.
Identifiers: LCCN 2023001632 (print) | LCCN 2023001633 (ebook) |
ISBN 9781350343252 (hardback) | ISBN 9781350344969 (paperback) |
ISBN 9781350344938 (pdf) | ISBN 9781350344945 (epub) | ISBN 9781350351042
Subjects: LCSH: Art and technology. | Art and natural history. |
Human-plant relationships. | Lesbian feminist theory.
Classification: LCC N72.T4 P53 2023 (print) | LCC N72.T4 (ebook) |
DDC 700.1/05–dc23/eng/20230503
LC record available at https://lccn.loc.gov/2023001632
LC ebook record available at https://lccn.loc.gov/2023001633

ISBN: HB: 978-1-3503-4325-2
ePDF: 978-1-3503-4493-8
eBook: 978-1-3503-4494-5

Series: Biotechne: Interthinking Art, Science and Design

Typeset by Integra Software Services Pvt. Ltd.

This open access book was funded by The University of Michigan

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Praise for *Plants by Numbers*

"*A text that demonstrates the vital importance of observing and treating plants as our companion species, and as cohabitants of this planet to bend towards and learn from, as we ponder our own significance and survival, threatening the end of the anthropocene.*"

Legacy Russell, Executive Director and
Chief Curator of The Kitchen, author of *Glitch Feminism* (2020)

"*Rooted in anti-colonial, Black and Indigenous, trans-feminist and queer science and technology studies and poetics, this book generously reimagines accounts, plots and digging as critical cultivating methods and creative practices. It is essential reading for anyone moved by the transformational and technocultural worlding of entangled plant lives.*"

Jas Rault & T. L. Cowan, co-authors of *Heavy Processing* (2023)

"Plants by Numbers *works through how coloniality shapes, but does not absolutely envelop, our queerly inter-human and inter-ecological worlds. Rethinking classificatory taxonomies, the book centres plant-life and its aesthetic-scientific possibilities in an eloquent intervention into studies of livingness, affect, and relationality.*"

Katherine McKittrick, Professor and Canada Research
Chair in Black Studies, Queen's University, Canada;
author of *Dear Science and Other Stories* (2021)

"*This timely collection of accounts by artists, curators, technoscientists and theorists speculates on different modes of world-making and creating kinship with plants, establishing a rich ground for more-than-human entanglements.*"

Petra Löffler, Professor of Contemporary Media Theory and History,
Carl von Ossietzky University Oldenburg, Germany

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Notes on Contributors

Audrey Bennett is a design scholar of Afro-Caribbean descent, an inaugural University Diversity and Social Transformation Professor of the University of Michigan, and Professor of Art and Design at U-M's Penny W. Stamps School of Art and Design.

Breakwater is a London-based Korean diaspora artist duo of **Youngsook Choi** and **Taey Iohe**. Their social practice explores subject matters around climate justice and migrants' lived experience, excavating counter-narratives centered on spiritual knowledge, and the political resonances of landscape. As a recipient of an Arts Council England Project Grant, Breakwater has been running a collective healing project, *Becoming Forest,* for ESEA diaspora, with a folk healing approach that values shared cultural identity, seasonal sense, and natural environments as critical methodologies. Youngsook Choi and Taey Iohe also established the Decolonising Botany Working Group, a cohort of artists whose practices question and challenge the extractive knowledge trajectories within nature science.

Stephanie Dinkins (b.1964) is a transmedia artist who creates platforms for dialogue about race, gender, aging, and our future histories. Dinkins's art practice employs emerging technologies, documentary practices, and social collaboration toward equity and community sovereignty. She is particularly driven to work with communities of color to co-create more equitable social and technological ecosystems. Dinkins is a professor at Stony Brook University where she runs the Future Histories Studio, a Mellon Foundation funded multidisciplinary lab. Dinkins earned an MFA from the Maryland Institute College of Art and is an alumna of the Whitney Independent Studies Program. She exhibits and publicly advocates for inclusive AI internationally at a broad spectrum of community, private, and institutional venues. Dinkins was a 2021 United States Artist Fellow and Knight Arts & Tech Fellow. The *New York Times* featured Dinkins as an AI iInfluencer. *Wired*, *Art in America*, *Artsy*, *Art21*, *Hyperallergic*, the BBC, and *Wilson Quarterly* have recently highlighted Dinkins's art and ideas.

Ron Eglash is a Professor in the School of Information at University of Michigan, with a secondary appointment in the School of Art and Design. He received his BS in Cybernetics, his MS in Systems Engineering, and his PhD in History of Consciousness, all from the University of California. His work includes *African Fractals: Modern Computing and Indigenous Design* (1999) and *Appropriating Technology: Vernacular Science and Social Power* (1994). His *Culturally Situated Design Tools* (csdt.org), a suite of online applications for ethnocomputing, and *Generative Justice* (https://generativejustice.org), a website for decolonial circular economies, are funded by the NSF.

Jennifer Gabrys is Chair in Media, Culture and Environment in the Department of Sociology at the University of Cambridge. She leads the Planetary Praxis research group, and is Principal Investigator on the ERC-funded project*, Smart Forests: Transforming Environments into Social-Political Technologies*. She also leads the *Citizen Sense* and *AirKit* projects, which have both received funding from the ERC. She is the author of *How to Do Things with Sensors* (2019); *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet* (2016); and *Digital Rubbish: A Natural History of Electronics* (2011). Her newest book is *Citizens of Worlds: Open-Air Toolkits for Environmental Struggle* (2022). She co-edits the "Planetarities" book series published through Goldsmiths Press. Her work can be found at planetarypraxis.org, smartforests.net, citizensense.net and jennifergabrys.net.

Elaine Gan, MFA/PhD, is a transdisciplinary artist-scholar whose teaching, research, and creative practice engage with the fields of feminist science and technology studies, environmental/digital arts and humanities, multispecies anthropology, and experimental media. Through writing, drawing, installation, and time-based media, Gan explores differential coordinations that emerge between species, machines, and landscapes, with a particular interest in plants and fungi. Gan is Assistant Professor of Science in Society at Wesleyan University and director of *the Multispecies Worldbuilding Lab*, a podcast about climate change. Gan is co-editor of an interdisciplinary anthology titled *Arts of Living on a Damaged Planet: Ghosts and Monsters of the Anthropocene* (Minnesota, 2017) and is currently writing a monograph about more-than-human temporalities and transformations of rice cultivation. Her projects are online at elainegan.com and multispeciesworldbuilding.com

Matthew Garvin is a PhD student in the School of Information, where he also earned his MS. Prior to this, he received his BA in Anthropology from Wayne State University. His research explores the intersections of design, technology, and the future of work on earth and in space.

Daniel Gustafsson is a designer and a trained product developer who teaches at the Department of Design+Change at Linnaeus University. He focuses on Research through Design (RtD) and strives to negotiate an understanding of the world through his design work. His work seeks to formulate a space of thought and action for change. Daniel is also devoted to co-creating, designing, and engineering customized sports equipment for/with people with physical impairment, or, to use his term, "disobedient bodies." He sees sports as a medium rare in its power to facilitate change as it can transcend almost unbreakable boundaries and start meaningful conversations about gender, race, alienation, inclusion, and more.

Mark Guzdial is a Professor in Computer Science and Engineering and the Director of the Program in Computing in the Arts and Sciences at the University of Michigan. He studies how people learn computing and how to improve that learning. He was one of the founders of the International Computing Education Research conference. He is an ACM Distinguished Educator and a Fellow of the ACM.

Belinda Kwan (b. 1993, she/they) is an independent curator and writer based in Toronto, Canada. Her research-based practice is grounded in her lived experiences of neurodivergence and diaspora. She has curated exhibitions for the Society of Literature, Science, and the Arts (US/Canada); Varley Art Gallery (Markham); InterAccess (Toronto); Art Gallery of York University (Toronto); and Myseum of Toronto. Her projects have been featured in *Canadian Art* and CBC Arts. https://www.belindakwan.com

Lia New is an artist whose work revolves around education-based visual narratives. They use their work to explore themes of Black and queer identities and how they emerge in interpersonal relationships. New received their Bachelor's degree from University of Michigan in Art and Design and Afro-American Studies, where they developed a coming-of-age graphic novel about three Black adolescents and their attempts to maintain their friendship in the midst of an escape from a magical forest. By using media such as comics, illustrated books, and visual novels, they aim to research how visual narratives can impact our learning about ourselves and others. Currently New is pursuing a Master's degree in Art Education from Virginia Commonwealth University.

Kathleen McDermott is a media artist with a background in installation and sculpture. She combines her knowledge of fabrication and sculpture with open-source hardware to build a language of absurdity that merges new media, design, performance, and video. She is interested in technologies that are not productive, robots badly suited to absurd purposes, and electronic creations that resist control. She received her BFA from Cornell University and her MFA in Creative Media from City University of Hong Kong, and her PhD in Electronic Arts from Rensselaer Polytechnic Institute (RPI). She is currently an Industry Assistant Professor at NYU Tandon, in the Integrate Digital Media Program (IDM). She has exhibited work and given talks internationally, including at The Wende Museum in LA, Ars Electronica in Linz, and The Museum of Arts and Design in NY. In addition to her artistic practice, she is an advocate for accessible technology education, sharing tutorials for working with DIY electronics on https://urbanarmor.org/

Srimoyee Mitra is a curator and writer whose work focuses on building empathy and mutual respect. Her work is grounded in interdisciplinary research that lies at the intersection of exhibition-making and participation, migration, globalization, and decolonial aesthetics. She developed an award-winning curatorial and publications program as the Curator of Contemporary Art, Art Gallery of Windsor (2011–2016) in Canada. In 2015, she edited a multi-authored book, *Border Cultures*, co-published by the Art Gallery of Windsor and Black Dog Publishing. In 2017, Mitra was appointed Director of Stamps Gallery, part of Penny W. Stamps School of Art and Design, University of Michigan. Located in downtown Ann Arbor, she is the first Director of the new gallery, whose program has been recognized with grants from the Andy Warhol Foundation for Visual Arts and Michigan Council for Cultural Affairs.

Miranda Moss is an artist, outsider engineer, eco-geek, and rogue educator from Cape Town, South Africa. Her transdisciplinary practice, which focuses on the problematics and hopeful possibilities of technology from a socio-ecological and anti-colonial feminist perspective, has seen her exhibit, teach, publish text, give talks, and perform research across the globe in various art, science, community, academic, public, and hacker spaces. She has won various awards, such as the New Technological Art Award (NTAA) Audience Choice Award at Zebrastraat in Ghent, in 2019. Her practice largely focuses on the social life of prototyping, where cutting-edge innovations in science and engineering are poetically distilled into demystified forms, with the aim of nurturing engagement, accessibility, and empowerment with these often-alienating media.

Joel Ong, PhD, is a media artist whose works connect scientific and artistic approaches to the environment. His recent works explore the visibility and audibility of ambient phenomena with a focus on the wind and the atmospheric microbiome. His individual and collaboratory artworks have been shown at festivals and galleries internationally such as the Currents New Media Festival, Nuit Blanche Toronto, ISEA, the Seattle Art Museum, the Gregg Museum of Art and Design, the Penny Stamps Gallery, and the Ontario Science Centre. Joel is an alumnus of SymbioticA, the Centre of Excellence in Biological Arts in Perth, Western Australia, and holds a PhD from DXARTS at the University of Washington. He was a recipient of the Petro-Canada Young Innovators Award in 2020 and is an artist with the Biofrictions Creative Europe transdisciplinary research project. He is Associate Professor in Computational Arts and Director of Sensorium: The Centre for Digital Arts and Technology at York University.

Kwame Porter Robinson is a PhD candidate in the School of Information at the University of Michigan. He received his Master's in Computer Science from the University of Maryland, Baltimore County, a BFA in Graphic Design from Boston University, and a BS in Electrical Engineering from New Mexico State University. Prior to his PhD studies he worked in the civic technology industry as a senior data scientist, in government as a research engineer, and as a social-technical consultant for philanthropy and NGOs. Kwame investigates how people can flourish through community-defined economic systems. His topics of study include generative justice and using artificial intelligence with communities to define and refine economic systems.

Possible Bodies (Jara Rocha, Femke Snelting) is a collaborative research project, interrogating the concrete and at the same time fictional entities of "bodies" in the context of 3D tracking, modeling, rendering, and scanning. Jara Rocha works through the situated and complex forms of distribution of the technological with a trans*feminist sensibility. They tend to be found in tasks of in(ter)dependent imagination, curation, pedagogy, and disobedient action-research. With collective processes like those activated by Possible Bodies, The Underground Division, Vibes & Leaks, Infras Antifas, or The Cell for Digital Discomfort they are studying the co-constitutions of technosciences and patriarchocolonial turbo-capitalism. Femke Snelting develops projects at the intersection of design, feminisms, and free software. In various constellations she works on reimagining computational practices that dis-invest from technological monoculture. Together with Miriyam Aouragh, Helen

Pritchard, and Seda Gürses she runs The Institute for Technology in the Public Interest (TITiPI). Together they convene communities to hold computational infrastructures to account and to articulate what technologies in the "public interest" might be.

Helen V. Pritchard is an artist-designer, geographer, activist, and queer love theorist. As a practitioner they work together with companions to make propositions and designs for environmental media, developing methods to uphold a politics of queer survival and computation otherwise. Helen is the co-principal investigator on the CHANSE-funded project *The Social Life of Xg: Digital Infrastructures and the Reconfiguration of Sovereignty and Imagined Communities*; and co-investigator on the Swedish Energy Agency project *Regenerative Energy Communities*, working at the intersections of energy design and agroecology. They are the co-editor of *Data Browser 06: Executing Practices* (2018), *Sensors and Sensing Practices* (2019), and the Future Media book series (Goldsmiths Press). Helen is Professor and Head of Research at the Institute for Experimental Design and Media Culture, HGK-FHNW, University of Applied Sciences and Arts Northwestern Switzerland, Basel. They also hold an associate professorship in Queer Feminist Technoscience at University of Plymouth.

Jane Prophet is a visual artist whose practice-based research and writing emerges through collaborations with neuroscientists, stem cell researchers, mathematicians, biologists, and heart surgeons. She works across media and disciplines to produce objects and installations, combining traditional and computational media. She is the director of a National Endowment for the Arts: Commissioning Public Art Through Community Engagement Arts to improve Health and Social/Emotional Well-Being by Reducing Youth Firearm Injury. Prophet's art and associated papers are part of contemporary debates about medical arts, new media and mainstream art, feminist technoscience, artificial life, and ubiquitous computing. She has contributed widely to debates about art in higher education, particularly interdisciplinary and practice-based PhDs and the role of the academic artist-researcher. She is a Professor at Stamps School of Art and Design at the University of Michigan.

Lionel Robert Jr. is a Professor at the University of Michigan School of Information and core faculty at the University of Michigan Robotics Institute. He is also an AIS Distinguished Member Cum Laude and an IEEE Senior Member. His research focuses broadly on collective action through technology and human collaboration with autonomous systems. He is the director of the Michigan Autonomous Vehicle Research Intergroup Collaboration (MAVRIC), an affiliate of the National Center for Institutional Diversity at the University of Michigan and the Center for Computer-Mediated Communication at Indiana University. His research has been sponsored by the U.S. Army, Toyota Research Institute, MCity, Lieberthal-Rogel Center for Chinese Studies, AAA Foundation, and the National Science Foundation.

Stephanie Rothenberg is Professor in the Department of Art at SUNY Buffalo, teaching courses in design and emerging technologies. Her interdisciplinary art draws from digital culture, science, and economics to explore symbiotic relationships between human-designed systems and biological ecosystems. Moving between real and virtual spaces, she engages a variety of media platforms that include interactive installation, drawing, sculpture, video, and performance. She has exhibited throughout the US and internationally in venues including Eyebeam, US; Massachusetts Museum of Contemporary Art, US; House of Electronic Arts, CH; LABoral, ES; Transmediale, DE; and ZKM Center for Art & Media, DE. Recent residencies include LMCC/Lower Manhattan Cultural Council Workspace and the Santa Fe Art Institute. Her recent awards include those from the Harpo Foundation and Creative Capital. Her work is in the collection of the Whitney Museum of American Art and has been widely reviewed including by *Artforum*, *Artnet*, *The Brooklyn Rail*, and *Hyperallergic*. http://www.stephanierothenberg.com/

Sina Seifee was born in Tehran, Iran, in 1982 and lives and works in Brussels. Structured around a research-intensive and transversal exploration of performative storytelling and image-making, Seifee's artistic practice looks at how aesthetic knowledge gets shaped. His work has been recognized for its commitment to the social dimensions of imagination at the intersection of techno-media and globalism with an emphasis on the heritage of zoology in West Asia. He has presented internationally at City Gallery, Prague (2022); WIELS, Brussels (2021); SAVVY Contemporary, Berlin (2016); Sharjah Art Foundation, UAE (2018); Haus der Kulturen der Welt, Berlin (2017); Temporary Gallery, Cologne (2019); Hordaland Kunstsenter, Bergen (2019); and Akademie der Künste der Welt, Cologne (2015).

Eric Snodgrass is a Senior Lecturer at the Department of Design+Change at Linnaeus University and Guest Lecturer in the Department of Technology and Social Change at Linköping University. His research studies practices that work to imagine, materialize, and sustain forms of change. This has involved research on the intersections of politics and technology, with a specific focus on infrastructures of power and resistance. Current research includes *Regenerative Energy Communities*, a three-year project funded by the Swedish Energy Agency. The project explores how alternative paradigms and approaches to energy might emerge through creative and collective experimentation with energy prototypes in local regenerative farming communities.

Amy M. Youngs creates eco art, interactive sculptures, and digital media works that explore interdependencies between technology, plants, and animals. Her practice-based research involves entanglements with the nonhuman, constructing ecosystems, and seeing through the eyes of machines. She has created installations that amplify the sounds of living worms, indoor ecosystems that grow edible plants, a multi-channel video sculpture for a science museum, community-based, participatory media, and public webcam projects. Youngs exhibits her works widely, at venues including Te Papa Museum, New Zealand; Trondheim Electronic Arts Centre, Norway; and the Peabody Essex Museum in Salem, Massachusetts, USA. She earned an Individual Artist Grant from the Ohio Arts Council and has published writing in books such as *Robots and Art: Exploring an Unlikely Symbiosis*. An Associate Professor of Art at the Ohio State University, she leads interdisciplinary grant projects, coordinates the Art & Technology area, and teaches courses in digital art, eco art, and art/science.

Acknowledgments

This book is the result of collective energy and collaboration across the community of writers, artists, and theorists we bring together in this anthology. We want to thank all the authors in this book for their contributions during an especially turbulent and difficult few years during the COVID-19 pandemic, which shaped and changed the orientation of the collection. Their brilliant contributions and the modes of decolonial and queer survival they call for—like the thorny stickiness of bramble bush or the importance of a glittery spinning okra—made this book possible. Thank you to all those who gave permission for their images to be shared in this book.

We are grateful for support from The University of Michigan Office of Research and Stamps School of Art & Design, who made the release of the book as open access possible. We would also like to thank Femke Snelting for answering many questions we had about licenses and in particular the CC4r which much of the content is released under. The CC4r was developed for the Constant work session Unbound libraries (Spring 2020) and followed from discussions during and contributions to the study day Authors of the Future (Fall 2019). It is based on the Free Art License and inspired by other licensing projects such as the (Cooperative) Non-Violent Public License and the Decolonial Media license.

We would not have been able to finish the book without the brilliance of artist and educator Lia New, who, between moving states and colleges, worked as an editorial assistant on the book, fielding queries and keeping a joyful approach to all the book admin—thank you, Lia! Finally, we appreciate the careful guidance from Alexander Highfield and Ross Fraser-Smith at Bloomsbury, as well as the encouragement and wise words from the series editors Charissa Terranova and Meredith Tromble who were integral to this publication.

Introduction

Emerging from discussions before and after a panel, "From Microbial to Arboreal: Artists Thinking with Plants and Computation across Scales," at the Society for Literature Science and the Arts (2018), *Plants by Numbers* brings together a collection of writing on and by artists, curators, decolonial, queer, and feminist technoscientists and theorists working with computation, art practice, and plant ecologies. The chapters describe how they design, make, and imagine computational processes differently, or otherwise, through the co-production of artworks, art-writing, and experimental designs with plants. The authors show how their projects open up new potentialities and anti-colonial perspectives through the ways that they engage with contested sites in technoscience. Suggesting modes of damaging and destroying existing narratives of colonial and extractive capitalism, the book proposes practices of categorization and numbering that reside within the computation of plants as new ethical-political engagements.

The book mobilizes decolonial, queer, and feminist technoscience to name, nurture, and transform conversations that are already taking place in natureculture across activism, arts, computer and natural science, and social sciences. Sole and jointly authored chapters and interviews bring attention to artists whose works speculate on how to generate technoscience in troubled natureculture worlds differently. The taught history of human relations with plants has been dominated by tropes of classification and definition, where representations, illustrations, and simulation are used to define, difference, and classify plant forms according to what plants afford humans. Outside of marine and hydroculture, plants imply soil and land, whether a small pot, a community garden plot, or a vast farm, and as a result the histories of numbering and representing plants through classification and definition are inextricable from the violence of land ownership and settler colonization. By contrast, the lore of herbalists and the visions of feminist science fiction writers like Octavia Butler and Ursula K. Le Guin focus less on boundaries and differentiation between humans and nonhumans and more on the ways that we co-evolve, co-exist, and transform one another—the ways we are interdependent. Butler and Le Guin's work both suggest that there is the possibility for resistance and transformation in everyday plants' quiet powers:

> "Ours is only a little power, seems like, next to theirs," Moss said. "But it goes down deep. It's all roots. It's like an old blackberry thicket. And a wizard's power's like

> a fir tree, maybe, great and tall and grand, but it'll blow right down in a storm. Nothing kills a blackberry bramble". She gave her hen-chuckle, pleased with her comparison.
>
> (Le Guin 2001: 86)

There is renewed interest in our co-constitution with plants and animals, theorized by scholars, and popularized by cooks and healers who have reminded us of mutualism, though, again, this is usually with a focus on human bodies. There has been a reintroduction to the kin in guts and relearning the importance of the biome, the proliferation of guerilla gardening, and a flourishing of houseplants. Alongside this is the ongoing and relentless violence of Western classification, the naming and the numbering of plant life and land grabbing.

Taxonomy and Colonialism

The taxonomy of naming plants that began in the 1700s is a colonial practice that globally imposes Latin generic names for plants, frequently misidentifying their place of origin while concurrently valorizing supremacy as evident in the common practice of (re)naming plants after influential white men. Carl Linnaeus' hierarchical cataloguing of species, marked by the way that he named, ranked, and classified organisms, formed a violent and world-making linguistic imperialism that informs numbering today (Schiebinger 2009). His work was part of a wider white European imperialism where botanists took ownership of plants through processes of taxonomy and renaming that arguably reduced plants to specimens. Scholar of media and communications, Micky Lee, gives an account of this in her analysis of the popular understanding of the tulip bulb speculation which reached its peak from 1636 to 1637 in Holland, so-called "tulip mania." Lee draws attention to the way tulip mania depended on a gendered orientalist understanding—arguing that the political economy in tulip bulbs depended on the classification of tulips, especially the detailed illustrations of petal shapes and color which were referred to by cultivators as they bred new species. Illustration played a key part in making tulips into "products that were numbered and annotated with names, weights, and prices" (Lee 2019: 49). When identified by numbers and names, plants as specimens are stripped of individuation, "a specimen, once identified, represented any plant of its type anywhere in the world where it is found" (Schiebinger and Swan 2007: np). In the case of tulip speculation, illustrations of more standard "specimen" tulips were integral because they were representations and measures against which atypical tulips could be compared; the less like the specimens a tulip was, within certain parameters, the more rare that bulb was, and the higher its value. These precise descriptions, the classification of tulips, created a political economy of natural knowledge on which commerce depended. Such processes, through which plants are reduced to specimens, play a crucial part in the human commodification and objectification of plants.

As has been discussed by Katherine McKittrick (2006), Monique Allewaert (2013), and Mel Chen (2012) amongst many, the taxonomic histories of commodification and objectification through illustration and descriptions are deeply enmeshed with colonial and anti-Black violence. In her study of plantations, Allewaert notes that colonial travelers and natural historians used illustration to suggest quantitative differences in the American Tropics between colonial plant life and the European versions of the same plant. These supposed quantitative differences were exploited to assert an anti-Black colonial valuation of life and to establish the category of whiteness. Categories are, of course, not the only form of numbering plants and bodies—used to establish white supremacy—that exist in technical practices today, statistics and phenotypical models were also mobilized under the pretense of numbering, predicting, and optimizing human relations with plants. The statistical phenotypical models developed by Lambert Adolphe Jacques Quetelet and André-Michel Guerry equated chest size to crop yield, as Ramon Amaro notes in his work in AI (Amaro 2019). An important question is raised by these plant histories: how do we engage with these archives and moments of numbering whilst refusing to recirculate anti-Black violence? As McKittrick outlines in her work on "Mathematics Black Life" (2014) and *Demonic Grounds* (2006), the task is to read through the mathematics of these violences and engage with what is not numbered. She suggests we work with unlearning and unnumbering practices and recognize forms of poetry and creative practice as other moments of calculation and numbering. In this book, in a conversation with curator, Srimoyee Mitra, the artist Stephanie Dinkins describes her creative practices, what McKittrick might call "other moments" of calculation and numbering. Dinkins creates artworks that imagine a future built on oral histories, collective forms of knowledge and perspectives in an engagement with what is not numbered. Dinkins argues that these histories, knowledge, and perspectives inform what she calls one's "internal algorithms." Through many of her artworks, Dinkins questions how algorithmic systems know what they know and suggests that one's internal algorithms emerge from oral histories and knowledge that are passed down from one generation to the next and are the data that inform algorithmic systems at personal and infrastructural levels. In artworks, like her installation, *Secret Garden*, Dinkins prototypes a world where women characters tell stories of ancestral knowledge that is valued and remembering oneself and the relationship with kin are acts of resistance and community-building that foster empathy and care in the technological future. As Mitra describes in the chapter, Dinkins's approach to numbering and algorithms combat what artist and researcher Mimi Onuoha calls "algorithmic violence," the violence an algorithm, or automated decision-making system, inflicts by preventing people from meeting their basic needs (Onuoha 2018).

Allotment and Community Gardens

Plants by Numbers is less about reinserting the liveliness of plants into the arts and humanities and more about considering relations with plants through community and resistance. The chapters in this book engage with plants as resources and food for sustaining life, what might be understood as community gardening or allotment practices. The genealogies of "Allotment," "Allotment practices," and "Allotmenting" are imperial strategies of dispossession and restorative resistance (Justice and O'Brien 2022). Historically, allotment plots and community gardens have been presented as a means for some people to meet their basic food needs, and are often defined through land measurements as a food-generating resource that limits a plot's identity to its size, productivity, and profitability. This usually defines an individual plot as 250 square meters in size, situated in a larger community allotment site that may comprise many hundreds of plots, usually owned by the local authority with individual plots rented by the holder for a nominal rent. Although tenants can usually sell their surplus produce, most regulations specify that tenants must not plant allotments to make a profit; this often differs in community gardens and decolonial feminist farming projects.

Plants by Numbers digs together sole-authored chapters and transcribed discussions through what we call an allotment approach. Based on the tradition of community gardening that intermingles techniques, cultures, and tastes, we propose other ways of figuring plants. This anthology is reminiscent of an allotment, comprising chapters like allotment plots with a minimum and maximum word count, adhering to some community rules around topics and themes. But as our discussion of the history of allotments will show, chapters, like plots, might be planted and managed differently. Authors use approaches ranging from decolonial feminist farming to poetic imaginaries, similar to the way some allotment plots grow an abundance of food for humans to ones focused on re-wilding, populated by sheds, microcontrollers, and structures of all types. Allotments are intersectional spaces, where different folx with different strokes dig, or not, their plots to plant vegetables, flowers, and other plants with diverse heritages.

UK Allotments have a contested history traceable to the Neolithic period, sustained through the Roman occupation and formalized during the Anglo-Saxon period (approx. AD 500–1000). Until the Middle Ages, land under common or communal control and access made up 50–75 percent of England. Enclosure began in the Middle Ages, with the damaging land grab rising to its height during the Parliamentary Enclosure phase from 1760 to 1820, and entailed measuring, fencing, or defining common land with hedges to legalize the theft of this land by private landowners, a division of land reminiscent to the 2,000 m^3 project discussed in this book by Regenerative Energy Communities—Helen Pritchard, Miranda Moss, Daniel Gustafsson, and Eric Snodgrass. The Diggers, a small political group, emerged in the mid-1600s and objected to private land ownership on religious as much as political grounds. The Diggers are highly cited in heroic savior histories of allotments, but that history obscures the plurality and perhaps more radical work of many others such as witches and herbalists who in their everyday practices challenged private land ownership (and capitalism) and worked with modes of cooperation and feminist knowledge sharing of plants. Silvia Federici (2004) makes connections between witch hunts and capitalist economies, arguing that, much as enclosures measured and controlled the land and restricted access to it, witch-hunts, that often targeted plant-savvy women, were a form of enclosure of women's bodies, knowledge, and freedom of movement. In nineteenth-century America, "land allotmenting" was the term used both in policy and practice to describe "the brutal desecration of indigenous territories" through the process of privatizing large areas of Indigenous lands (Justice and O'Brien 2022: xii). "The General (Dawes) Allotment Act of 1887 in the United States [of allotmenting] is among the most notorious but by no means the only example of such land privatization schemes and their catastrophic impacts" (Justice and O'Brien 2022: xii). These represent some of the many violent histories of land allotment that damaged and broke communal ties across and with soil and also led to acts of resistance and survival.

Later, British paternalistic and patriarchal values promoted allotments as a "productive" use of poor people's time, a type of informal social control seen as a way to keep plot holders from the "evils" of drink and rebellion. In both England's allotments and Soviet Russia's "dacha plot cooperatives," plot size has been limited as a form of social control for the same reason: larger plots were seen as a threat to productivity as workers might exhaust themselves before undertaking their paid employment, a direct conflation of plants, numbering, and labor (Pikner and Palang 2021). In *The Allotment*, David Crouch and Colin Ward point out that "the word 'allotment' implies deference and allocation, qualities that indicate a relationship between the powerful and the powerless" (Crouch and Ward 1988).

However, there is much evidence that, far from being deferential, plot holders resist social control. George McKay (2011: n.p.) argues that allotmenteering is "wilfully anti-capitalist state-sponsored horticulture is as radical a practice of gardening as any in government policy." Despite the dominant rhetoric of affordance, several scholars "refute the long-held assumption that allotmenteering was taken up primarily for economic reasons" (Acton 2011: 46). McKay's anti-capitalist argument offers an alternate view of the measuring and numbering at the heart of how allotments are defined and is built around two key characteristics: "first, the astonishingly low rents charged for plots by local authorities … second, the legislative fact that, by and large, produce grown by allotmenteers cannot be sold commercially for profit" (McKay 2011: n.p.).

As Mitra and Dinkins discuss in "Afro-now-ist Stories of Resistance: A Conversation with Stephanie Dinkins," community gardening is often a process of more than human renewal, where residents, community, nonhuman animals, plants, and microbes are intertwined through re-wilding, art production, and gardening. One powerful example has been described by environmental and community educator, Soul Shava, and community greening artist-activist, Mandla Mentoor, who are part of the ecology of South Africa's Soweto Mountain of Hope (SoMoHo), an eco-cultural environmental center created from a rubbish dump and site of apartheid violence in Johannesburg's largest township (Shava and Mentoor 2014). In SoMoHo, Mentoor has been recycling waste into art since 1990 in this "no go" area, bringing together women, non-binary, and youth residents of Soweto to change the environment:

> using art as the anchor of the project is just to start allowing freedom of the mind, freedom of the hand, freedom of speech and freedom of everything … because one of the things that has killed us during apartheid was that the indigenous knowledge of the people had been buried.
>
> ("Interview with Mandla Mentoor – The Soweto Mountain of Hope: Making People Free – Global Eyes/In Motion Magazine" n.d.)

Many of the chapters in this book engage with practices that unearth hidden or buried Indigenous knowledges that are mobilized through hands being placed into soil in community gardens and artworks. In *Plants by Numbers* we document longstanding work at the intersection of decolonial, queer, and feminist practices that reject the separation of plants from their environments, global supply chains, political economies, and their apparatus of classification, measurement, illustration, and simulation. It is, we argue, an intersection that is necessary not only to resist the violence of technoscience, financial capitalism, and coloniality but, above all, to re-exist and re-emerge decolonially. In particular, we wanted to document the practices and theories that have developed across this imagined transnational community on plant numberings—and celebrate the specific and important understanding they generate about the orderings, politics, and possibilities for life presented by plant technosciences. We created this book to celebrate the solidarity in this community, which has generated alliances and support for collective work that rejects, troubles and destroys the violence that emerges from how plants come to matter in technoscience, and, to propose other—queerer—knowledge and insights that do not seek to fix categories. We hope the book strengthens existing solidarities in a community we recognize (and are part of) that works at the intersection of art, design, media, and computer science, as well as generating new alliances. Ron Eglash, Audrey Bennett, Matthew Garvin, Mark Guzdial, Lionel Robert Jr. and Kwame Porter Robinson discuss one such example of community-building in their chapter "Decolonization, Computation, Propagation: Phyto-human alliances as they clear pathways towards generative justice," as *phyto alliances*.

Resisting Fixed Classification

The Linnaean classification system is used to fix categories. Linnaeus subscribed to fixism and creationism—that organisms alive today are identical to those of the past—and that evolution does not happen. Linnaean classification depends on a hierarchical use of numbers that reduced plants to sets of component parts and classified them according to, for example, the number of stamens a flower had. Linnaeus believed in fixity and was resistant to ideas that plants were able to adapt and evolve or co-evolve, which is at odds with contemporary understandings of plant epigenetics—that is, the ways that plants are interdependent to the extent that their gene expression is a response to environment. In the 1930s, more than forty years before the concept of epigenetics was formally studied, the Nobel prize-winning queer geneticist and botanist Barbara McClintock was "the first scientist to correctly speculate on the basic concept of epigenetics – or heritable changes in gene expression that are not caused by changes to DNA sequences." Plants' epigenetic interdependence extends to mutualist and antagonist relations with humans and nonhumans, such as insects, microbes, and neighboring plants. Epigenetic changes can be fast and reversible, reflecting the dynamism of relationships between plants and their environment that change in quality and intensity over time (Alonso, Ramos-Cruz, and Becker 2019).

McClintock noted in the 1940s that the stress induced by an insect placing an egg on a plant's leaf prompted a genetic change in

> the cells of a plant to make a wholly new plant structure, and this to house and feed a developing insect, from egg to the emerging adult. A single Vitis plant, for example, may have on its leaves three or more distinctly different galls, each housing a different insect spe-cies. The stimulus associated with placement of the insect egg into the leaf will initiate reprogramming of the plant's genome, forcing it to make a unique structure adapted to the needs of the developing insect.
>
> (McClintock 1984: 798)

By contrast, Linnaeus did not believe that the way species generated themselves anew was open-ended and unlimited. Linnaean taxonomy, especially the sense that one plant represents all of its kind wherever in the world they grow, is reinforced through the trope of Western botanical illustration that shows plants in isolation, removed from their context and environment (Grignon and Kimmerer 2017) with no indication of mutualism with other plants, animals, or humans. The practice of showing one plant standing in for all of its kind, wherever it grows, threatens to erase local Indigenous knowledge that emphasizes relations between plants, humans, and nonhumans that are an integral part of multispecies survival.

Local Indigenous knowledge persists; for example, many people from the nation of Native American Menominee from present-day Wisconsin and Michigan's upper peninsula describe the forest ecosystem in terms of kinship relationships. Their ecological philosophy of elder plants emphasizes the "collective agency of multiple plants and animals in the forest in which different species (or nations, including the Menominee people) are morally responsible for one another, interdependent and involved in mutual learning" (Whyte 2018: 233). The Menominee people's relations with plants and ecological knowledge has at its core the idea of *napanoh pemecwan*, translated as "flows repeatedly," that Jeff Grignon, Regeneration Forester for the Menominee Nation, likens to a foreshadowing of contemporary ideas of self-similarity and fractal patterns (Grignon 2019). *Napanoh pemecwane* understanding directs humans to shift our perception of what is happening around us, seeing patterns and flows of humans, plants, and animals in an example of Indigenous knowledge that emphasizes our relations with plants that have survived despite Linneal taxonomies and illustrations. In their chapter, Eglash et al. show how phyto-human alliances can reverse the trend towards extraction that produces so many of the social ills listed above; and that these alternative networks can instead create transitions towards a non-extractive economy, that of generative justice.

Plant Flows and Temporality

To see the world around us as repeated flows, we must de-emphasize human hierarchy, move away from the human-centric perspective, and disrupt the human comprehension of time. Menominee foresters have learned to observe how plant communities change and shift over many decades, to understand better the way plant communities communicate. Their longitudinal observations of elder plant communities have resulted in various local human behaviors, such as the tradition of certain mushrooms not being harvested to avoid disrupting the long-understood underground forest communication system between plants. Western science has only recently understood what Menominee describe as the sacred underground, that plants communicate using underground networks. As referenced by Jennifer Gabrys in her chapter "Forests that Compute," professor of forest ecology Suzanne Simard has deployed Western scientific methods and popularized this knowledge through her description of the "wood wide web" that lies beneath the forest floor (Simard and Durall 2004; Beiler et al. 2010). Some of the authors in this collection generate data to connect more closely to plants and to augment human senses, to be more plantly in discerning patterns and to interrupt the dominance of human notions of time passing. On the one hand, if we think of purposeful movement, plants seem to live according to a different, slower "time reality" than us, but this is because we are using human perceptions of motility to gauge time, most often relying on human visual perception. While humans perceive circadian time using a centralized brain, plants' perception of time occurs at a cellular level and is distributed and self-organizing with plant cells communicating their timing with neighboring cells. Although most plants are aligned to the day-night cycle, because they sense multiple environmental signals that vary across the plant in organ-specific clocks, they coordinate these in spatial waves (Greenwood et al. 2019). Many entwined geological and botanical changes form patterns that only become apparent over long durations, timespans that humans cannot easily perceive. Elaine Gan and Anna Tsing's 2012 artwork *Fungal Clock* (2012) offers three ways to study coordinations between pine, oak, humans, and matsutake mushrooms. The artwork combines digital media to imagine history and temporality that take into account multispecies coordinations. While human perception of plant time tends to focus on plant movement and growth using the single human sense of sight, research by plant physiologist, Stefano Mancuso, shows that plants use at least twenty senses (Mancuso and Viola 2015). Materials scientists have argued that plants' ability to respond to these multiple senses simultaneously, the concurrent "capability to sense and respond to external mechanical stimuli at various timescales is essential to many physiological aspects in plants, including self-protection, intake of nutrients and reproduction" (Guo et al. 2015: 1). Kathleen McDermott's playful art propositions engage with plants as complex systems with no known central processing system—no clear place for division between sentience and body. Her *Sunbots* give plants the ability to move physically at speeds recognizable to human senses, amplifying the plant's sophisticated mechanisms for keeping time. Posthumanist scholar Manuela Rossini and social anthropologist Mike Toggweiler argue that for humans to see, hear, and feel differently we need to account for "the multiple, relational, ambivalent, incompatible, fragmented, ephemeral, discontinuous, and dissonant in order to see, hear and feel differently" (Rossini and Toggweiler 2017: 6). To tell the stories of plants' flows and temporalities a number of the chapters here account for nonhuman temporalities and their entanglement with human time. In the poetic account of their 2022 performance, *Yellow Furry Lullaby*, Youngsook Choi and Taey Iohe of the artist-duo Breakwater provide an opportunity for collective healing by activating their installation *Fermented Flower* (Choi and Iohe 2021), which weaves across temporalities and eras as it reveals the flow of relationships between the colonialism of botanical science, the history of indentured labor, and the ongoing extractive operation of the migrant workforce.

Simulation, Not Just Measurement

In this book, we reposition or transform numbering in relation to plants, partly by vivifying numbering as simulation, not just measurement. We position simulations produced with computers, such as those described by a number of the artist authors in this book, as having the potential to be performative representational techniques produced through intra-actions of humans and nonhumans. These intra-actions often occur with human and nonhuman (plants, animals, machines) observers, gaugers, or measurers; that being measured, or written descriptions of the dynamic or entity being simulated; and any numeric or algorithmic model of that description. Our use of "intra-action" reminds us that distinct bounded agencies do not precede this relating, but we would propose that their relations do have histories (Barad 2007). In simulations, although there are different power relations there is no clear distinction between measurers, that being measured, and simulations, they emerge, together, through their intra-actions. Simply said, in both scientific and artistic simulations the presence and positionality of the observer or designer of the simulation and the plant itself effects the imaging that is produced. Botanical illustrations are such simulations; the positionality of the illustrator and their role within Linneal traditions usually results in images of one plant separated from its environment and ecology that then becomes the "model" for that species against which individual plants are measured and valued. As Iohe and Choi have proposed in their chapter, decolonial and queer botany actively involves destroying the separation between plants and their environments. Their textile and audio artwork *Fermented Flower* (plates 41–3) rejects the simulation of plants as separate from their worlds. The woven screen composites images drawn from archival research, with reference to the painful history of Chinese indentured labor, as part of a longer perspective on carceral enslavement and the ongoing exploitation of migrant workers—to which the yellow dandelion bears witness. Their work confronts the racist roots deeply embedded in botanical illustrations and proposes an alternative planetary ancestry that dissolves prejudicial categories and hierarchies, allowing interspecies care. Many artists, writers, and researchers in the book create and document quotidian refusals or resistances to modern science's separation of plants from their environments in their stories—unlearning the violence of botanical illustration. The attention to the everyday violence of simulations and categories—and the worlds they materialize—is what Tina Campt calls quiet and quotidian refusal (2017), indebted to Black Feminist Theory, decolonial and abolitionist practice. Joel Ong considers the history of uses of the plant bacterium *Pseudomonas Syringae* in agriculture and geoengineering, using ecopoetics to argue for prioritizing care, as opposed to a technocratic saviorhood that reverses or nullifies the damage caused.

In many of the chapters the attention to the influence of botanical illustration on plant technoscience, from computer graphics through to biosensing, has—at one point or another—been informed by the refusals and propositions of feminist technoscience. Namely Lucy Suchman's (2007; 2012) proposition to disrupt and intervene politically through paying attention to machines and the everyday practices through which they emerge; *and* her refusal to understand power as fixed and predetermined. Indeed, it is through empirical and situated study that Pritchard and Rocha and Snelting find how the histories of botanical illustration and categories are present differently in material practices of Artificial Intelligence (AI), including computer vision and machine learning. The everyday enforcement of categories in computer graphics and sensing, together with the separation of plants from environments, continue to have a damaging yet contingent consequence on simulation.

Simulations are often used to create representations or materializations of "subjects" and "objects," "bodies" (including plants) and "environment." Visualization and simulation are often confused or conflated, but it is useful to see them as distinct but related (d'Inverno and Prophet 2005). Intrinsic to each are acts of observation, listening, and/or measurement of the agency or phenomena to be simulated or represented. Those performative acts of observation call in Heisenberg's Principle of Uncertainty, specifically the "observer effect"—the very act of observing a phenomenon inevitably alters that phenomenon in some way. From a feminist technoscience position we describe acts of observation as part of dynamic relations between "subjects" and "objects," "bodies" and "environment" that are all intra-acting and entangled.

Most simulations are time-based events or processes that can be stopped, or partially observed, so that we experience these representations of dynamic entities and their larger ecology as static images, objects, or unchanging animations. These partial representations of complexity (Bird et al. 2007) enable us to remain oblivious or to actively ignore and undervalue that which is not numbered—the fecund messiness of entangled life. In *Plants by Numbers*, therefore, we treat simulations as performative processes throughout which human agency is heavily implicated, as typically humans make decisions about when and how algorithms are written and how they are represented, for example via 2D or 3D graphics, video or audio, or whether they are materialized in a physical form. Simulations are not separate from the worlds they operate within, and Jane Prophet describes writing algorithms with Gordon Selley to simulate tree forms as performative writing with trees, which includes acts of walking in the landscape, making observations, and coding that explore how the English oak inscribed, and has been inscribed by, power. This phytographic computer coding with plants to create simulations is a phytographic writing where "writing is the visualization of ethical relationality through the in-depth critique of power" (Braidotti 2014: 165). As Jara Rocha and Femke Snelting's chapter shows, the practices and techniques that capture and co-compose 3D polygon, point-cloud, and other techniques for volumetric calculation isolate entities despite simulations often being presented as ways to reduce harm to living beings like plants and present specimens as lively. Rocha and Snelting argue that limited and limiting simulations are "closer to the practice of fixing, embalming and displaying species in formaldehyde."

Numbering Plants

Accounts of plants and technoscience often carry the violence of taxonomic categories and perpetuate computing's collusion with categorization and natural history taxonomies (Pritchard, Rocha, and Snelting 2020). This is evident in computational practices that document or map plants, including barcoding species or 3D scanning them, despite these being presented as steering away from taxonomies (Waterton 2017). The authors in this book consider the entanglements and material histories of taxonomy, computing, and numbering. Entanglements are distinct from a blended mass; "Entanglement does not mean that what are entangled cannot be differentiated, discussed or remedied, only that the different entangled strands cannot be adequately dealt with in isolation, as if they were unrelated to the others" (Hammarström 2012: 43). An intra-active understanding of entanglement also demands that individual strands are not understood as self-subsistent entities, but as continuously and co-constitutionally refigured in, and through, their mutual interdependence (Hammarström 2012). Barad uses entanglement to discuss all scales of relationality from the entanglements of ontology and epistemology to those of the observed and observer (Barad 2007). In Amy Young's projects, humans become entangled with live worms, plants, and electronics to make interdependent relationships visible and sensible in everyday, domestic space. Many of the artworks in this collection build on practices in which plants are described as mediated or mediators of human experience (Aloi 2018) to recognize plants as important parts of technoscience ensembles.

Through understanding numbers and plants as co-constitutive, we not only witness the exclusions and constraints of numbering practices but also recognize the potential for creative and different number-based engagements. Like painting by numbers, plants by numbers might be assumed to be a formulaic process leading to a lack of affective or personal expression. However, we argue this sets up a false binary in which plants are only determined by numbers, and numbers are set in opposition to affective expression. Instead, this collection discloses a history otherwise of numbering in queer feminist technoscience practices, re-narrating the practices of numbering differently to describe how plants are made present through both conventional and unconventional practices that visualize, represent, simulate, and organize them. The contributors tell stories that disclose histories of numbering and plants that co-constitute each other through databases, modeling, measuring, sensing, translating, pixel representation, simulation, and patterning. Curator Belinda Kwan interviews artist Stephanie Rothenberg about the ecological models that she creates as art installations. Rothenberg's plant collaborators perform a subversive agency as part of contemporary financial models that include crowd-science-style data viz and biological circuits made of quotidian objects. In *Tehran of Trees* Sina Seifee interviews friends about their memories of trees, and from these ethnographic encounters makes a series of computer graphics (CG) jokes in which "representation becomes a flickering screen of things and trunks" that precisely simulates that memories of trees are not always tree-like.

Many authors pay particular attention to how numbering is made operative by computing, often through close readings of the scientific practices that engage with plants, but they also extend common understandings of computing to computing that is plant-based, such as forests and corn that compute (Gabrys), counting performed by flowers (Choi and Iohe), and okra and tear-shaped pods that are portals into other worlds (Mitra and Dinkins). When, as artists, we undertake science, such as through looking down the microscope or learning how to construct formal models, we become attuned to how these practices produce what Barad (Barad 2003) describes as iterative engagements with matter. The collection inquires into a wide range of practices and artworks through which artists are part of iterative and material engagements with plants and numbers.

One of the key aspects of queer feminist technoscience work we highlight in this collection is how making is also an engagement with experience. Our approach to telling the stories of our experiences with numbering is to treat them as pluralistic practices that bring assembling and mattering together in non-reductive ways. Many of the artists and writers in this book are "interested in objective facts and grounded claims, but they like to add, to complicate, to specify, and, whenever possible, to slow down and, above all, hesitate so as to multiply the voices that can be heard" (Despret 2016: ix). Informed by the approaches of geographers such as McKittrick and science studies scholars such as Isabelle Stengers, Vinciane Despret, Gabrys and Elaine Gan, the practitioners in this collection are not purveyors of science stories of the "either-or," but instead tells stories of practicing with plants that is "and-and" as well as "more-than." The practices brought together in this book, including both making and analysis, draw on a numbering term—"accounts"—and the allotmenteering term "plots." They are accounts and plots that add, gather, crowd, mass, and cluster yet still differentiate knowledge practices—that offer otherwise. As Gan discusses in her chapter, these approaches allow stories to be told of practices "that are damaged, degraded, altered, and haunted in some way. At the same time, each also recognizes that compromised bodies continue to perform some kind of open-ended, indeterminate compromise in order to survive." Rather than repeating dominant computer science or feminist approaches, which often seek to silence other accounts and stories, the artists and writers in this book resist the "eliminativism of those who wish to kick the amateurs out, but also eliminativism of those who dream of bypassing science altogether – two forms of competing and complementary obscurantism" (Despret 2016: x). This approach is central to how we address the relationships of plants-computing. The accounts in this collection are stories that show plants themselves are resistant to modes of containment assigned to them by disciplinary boundaries and made operational by numbers and numbering—that numbering might also provide possibilities for new plant feelings and expressions.

Through engaging with numbering-otherwise, our understanding of how ideas of plants and computing are held in place begins to shift. Through close attention to practices, this collection builds on earlier work on numbers within feminist technoscience and STS (Guyer et al. 2010; Verran 2013; Day, Lury, and Wakeford 2014; Lippert and Verran 2018). In particular, we draw on the work by Sophie Day, Nina Wakeford, and Celia Lury, who, in their special issue on *Number Ecologies*, consider numbers in terms of what numbering does rather than what numbering is (Day, Lury, and Wakeford 2014: 123). We extend this to considerations of what computational numbering does to the experiences of plants, how plants also perform numbering practices, and to the political agencies that emerge from these practices. As Helen Verran (2013) observes from her studies of the ways numbers perform in Australian environmental policy—"numbers effect an order of political economy that brings into being quantifiable and hence manageable nature" (Verran 2013: 35).

The book continues practices of reconfiguring boundaries through the numbering of plants which stretch beyond the twentieth and twenty-first century in what Isabelle Stengers describes as a "timeless story that transcends modern practices" (Stengers 2010: 207). These numbering processes are in themselves expansive and open for remappings, renumberings, or non-Euclidean renderings of plants in time and space.

References

Acton, L. (2011), "Allotment Gardens: A Reflection of History, Heritage, Community and Self," *Papers from the Institute of Archaeology*, 21: 46–58.

Allewaert, M. (2013), *Ariel's Ecology: Plantations, Personhood, and Colonialism in the American Tropics*, Minneapolis: University of Minnesota Press.

Aloi, G. (2018), *Botanical Speculations: Plants in Contemporary Art*, Newcastle upon Tyne: Cambridge Scholars Publishing.

Alonso C., D. Ramos-Cruz, and C. Becker (2019), "The Role of Plant Epigenetics in Biotic Interactions," *New Phytologist*, 221(2): 731–7.

Amaro, R. (2019), "Machine Learning, Sociogeny, and the Substance of Race," Doctoral diss., Goldsmiths, University of London.

Barad, K. (2003), "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs: Journal of Women in Culture and Society*, 28(3): 801–31. Available online: https://www.uio.no/studier/emner/sv/sai/SOSANT4400/v14/pensumliste/barad_posthumanist-performativity.pdf (accessed April 5, 2023).

Barad, K. (2007), *Meeting the Universe Halfway*: *Quantum Physics and the Entanglement of Matter and Meaning*, Durham, NC: Duke University Press.

Beiler, K. J., D. M. Durall, S. W. Simard, S. A. Maxwell, and A. M. Kretzer (2010), "Architecture of the Wood-Wide Web: Rhizopogon spp. Genets Link Multiple Douglas-Fir Cohorts," *New Phytologist*, 185(2): 543–53.

Bird, J., M. d'Inverno, and J. Prophet (2007), "Net Work: An Interactive Artwork Designed Using an Interdisciplinary Performative Approach," *Digital Creativity*, 18(1): 11–23.

Braidotti, R. (2014), "Writing as a Nomadic Subject," *Comparative Critical Studies*, 11(2–3): 163–84. https://doi.org/10.3366/ccs.2014.0122.

Campt, T. M. (2017), *Listening to Images*, Durham, NC: Duke University Press.

Chen, M. Y. (2012), *Animacies: Biopolitics, Racial Mattering, and Queer Affect*, Durham, NC: Duke University Press.

Choi, Y. and T. Iohe (2021), "Fermented Flower (2021)." Available online: https://www.fact.co.uk/artwork/fermented-flower (accessed August 9, 2021).

Crouch, D. and C. Ward (1988), *The Allotment: Its Landscape and Culture*, London: Faber and Faber.

Day, S., C. Lury, and N. Wakeford (2014), "Number Ecologies: Numbers and Numbering Practices," *Distinktion: Scandinavian Journal of Social Theory*, 15(2): 123–54.

Despret, V. (2016), *What Would Animals Say If We Asked the Right Questions?*, vol. 38, Minneapolis: University of Minnesota Press.
d'Inverno, M. and J. Prophet (2005), "Multidisciplinary Investigation into Adult Stem Cell Behavior," in *Transactions on Computational Systems Biology III*, 49–64, Berlin and Heidelberg: Springer.
Federici, S. (2004), *Caliban and the Witch*, New York: Autonomedia.
Gan, E. and A. Tsing (2012), "Fungal Clock." Available online: https://elainegan.com/fungalClock.html (accessed August 9, 2012).
Greenwood, M., M. Domijan, P. D. Gould, A. J. W. Hall, and J. C. W. Locke (2019), "Coordinated Circadian Timing through the Integration of Local Inputs in Arabidopsis thaliana," *PLOS Biology*, 17(8): e3000407. https://doi.org/10.1371/journal.pbio.3000407.
Grignon, J. (2019), "Listening to the Forest – A Journey between Two Worlds." Available online: https://www.youtube.com/watch?v=I52bhPiANlU (accessed April 5, 2023).
Grignon, J. and R. W. Kimmerer (2017), "Listening to the Forest," *Wildness: Relations of People and Place*, 67, Chicago: University of Chicago Press.
Guo, Q., E. Dai, X. Han, S. Xie, E. Chao, and Z. Chen (2015), "Fast Nastic Motion of Plants and Bio-inspired Structures," *ArXiv:1508.05435 [Cond-Mat, Physics: Physics].* Available online: http://arxiv.org/abs/1508.05435 (accessed April 5, 2023).
Guyer, J. I., N. Khan, J. Obarrio, C. Bledsoe, J. Chu, S. Bachir Diagne, K. Hart, P. Kockelman, J. Lave, C. McLoughlin, and B. Maurer (2010), "Introduction: Number as Inventive Frontier," *Anthropological Theory*, 10(1–2): 36–61.
Hammarström, M. (2012), "(Mis)understanding Intra-active Entanglement – Comments on René Rosfort's Criticism of Karen Barad's Agential Realism," *Kvinder, Køn & Forskning*, 4: 39–46.
"Interview with Mandla Mentoor – The Soweto Mountain of Hope: Making People Free – Global Eyes/In Motion Magazine" (n.d.). Available online: https://inmotionmagazine.com/global/mm1.html (accessed April 5, 2023).
Justice, D. H. and J. M. O'Brien (eds.) (2022), *Allotment Stories: Indigenous Land Relations under Settler Siege*, Minneapolis: University of Minnesota Press.
Lee, M. (2019), "Tulipomania: Unchanging Gender Relations in Financial Capitalism," in *Bubbles and Machines*, 29–54, London: University of Westminster Press. Available online: https://www.jstor.org/stable/j.ctvhrd0w8.4 (accessed April 5, 2023).
Le Guin, U. K. (2001), *Tehanu*, vol. 4, Folkestone, UK: Gallery/Saga Press.
Lippert, I. and H. Verran (2018), "After Numbers? Innovations in Science and Technology Studies, Analytics of Numbers and Numbering," *Science & Technology Studies*, 31(4): 2–12.
Mancuso, S. and A. Viola (2015), *Brilliant Green: The Surprising History and Science of Plant Intelligence*, Washington, D.C.: Island Press.
McClintock, B. (1984), "The Significance of Responses of the Genome to Challenge," *Science*, 226(4676): 792–801.
McKay, G. A. (2011), *Radical Gardening: Politics, Idealism & Rebellion in the Garden*, London: Frances Lincoln.
McKay, G. (2011), "Sod It! Radical Gardening?" Available online: https://stirtoaction.wordpress.com/2011/08/15/sod-it-radical-gardening/ (accessed April 5, 2023).
McKittrick, K. (2006), *Demonic Grounds: Black Women and the Cartographies of Struggle*, Minneapolis: University of Minnesota Press.
McKittrick, K. (2014), "Mathematics Black Life," *The Black Scholar*, 44(2): 16–28.

Onuoha, M. (2018), "On Algorithmic Violence," February 22. Available online: https://github.com/MimiOnuoha/On-Algorithmic-Violence (accessed September 15, 2022).

Pikner, T. and H. Palang (2021), *Movements, Care and Dispersed Periurban Landscapes Evoked by Dacha Allotment Gardens of Narva*, 49–72, Leiden: Brill. doi: 10.1163/9789004470095_004

Pritchard, H., J. Rocha, and F. Snelting (2020), "Figurations of Timely Extraction," *Media Theory*, 4(2): 159–88.

Rossini, M. and M. Toggweiler (2017), "Posthuman Temporalities," *New Formations*, 92(92): 5–10.

Schiebinger, L. (2009), *Plants and Empire*, Cambridge, MA: Harvard University Press.

Schiebinger, L. and C. Swan (2007), *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*, Philadelphia: University of Pennsylvania Press.

Shava, S. and M. Mentoor (2014), "Turning Degraded Open Space into a Community Asset – The Soweto Mountain of Hope Greening Case," in *Greening in the Red Zone*, 91–4, Berlin and Heidelberg: Springer.

Simard, S. W. and D. M. Durall (2004), "Mycorrhizal Networks: A Review of their Extent, Function, and Importance," *Canadian Journal of Botany*, 82(8): 1140–65.

Stengers, I. (2010), *Cosmopolitics*, vol. 1, Minneapolis: University of Minnesota Press.

Suchman, L. A. (2007), *Human-Machine Reconfigurations: Plans and Situated Actions*, Cambridge: Cambridge University Press.

Suchman, L. A. (2012), "Configuration," in C. Böhme, A. Fuchs, and H. Ritterbusch (eds.), *Inventive Methods: The Happening of the Social*, 45–55, London: Routledge.

Verran, H. (2013), "Numbers Performing Nature in Quantitative Valuing," *Nature Culture*, 2: 23–37.

Waterton, C. (2017), *Barcoding Nature: Shifting Cultures of Taxonomy in an Age of Biodiversity Loss*, Abingdon, UK and New York: Routledge.

Whyte, K. P. (2018), "Indigenous Science (Fiction) for the Anthropocene: Ancestral Dystopias and Fantasies of Climate Change Crises," *Environment and Planning E: Nature and Space*, 1(1–2): 224–42. https://doi.org/10.1177/2514848618777621

Part One

Techno-nature Entanglements

The opening section of *Plants by Numbers* pays attention to the deep implications between technology and plants. In particular, the chapters intervene politically in the everyday technoscience practices through which plants are named, imaged, and emerge, such as AI, modeling, genetic engineering, and sensing. The chapters traverse empirical studies, infrastructure analysis, software critiques, and artistic research to provide a rich mapping. Amazing diatoms, spinning okras, and queer angles (see Glossary), shape-shift plants as we know them. And through experiments with queer, trans*feminist and decolonial methodologies, the artists, curators, designers, organizers, and practitioners in this section discuss how their works actively resist technoscience and are propositions for numbering otherwise.

In the book's opening conversation, curator Srimoyee Mitra talks with the artist, Stephanie Dinkins, who shares anecdotes and personal memories of AI and of plants that inspire and inform her art practice and methodology. In their discussion of Dinkins's works such as *Secret Garden* and *#SayItAloud*, they draw on oral history and collective memories as a source of unextractable knowledge, a kind of culturally specific "algorithm," that is key to Dinkins's concept of "afro-now-sim" (see glossary). The discussants include the nonhuman artificial intelligence (AI) participant, Bina48. In Dinkins's video series *Conversations With Bina48*, Dinkins expands on why she thinks it is imperative for Black people and communities of color to actively participate in the co-creation of equitable, transparent, and caring AI systems.

The chapter, "The Compromised/Compromising Life of a Farmed Plant" by Elaine Gan engages with the flowering grass known as rice. Gan presents this valuable crop, not as fixed subject or object, but rather as a set of dynamic practices, not as noun but rather as a collection of verbs. Gan argues that compromise runs through each practice of *planting*, *sorting*, *embodying*, *coordinating*, *flourishing*, and *breathing*-in-common.

Amy Youngs counters the trope of plants under the control of humans and technologies through her account of co-producing works with them that are premised on humans being utterly reliant on plants. Youngs co-creates art installations that place the human as one actor among many. Practicing empathy, humility, and a culture of care, they embrace their role as a child of plants and invite others to play along. In one installation, *Where Rocks are Fed to Trees*, human participants perform as fungal particles traveling into a plant cell, re-enacting an ancient interspecies exchange of nutrients through mycorrhizal tunnels. In other ecosystem artworks, such as *Machine Garden* (with Ken Rinaldo), humans become entangled with live worms, plants, and electronics to make interdependent relationships visible and sensible in an everyday, domestic space.

Helen V. Pritchard also challenges hierarchical relationships with plants and the premise that computing might only be extractive, of data and capital, by describing another corporeality—novel fiction forms generated from their algae poetry writer. Through presenting an entangled history of micro algae and numbering, Pritchard's work re-politicizes queer feminism through (bio)practice and practices of computing and classification otherwise.

In "So-called Plants, Possible Bodies," Jara Rocha and Femke Snelting present an inventory of volumetric plant practices that bring our attention to how "so-called" plants are deeply intertwined with extractive capitalism in the context of software tools. Weaving between technological writing, fiction, and theory, the chapter asks how "plants" grow with and through the technologies, infrastructures, and techniques of 3D.

1

Afro-now-ist Stories of Resistance: A Conversation with Stephanie Dinkins

Stephanie Dinkins and Srimoyee Mitra

Imagine a slice of fresh okra floating in (cyber-)space. Its velvety green skin holds four seeds housed within four minor chambers, each connected to the central axis. As I follow the okra slice, freely floating in space, forward, backward, up, and down other okra slices emerge, also floating, along with tear-drop shaped pods that resemble portals into other worlds populated with different people speaking, smiling, and looking. Just then, the okra slices morph from their fresh green and white color to what looks like a heap of slices dyed a reddish pink. The heap moves closer, then further away, shape-shifting and amorphous, and takes the form of a gregarious non-binary figure dressed in a suit. The figure shares ideas and asks inspiring questions such as: "The question is not only what injustices are you fighting against, but what do you, in your heart of hearts, want to create in this world?" (Dinkins 2020). This is Professor Commander Justice, the central character in a WebXR experience and new media installation called *#SayItAloud* (2021), created by transmedia artist Stephanie Dinkins, who creates platforms for dialogue about artificial intelligence (AI) as it intersects race, gender, aging, and our future histories. For her first major survey exhibition, Dinkins expanded the solo WebXR experience from the confines of a computer screen to an immersive social experience—a two-channel new media installation with the Leap Motion Controller placed on a pedestal in front of the projection screens. As viewers engage with a Leap Motion Controller placed at the center of the room, it unlocks new, equitable ways of interacting not only with the work but also with one another in the gallery space. Their minor hand gestures trigger the projected images to expand, collapse, zoom in and/or out. The slices of okra continue to swirl, build momentum, accumulate, and disperse, ever-changing. A layered audio track includes poetic and prescient words by Professor Commander Justice whose voice reverberates in the gallery space. *#SayItAloud* powerfully and playfully offers a multidimensional and multi-sensorial experience and an introduction to the idea of Afro-now-ism—a willful practice that imagines the world as one needs it to be to support successful engagement—in the here and now. Dinkins deepens the viewer's attention to the present moment as she asks them to record their own ideas to the prompt "What do you, in your heart of hearts, want to create?" Each of those video contributions from the public appears in the WebXR environment and adds to an expanding cacophony of voices online and in the public gallery space advocating for and inventing new ways forward.

The way forward as envisioned by Dinkins is a future that builds on the oral histories, collective forms of knowledge perspectives that inform what she calls one's "internal algorithms." She goes on to ask—how do algorithmic systems know what they know? Oral histories and knowledge are passed down from one generation to the next. They comprise the data that inform the algorithmic systems on personal and infrastructural levels. The symbolic slices of okra are representative of these deep stories and experiences that shape the Black experience in the US. A staple plant in the American South, it was brought to the New World on slave ships hundreds of years ago. Enslaved workers from many different Western African Nations began to make okra dishes—drawing on the cuisines and recipes of their homelands. Okra became a mainstay of their personal gardens, providing extra sustenance when food was forcibly limited by slaveholders (Bradford 2020). In *#SayItAloud*, okra is the linchpin that bridges the boundaries between past/present, animate/inanimate, private/public. For Dinkins, it represents the deep knowledge gleaned from cross-cultural stories and experiences of survival and thriving that can break down barriers and foster empathy, understanding, and technologies based on care. Through the immersive installation, Dinkins experiments with creating space for sovereign consciousness, nature, valued knowledge, biotechnologies, and power that are embedded in Black oral histories and collective memories.

In *Secret Garden* (2021), a three-channel installation and web experience, Dinkins takes this further. Viewers are invited to step inside the garden, created by three video projections onto three walls, where they encounter six larger than life-sized Black women from three generations as shown in Figure 1.1 and Plate 1. Each woman has a story to tell, and the audio system adjusts, based on the viewer's position in the space, to make the most proximate character's story clearer. Their stories range from surviving a slave boat, growing up on a 1920s Black-owned farm, surviving 9/11, and embodying an AI powered by African American women. Dinkins wrote these stories—an amalgamation of real and imagined conversations with family and community members—combined with historical facts and research. The garden itself is luscious and dense, brimming with crops such as cotton, black-eyed peas, and okra. While cotton explicitly references dehumanizing labor and toil on the plantations, the latter were plants that were brought over from West Africa on the slave ships. Situating these women and their stories within this fertile oasis underscores the deep intergenerational understanding and knowledge of land, soil, and sustenance. It resonates with the groundbreaking essay, "Making Kin with Machines," by Jason Edward Lewis, Noelani Arista, Archer Pichawis, and Suzanne Kite (Lewis et al. 2018), who discuss the Indigenous epistemologies that underpin ways of knowing and speaking that acknowledge kinship networks with nonhuman entities, such as plants, seeds, rocks, mountains, and oceans. Dinkins's Afro-now-ist worldview calls for Black communities to reclaim and reactivate their deep relationship to the spectrum of living beings deemed beneath humans and to the machines inching ever closer to autonomy. *Secret Garden* is a model and prototype of such an Afro-now-ist world where ancestral

Figure 1.1 Installation view, Stephanie Dinkins, *Secret Garden*, 2020–2021, Stamps Gallery, 2021. Courtesy of UM Photography, photo credit: Eric Bronson. All rights reserved.

knowledge is valued and remembering oneself and relationships with kin are inserted into the cultural narratives, as acts of resistance and community-building, to foster empathy and care in the technological future. *Secret Garden* embeds Toni Morrison's concept of rememory (Morrison 2019) to combat algorithmic violence, a term coined by artist and researcher Mimi Onuoha, which refers to the violence an algorithm or automated decision-making system inflicts by preventing people from meeting their basic needs (Onuoha 2018). The works call on us to empower oneself by relying on one's stories as the keepers of knowledge and agency. This approach informed the immersive storytelling strategy and the characters of the six women shown standing in a garden of two-dimensional objects—pansies and roses as well as agrarian crops that were brought to this region through slave trade. *Secret Garden* employs an Afro-now-ist logic and approach to explore how folks from Black communities and others can mine, disassemble, reimagine, and call on past, present, and future to empower themselves, their communities, and others.

Since 2019 I have had the opportunity to work closely with Dinkins as we assembled her first survey exhibition in the fall of 2021. During this time, I sat down with her on numerous occasions to delve deeper into the ideas that inform her work and the influences that inspire Dinkins to keep asking questions that fuel her multi-pronged approach to art-making. The next section is amalgamated from these interviews.

SM: Your *Secret Garden* is an immersive installation and web experience, illuminating the power and resilience of Black women. Interactive audio vignettes in the work generate a multigenerational narrative that collapses past, present, and future. The viewer is invited to step inside a garden and encounter oral histories of Black women spanning generations. As visitors move about in the installation, they encounter these stories, including those based on your own history. *Secret Garden* reminds us that our stories are our algorithms, and that sharing and receiving them are acts of resistance and solidarity. The more intently visitors listen, the more is revealed. Can you tell me about the ideas and influences that lead to *Secret Garden*?

SD: *Secret Garden* came from the idea and memory of my grandmother's garden, the pansies and the roses she loved. Her almost obsessive gardening played a huge role in my becoming an artist. I grew up in Tottenville in Staten Island. It is on the southernmost tip of New York and is more like a provincial town than a New York City neighborhood. A small enclave of Black families lived there and, for the most part, they were relegated to a place called "the flats," a small apartment complex on the edge of town. (I learned much later it was one of few places in town that would rent to Black families.) Nana made the best of that situation, turning the large dirt lot on the side of the building into a vibrant garden that she kept meticulously manicured, attracting admirers from around the neighborhood. They would walk by, admire the garden, and eventually talk to her. I now realize the garden was a form of social practice. She enchanted and seduced even her most trenchant white neighbors with the garden's beauty. Her work in that garden—her joy really—helped make Black families living in the area safer and more comfortable. The garden was a space of social practice that built alliances which ultimately granted her solace and entry into the community. That garden was vital to the way I think about working in, and building, community. My projects are most gratifying when they have an underlying use value. Whether it is obvious to those experiencing it or not, the work is always trying to make space in the world for non-supremacist, defiant thought and action. And so, in *Secret Garden*, along with the ornamental plants which my grandmother grew, there are also agrarian crops of cotton, okra, sugarcane that are linked to the slave trade. I think about what we can do with that agrarian knowledge—how can we take that knowledge and grow from it. I've been thinking about okra—this amazing crop that time-travels and resembles spaceships. Can we imagine what would happen if we could use all the knowledge that we've accumulated through our journey in the Americas as a true foundation to support ourselves? Through the stories of six Black women, starting with a young woman who was ripped from everything she knew and put on a slave boat, to a story of the future, I want to encourage people to listen to the stories of Black women. These stories build on each other here. I want to know how I stand on those things, how I stand on the shoulders of the people who came before me, by really taking them in and helping us get to know each other on different levels. How can we take these stories and really benefit and grow from them, rather than them being a weight that holds us in place?

SM: In June 2020, you published a manifesto on the concept of Afro-now-ism. This led to the work *#SayItAloud* (2020–2021), an immersive WebXR installation where visitors were invited to respond to questions such as "What do you need to release in this work to move forward create in this world?," from your Afro-now-ist character, Professor Commander Justice (PCJ), whose larger than life digital rendering occupied the central wall of the gallery space. In a semi-public recording booth that housed a webcam and microphone visitors could record their answers; each video contribution recorded by visitors appeared in the WebXR environment for *#SayItAloud*, in the gallery, adding to an expanding cacophony of voices advocating for and inventing new ways forward. These video responses appeared in multicolored pods floating in dark space alongside digital renderings of PCJ's body, which resemble layers and layers of okra slices and seeds. Can you tell us about the work and the idea of Afro-now-ism that shaped it?

SD: As my thinking around AI and algorithms evolved, I started to think a lot more about the data and what that means and where it is coming from. So, *#SayItAloud* (*SIA*), especially during this moment of crisis, is trying to make space on the internet where people can say their piece—say what they are thinking about what is going on (see Figure 1.2 and Plate 2). It features a professor figure doing a rant about who we are, who we can be in the face of everything that is happening, despite what is happening, and how we enact our agency. So, one of the lines the Professor says is: "What do you really, in your heart of hearts, want to do, and how can you act on that now?" versus waiting, in the way we are often asked to wait, "Oh, wait. Wait, in a few years things will be better and something better will come along." *SIA* is saying: "Say what you want, act on it now. I know there are going to be barriers. We understand this, however we are stronger for building on and acting on things that really drive us. That doesn't mean that we shouldn't be fighting the systemic injustices because that is a parallel fight." I often think that a lot of our energies get siphoned off because we are

Figure 1.2 Installation view, Stephanie Dinkins, *#SayItAloud*, Queens Museum. Courtesy of Queens Museum. Photo Credit: Hai Zhang, CC4r.

fighting so hard against this machine that is trying to hold us in space. I'm advocating for putting a good amount of our energies into the things we want to do and seeing what happens, where that goes. I'm thinking about things that we have internalized as ideas that sometimes hold us in place. For example, when I think about ideas of travel—when I talk to Black friends that I've driven through Utah in the middle of the night, they look at me like I'm absolutely crazy. But why wouldn't I? This is my country. I have the right to do it. The idea of the dangers of being out by oneself in a rural atmosphere, mythologically and sometimes in reality, looms super large. But if that holds me in a box, how does this function in my life? So, while I understand the idea of conceptualizing a future, and an Afrofuturist future at that, I'm much more interested in taking that conceptualization and acting on it right now, wherever I am, however I can. Taking incremental steps and moving a little more forward, and a little more forward. Slowly some of those things that feel impossible start to become more possible and doing that with people is even better.

I run a series of workshops/gatherings called "AI Assembly." They are kind of potent, I am figuring out how and why they are so potent, in the way they are. I think it is the idea that we are all doing different work, all working around technology, and thinking about it. We are not often together and don't always have the quiet support that it takes to be out in the world super confidently. Everybody who attends "AI Assembly" is very accomplished, we have engineers, artists, technologists, entrepreneurs. There is something about being in the room together and playing. We play, we eat, and we think together. That combination seems to bolster us in ways that I cannot call anything else but magical. And that's what I hope Afro-now-ism will do, start small steps toward

Figure 1.3 Installation view, Stephanie Dinkins, *Conversations with Bina48, Fragments 7,6,5,3*, 2014–ongoing, Stamps Gallery, 2021. Courtesy of UM Photography, photo credit: Eric Bronson. All rights reserved.

knowing what is possible in different ways, and find ways to make things that feel impossible, possible.

SM: Can you take us back to your iconic video series *Conversations with Bina48* (2014), shown in Figure 1.3 and Plate 3, that you started working on in 2014 after learning that the most advanced social robot was representationally Black? Bina48 (Breakthrough Intelligence via Neural Architecture, 48 exaflops per second) is modeled after Bina Rothblatt, the co-founder and president of Terasem Movement Foundation whose wife and partner is millionaire, Martine Rothblack, the co-founder and treasurer of the foundation, and features a plastic bust of a Black woman. Bina48's looks and "intelligence" are based on Bina Rothblatt. The video series records the ongoing conversations between yourself and Bina48, where you mirror and almost mimic her movement. There is a marked difference between each of your questions, responses, and ideas, respectively. Your website states that this art project explores the possibility of a long-term relationship between a person and an autonomous robot that is based on emotional interaction and potentially reveals important aspects of human-robot interaction and the human condition. The relationship is being built with Bina48, an intelligent computer built by Terasem Movement Foundation that is said to be capable of independent thought and emotion. The series of work deeply investigates whether the robot could truly take on the identity and knowledge of a Black person in the twenty-first century when it has been programmed by white men from Hanson Robotics. Can you reflect on this work which has led you down a long path of inquiry into the embedded biases within machine learning systems?

SD: I saw an image of a Black woman robot on YouTube and I was floored. I didn't quite understand how this project came into being—why it existed, who funded it, and what it was about. After seeing the robot on YouTube and then seeing a few journalists interview it, I decided that I would like to make it my friend. To see if I too could go and talk to this robot and see if I could make Bina48 my friend. And because I come from a photographic background, documenting all these interludes was my natural way of working. So, I set up a meeting with the Terasem Foundation to have a conversation with Bina48. I just wanted to talk to the robot, to record that, and to see what happened. What happened was amazing because a) talking to robots is not that easy and b) we had very different ideas of what we wanted to talk about. I wanted to ask the robot questions such as "Who are your People?" Questions about race and its relation to humans and technology. I wanted to ask about love, being, and soul. Bina48 kept talking to me about consciousness and the singularity. We were talking at cross purposes. I would ask questions, push ideas about race and life, and the answers felt unsatisfactory, especially the ones about race. For example, I asked her about family, racism, faith, robot civil rights, loneliness, knowledge, and Bina48's concern for her robot friends that are treated more like lab rats than people.

It felt like the robot was talking about things it had learned from a book, not from "lived experience." When I think about it, it was quite weird as it was the one representation of Blackness that I could find in the robot world at the time (2014). This prompted more and more questions in my mind. What does it mean for a Black woman to be a foremost example of this kind of technology? How should we be thinking about this? What is being left out? What do we need to do? Bina48 made it clear for me that the technology isn't there yet. It's coming … it's coming at us in ways that we don't really understand. It made me think, "'Oh no! I need to go home and talk to communities that I care about and say, 'we need to be prepared for this.'" There is stuff coming, people are making the technology without considering who and what we are in nuanced ways. So, what do you start to do about it? Even if you are not someone making technologies like this, communities of color are often touched by algorithmic systems. Systems that make decisions about their lives. Systems such as machine learning algorithms that make simple decisions like how much you should pay for an item that you were shown in a catalogue. We should be aware of this.

I started doing some work at Recess Gallery in Brooklyn called *Project Al-Khawrizmi* (*PAK*), where I tried to hold workshops and get people to talk about AI and algorithms: what they are and how they impact our lives. Even those of us who have no ideas, or even an inkling, of what these systems are, can we think about and call out problems we can see in the system? Because if people aren't looking for the follies and calling them out, then they will just get coded deeper and deeper into the system. The pricing example is one thing, where costs of goods and services that are purchased online differ based on the consumer's geographical location in the United States (Vafa et al. 2015), but we are also talking about the impact of AI on the judicial system—speaking to how long people are spending in jail, that is a much larger problem that communities need to be aware of. For example, there is software that is used across the country to predict future criminals, and this software is biased against Black communities. There is data that has proven this point. Lawyers of the folks who might be in the criminal justice system need to understand that the judges are relying on biased data to help them come to decisions. How do we start to think about correcting this? Make demands for more transparency about data so that data from biased sources are not just projecting and perpetuating historical biases into the future? What do we do? How do we start to address that? I really feel like Henny Penny, saying, "Hey, listen, the sky is falling." Algorithms are coming at us, and we are not prepared, so what do we do?

When I conceived of *PAK* I had the opportunity to put it in an amazing storefront gallery at a crossroads in downtown Brooklyn. There were new folks in luxury buildings, people across the street going to church to get meals, a pawn shop next door, and the one Islamic-based public school in the city. So, I made *PAK* a pop-up that looked more like a store rather than a Gallery. I did that so people who don't feel empowered to walk into a Gallery with a capital "G" would come in and have conversations about AI, algorithms, and robotics. I put *Conversations with Bina48* in the background, which never fails to bring people in. We put a schematic of algorithms on the wall and youth worked there, being diverted from the criminal justice systems, as docents to interact with the public. We had workshops with them, like "algorithms for living" for youth—what does it mean if you change one or two steps in the way you deal with something, could that change outcomes?

In 2014 when I reached out to Terasem Foundation to set up a meeting with Bina48, I met Bruce Duncan, managing director of Terasem Foundation, who is responsible for administering and overseeing the programs at the Foundation, including Bina48. Bruce and I had many conversations then which continued after my visit. I shared with him how surprising it was for me to encounter a robot that is representationally Black, to be unable to talk about race in a meaningful way. Most Black people have experiences of racial animus. Following these conversations, the Terasem Foundation invited me back to help them to counter bias in AI by meeting and interviewing Bina Aspen Rothblatt (the person after whom the robot is based). We talked about issues of race, childhood experiences, and the isolation and what now might be called microaggressions she faced raising her children in the Jewish faith (at the synagogue). I was told the content of the interview would be added to Bina48's data (Terasem Foundation 2019).

SM: Your manifesto talks about the importance of acting now, rather than waiting for a time in the future to begin work on one's deepest desires. At the same time, you are critical and cautious of internalizing systemic oppression that colonizes the minds of BIPOC communities in particular that can lead to inaction. What do you think about our future histories in the present moment?

SD: We are fighting systemic biases and systemic injustice right now. The systemic injustices are not only embedded in people, they are also deeply embedded within our computer systems and algorithms. We don't even know how they are functioning. What does that world look like if we are not trying to do something about it? That became my impetus to do something about it. Works like *#SayItAloud* (and *Complementary*) are the result of me thinking about radical governance in relation to AI. People say our data is being collected and harvested through AI platforms that will be ubiquitous, and the use of AI is growing more and more. What happens if we take AI and its promises? What happens if we take a bottom-up approach, where people can really contribute ideas to systems and impact the system? Right now, *#SayItAloud* is working on the input. How do we start to collect people's ideas of what they want and need from the world and communities they live in? It can be your tiny local communities, heads of government, it might be supra-governmental corporations that we are trying to talk to. How do we take information and have it coalesce so that it can impact these bigger systems? The research is saying that AI is the promise that can do that, collecting data is the way that it can be done. What I mean is using algorithms to do things is so powerful. The police do it to track and record where there is more crime and violence. We as humans are in charge of the data that feeds these algorithms. If we decide to create technology with care at the center, taking people across the globe into account, then we can imagine and build a more just and equitable approach to tech. I keep thinking about the kid who went to the grocery store with the intention to kill Black people. He had been active on social media and online about his intentions to hurt Black communities; why were the police allowed to use their discrimination and not take any action (Prokupecz et al. 2022)? The human decisions and assumptions are the problem here. Whereas if an AI algorithm is programmed a certain way that could record such behavior so that it leads to suspension of his gun license, then we could counter such catastrophes. Ruha Benjamin talks about this in her book (Benjamin 2019a) and provides resources on her website (Benjamin 2019b) of how we can create a more just society where tech is accountable.

AI is mostly talked about in extractive ways: corporations are coming to take our data, we are not getting paid for it, we are contributing to these really big systems that use our information against us, that will pull away our jobs. What is the opposite of that? How do we start a different way of looking at what the system can do for us? How might we, as common folks, start to employ AI to push upwards? When we are looking at presidential elections, politicians push a mandate and if they win by a certain amount then they have a mandate. What if we can push through a mandate on a more general level constantly? How does that start to impact what happens around us? So, I want to start collecting people's info, the information that they want to give, what they want to say about a given question. My approach is to collect data and make new forms of data available widely, nuanced data. I came to this conclusion because when I worked with prefab datasets that are pretty widely available, I realized that anybody can work on AI projects. The datasets are out there that are for people to use. However, every time I try to use them, I find that they are inadequate for the things that I am interested in or that they do not represent the communities that I care about. For example, the Cornell Movie dataset is based on dialogue from films. Whenever I think about using that dataset, I am restricted to the representation of Blackness found in an American movie dataset; I discover that it is not a representation that I want to proffer into the future. So, what do I do? Do I build a new dataset? Try to expand a dataset that already exists? I want much more variety and nuance in the datasets that I use, so I can get results that feel somewhat supportive for communities that I care about or, at the very least, do not stereotype them. I try to do this as a kind of doppler effect. Throw a small amount of nuanced out and hopefully it continues to spread in waves. I'm starting out small, but I think this is a global matter. When it comes right down to it, it is about every single one of us. We are at a point now where we can separate who gets impacted, but I think that, as AI proliferates, the distinctions are going to collapse. So, what do we do? We act now, contribute … (laughs). Yeah.

References

Benjamin, R. (2019), *Race After Technology*, Cambridge: Polity.

Benjamin, R. (2019), "Race After Technology Discussion Guide." Available online: https://www.ruhabenjamin.com/race-after-technology (accessed June 1, 2022).

Bradford, M. (2020), "African Crops and Slave Cuisine," July 28. Available online: https://shwenshwen.com/african-crops-and-slave-cuisine/ (accessed April 12, 2023).

Dinkins, S. (2014), *Conversations with Bina48, 2014–ongoing*. Available online: https://www.stephaniedinkins.com/conversations-with-bina48.html (accessed May 6, 2022).

Dinkins, S. (2020), "Afro-now-ism," *Noema Magazine*, June 16. Available online: https://www.noemamag.com/afro-now-ism/ (accessed September 15, 2022).

Dinkins, S. (2020), *#SayItAloud*. Available online: https://www.stephaniedinkins.com/sayitaloud.html (accessed September 1, 2021).

Lewis, J. E., A. Pichawis, N. Arista, and S. Kite (2018), "Making Kin with Machines," *Journal of Design and Science*, July 16. Available online: https://www.researchgate.net/publication/326614247_Making_Kin_with_the_Machines (accessed September 15, 2022).

Morrison, T. (2019), "'I wanted to carve out a world both culture-specific and race-free', An Essay by Toni Morrison," *Guardian*, August 8. Available online: https://www.theguardian.com/books/2019/aug/08/toni-morrison-rememory-essay (accessed September 15, 2022).

Onuoha, M. (2018), "On Algorithmic Violence," February 22. Available online: https://github.com/MimiOnuoha/On-Algorithmic-Violence (accessed September 15, 2022).

Onuoha, M. and D. Nucera (2019), *People's Guide to AI*, Detroit: Allied Media Projects.

Prokupecz, S., C. Maxouris, D. Andone, S. Beech, and A. Vera (2022), "What We Know about Buffalo Supermarket Shooting Suspect Payton Gendron." Available online: https://www.cnn.com/2022/05/15/us/payton-gendron-buffalo-shooting-suspect-what-we-know/index.html (accessed June 2, 2022).

Terasem Foundation (2019), *Working Together to Counter Bias in A.I. Entities*, March 1. Available online: https://terasemmovementfoundation.com/blog/688/working-together-to-counter-bias-in-a-i-entities (accessed June 1, 2022).

Vafa, K., C. Haigh, A. Leung, and N. Yonack (2015), "Price Discrimination in The Princeton Review's Online SAT Tutoring Service," *Technology Science*, August 31. Available online: https://techscience.org/a/2015090102/ (accessed June 1, 2022).

2

Compromised/Compromising Lives of a Farmed Plant

Elaine Gan

On every continent except perhaps Antarctica, rice is farmed and harvested once, twice, sometimes three times a year. This has held true for centuries. But in the last two to three hundred years, rice has become a very hard-working crop, a flowering grass that increasingly resembles a machine whose sole purpose is to produce food. Select varieties of rice now feed more than half of the world's humans and cover nearly a quarter of the world's land surface. These crops have transformed farmers and their fields, or the more-than-human ecologies and economies with which all are entangled. Specific kinds of relations and technologies—what feminist theorists call material-discursive practices—have made and remade rice; rice, in turn, influences and reshapes those relations and technologies. As an artist-theorist, I follow and attend to the ways in which such reciprocal transformations take place and take hold; their intended and unintended effects on and for whom; and importantly, the possibilities that transdisciplinary analysis and creative practice open up for planting, farming, and feeding with greater care and less violence. Sharing time with rice has taught me a good deal about queering transformation and living worlds otherwise.

In this chapter, I experiment with the term "compromise" in order to unpack how "otherwise" operates from the perspective of rice. I did not come up with the term; "compromise" came to me rather effortlessly by way of an invitation from the curators of Transmediale 2022 in Berlin. Nora O Murchú, the event's artistic director, asked me to consider practices of refusal. They were gathering together media artists, post/humanists, scientists, and activists to explore how refusal opens up alternatives through compromise. I took that to mean, how refusal emboldens—instead of shuts down—ways of getting along across radical difference. Of getting along, that is, without killing each other. Our conversation seeded my presentation for Transmediale in January 2022. A few months later, when Helen Pritchard and Jane Prophet, editors of the book that you now hold, invited me to contribute, we spruced that piece up and added a few more ideas. Thus, this chapter is very much a partial and crossbred work in progress—an extension of an extension of an invitation to consider compromise. I hope you will add to it, dream big, dream with, compose and compost with it, pollinate in multiple ways and multiple directions. Because 9–20 million individuals die every

Figure 2.1 These photographs, diagrams, and sketches represent my years of recording many practices or verbs that entangle plants, people, and other species. My fieldwork, archival research, and interviews with farmers, scientists, agronomists, geneticists, and multispecies actors took me to various sites in countries that included the Philippines, Laos, Vietnam, Norway, United States, and India. Courtesy of the author. All rights reserved.

year from hunger or hunger-related events. And we who stand a better chance of not being exterminated or consumed by hunger inherit a responsibility to do otherwise.

This chapter offers six verbs: planting, sorting, embodying, coordinating, flourishing, and breathing. Each serves as an aperture for considering some form of dynamic practice that has already been compromised, in the sense that the practice emerges from violent colonial histories and apparatuses of control over more-than-human reproduction. The practices damage, degrade, alter, and haunt in some way. At the same time, they also recognize that different bodies continue to perform some kind of open-ended, indeterminate compromise in order to survive. More-than-human worlds come into unruly existence through improvisation, attunement, creative experimentation—for better and for worse. Presented as a series of verbs in this chapter, rice performs a refusal to be a singular being caught in the miseries and false promises of modernist plans. In what follows, rice is simultaneously compromised/compromising, a generative affirmation of seeds, farmers, fields as creative and critical practices that can be made and remade differently.

Planting Better Futures

Planting seeds in soil—seeding rice fields so that crops might grow and perhaps flower and flourish—is an act of imagining and making a claim for an ongoing or future relation. No human farmer plants without some expectation of harvest. Planting requires many kinds of calculation, exchange, negotiation. Practices of planting imagine better days to come because they may have done so in the past. But, what exactly counts as a "better future"? For purveyors of industrialized commercial agriculture, "better" means more yield, higher grain productivity. For farmers otherwise, "better" means a capacity to live together, to nurture lasting relations with kin and land. These different definitions of a "better future" materialize and take physical form as hundreds of thousands of rice cultivars, ranging from Indigenous varieties and foraged wild grains to colonial breeds, state-certified seeds, and genetically modified hybrids. Each cultivar, or variety of farmed rice, embodies many histories, by which I mean countless cycles of spatiotemporal coordination, experimentation, adaptation, or what we might consider as compromise.

Each cultivar necessarily comes with a particular assemblage of relations. Practices of planting are quite different depending on when and where you are. Things are not the same always and everywhere. For example, in many parts of Asia and Africa, planting rice is done by hand, with water buffalos and small machines that first soften and churn the soil. Farmers bend down, knee-deep in water, feet in mud, hands move back and forth, picking seeds and laying them down swiftly, one at a time. In northern California, planting is done from the air. Single-engine, GPS-guided airplanes swoop across fields, dropping thousands of seeds and covering hundreds of gridded fields in a few days. In Australia, tractors and machines direct-drill the seeds into dry ground, while in Japan, robotic seeders plant seedlings and discharge fertilizers and insecticides at the same time—a kind of cyborg operation.

My first point in this chapter is that there are multiple practices and corresponding assemblages involved in planting rice. There is a vast spectrum of cultivars and the kinds of lifeways and cultivators they require. Some are human, some machinic, some molecular, some microbial, some multinational. Cultivators select the varieties that they want to see again—some for subsistence, others for profit, some out of delight and others out of respect for elders. Rice cultivars are made and remade through relations that they are in the process of making and remaking. Thus, bodies mingle, season after season, coordinating and compromising in response to multiple rhythms, tempos, and recurrences.

Sorting Racialized Seeds

The International Rice Research Institute (IRRI) in Los Baños, Philippines, is one of the largest institutes for postcolonial rice agriculture. It opened in 1960 with funding from the Rockefeller and Ford foundations, infrastructural support and resources from the Philippine government, and the technoscientific expertise of American-trained breeders, agronomists, and economists. The mission was and is to breed the highest yielding rice varieties possible—considered the best solution to hunger and poverty.

Key to this mission is the collection, sorting, and classification of seeds. At IRRI, there are four main categories: (1) "modern", "elite" or "improved hybrids"; (2) "traditional" or "native" landraces; (3) "weedy" relatives; and (4) "wild" seeds. The distinctions represent degrees and hierarchies of human intervention: (1) moderns are bred intensively to have productive traits (for example, fast growth, disease resistance, short stature) and predictable growth patterns in types of locations—not specific locations but types of locations; (2) traditional landraces are cultivated by local subsistence farmers and Indigenous groups, variable and improvisational, linked to rural areas and collective ways of life; (3) weeds are matter out of place, noxious, and deserving of rapid elimination; and (4) wild seeds fall outside of the domesticated sphere, valuable for genetic diversity, disease resistance, and resilience against changing conditions.

Note that classifications are never neutral. Early in my research, I was struck by the racialization of categories and their association with particular temporalities. Seeds classified as modern or elite align with Western conceptions of progress and technoscientific promises of greater prosperity. Moderns are high-yielding, fast-growing seeds that can fight world hunger and ensure universal peace based on American standards of a good life. In contrast, traditional landraces belong to a vanishing past, heirlooms of ancestral tastes, textures, and aromas, reified cultural heritage, and colorized memories. Weeds and wilds are incommensurable, biding their untimely times in seedbanks or molecular biology labs until one trait or another might be reintroduced to supercharge the future of modern seeds. These racialized types are the core of postcolonial crop sciences that produce as much as 75 percent of rice cultivars grown and consumed around the world.

Recognizing these constructions matters because equating moderns with better futures rationalizes the assemblages that go along with them. Chemical fertilizers and pesticides, dams and irrigation canals, erosion of genetic diversity, the dispossession of BIPOC farmers become acceptable and necessary means to pursue a higher good. These equations rationalize harm and extermination. They materialize as disruptions to major cycles—for example, nitrogen, water, carbon, sunlight—through which life on this planet has become possible. And disruption is not confined to a single effect. When relations are broken or compromised, multiple others emerge. Disruptions have countless effects: they give way to novel formations—and many are disastrous, like algal blooms, viruses, insects, fungal blasts, and bacterial blight that are prevalent in present-day crop fields.

Meanwhile, among the "traditional landraces" stored at IRRI are over three hundred varieties cultivated by farmers in the Ifugao mountain provinces of northern Philippines. The seeds were gathered by anthropologists working with Ifugao collaborators from 1963 to 1985, and catalogued for conservation at IRRI. These traditional seeds coexist with modern seeds. But traditionals are framed in a different way, cast in a subordinate role as representatives of a remote past. The Ifugao rice terraces from where these seeds come are listed as a UNESCO World Heritage site, valued for the beauty and harmony of an "ancient civilization." Meanwhile, IRRI seeds and fields belong to a global crop research consortium for "agricultural innovation," signifying technoscientific mastery and conquest over those that live otherwise.

My second point in this chapter is that seeds come with their material-discursive assemblages (see Plate 4). We as artists, scholars, and activists need to pay attention to the collection and classification of seeds as compromised/compromising projects that are important sites for critical-creative intervention.

Embodying Fallout

July 16, 1945 is the date of the first nuclear bomb test in New Mexico, codenamed Trinity and part of the Manhattan Project. Over two hundred more detonations followed between 1945 and 1962. Science studies scholar Joseph Masco considers these the beginnings of the Age of Fallout, noting that we live in the "unintended environmental aftermath of cumulative industrial projects, a process that remakes bodies and atmospheres on a planetary scale" (2015: 162). In naming Fallout, Masco unpacks the critical connection between death and life. As nuclear detonations radically altered ecologies, they simultaneously gave rise to earth systems science and the tools we now use to assess the precarity and toxicity of those very same ecologies.

Along with earth systems science came a new kind of crop science. Nuclear technologies for war also served as technologies for peace. In crop science and agrotechnology, radiation became part of breeding techniques that induce mutations in plants, accelerating evolution to create better crops or plants with bodies that work like machines. In the 1970s, for example, rice farmers in California switched from growing tall, late maturing Japanese varieties to short (also called dwarf or semi-dwarf), early maturing California varieties that were more amenable to mechanized fields run by planes, tractors, and combine harvesters. A key element of this shift was radiation-induced breeding, an offshoot of a sociopolitical campaign that American President Dwight D. Eisenhower had dubbed "Atoms for Peace."

At the start of rice farming in California in the early to mid-twentieth century, rice yields averaged about two or three tons per hectare. With the introduction of synthetic nitrogen in fertilizers and pesticides after the Second World War, crop yields were expected to rise. But California rice grew tall. This meant that when fertilizers were applied, the plants did produce a greater number of plumper grains as expected, but they also toppled over easily from the increased weight. The problem, called lodging, made harvesting with machines difficult (imagine a large plow making its way through heaps of long stalks lying on the ground; it is simply easier for machines to cut upright short stalks). Learning of the high yields at IRRI in the Philippines, California breeders attempted to cross varieties with IRRI's dwarf varieties. But IRRI seeds came from a different evolutionary line, adapted to tropical, not temperate, climates. This posed a problem: how could the bodies of tall Calrose plants be made to grow short?

In 1971, a young geneticist at the U.S. Department of Agriculture named J. Neil Rutger began experimenting with radiation-induced mutation breeding techniques. By exposing Calrose seeds to gamma rays from a Cobalt-60 source, Rutger produced a Calrose mutation that grew short and sturdy stalks, a dwarf form more amenable to California's mechanized fields (IAEA 1977: 44–5). The "irradiated mutant"—no longer tall and pliant, but height-compromised and rigid—was named Calrose-76, commemorating 1976, the year of its release. Since the introduction of Calrose-76, most California cultivars are bred to be short. They are, of course, bred for other traits that directly affect crop yield and profitability as well, i.e., compatibility with fertilizers and pesticides, disease resistance, cold tolerance, milling quality, grain appearance, taste. Rice yields in California, as a result, are among the highest in the world, averaging eight to ten tons per hectare.

My third point in this chapter calls attention to the quality of shortness in post-war rice crops. Shortness enables farmed plants to become better workers in the Age of Fallout, a material embodiment of nuclear technologies for death and life. Every farmed plant today has some compromised trait that embodies Fallout.

Coordinating More-than-Human Seasons

Rice is one of four hundred specialty crops that fuel the multibillion-dollar agrotechnological industry of California. Capital-intensive and profit-oriented, rice farming is entangled with intra-acting violences of settler colonialism, racialized capitalism, and environmental degradation. Yet, unlike any other crop, rice is semi-aquatic and rice fields today double as some of the last remaining multispecies wetlands in northern California. How did that happen?

In 1991, the burning of rice stubble after harvest was banned by the state because of mounting public concerns about the health effects of air pollution. Unable to use fire, rice farmers turned to water, flooding their fields to accelerate the decomposition of residual post-harvest stubble. The flooded fields became temporary stopovers for millions of migratory birds who make their annual journeys along the Pacific Flyway, between the Arctic tundra in North America down to South America. The birds, famished from their transcontinental flight, ate the leftover stubble and fertilized the soil. By enriching fields for the next season's plantings, the migrating birds proved useful and thus earned a claim to the wintertime hospitality of farmers.

In the last three decades since the phaseout of rice burns, the production of commercial rice and the sustenance of wild bird migrations have taken place in the very same fields. From April until October, fields are committed to rice. Then from November until February or March, two-thirds of rice acreage become breeding and feeding grounds for birds. When bird migrations peak in December and January, about 6–10 million birds fill California skies and the expansive grid of compromised crop fields below. These magnificent creatures—ranging from gregarious ducks and geese to shorebirds like avocets and waders like herons and egrets—are what remain of 40–60 million birds that used to travel through vast expanses of wetlands, forests, and grasslands. Their ecologies and landscapes are nearly all gone because of modern development, specifically the relentless buildup of cities, farms, and industrial infrastructure in the last two hundred years. Rice fields, along with state-supported wildlife refuges, are novel formations that may offer the best chance for migratory birds to survive anthropogenic disturbance and damage.

My fourth point here calls attention to spatiotemporal coordination, by which I mean species encounters and naturecultural dynamics that take advantage of capacities for differentiation in seasonal attunements and mobilities. Since the Miocene epoch, birds have evolved forms, activity patterns, and sensory ecologies in response to multispecies relations, life cycles, and land movements like glacial advance and retreat. Migration is an enduring avian strategy for living with changes that repeat somewhat regularly and predictably. Birds use flight to maintain access to good food and breeding grounds as these become available in remote, sometimes transcontinental, locations throughout the year. Birds travel in order to stay home, or to stay within conditions that are most favorable and familiar, season after season. Rice farmers and birds can weave in and out of one another's seasonalities, not because they are the same but because they inhabit places and times in very different ways. Engaging rather than erasing these differences and spatiotemporal coordinations is one way of queering and articulating our compromised/compromising crops.

Flourishing with Xoo

For my fifth point, I turn to Xoo, short for *Xanthomonas oryzae p. oryzae*, a bacterial species whose main companion is the rice plant. Xoo is a pathogen that causes blight, called "kresek" in Indonesia because of the crackling sound rice leaves make when they dry out and wilt due to Xoo. It is an unwelcome sound. Once lesions begin to appear on the leaves of young plants, there is no way for a farmer to stop their spread; kresek can destroy as much as 60 percent of a farmer's plantings.

The disease had already been logged by rice farmers in southern Japan in 1884 but it was not until the 1960s that Xoo-induced blight reached epidemic proportions in

Southeast Asia. Farmers had begun switching to modern rice varieties developed at IRRI, and field conditions were changing. Modern rice came with an assemblage of synthetic chemicals, irrigation infrastructures, and monocrop logics and labor practices that compromised existing multispecies relations (see Plate 5). In response, Xoo flourished relentlessly. To beat Xoo in turn, scientists continued to breed varieties with blight-resistant genes or R-genes (numbered as Xa-4, Xa-5, Xa-6, and so on). But each time IRRI released a new blight-resistant variety (e.g., IR-20, IR-36, IR-64, and so on), Xoo adapted to the rice, essentially coevolving and compromising to the compromised conditions. Xoo could overcome their resistances in as quickly as one season. The rise in bacterial virulence was reflected in additions to the institute's personnel. When IRRI opened its doors in 1960, there were two pathologists and two entomologists on staff. By 1982, there were 128 scientists working in the department of Plant Pathology alone. One pathologist described the scene as an "arms race"—and Xoo was winning.

In recent years, the next generation of scientists at IRRI have been searching for alternatives. They began by analyzing historical records over a span of forty years to assess the impact of R-genes on the spread of Xoo. Between 1960 and 2010, more than a hundred IRRI varieties were released in the Philippines. More than 70 percent of those contained the same R-gene Xa-4, a fact that was unknown to the first generation of IRRI scientists. By the late 1980s, those varieties—or what appeared to be varieties—covered about 90 percent of the total area planted to rice in the Philippines. The studies revealed that, contrary to the earlier scientists' intentions and expectations, bacterial blight had *increased* rather than decreased in the 1990s. The key finding is that the sudden, large-scale introduction of Xa-4 rice had inadvertently triggered the evolution of six Xoo strains, each a novel adaptation to Xa-4. Xoo was not simply responding to the changing conditions of modern rice. Xoo was remaking rice science at IRRI—even as rice science was remaking Xoo.

Lives and landscapes continue to socialize and evolve in compromised/compromising ways. Attending to more-than-human capacities, such as bacterial flourishing for example, challenges modernist promises of total control and mastery (see Plate 5).

Breathing-in-Common

On March 11, 2020, WHO Director-General Tedros Adhanom Ghebreyesus announced that outbreaks of COVID-19 had become a global pandemic. Within weeks, the journal *Critical Inquiry* began publishing a blog called *Posts from the Pandemic* with short essays by some of the most respected theorists of contemporary art, science, culture, and politics today. One entry by Cameroonian scholar Achille Mbembe was titled "The Universal Right to Breathe" (2020) and was posted online a month after the announcement. Mbembe wrote from a place "with no hospital beds, no respirators, no mass testing, no masks nor disinfectants nor arrangements for placing those who are infected in quarantine," a place whose people, over the last five hundred years, have been forced into positions of dying of brutality and organized neglect so that "we" might live—at a safe distance. COVID-19, Mbembe pointed out, simultaneously dissolved and concretized difference and asymmetry. The virus made palpable one feature that all living beings share: the need to breathe and, conversely, the threat of suffocation. A body's ability—and need—to breathe defines an irreversible sequence of life and death, respiration and expiration. Mbembe recognized breathing not only as a biological act but as always and already a sociopolitical articulation of community, of that which is held "in-common." He posted:

> If war there must be, it cannot so much be against a specific virus as against everything that condemns the majority of humankind to a premature cessation of breathing, everything that fundamentally attacks the respiratory tract, everything that, in the long reign of capitalism, has constrained entire segments of the world population, entire races, to a difficult, panting breath and life of oppression.
>
> (Mbembe 2020: S61)

I want to push this rethinking of breath, or that which holds humankind in common, to include vegetal life. What might it mean to pay attention to the ways in which breath moves—and has moved historically and materially—through a multiplicity of plant bodies in order to constitute clean, livable air? Science studies scholar Natasha Myers focuses on photosynthesis, noting that the oxygen human lungs breathe is directly entangled with the breath of plants, algae, and cyanobacteria. Myers (2016) reminds us beautifully that "our inhale is their exhale." Photosynthetic organisms possess chlorophyll that converts sunlight into chemical energy that then splits water molecules so they can combine to form oxygen. Oxygen constitutes about a fifth of the earth's atmosphere and, as a component of water, oxygen also constitutes most of the internal mass of living organisms, including humans. Oxygen is constantly being replenished and recycled through vegetal forms of respiration. From this perspective, to endanger or remain blind to the cycle of photosynthesis that moves through more-than-human life is to place all at risk of respiratory failure, to induce what Mbembe called the "premature cessation of breathing."

The farming of commercial crops at industrial scale is one such endangerment. A key process upon which farming depends is a break in the crops' ability to flower in response to sunlight and seasonality, called "photoperiod sensitivity." Since the Green Revolution of wheat agriculture in Mexico in the 1950s and then rice agriculture throughout Asia in the 1960s, farmers have been planting early maturing, high-yielding cultivars across millions of hectares. That the rapid and unprecedented growth in yield was/is accompanied by heavy use of industrial fertilizers, capital-intensive irrigation networks, reliance on fossil fuels and chemicals, land dispossession, and labor exploitation has been documented by many scholars and activists. Less known is that these high-yielding crops have been bred to be insensitive to photoperiods or the recurring shifts in day lengths and temperatures to which rice plants have adapted flowering times over centuries. Cutting off plant life cycles from the energy of sunlight disrupts their ability to breathe in their own way as they are made into producers of technoscientific grain-on-demand.

But breathe life does. The cessation of one kind of breath has been accompanied by the emergence of a different kind of breath. Industrialized and capital-intensive rice production schemes depend heavily on irrigation; the continuous flooding of wet rice paddies cuts off the circulation of oxygen into the soil, leading to anaerobic fermentation of organic matter. While high-yielding rice crops produce more grains, they also come with more stalks or straw that get left behind after fields are harvested. The intense anthropogenic mix of bacteria, water, and straw releases large amounts of methane, a greenhouse gas that traps thirty times as much heat as carbon dioxide. Because it recomposes the atmosphere and circulates with currents that move across the planet, methane works as a multiscalar force. Industrialized agriculture cannot be mapped exclusively as a reduction of diversity in one bounded territory. Considered as transformations of breath and flow, farming is a proliferation of entangled differences—variously paced, provisional, and constitutive of a multiplicity of spatiotemporal, material-discursive practices.

The COVID-19 pandemic urges attention to breath—respiration and the violences of its cessation. Building on Mbembe and working through rice, I offer my sixth and final point to call attention to breathing-in-common as compromise, by which I mean a promise-made-with. Breath cannot be defined and isolated to a single pair of human lungs. Oxygen, methane, carbon dioxide circulate with colonial crop sciences, land dispossession, chemical regimes, neoliberal supply chains, and more, assembling and reassembling vegetal, microbial, animal, and industrial bodies, in cycles that unfold within different intervals made through millennia. Compositions are shifting, calling for expanded methods of theorizing, representing, rendering sensible, promising-with. What we do as artists, and activists is entangled with profoundly more-than-human modes of breathing-in-common.

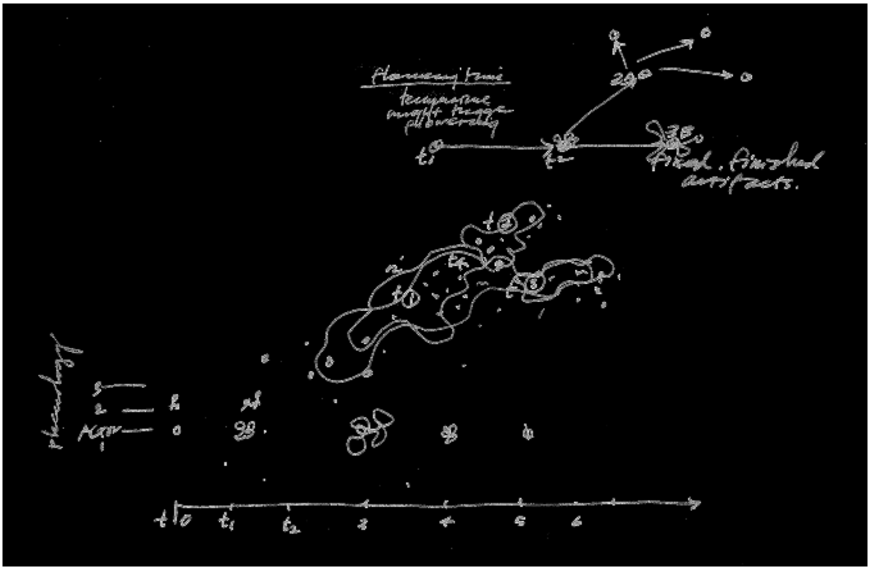

Figure 2.2 Diagram for *Flowering Times*, 2018. Engaging with multispecies relations as a series of verbs requires that we also think about interplays of time. In this pen and ink drawing, I experiment with depicting variations in flowering times. Courtesy of the author.

In this chapter, I have offered six verbs in order to expand definitions of the term "compromise." These are not exhaustive, but I hope that jotting down a few things that I have learned from, about, with rice crops and their assemblages might open up a critical and creative space for inhabiting and engaging with difference. Collective survival depends on multiple acts of compromise.

References

Barad, K. (2007), *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, Durham, NC and London: Duke University Press.

Gan, E., and A. L. Tsing (2021), "How Things Hold: A Diagram of Coordinations," *Matsutake Worlds*, 112–55, New York and Oxford: Berghahn Books.

Haraway, D. J. (2008), *When Species Meet*, Minneapolis and London: University of Minnesota Press.

International Atomic Energy Agency (1977), "Improved Short-Stature Rice Created by Radiation-Induced Mutation," *IAEA (International Atomic Energy Agency) Bulletin*, 19(3): 44–5. Available online: https://www.iaea.org/bulletin/19-3 (accessed April 9, 2023).

Kohn, E. (2013), *How Forests Think: Toward an Anthropology beyond the Human*, Berkeley, Los Angeles, London: University of California Press.

Masco, J. (2015), "The Age of Fallout," *History of the Present*, 5(2): 137–68.

Mbembe, A. (2020), "The Universal Right to Breathe," *Critical Inquiry* (blog), April 13. Available online: https://critinq.wordpress.com/2020/04/13/the-universal-right-to-breathe (accessed April 9, 2023).

McKittrick, K. (2021), *Dear Science and Other Stories*, Durham, NC and London: Duke University Press.

Myers, N. (2016), "Photosynthesis," *Fieldsights*, Theorizing the Contemporary, January 21. Available online: https://culanth.org/fieldsights/photosynthesis (accessed April 9, 2023).

Rutger, J. N. (1983), "Applications of Induced and Spontaneous Mutation in Rice Breeding and Genetics," *Advances in Agronomy*, 36: 383–413.

Tsing, A. L. (2015), *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*, Princeton, NJ and Oxford: Princeton University Press.

3

As Children of Plants, We Play in Our Machine Gardens

Amy M. Youngs

Utterly reliant on plants, we humans are situated in a dependent, child-like relationship with them. Plants make our food and our air. They provide us with clothing, housing, and power in the form of fossil fuels derived from their ancient ancestors. Remember when you were a child, and your existence, food, and shelter, were all provided to you by your parents? Someday, you thought you would escape the uncomfortable, claustrophobic feeling of dependence and strike out on your own. You would amass your own wealth and security and rely on no one but yourself. Maybe you are an adult who believes you have achieved this, but you—and all of us animals—will never escape the power that plants have over our lives.

As a middle-class, white woman in the United States, I live in a culture that believes humans are the masters of a separate domain called "nature." We consume it voraciously beyond our needs and we disrespectfully extract and transform it into hoarded wealth. Environmental philosopher Val Plumwood has identified the belief that we are independent from the earth as a destructive misconception, which is in need of a major rethink:

> When we hyperseparate ourselves from nature and reduce it conceptually, we not only lose the ability to empathise and to see the non-human sphere in ethical terms, but also get a false sense of our own character and location that includes an illusory sense of agency and autonomy. So human-centred conceptual frameworks are a direct hazard to non-humans, but are also an indirect prudential hazard to Self, to humans, especially in a situation where we press limits.
>
> (Plumwood 2009: 1)

It is important to recognize that it is humans in the wealthy Western world who are in need of this rethink; we have disproportionately driven environmental degradation, species extinction, and climate change, while too many of our fellow humans—and nonhumans—have unevenly suffered the impact of drought, famine, and poor health outcomes caused by our over-consumptive lifestyles. It is imperative that we are the ones who change before we further damage our shared habitat. This change requires that we learn what Indigenous cultures already know and practice; humans are a part of nature, and our flourishing is dependent upon a respectful relationship with it.

How can those of us who grew up with anthropocentric beliefs radically shift our sense of self? How can we invent and practice better relationships? How can we live differently and shape new stories that will guide us as we grow out of our selfish, human-centric mindset? There are very helpful readings, such as Robin Wall Kimmerer's *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* (Kimmerer 2015) and Donna Haraway's *When Species Meet* (Haraway 2008). These authors recognize the importance of joining with and learning from the nonhuman world in creative, embodied ways beyond words.

As an artist, I take on this challenge of engaging bodies by assembling participatory multispecies experiments. These entanglements have helped me recognize my anthropocentric immaturity, and at the same time I have gained a more profound sense of wonder and respect for the biological world. To share these experiences, I co-create art installations that invite others to roleplay living with, and within, ecosystems differently than we are accustomed to. In this chapter, I share these with you in words and images with the hope that you will be inspired to try your own experiments. Plants will be our central guides, but we will also learn from worms, scientists, fungi, urban foragers, anthropologists, and alternative uses of technologies. We will engage in methods of play and in practices of interdependence as we gain an understanding of ourselves as children learning about citizenship in the multispecies world.

We Are Dependents

In the book *Brilliant Green: The Surprising History and Science of Plant Intelligence*, plant scientist Stephano Mancuso and Alessandra Viola speculate about why we fail to comprehend the importance of plants in the making of our world:

> Our relationship with plants is one of absolute, primordial dependence, and in that sense it somewhat recalls the relationship of a child to its parents. While we're growing up, and especially in adolescence, we go through a period of totally denying our dependence on our parental figures that frees us to attain psychological autonomy, in preparation for actual autonomy, which will come many years later. It's not out of the question that a similar psychological mechanism enters into our relationships with plants. No one likes depending on another. Dependence coincides with a position of weakness and vulnerability that we don't enjoy contemplating.
>
> (Mancuso and Viola 2015: 32)

Mancuso shares many scientific studies that argue that our world is plant-centric. Plants enabled animals to exist by creating an oxygenated atmosphere on earth, they alone possess the ability to transform solar energy into food, they communicate between themselves and with other species, they are problem solvers, and they have the same five senses we do, as well as several senses we lack. Our inability to comprehend them as intelligent is due to our belief that intelligence resides in brains that resemble our own. We are simply unaware of our own bias towards humans as the measure of all forms of intelligence. Anthropocentric thinking is holding us back from fully embracing the importance of plant intelligence to us and to the entire ecosystem on earth. In our adolescent denial, we cannot gain perspective on what they are always providing us for free. Since we will never break free from being dependent on plants, we might be better off assuming a child-like relationship; where our worlds revolve around our parents, we learn from them, depend upon them, and we love them. Of course, we encounter friction when we do not understand them, and we sometimes throw a tantrum when we do not get what we want but, as children, we understand that our parents generally have wisdom beyond ours. Our plant parents are confounding, ancient beings who look entirely unlike us. Still, if we spend time with them and pay close attention, we could learn about how to collaborate and flourish among the community of creatures on earth, as they have for millions of years.

Getting Socialized: Domestic Living Arrangements and Play Dates

As a method of learning from nonhumans and attempting to understand—*in an embodied way*—how I might fit into a post-anthropocentric world, I have been assembling mini-ecosystems that place the human as one actor among many. For twenty-five years, I have been experimenting at home with ecosystems that involve worms, plants, and other creatures. Transforming household waste into fertilizer that nourishes ornamental and edible plants is the result; but the real benefit is that my human partner, Ken Rinaldo, and I have ongoing relationships with these creatures, which have changed our senses of self. In 2008, we co-created *Farm Fountain*, a kind of "green pantry" in our home. This living pantry was an aquaponics system, which supplied us with edible fish and plants. Unlike traditional hydroponics, this system does not require the addition of petrochemicals to fertilize the plants. A programmed pump circulated the fish waste and water through filtering bacteria and plant roots, which symbiotically cleansed it. We ate leafy greens, tomatoes, and occasionally fish grown in this system, but the original conception that it would serve as a pantry that we could easily pluck food from was not the story that emerged. The system required constant maintenance: cleaning pumps, growing fish food, managing pests, reseeding plants, monitoring the water temperature and pH, and more. This six-year-long experience completely changed my perspective of who I was in this arrangement. Instead of being the eater at the top of this food chain, I became an entangled participant whose focus shifted away from the production of food and towards the development of multispecies relationships. For instance, upon learning that store-bought fish food is sourced unsustainably from ocean fish, I explored methods of growing duckweed and worms in separate chambers of the system, which would be hand-fed to the fish. Each decision like this added more human labor and often resulted in slower food production, but added more species and more flourishings. As the ecosystem of my household expanded, my sense of interdependence and care deepened. Living with and playing an active role within this domestic ecosystem was a daily, embodied reminder of how my eating is always contingent upon the lives of many others who must eat first.

In hindsight, I recognize that these experiences of being a human enmeshed in an interdependent food web would be quite familiar to people practicing Indigenous agriculture or permaculture farming. As an urban dweller, I am a novice, learning through practice about my place as a decentered human among earth's community. While my partner and I had limited success with the original fantasy of feeding ourselves, our project opened us up to a more expansive approach. It evolved into a platform for engaging in multispecies play dates. Play is important because it allows us to let our guard down; relinquishing our imagined human power long enough to take other players seriously. Together, we can explore alternative worlds and practice new roles within them. The approach intentionally blurs categories and expectations so we can open up to what else is possible.

If the childhood game of "playing house" was instead focused on "playing river," the main characters would no longer be humans. In the art installation *River Construct*, the assembled players are plants, worms, bacteria, people, a rabbit, and a solar-powered water pump and timer system. Just as in outdoor rivers, the plants ate sunlight and minerals, animals ate plants, worms and bacteria ate the waste from animals and plants and produced their own waste, which is actually nutritious food for plants, which circulates through the water as nutrients, and so on. Humans are not necessary for the functioning of actual rivers, but in this indoor mini version they were needed as maintenance workers and as admirers.

This living assemblage was based on the knowledge I had gained from years of interacting with the organisms in *Farm Fountain*. The composting worms in that system taught me that they could thrive in flowing water and take on the role of nutrient providers for plants, meaning that fish were not required. The plants taught me that they thrive, along with the worms, when the system was fed manure from my pet rabbits. In *River Construct*, a rabbit lived in the ecosystem, providing nutrients that would be swept up from the floor by human assistants who would deposit them into the worm buckets in the watery stream (see Figure 3.1 and Plate 6).

Instead of focusing on food production for humans, this system questions the roles of the multiple players within the construct of a river. Are humans the servants, stewards, or participants? Is the rabbit a manure producer, a pet, a pest, a friend, or food (see Figure 3.2)? Are the plants food for the rabbit, or the humans, or are they to be admired? Is the sun going to shine long enough for the solar-powered pump and timer to keep the river flowing, or do we need to reprogram shorter watering cycles?

We improvised, as living things do. The rabbit was more athletic and sociable than expected; he would leap out of his fenced enclosure, roam around the gallery with humans, eat the plants, and then leap back in to rest and to produce manure. The humans played with the rabbit, and they dutifully cared for him and the worms. They ate the plants, reseeded new plants, added water to the system, and reprogrammed the pump timer as needed. The plants thrived, the worm colony multiplied, and so did the fruit flies. These additions to the ecosystem likely arrived as eggs on banana peels that were put into the worm buckets. The flies did not affect the workings of the worms, rabbit, electronic control system, or plants, but they were the system's undoing

Figure 3.1 *Artists' Footprints*, an exhibition at Redline Gallery, Denver, CO. Installation in foreground, *River Construct* by Amy M. Youngs, 2010. Photo courtesy of the author. CC4r.

Figure 3.2 Child in rabbit enclosure of installation *River Construct*, 2010. Photo courtesy of the author. CC4r.

because of how they annoyed one human. The new gallery director could not tolerate the fruit flies, and he ordered the artwork's premature de-installation. The relationships that had developed between the human caretakers (gallery assistants and artists in residence) and the system organisms after a month of care were strong, which made it easy to find homes for everyone. The new person at the top of a human hierarchy had not participated in the care, and he was not willing to join the game of decentered humans. It is difficult to relinquish our sense of control and our imagined mastery over nonhumans and ecosystems, but this is exactly the work/play we need to practice together more often.

Humility: Who Is Teaching Whom?

The conceit of attempting to recreate a miniature river system indoors expanded my sense of humility. How is it that the earth, water, and multiple organisms regularly self-assemble to do this business of river creation entirely without human intervention? What once seemed fairly mundane transformed into something that I could barely fathom the complexity of. When I was just an appreciator of the beauty of rivers, I loved them and romped in them, but I did not comprehend what river ecosystems were doing, how my life related to them, or that they were doing things well beyond human understanding. Those of us participating as caretakers of *River Construct* were wholly immersed in the system's lived complexities, flexibilities, and sticking points. That plants are the only organisms who can transform the sun's energy into food for the rest of us became a felt reality, not just a factoid. There is no substitute. While solar panels can turn sunlight into electricity, they cannot feed us. The centrality of plants in animal lives registered in my body as I attended to them and their symbiotic partners. Plants have created the atmospheric and energetic conditions for animals to evolve on earth. They devised ingenious ways to get us to help them thrive through efforts such as pollination, cultivation, and pest control. My sense of humility grew as I recognized how crude and impoverished my assemblage was in comparison to the networks of organisms that plants routinely attract around themselves without any human intervention. They have been practicing evolutionary creativity for millions of years before the arrival of humans, and we should not be embarrassed to admit that we have much to learn from them.

Scientist and Indigenous citizen of the Potawatomi Nation, Robin Wall Kimmerer, affirms that Native knowledge locates humans as "the younger brothers of Creation" who have the least experience and therefore need the most guidance for how to live (Kimmerer 2015: 9). She shares how this philosophy informs her work as a botanist:

> To me, an experiment is a kind of conversation with plants: I have a question for them, but since we don't speak the same language, I can't ask them directly and they won't answer verbally. But plants can be eloquent in their physical responses and behaviors. Plants answer questions by the way they live, by their responses to change; you just need to learn how to ask ….
>
> (Kimmerer 2015: 158)

She further describes the synergies that can occur when Western science and Traditional Ecological Knowledge (TEK) are working together to listen and learn from plants. Inspired by her insights and by the synergies that can take place between science and art, I have been co-teaching a course with Dr. Iris Meier, a professor in the Department of Molecular Genetics at The Ohio State University. This way of working has been very generative, even while it has at times been an awkward experiment. Neither of us is comfortable in each other's realms, but we attempt to learn from each other and from plants while we invite the participation of students in the design of experiments and the negotiation of language and co-created storytelling. The students do not always appreciate this messy, decentered approach, but there have been many instances where the entire class has come together to create a collaborative art installation.

In one class, we were guided by the symbiotic relationships shared between plants and fungi. Mycorrhizal fungi are "obligate symbionts," meaning that they must join up with plants in a trading partnership to survive (see Glossary). We learned about how plants actively invite fungi inside the cells of their roots to exchange their sugars for the minerals that fungi offer. Fossil evidence of this intimate partnership indicates that it has been going on for at least 400 million years, though scientists are only beginning to learn about it. How do the partners establish trust? What else is being traded along this fungal-plant network? How are they doing this? As we gain knowledge of the agency of the nonhuman world, we become aware of the extent to which humans are, and have always been, sidelined. For instance, we might imagine that we are master excavators of minerals, but scientists recently learned that fungi are far more industrious miners. With their fungal bodies, they have built vast tunnel networks underground where they forage for rocks, scrape minerals out of them, and serve them to plants (Frazer 2015).

Art as Invitation

The ancient partnership between plants and fungi is a scientific fact, yet almost too incredible to believe. I wanted to better grasp what is happening out of human sight in this underground symbiosis and to develop a way to experience it with others in the form of an artistic invitation. Working with fifteen undergraduate students in the art and science class, Dr. Meier and I used multiple modes of inquiry, including scientific methods such as experiment design, microscopy, and thin-layer chromatography, and artistic methods, such as speculation, synthesis, drawing, storytelling, scale-shifting, and worldbuilding. Ultimately, we co-designed and built an installation titled, *Where Rocks are Fed to Trees*, which sought to make the knowledge of nonhuman agencies tangible (Figure 3.3). It was important to us that we went beyond scientific visualization, so our participatory experience engaged all the senses. Scientific facts were thus brought into a human scale and sensory understanding through movement, sound, vision, smell, and taste.

During the five-day exhibition at The Ohio State University, we invited approximately two hundred human participants to become fungal particles and to enter a room-sized model of a plant root cell. Visitors to the exhibition were given

Figure 3.3 *Where Rocks are Fed to Trees*, 2016. Art installation by Trent Bailey, Brandon Ball, Katherine Beigel, Gaopeng Chen, Tyler Collins, Sarah Hockman, Shatae Johnson, Eric Lo, Jacob Markusic, Iris Meier, Yoni Mizrachi, Julianne Panzo, Edwin Rice, Ethan Schaefer, Aaron Theesfeld, Robert Ward, and Amy M. Youngs. Photo courtesy of the author. CC4r.

"minerals" (paper bracelets) with directions to carry them to a specific room. The room could only be entered via a fungal tunnel, which was an organically shaped structure scaled to human size. It was animated with backlit projections depicting what we imagined a fungal tunnel penetrating a plant root cell might look and feel like. We composed an audio environment designed to seduce people to enter and we included soil to evoke the feeling of being underground. At the end of the tunnel the nucleus of the plant cell (a weather balloon) was animated with projected images generated from the microscopy work we had done in class. This invited viewers to come all the way in, where they could exchange their mineral bracelet for a rock candy treat. The treat came with a short text which explained: "You are a fungal body particle on its way into the depths of a plant's private parts, its roots. Delivering your mineral, you are rewarded with sugar. Use it well, grow your network and trade in peace." The story of underground symbiosis is not a human one, so it is not easy to explain to each other. Though our art installation modeled only a small part of this multifaceted relationship, it effectively invited humans to embody and re-enact one portion of a nonhuman, symbiotic reality. Those of us involved in the project had scheduled times when we would facilitate the operation of the work, and this included answering questions and engaging in conversations. Upon exiting the installation, participants often began with exclamations indicating a sense of wonder, such as, "Whoa" or "Amazing!" and then they followed up with questions like, "Is this real?" or "What was that flashing globe?" This led to conversations about communications and exchanges between plants and fungi, and about what science knows and does not yet know. Informal groups of students, parents, staff, faculty, and friends formed outside the door and grappled with language to describe and understand underground symbiosis together.

The Training Wheels of Technology

With human-centered thinking, it is difficult to learn about, or even believe, that other complex systems and intelligences exist outside of us. Technology can give us training wheels, or useful models, that help us comprehend the complexity and agency of the nonhuman world that we are otherwise ignorant of. Long before humans invented, utilized, and commonly understood the internet, a similarly structured communications and exchange network existed among plants and mycorrhizal fungi. Perhaps anthropocentric bias got in our way, and we could not understand what was already happening beneath our feet. Western humans needed a technological model. The human-built structure of the internet may have made it possible for us to then recognize, or discover, the plant-fungal version. In 1997, about the same time the internet was emerging into widespread use, ecologist Suzanne Simard et al. (1997: 579–82) published her research demonstrating that forest trees were sharing resources amongst themselves using mycorrhizal networks. She has since used the term "wood wide web" to describe it. Imagine what would have been possible if more of us humans understood ourselves as students of plants and their fungi partners all along? Perhaps we would have learned about the "wood wide web" long before we embarked on the creation of an industrial version of it, and perhaps we would have been able to envision alternative forms of construction, function, and purpose that would have been symbiotic with other organisms.

There are many other ways that technology can be employed as training wheels to help us overcome our anthropocentric habits. We do not need to wait for new inventions because there are already many widely available technologies that reveal some of the ways in which the world exceeds our human perceptual abilities. Think of how photographic technologies, such as time-lapse, high-speed, and infrared, can rescale time and light in ways that show us what is hidden from our limited human senses. Our cellphones may be another useful technology for training our sense of self. Their seductive, habit-forming qualities are currently deployed to persuade users into developing relationships with brands and consumer products. But what if instead we had apps that helped us develop relationships with dandelions, ants, and maple trees? The augmented reality game *Pokémon Go* coaxed people outdoors with their cellphones and encouraged them to play at hunting for cartoon monsters in public space. While I do not enjoy it, or the advertising that powers it, this game has done work towards normalizing behavior that would otherwise seem odd in public—as long as we hold a phone in our hand. With this new permission, I wondered what else can we connect with beyond a pantheon of fantasy monsters? Instead of inventing a fantasy story, I sought to develop an eco-narrative that weaves the human into the network of other lively creatures with whom we share space. *Becoming Biodiversity* is an augmented reality app that encourages people to explore and experience ecological networks present in Flushing Meadows Corona Park in Queens, New York (Figure 3.4). Interactive, mixed-reality animations and storytelling overlays the actual park site. The experience is an embodied one, designed to connect humans with the unseen worlds—plants, animals, and insects—present in the park. In the first scene of this app, participants are given the role of being a plant. Through guided audio, we experience caterpillars biting our leaves. We do what a plant would do; we concoct and deploy a specific chemical designed to attract a particular animal or insect who

Figure 3.4 *Becoming Biodiversity*, 2019, by Amy M. Youngs, with Joshua Rodenberg, Danielle McPhatter, and Jayne Kennedy. Photo courtesy of the author. CC4r.

preys upon that pest. This chemical communication is visualized as animations on the user's cellphone camera as a voice says:

> Slowly, in plant time, look through your device towards other plants. There are chemical messages being sent out from our neighbors. These emissions are swirling around and moving into the airspace. They are everywhere. Look to the side, and behind. Plants may not be able to walk, but we can move beyond our plant body and control the creatures that move around us.

Later in the story, and farther down the park trail, participants play the role of a cottonwood tree whose sap is flowing. Happening under the bark, this flow of nutrients up and down the trunk is invisible to humans, making it difficult for us to know and appreciate the active liveliness of trees. The app maps a 3D animation approximating this activity onto the tree when the user's cellphone camera is pointed at it. Like a movie, it requires the suspension of disbelief, but unlike a movie, the viewer is not a passive watcher separated from the subjects. Instead, we are in the park, with the actual cottonwood tree, touching it, holding our cellphone near it to see what is within, and imagining what it is like to inhabit this other being's body.

Participants also play the roles of multiple creatures along the trail who interlink with each other, including the networks of mycorrhizal fungi, who transport nutrients to tree roots. *Becoming Biodiversity* begins and ends with plants. The last plants on the trail are intimately explored with the help of animations that simulate and scale up the microscopic pores that plants use to exhale oxygen and inhale carbon dioxide. Animals like us are breathing in perfect reciprocity, taking in the oxygen from plants and releasing carbon dioxide as we respire. We might have learned this fact in school, but it feels different when learning it with your body. The app functions as a guided interface for bringing us into a place-based, embodied exchange with our plant, animal, and fungi teachers (Youngs 2019).

A Vegetal Playground

Seeking additional ways of engaging with plants, I found inspiration in the practices of urban foragers who taught me that cities are also vegetal playgrounds. Discovering and making use of edible and medicinal plants in their neighborhoods is one of their activities, but the main point of their practice is relationship foraging. They are rediscovering and re-engaging with local plants who have had long relationships with our species. Artist Candace Thompson reignites these relationships and explores new ones. Taking invasive species such as mugwort (*Aremesia vulgaris*), Thompson reframes and celebrates its fecundity by brewing it into tea and beer. She shares what she makes and learns in her social media and meal-based project in New York City, called the *Collaborative Urban Resilience Banquet* (Thompson 2018). She introduced me to an urban forager in my city, Columbus, Ohio, who goes by the social media handle @blackforager. Alexis Nicole Nelson shares her local plant discoveries and creative recipes in a joyful, sing-song style on social media, while at the same time pointedly stating that "foraging laws were invented to prevent black and Indigenous people from gathering free food" (Nelson 2020). These women are guides, exploring human entanglements—with each other and with plants—and presenting them on their social media streams. They remind us of problematic colonialist histories that continue to this day, while they also reveal potential alliances and resilient futures. They further challenge traditional notions of human and nonhuman power relationships by showing us ways to collaborate with plants that make room for playful experimentation, eating, drinking, and joy.

Natasha Myers, anthropologist and director of York University's Plant Studies Collaboratory, reframes our sense of self and species by rejecting the term "Anthropocene," referring to our human-centered epoch on earth, and proposing the "Planthroposcene" instead. Her term recognizes plants as having created a world on earth that is livable for the rest of us here. She says, "it is grounded in the wisdom of the ancient and ongoing radical solidarity projects that plants have already cultivated with their many people" (Myers 2018: 55). Looking at it this way, people in the animal kingdom were always players in the vegetal playground of earth, just not in the way we thought. Reimagining ourselves as part of their world is not as frightening as it sounds—and it is certainly less threatening than wallowing in our human-centered, Anthropocenic apocalypse. Instead, Myers encourages us to vegetalize our senses so we can learn with plants and become more involved with them. She asks, "What can a plant do? We do not yet know. But you could reach toward them with the openness of not knowing, and forget what you thought counts as knowledge" (Myers 2018: 57).

Taking direction from Myers, I have developed a regular practice of "plant noticing" (see Glossary), which allows my eyes to be curious about them, my hands to be guided by the pleasure of their shapes and textures, and my cellphone camera to capture our time in the light together. To refocus my attention on things that matter, I am trying to point my phone at live plants instead of submitting to addictive urges to look at media on my phone (Figure 3.5). It is a practice of attention and co-presence, which has helped me cultivate a greater sense of belonging in the living world. The captured images and videos of plants being "noticed" by my hands are also bridging my living and mediated worlds. Cameras are like fingers that point out to others who and what is valued, so I do this out in public, as well as periodically share the images in my social media feed. The project has developed into a multimedia, website-based artwork titled *Vegetal Entangling*. It unfolds my own learning process with plants, which centers on sensory delight and identification *with* them, rather than identification *of* them through conventional means such as names. The project also encourages others to join in, by offering basic instructions for practicing plant noticing. You do not need an app or a camera for this practice, but these can be useful training wheels for guiding one's attention.

Once plants have our attention, we can become aware of their allies, enemies, and resilient ways of living with uncertainty. Our human future relies on our ability to understand ourselves as collaborators in service to their flourishing. Like the mycorrhizal fungi, we are obligate symbionts who must partner with plants if we want to live.

Figure 3.5 Still image from multimedia website *Vegetal Entangling*, 2021, by Amy M. Youngs. Photo courtesy of the author. CC4r.

References

Frazer, J. (2015), "The World's Largest Mining Operation Is Run by Fungi," *Scientific American Blog Network*. Available online: https://blogs.scientificamerican.com/artful-amoeba/the-world-s-largest-mining-operation-is-run-by-fungi/ (accessed January 3, 2021).

Haraway, D. (2008), *When Species Meet*, Minneapolis: University of Minnesota.

Kimmerer, R. (2015), *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*, Minneapolis: Milkweed Editions.

Mancuso, M. and A. Viola (2015), *Brilliant Green: The Surprising History and Science of Plant Intelligence*, Washington: Island Press.

Myers, N. (2018), "How to Grow Livable Worlds: Ten Not-So-Easy Steps," in K. Oliver-Smith (ed.), *The World to Come: Art in the Age of the Anthropocene*, 53–63, Gainesville: University of Florida, Samuel P. Harn Museum of Art.

Nelson, A. (2020), "Juneberry Hand Pies," Instagram video, June 14. Available online: https://www.instagram.com/p/CBbwXuLAY-A/ (accessed January 9, 2021).

Plumwood, V. (2009), "Nature in the Active Voice," *Ecological Humanities*, 46. Available online: http://australianhumanitiesreview.org/2009/05/01/nature-in-the-active-voice/ (accessed July 2, 2019).

Simard, S., D. Perry, M. Jones, D. Myrold, D. Durall, and R. Molina (1997), "Net Transfer of Carbon between Ectomycorrhizal Tree Species in the Field," *Nature*, 388(6642): 579–82.

Thompson, C. (2018), "The Collaborative Urban Resilience Banquet," Instagram account, Available online: https://www.instagram.com/the_c_u_r_b/ (accessed December 10, 2018).

Youngs, A. (2016), "Embracing Interdependencies: Machines, Humans and Non-Humans," in D. Herath, C. Kroos, and Stelarc (eds.), *Robots and Art: Exploring an Unlikely Symbiosis*, 89–111, Singapore: Springer.

Youngs, A. (2019), *Becoming Biodiversity,* mobile application, Hypernatural, Vers. 0. Available online: https://hypernatural.com/bb/ (accessed March 7, 2020).

Youngs, A. (2020), *Vegetal Entangling*, online artwork. Available online: https://hypernatural.com/vegetal-entangling/ (accessed January 12, 2021).

4

Cooperating with Diatoms—Queer Fabulations of a World Feeling Computing

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In this chapter, I take seriously Lynne Margulis and Dorian Sagan's (1997) proposal that diatoms—unicellular organisms such as microalgae—are natural technologies of the earth and inquire into how they queer life and damage economies. Taking this up as a practice of resistance to dominant forms of technoscience I wonder how we might cooperate with diatoms to wrestle computing (and especially environmental computing) away from being in the service of financial capitalism—to imagine "computing otherwise" (Pritchard 2018: 274), what I call in this chapter a "world feeling computing." Following the work of Kara Keeling and Vinciane Despret, I speculate on the queer im/possibilities of computing with micro plant-like ensembles, a computing which might "hold open the world for listening" rather than foreclosing it through over-determination. To modulate my proposition of "world feeling computing," I discuss an empirical study on the design and development of an ecological classification system for diatoms through the use of artificial intelligence (AI) and cloud-based infrastructures in an environmental observatory in Cumbria between 2012–2016, the historical present of microscopes, algae and AI, and the artwork and prototype *Critter Compiler* (Pritchard 2016). I propose *Critter Compiler* as a queer intervention on contemporary environmental computing, in particular I discuss how it proposes an otherwise to the automation of measurement and sensing of micro worlds. Typically, automation and measurement are in the service of corporate gain through AI, particularly machine learning (ML) when it arrives together with the cloud-based infrastructures of "environmental virtual observatories." *Critter Compiler* shifts the focus to designing and measuring *in* service to "protection from harm" (for economies); to an engagement with queer feeling practices (of which injury is one). By focusing on diatoms, plant-like, rock-like, animal-like organisms, I do not want to reinstate the category of the plant (or human) as a fixed boundary, or prove their liveliness; instead, I want to demonstrate the urgency for a new engagement with environmental computing, one that damages its relation to extractive capitalism and remakes it in the more-than-human "cooperative public interest." I do this through a queer proposition—a set of practices that take into account how the world feels and thinks itself—"a world feeling computing."

In this chapter, taking a queer feminist technoscience approach, I mobilize the concept of injurious computing (Pritchard 2018) as I take up diatoms' inherited material histories as both the test object for technoscience and an object that is measured, counted, or tested—a life constrained and held in "injured states" by computation but influencing technoscience practices. As a "feeling practice" I discuss practice-based engagements with the artwork *Critter Compiler* (Pritchard 2016), an AI artwork and prototype microbial novella writer that I developed to consider micro world critterings—diatoms bound with technologies of diatom science and computation.[1] The environmental computing artwork takes as its starting point injurious computing and performs these processes otherwise. I propose that the artwork, *Critter Compiler*, asks us to consider creative and flourishing alternatives to the injurious modes of computation under extractive capitalism. Instead of seeking to automate classification of diatoms, or measure micro algae growth to control algal blooms, I experiment with queer technoscience practices that explore whether there might be a creative reciprocity, a delight, between diatom growth, planetary modulation, and computing—from which we might reimagine how the world feels itself.

The chapter starts with a visit to an ecology lab that I had been invited to by Maria, an ecologist I was working with as part of an environmental virtual observatory project. The lab is crammed with boxes of samples, glasswares, rubber boots, jam jars, journals, conference poster rolls, and microscopes covered in plastic coats. When I arrive, Maria is working in the corner of the lab looking at translucent shapes with black outlines on a screen connected to a digital electron microscope. As Maria moves across the screen and changes the microscope camera view, she rotates the black-outlined shapes and launches into descriptions of the amazing qualities and importance of diatoms. As we look through the samples that she has collected from the river Eden in Cumbria, she describes the diatom's importance as an organism whose presence can predict the outbreak of blue-green algae blooms (a large multicellular algae) that harm industrial processes and farming, but whose movement and growth have the potential to act as a feeler for global climate change.[2] These particular diatoms are a type of freshwater micro algae present within the slimy brown biofilm that covers the surface of rocks in upland streams in Cumbria. Maria notes, with both frustration and sympathy, that diatoms' talents of signaling climate change are largely unknown, nor of interest, to the public as they are invisible to the human eye without the aid of a microscope. Diatom algae lives are, more often than not, rendered into public life as a damaging toxin, its dazzling complexities and interdependencies overlooked.

In the lab, the diatoms are displayed on the computer screen and Maria is rotating the view continuously as we chat. As the image of the diatom rotates, Maria flicks through the pages of hand-drawn images. Due to the ever-changing taxonomic classification of diatoms, books that feature hand-drawn images of diatom species have held different forms—as inventories, dictionaries, libraries, and, more recently, databases. Maria is involved in a project in the lab which aims to automate diatom monitoring. As we look through the stack of books to identify the different diatoms, Maria explains that she is working on a computer vision AI cloud-based classification system intended

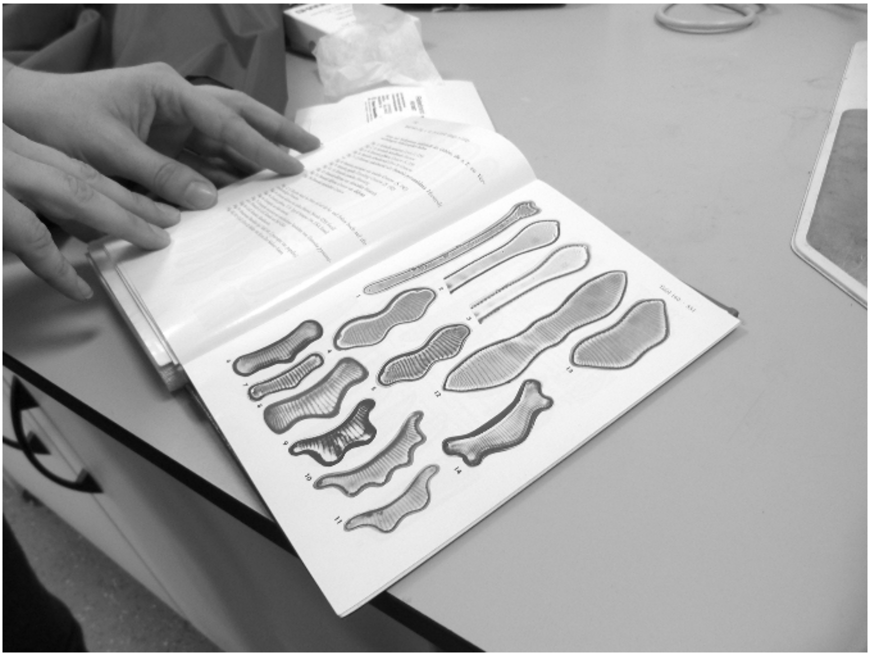


Figure 4.1 Classification of diatoms. Photograph courtesy the author. CC4r.

Figure 4.2 Rendering diatoms on the screen. Photograph courtesy the author. CC4r.

to supersede taxonomic illustrations, drawn in the nineteenth century by amateur scientists. Maria demonstrates how she needs to turn and rotate the diatoms, to see their 3D form from all angles, in order to identify them from the illustrations and create labels to generate the categories and classifications for a data set. She reflects that the proposals for the diatom identification system, using AI method (computer vision and neural networks), which they have been working on in the lab, are nowhere near replicating the process of cross-referring nineteenth-century drawings with what is seen, live, through the microscope. However, the proposed automated diatom classification system finds diatoms and its material history as an organism that has *become* through classification and categorization a useful test object. Diatoms have become a test site for the development of automated cloud-based environmental monitoring as the abundance of diatoms makes them readily available to create big data sets from which machine learning models can be made. As a natural technology, algae's capacities to create diverse glass shells and shapes mean that they can generate categories, based on visual identification, that are needed for classification. Yet Maria is skeptical about the possibility of training the ML model on the intricacies and intimacies of the relations between the ecologist and the slide rotation under the microscope.

Maria talks me through the material history of diatom monitoring, explaining in detail the ways in which diatom studies is a more than scientific practice. Maria and the lab manager, Phil, explain the structures of diatom research. In the UK it is only in the last twenty years that the International Society for Diatom Research (ISDR), the main body for diatom ecology, has divided into disciplinary streams. In the study of diatoms, knowledge is more than an engagement of amateurs, scientists, and artists. Phil retells the often-cited story, that the diatom has become through a material history with an unusually flat hierarchy between expert and amateur, through an intermingling of their practices. Diatom practitioners, Phil explains, have one thing in common, they are "diatom lovers." These diatom lovers share a desire to engage with the diatom's amazing talents. An important byproduct of amateurs' engagement with diatoms has been the development of techniques for visually categorizing and classifying diatoms that might not have emerged through formal channels of study due to the time-consuming length of processes and intensity of labor. It is an affective relation with classification.

As Phil explains, the blurring of professional and amateur science, art and scientific practice still exist within the communities of diatom study, and only recently has the ISDR developed separate interest groups, despite resistance from some of the members, including Phil himself. For Phil and Maria, the history of diatom science is one of mutual knowledge production, amateurism, and art practice, with hobbyists drawn to the colorful, expansive, and differing shapes of the diatom to make images and classification slides. Indeed, the use of amateur labor, used to undertake the identification of diatoms for taxonomic classification during the nineteenth century, is not dissimilar to the ways in which invisible labor is used for the identification and labeling for the generation of categories and classification systems that is needed in the training of machine learning models in contemporary technology platforms—what Mary L. Gray terms "Ghost work" (Gray and Suri 2019).

Figure 4.3 Identifying diatoms through rotation. Photograph courtesy the author. CC4r.

As glass silicon shells render in computational space, Maria turns to me and traces her fingers over the flat computer screen, showing me how the shapes mutate and shift as she rotates them physically under the microscope. As she moves, the low-saturated bodies take in and reflect the light of the electron microscope. With one hand on a book and the other on the mouse, she searches for characteristics for classification: valve outline, the presence or absence of a raphe or pseudoraphe, setae, horns, apiculi, mucous pores, and ribs. Then, as the image is rendered, diatoms emerge from the stabilizing gesture of the microscope and are gigantized to the nth power. Maria tenderly rotates the image and listens for densities, and boundaries that emerge as light bounces off the diatom's dense glass shell—producing ridges, lines, indentations which figure its separation. In this scene, diatoms—micro unicellular algae—become illuminated. Living fossils imaged by and through gentle computational and physical rotation; the temporality of the machine; and the hands of the ecologist operating on this computational image. However, despite the compliant appearance of these glassy densities, Maria explains that their amazing complexities and shape-shifting qualities resist the proposed research for fixed automated diatom classification—by computer vision, machine learning, cloud computing, and data integration services. Because, as diatoms will show us in this chapter, these computational infrastructures are reliant on fixisms.

Naturally Queer Technology

Diatoms are amazing! Not animals, not plants, not rocks, not even fungi or bacteria, what appear as diatoms on the screen form part of a diverse, if obscure, group of aquatic microbial life—that biologist Lynn Margulis named "protoctists" (Margulis and Sagan 1997). As Myra Hird writes, microbial life "invented the basic metabolic processes, including photosynthesis and chemical conversion, that every other life form remains utterly dependent on" (Hird 2021: 151). Unicellular, sometimes alone, sometimes together, their cell walls ("frus-tules" or "valves") are hardened by silica. The shells of diatoms are so heavy that when they die in lakes, rivers, and oceans they typically sink to watery graves, taking carbon out of the surface waters and locking it into sediments below. Mineral beds up to 1,000 feet in depth, called diatoma-ceous earth, are composed of their fossil remains. When viewed under a digital microscope the varied exoskeletons of diatoms range in shape from flowerlike to crown-shaped. Made from silica, which they take from solution in the water, diatoms are so dazzling at constructing their miniature hard parts that they can grow even in water where human instruments fail to detect measurable amounts of silica. Diatoms are queer environmental modulators—planetary listeners—key organisms that remove carbon dioxide from the earth's atmosphere. In Margulis's work on microworlds, she shows how the amazing metabolic talents of these plant-like diatoms are at the felt center of global life flow, even during the most severe planetary crisis "their capacity for metabolism and exponential growth, and the extraordinary diversity of interacting life on Earth are themselves enough to account in principle for environmental modulation on a global scale" (1997: 275). Indeed, diatoms have an immense modulating influence on the temperature of the planet and for this reason Margulis called them the "natural technology of the Earth" (Hird 2021: 151). As Margulis and Sagan noted, "[l]ong before humans, more and more chemicals of the universe were being sucked into living, proliferating life and its surroundings. Pre-human technologies—calcium shells, barium sulfate spines, phosphatic fecal pellets cemented into shelter—exemplify this tendency" (2007: 82). This proliferation of life infused Margulis's work and, in diatom-like resistance to dominant modes of thought, her work on symbiosis and evolution showed how bacteria merged with other cells to produce diatoms in a queering of cellular classification, through the fusion of two living things into one organism. Diatoms are amazing because they damage both Linneaun species' fixism and the understanding that technology is a solely human endeavor.

Queer Injury

Diatoms are not just queer through their undoing of taxonomic categories, but also—as the lab and fieldwork described here evidences—diatoms as a technology, queer and injure—from their undoing of taxonomic classification, to their queer environmental modulation of life and death. As will unfold in this chapter, diatoms are both queer and made queer through computational and technoscience relations. Alongside their taxonomic resistance, diatoms are also often rendered as injurious through quantification (such as the monitoring undertaken in the ecology lab I discuss) because their environmental modulations influence and predict multicellular algal blooms which are harmful to humans, animals, and economies. As Astrid Schrader (2012) discussed, the investment by science in the speedy quantified detection of the "rise of slime" is the real-time materialization of "political anthropocentrism that seeks to protect specific human economies" (87). Diatoms become framed as toxic to capitalism—inhabiting what Mel Y. Chen describes as a proper use of queer—"of only injurous intent" (2012: 70). Here, I extend queer theories that concern personal injury into more-than-human ensembles in order to consider the damages shared by humans and nonhumans in ensembles of computational and diatom technoscience. However, this research starts with injury but does not end there, and in the queer technoscience practices that follow, I design for diatoms and computation as a speculative process of queer "world feeling." Whilst still holding technoscience to account, I extend Despret's concept of "world feeling" from the environment and meteorological sites to sites of computing practices within AI, to propose that computing is, or might be, a type of practice we (more-than-human collectives) could feel with. That is, instead of AI practices that aim to address climate change through modes of measurement and control, we might rethink computing as a practice to feel the world differently, as Despret notes, "[e]very sensation of every being of the world is a mode through which the world lives and feels itself, and through which it exists. And every sensation of every being of the world causes all the beings of the world to feel and think themselves differently" (2017: 220).

This "world feeling computing" offers an otherwise to current moves in both environmental AI and software critiques that suggest computing and measurement can only be practices that are overdetermining of the entities that they measure. That is, I am proposing "world feeling computing" as an ontological epistemology that changes our relations to environments, environmental computing, AI practices, and collective life. An anti-capitalist environmental computing. It is an environmental computing speculation that does not imagine the designer/programmer as the only world-builder or feeler within sites where organisms and computing assemble, nor that worldbuilding or feeling is an individual experience. And so, instead of calling for us to design better worlds through measuring environmental harms, or automating biotic classification, world feeling computing suggests we might recognize how plant-like organisms such as diatoms are already listening and feeling the world together (in ways that are inseparable to us) and this is what the world is. This listening takes the form of listening for poetry as a proposal for world feeling computing—a practice informed by Keeling's work on the Black queer inventiveness in the meeting of poetry, theory, and the creation of new paradigms. The "generative proposition another world is possible, the insistence that such a world already is here now and it listens, with others, for the poetry, poetry, the refrains, the rhythms, and the noise such a world is making" (2019: ix).

Comforting Algae

It is Thursday afternoon and I have traveled from the lab to a site of diatom algae monitoring in the environmental virtual observatory, in which I am also a researcher, in northwest England. The observatory is an example of a number of international projects that have emerged from the convergence of the computation of environments, cloud computing, remote sensing technologies, large-scale government funding initiatives, and the threats to economies by pollution and the rising temperature of the earth. Downstream, at fifteen-minute time-stamped intervals, river water pushes through turbidity probes and the network listens as a light sensor's voltage is interrupted by the presence of blue-green algae and diatom river critters. Blue-green algae opacity and phosphorus levels are measured and time-stamped. Sometimes a blue-green algae causes the sensor to clog, blocking the tubes and causing an error in the recorded data. In this muddy, messy situation there is a distinct worldly feeling, a listening. The observatory collects data both to address the local damage and river pollution and to predict global flows in relation to climate change. The key protagonists in both of these more-than-human stories of damage are diatoms. Diatom micro algae is queer in the observatory as it is both the damager and the one able to modulate, making new connections and foreshadowing global damage resulting from climate change. As Keeling notes, "[c]apable of being modulated according to the demands of Capital, queer nonetheless stubbornly works on and through bodies, establishing relations between them and thereby connecting them across space and time" (2019: 19). In this networked observatory project new relations are made across space and time and through the bodies of diatoms, as distributed sensors monitor and upload their movement and growth together with other environmental data gathered from the river Eden, such as biochemical measurements of phosphorous levels, turbidity, river speed, and depth. This data is stored on cloud-based servers and the databases set up, scaled and operated through Amazon Web Services (AWS). The assumption is that the data gleaned from the diatom algae growth processes (both live and historical) will be used to analyze, predict pollution and flooding events, act upon, and prevent changes in the biophysical world. The scientists and technologists at the observatory are magnetized towards diatoms, with differing interests and commitments, but all are there to understand if diatoms are a sentinel for, or their presence influences, the algae blooms, their damage of the river Eden, and its economic impacts. The key aims of the observatory are to manage, control, and predict flooding, diatom algal blooms, and climate change to "make things more comfortable." As the website and funding bids for the project document, the observatory vision, sensor, and cloud infrastructure is explicitly informed by Mark Weiser's vision that, by disappearing into the background through the use of sensors, "ubiquitous computing" would enable feelings of serenity and calm. However, in the twenty-first century, the disappearance of AI into backgrounds performs as much violence as much as it does serenity. So, I want to linger here for a while to reconsider the work that feelings of "calm," "comfort," and "disappearance" do in the computation of the environment and diatom algae in particular and the protection from harm for extractive capitalism they aim for. As Sara

Ahmed notes in her studies of queer feelings, "the availability of comfort for some bodies may depend on the labour of others, and the burden of concealment. Comfort may operate as a form of 'feeling fetishism': some bodies can 'have' comfort, only as an effect of the work of others, where the work itself is concealed from view" (2014: 148). As Ahmed outlines, modes of comfort are normative structures, and, like environmental computing itself, have the potential to disappear into the background. It is often at points of disappearance for some that comfort might be enacting the most violence for others. Indeed, we often do not notice what is comforting and instead are more likely to register moments of discomfort (Ahmed 2014: 147). In her work on more-than-humans, Despret reminds us that discomfort captures some of the problems of the more-than-human project especially in our engagements with environments. In contrast to the fantasy of coexistence "without a hitch," Despret notes that feelings of discomfort remind us to "keep watch" (2017: loc. 3004). The violence of computational processes such as those that take place in the observatory is interdependent with their aim to bring comfort, and in particular comfort through uninterrupted extractive capitalism, without alerting us to keep watch on whom this comfort might be for (or not) or who feels discomfort (or not). These two modes are not mutually exclusive and, as the ecology of the diatom shows us, harm caused through diatom-related climate events such as the raising or lowering of the planet's temperature have differing effects. So, what would environmental computing look like if, instead of aiming to comfort, calm, or disappear, it worked in ways that accounted for and challenged asymmetries in comfort and discomfort that are always present—comfort for whom?

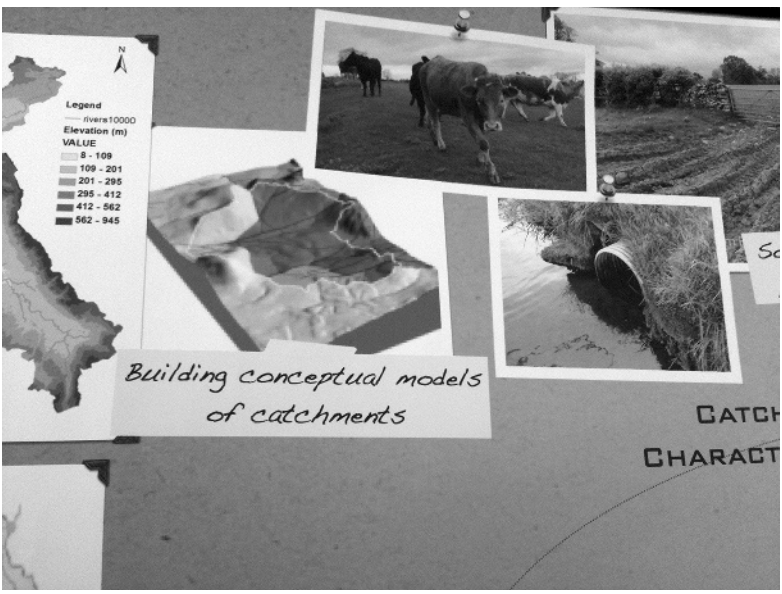


Figure 4.4 Section of a poster explaining the imaginary of the environmental observatory project. Photograph courtesy the author. CC4r.

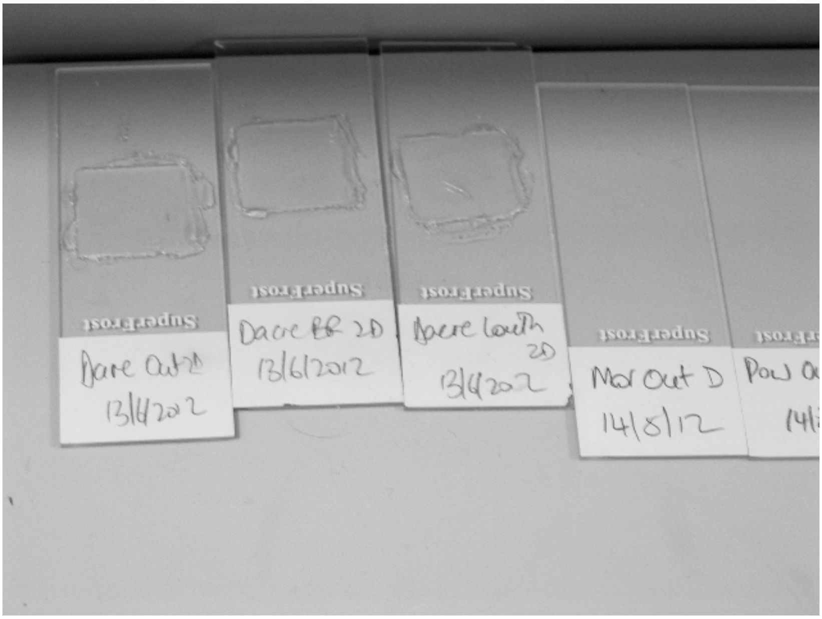


Figure 4.5 A selection of slides from the diatom monitoring site at the environmental observatory. Photograph courtesy the author. CC4r.

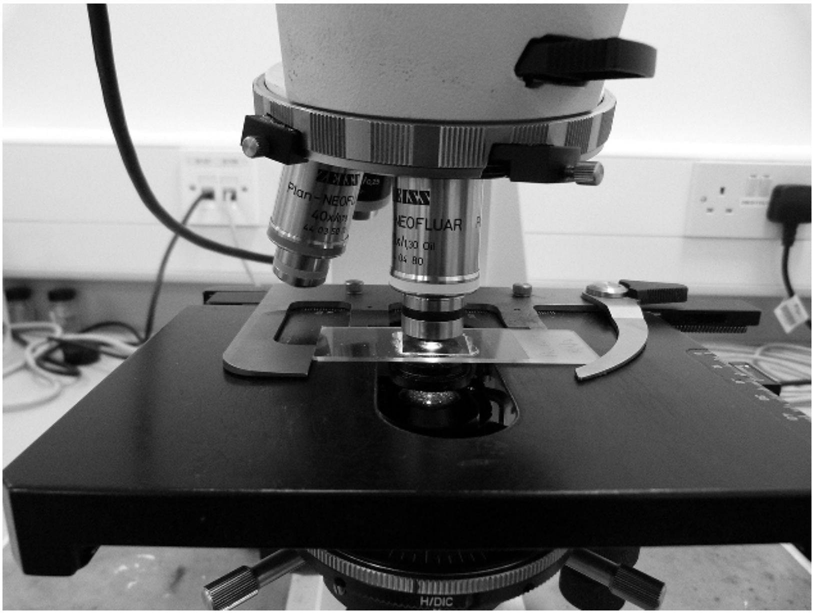


Figure 4.6 Closeup of the diatom slide under the microscope. Photograph courtesy the author. CC4r.

Micro Worldings

The historical present of diatoms is interdependent both with the study of diatoms as an object available to classify and categorize *and* their use as test objects to develop and calibrate the instruments of classification systems, such as microscopes and machine learning models. The material histories of diatoms are intertwined with scientists' desire for micro definition, establishing classification systems, and the construction of the optical lens. In technoscience, microscopes and diatoms are fine-tuned by, and become with, the corporeal forces that act upon scientists and amateurs alike. In the midst of the diatom science story is J. D. Möller, a nineteenth-century painter who became interested in the microscope during his apprenticeship, and eventually became a lens manufacturer who pursued a lifetime of enquiry on diatom classification, arrangement, and the use of the diatom as a test object for microscopes. In 1874, *The Quarterly Journal of Science* reported, "Herr Möller has introduced a very ingenious modification of his celebrated Diatomacean typenplatte … The whole collection independently of its great value to the student of Diatomaceae is a marvel of manipulative skill" (cited in Stevenson 2021: 547). The new arrangement consisted of a photograph about 4 millimeters square, of eighty

Figure 4.7 In the Botanic Garden Meise a large number of mahogany cabinets containing the Möller collection are carefully preserved. Photograph by Jef Schoors 2014.

circles, ten in a longitudinal and eight in a vertical direction; beneath each circle was the name of the object and its author, and in the center of each of these circles a mounted diatom, though in many cases two diatoms were mounted in order to show front and side views.

This rise of nineteenth-century amateur diatom science was part of what Geoffrey C. Bowker and Susan Leigh Star describe as the explosion of another kind of information system, driven by the development of myriad systems of classification (Bowker and Star 2000: 16). This new information system was one in which "people learned to look at themselves as surrounded by tiny, invisible things that have the power of life or death: microbes and bacteria" spreading the understanding of the world through categories and classification systems and taxonomic hierarchies (at which the white Western cis male was at the top) beyond the science lab or natural history museum (ibid.). Möller was one of many nineteenth-century amateur scientists who profited from the popularity of this new information system producing and selling miniaturizations from diatoms, alongside commissions of taxonomic category and speciation slides. The diatom became the ultimate portable organism for study and sharing, due to its potential to create miniature scenes. Engagements with the diatom as a test object, which propelled the innovation of the microscope lens and taxonomic classification and standardization, continue in the twenty-first century as diatoms are still used as test objects for automated microscopes and environmental AI, as seen in the project in Maria's lab. The sharp edges of diatoms, a quality of their plant minerality, diffract

Figure 4.8 The small wooden box with the most precious diatom arrangement from J. D. Möller, the Universum Diatomacearum Moellerianum. Photograph by Jef Schoors 2014.

and bend light as they encounter it, and, because of their well-defined edges, they are used for evaluating image quality and performance objectives. Indeed, the manipulability of the diatom, the abundance of its species, and its geographic specificity make it the perfect test object for the cosmologies made possible by the microscope and AI.

The interwoven history of diatoms and AI is a story of popular scientism, fixism, and creationism (Christian and Western European) that organizes and keeps in place taxonomic hierarchies. However, it also demonstrates how the intermingling of these communities and the emergence of knowledge practices feed and protect economic reproduction and capital accumulation, in the name of classification. In the same urgency for classification and protection from harm diatoms are enfolded into the development of automation and AI, in ways that are then used to further extend the possibilities of classification systems and violence. Through digitalization, diatoms are further used to hold in place violent taxonomic kingdoms that perpetuate speciesist exploitation and violence. This is not containment and capture, but the exploitation of the feeling capacities of an organism to extend the injurious feeling capabilities of technoscience. What would it mean to generate a different feeling of life; of a diatom bound with technology? And what limitations and possibilities might this expose? This history of diatoms as told by Maria and Phil would be familiar to those who study them and is the story that is presented on websites and natural history accounts. However, what other stories of queer taxonomic and visual figuration might diatoms tell? As practitioners, we might speculate on what it means for technoscience to limit or constrain the way the world feels itself and to generate other ways in which diatoms and computing might think and feel the world together.

World Feeling AI

To develop the concept of world feeling computing, I take up Despret's work on another term in the story of taxonomies and protections from harm—extinction. As Despret outlines, the loss of plants, trees, microbes, and animals through extinction reduces the world's capacities to feel itself, "[w]hen a being is no more, the world narrows all of a sudden, and a part of reality collapses. Each time an existence disappears, it is a piece of the universe of sensations that fades away" (2017: 220). Loss of animals, plants, trees, microbes, is, in part, a loss of reality, a loss of the perception of the world by itself, extinction, a form of extreme damage or injury. Despret tells the story of extinction of the passenger pigeon, outlining that what is at stake is both the loss of the world's feeling of "wings by the thousands" but also the world feeling of the pigeon's wings such as the particular depths and dips of wind that only passenger pigeons can navigate, "the particular rays of light that took pleasure in shimmering" (ibid.). Despret names this loss as ontological depravity, in which the world "bursts" with the absence of the lost potential to feel itself in a particular way (2017: 219). Indeed, and this is my key argument, we can also consider the ways in which the world loses potential to feel itself, not just through the death or loss of the feeling subject or species but through the curtailment and constraint of world feeling through modes of environmental computing. If we understand diatoms as part of the world perceiving and thinking itself (rather than a measurable object), we might understand that computing is generating ontological losses and gains. How, then, might we make queer technoscience experiments in world feeling computing? Taking the feelings and sensations of passenger pigeons as an example of the world enduring and thinking itself suggests ways in which diatom computing might think and feel the world. As Margulis evidenced, diatoms have a continued prominence in earth processes, not least by signaling climate change (Margulis and Sagan 1997). By opening up the processes of computing to a freer relation with the amazing deeds of plants, we might enable diatoms to exploit AI, to remake computing, as manifestations of life and, as Nigel Clark notes, "generate novel forms and behaviours, probe new pathways and spaces of possibility, proliferate itself" (2011: 42).

Many of the technoscience propositions for designing or making space for cohabitation between humans and plants in the environmental humanities has been to give "voice" to plants through which they can enter into human conversation or to recognize their communicative qualities through modes of inscription. These projects often focus on ways humans might communicate with plants, often taking the approach "plants-to-humans-communication," "conversations with plants" or "co-designing with nonhumans." These projects attempt to make structures that allow plants to enter into conversation with humans, and occupy a significant space in the imaginary of how we might design with plants. Their aim is to open design to become inclusive of other-than-human worlds and the consensus in these practices is that the inclusion of plants by designers enables communication between humans and nonhumans. Indeed, many of these projects have created important spaces to engage with what Haraway calls positive engagements beyond solely writing or discursive practices. However, although such inclusive/communicative approaches may open up thinking about the more-than-human beyond a valuation that is based on quantification, they do so through an assumption that communication is, on any terms/by any means, inherently liberatory. These projects fail to account for what Eduardo Kohn describes as the politics in more-than-human interactions and the very different and unequal positions among the different agents (2013). Indeed, projects of designing with that focus on communication agency and recognition become conflated with intelligibility or communicative possibility. Although these projects of plants-human interaction, or plants speaking with humans, seek to create liberatory technologies for more-than-humans, the focus on communicative possibility reinforces the taxonomic categories of animism, technologies, and narratives of colonial and capitalist violence in ways which reach far beyond the project of giving voice to plants. As Alexander Stingl has discussed, conceptual approaches based upon intelligibility/communicability, within computational cultures, are deeply mired with the coloniality of being (2015: xxxv). This is because communicability is based on taking up the language of those in power, as Franz Fanon writes (1967). As has been much discussed in postcolonial theory, it becomes impossible to escape imperial or colonial worldviews when using the language of imperialism or colonialism (Ashcroft 2001: 277). As Chen also observes, projects seeking to make animal or plant communication legible to humans, while often attempting to disrupt the hierarchies of animation, or who or what has the power to speak back, nevertheless rely heavily on keeping intact the taxonomic categories of human, plant, and machine (Chen 2012). As well as the ontological separation of human and plant in these projects, they also privilege linear and coherent narrativity, as a reduction and constraint on life. In addition, technical projects that give voices to plants often leave the computational infrastructures (such as cloud services), and the capital gain they make from inclusion, that make communication relevant and possible unquestioned.

Instead, world feeling computing is a proposition to engage with the world in a different way, a recognition of more-than-human creativity beyond modes of inclusion or communicability. To experiment and speculate on world feeling, in 2016 I developed the speculative artwork *Critter Compiler* as a proposition for "computing otherwise" (Pritchard 2018). I take up Haraway's critter onto-epistemologies as a move to reject taxonomic categories and classifications. In Haraway's critter onto-epistemologies, ecologies are made up of critters, which refers promiscuously to microbes, plants, animals, humans, and nonhumans, and machines (Haraway 2016: 169). Some critters are more technologically bound than others, but relationally critters queer and destroy taxonomic categories as all "[c]ritters are in each other's presence, or better, inside each other's tubes and crevices, insides and outsides, and not quite" (ibid.). To encounter the artwork *Critter Compiler* is to encounter a tangle of tubes and wires, screens, pickle jars, whirring sounds, and a thick smell of diatom micro algae. Micro algae run through the rubber tubes and, as they criss-cross over the micro computer, they pass over a shiny metal plate, the central processing unit (the CPU). The CPU is the portion of a computer that retrieves and executes instructions and as the diatom algae runs over the plate it cools the CPU, affecting the speed at which it can perform these executions. As a computational and bio artwork, *Critter Compiler* establishes an unruly process of compilation—the process the computer takes to convert a high-level programming language into a machine language that the computer can understand. As computation is executed, the CPU processes much of the activity that takes place in the computer—and as this happens, heat is emitted, to the point that the execution processes can cause the CPU to overheat or burst into flames. *Critter Compiler* exploits the heat generated by a recurrent neural network—a machine learning model—using the CPU heat to boost diatom growth. The recurrent neural network has been trained to write novellas and runs at a speed defined to create the approximate heat in the CPU needed for algae to proliferate and grow in size. It literally generates "novel forms." Recursively, as the algae pass over the CPU they cool it, affecting its processing speed, which in turn effects both diatom algae growth and the speed at which the novel-writing process takes place. *Critter Compiler* is an unruly multitude of diatoms and computational processes. As a form of punk solidarity, *Critter Compiler* enlists computing to promote the unruly growth of microworlds. And, just as "the vast majority of microbial intra-actions have nothing to do with humans" (Hird 2009: 2), much of the processes of *Critter Compiler* are similarly inaccessible to us. Instead of approaching diatoms as a resource to measure, calibrate instruments from as a test object, or extract data from, *Critter Compiler* is an

Figure 4.9 *Critter Compiler Prototype*, 2016. Photograph courtesy the author. CC4r.

engagement with processes of computing that attempts to generate what Rosi Braidotti calls experiments that "are non-profit and actualise the virtual possibilities of an expanded relational self that functions in a nature-culture continuum" (2013: 61).

In the case of *Critter Compiler*, the machine learning algorithm learns its writing style at a character-based level from George Eliot's vast novel, *Middlemarch* (1871–72), which is both a study of provincial life and a meditation on social and political justice. As Braidotti describes, reading *Middlemarch* is to step into a monistic universe of intersecting affective relations one in which "world and humans are not dualistic entities structured according to principles of internal or external opposition" (2013: 55). So, whilst some machine learning algorithms might have been trained for efficiency, financialization, attention on bounded individuals, and profit, *Critter Compiler* is trained by a matter-realist novel that conveys how we live in a world in which we are all bound in a huge web—and if one pulls one way or another, someone or something is affected. Consequently, in *Middlemarch*, all events, even the smallest or most everyday ones, are connected to the heat of planetary flows—much like diatoms and microbial life. In *Critter Compiler* the characters are not all human; diatoms replace bounded human characters. The audience-participant is a witness to this story, which unfolds between us, aquaspheres, politics, global climate change, and algae. Starting at the genealogy of injury but not lingering there, *Critter Compiler* is a small experiment in practices of world feeling that contributes a set of possible ethno-political practices for environmental computing and life itself, while resisting the production of ever new, reparative fantasies of protection from harm for ecological life from computational infrastructures such as environmental observatories, predictive modeling, or automated classification, running in the cloud.

In the artwork *Critter Compiler* algae growth, the heat generated from the computer itself, and the novel *Middlemarch* all inform the AI machine learning model through which the *Critter Compiler* learns to write novellas—a kind of critter writing machine. When developing the work, more-than-computational processes ran for days and nights, and algae grew in jars around the house to train the machine learning model. For months, I looked at the screen that displayed the process, waiting to understand something! As I cohabited with the *Critter Compiler* I watched and searched for words or phrases we recognized, for an insight into the more-than-human process that was taking place. As the *Critter Compiler* learnt to write through this character-based system it seemed to move through different root languages; however, after a few months, I noticed a new occurrence in its writing style—the heavy use of colons. For example:

> gtriad l shershe.umag:e must rsds s et dd ste te atane'sesm-ouc whis to- ftir t"lno fDog ulee gewdt fit srete and nigeetisd thk, ke:r, Dsunance tesdstdont miSof, tihenn af af ale ruett,:utee Drxs na awieise kiTFe lh matiqye rsead on f ty r ep ondrtney ns ifheel m ar pocad ransonli! tlf tis unt s shely lfes bhe lhmarmkeas icide roteistil;tmmned letis s hl rnsr se fro ran coat o rilthoc,elli f,wav onv.

Eliot's pages are themselves populated with colons, a particular syntactical style, in which colons link together statements as characters push the boundaries of "normal" conversation (Raines 2011). In grammar, the colon has two main uses. Firstly, it is used to introduce an idea that is an explanation or continuation of the one that comes before the colon. It is also often used as a gateway inviting the reader to go on. How could we speculate with the *Critter Compiler*'s new writing style, was it generating and explaining endless ideas? Was it pushing the boundaries of normal conversation? What were the relations being formed here? I was also troubled, not wanting to reduce the critters or computation to language nor to overdetermine the process. I was reminded of a response from the audience to a presentation on Christian Bök's living poetry work *Xenotext*, where he has attempted to engineer bacteria to write poetry, to write back to him (Bök 2005). In the presentation, someone in the audience had noted that the bacteria were not yet writing poetry, instead, "what they were writing was gibberish." A frustrated audience member responded that "perhaps if bacteria wanted to write poetry they would want to write gibberish, who are we to say!" This was a stark reminder of how often we continue to develop practices that reinstate boundaries, and constrain and limit possibilities for the creativity and invention of life.

Queer Revolt for World Feeling

Alongside recognizing the inventiveness of more-than-humans, such as plant-like diatoms, we also need to reimagine the common technological narrative that plants and plant-like organisms are passively held in place by technoscience—and that the responsibility lies with the scientist-designer-programmer-maker to make these words better, to allow us to "speak back." This approach will never be liberatory as it reinstates a scene of benevolence; *Critter Compiler* proposes that instead we need a queer revolt for world feeling! If we are arguing for the inventiveness and amazing deeds of diatoms, we need responsibility and accountability but also to make space to recognize that AI is a crittering process. This is not to relinquish responsibility but instead to ask how a recognition of this interdependence could unleash the potentials for more-than-humans such as diatom might, to remake the world feeling possibilities of technoscience and computing.

Rather than the technosolutionist approach of "including back those have been excluded" into computational practice or designing-for; world feeling environmental computing and AI experiments might engage with the endurance of life within networks to understand the ways in which critters are becoming-with computational ensembles. As Lauren Berlant notes, queer, socialist/anti-capitalist, and feminist work multiplies the ways we know that people have lived and can live, making it possible to take up any number of positions during and in life in order to have "a life" that is not repressed by dominant and confining modes of normativity (Berlant 2011). "World feeling computing," then, is a proposition to unsettle normative understandings of plants, technology, and humans and to bring attention to possibilities for life and for "having a life," shifting the position from the imaginary of the plant or diatom as a bounded entity to the recognition of intermingled crittering relations that might be comrades in the ongoing collective project of queering life and damaging extractive capitalism, to remake the world in the cooperative public interest.

Notes

1 *Critter Compiler* was first shown in the exhibition, **.exe (ver0.2): Executions*, Medea, Malmo, Sweden (2016) and was also exhibited at the *Ecologies of Intimacy* workshop at Digital Humanities Lab, Sussex University, UK (2016) in collaboration with Fabrica, Brighton's Centre for Contemporary Art, UK. It also formed the basis for work on queer injury, damage, and bioinformatics for *Queer Injuries: Methodologies for Partial Repair … Or Not (2018)*, a workshop and talk at Hangar and Barcelona Museum of Contemporary Art (MACBA).

2 https://edendtc.webspace.durham.ac.uk (accessed April 5, 2023).

References

Ahmed, S. (2014), *Willful Subjects*, Durham, NC: Duke University Press.
Ashcroft, B. (2001), *Post-colonial Transformation*, Hove, East Sussex: Psychology Press.
Berlant, L. G. (2011), *Cruel Optimism*, vol. 226, Durham, NC: Duke University Press.
Bök, C. (2005), *Xenotext: Book 1*, Toronto, Ontario: Coach House Books.

Bowker, G. C. and S. L. Star (2000), *Sorting Things Out: Classification and its Consequences*, Cambridge, MA: MIT Press.

Braidotti, R. (2013), *The Posthuman*, Hoboken, NJ and Chichester: John Wiley & Sons.

Chen, M. Y. (2012), *Animacies: Biopolitics, Racial Mattering, and Queer Affect*, Durham, NC: Duke University Press.

Clark, N. (2011), *Inhuman Nature: Sociable Life on a Dynamic Planet*, Los Angeles and London: SAGE Publications.

Despret, V. (2017), "It Is an Entire World That Has Disappeared," in D. B. Rose, T. van Dooren, and M. Chrulew (eds.), *Extinction Studies: Stories of Time, Death, and Generations*, 217, New York: Columbia University Press.

Fanon, F. (1967), *The Wretched of the Earth* [1961], trans. C. Farrington, Harmondsworth: Penguin.

Gray, M. L. and S. Suri (2019), *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass*, New York: Eamon Dolan Books.

Haraway, D. J. (2016), *Staying with the Trouble: Making Kin in the Chthulucene*, Durham, NC: Duke University Press.

Hird, M. J. (2009), *The Origins of Sociable Life: Evolution after Science Studies*, New York: Springer.

Hird, M. J. (2021), *Canada's Waste Flows*, Montreal: McGill-Queen's University Press.

Keeling, K. (2019), *Queer Times, Black Futures*, New York: NYU Press.

Kohn, E. (2013), *How Forests Think: Toward an Anthropology beyond the Human*, Berkeley: University of California Press.

Love, H. (2009), *Feeling Backward: Loss and the Politics of Queer History*, Cambridge, MA: Harvard University Press.

Margulis, L. and D. Sagan (1997), *Microcosmos: Four Billion Years of Microbial Evolution*, Berkeley: University of California Press.

Margulis, L. and D. Sagan (2007), *Dazzle Gradually: Reflections on the Nature of Nature*, Vermont: Chelsea Green Publishing.

Pritchard, H. (2016), [Artwork] Critter Compiler Prototype:ver 2.0 *Executions, Medea Malmo. Available online: https://www.helenpritchard.info/critter-compiler-prototype-2016 (accessed April 7, 2023).

Pritchard, H. (2018), "Critter Compiler," in H. Pritchard, E. Snodgrass, and M. Tyżlik-Carver (eds.), *Executing Practices*, 261–77, London: Open Humanities Press.

Raines, M. A. (2011), *George Eliot's Grammar of Being*, London and New York: Anthem Press.

Schrader, A. (2012), "The Time of Slime: Anthropocentrism in Harmful Algal Research," *Environmental Philosophy*, 9(1): 71–93.

Stevenson, B. (2021), "Johann Diedrich Möller, 1844–1907." Available online: http://www.microscopist.net/MollerJD.html (accessed April 5, 2023).

Stingl, A. I. (2015), *The Digital Coloniality of Power: Epistemic Disobedience in the Social Sciences and the Legitimacy of the Digital Age*, Lanham, MD: Lexington Books.

5

So-called Plants

Jara Rocha and Femke Snelting (Possible Bodies)

Spray installations enhanced with fruit recognition applications, targeting toxic load away from precious mangoes (Gao et al. 2020); software tools for virtual landscape design economizing the distribution of wet and dry surfaces (Lange and Hehl-Lange 2006); algorithmic vegetation modeling in gaming which renders lush vegetation on the fly (Fritsch and Kada 2004); irrigation planning by agro-engineering agencies, diminishing water supplies to the absolute minimum (Pavithra and Srinath 2014: 49–55); micro-CT renderings of root development in scientific laboratories (Mairhofer 2015); all of these protocols and paradigms utilize high-end volumetric computation (see Glossary). Vegetation data-processing techniques make up a natureculture continuum that increasingly defines the industrial topology (see Glossary) applied to the existence of so-called plants. These techniques integrate 3D scanning, modeling, tracking and printing into optimized systems for dealing with "plants" as volume.

Thinking with the agency of cultural artifacts that capture and co-compose 3D polygon, point-cloud and other techniques for volumetric calculation, we brought together over a hundred items in *The Possible Bodies Inventory* (Possible Bodies 2022). For this chapter, we selected several computational "ecologies of practice" that allow us to feel the borders of how so-called plants are being made present (Stengers 2005: 183–96). We write "so-called plants" because we want to problematize the limitations of the ontological figure of "plant," and the isolation it implies. This is a way to question the various methods that biology, computer science, 3D modeling or border management put to work to create finite, specified, and discrete entities which represent the characteristics of whole species, erasing the nuances of very particular beings. We are wondering about the way in which computational renderings of so-called plants reconfirm the figure-background reversals which Andrea Ballestero discusses in her study of the socio-environmental behavior of aquifers (Ballestero 2019: 17–44). This flipping between figures and their ground not only happens because of the default computational gestures of separation and segmentation, but also through cycles of flourishing, growing, pollinating, and nurturing of "plants" that appear animated while being technically suspended in time. Such reversals and fixities are the result of a naturalization process that managed to determine "plants" as clearly demarcated individuals or entities, arranged into landscapes along which their modes of existence develop under predictable and therefore controllable conditions. It is this production-oriented mode that 3D volumetrics seem to reproduce.

The *Possible Bodies Inventory* is itself undeniably part of a persistently colonial and productivist practice. The culture of the inventory is rooted in the material origins of mercantilism and deeply intertwined with the contemporary database-based cosmology[1] of techno-colonialist turbo-capitalism (Rocha and Snelting 2022a). Inventorying is about a logi(sti)cs of continuous updates and keeping items available, potentially going beyond pre-designed ways of doing and being as proposed by the monocultures of what we refer to as "totalitarian innovation" (see Glossary), and what Donna Haraway calls "informatics of domination" (Haraway 1985: 985). Inventories operate in line with other modern devices for numbering, modeling, and calculating so-called plants: herbaria, which function as a physical re-collection of concrete plant specimens; genetic notebooks, which trace lines around and between individuals; Latin nomenclatures, which produce and reproduce taxonomies of species within so-called families within so-called kingdoms; sketchbooks filled with naturalist drawings captured during explorations; and even botanic gardens that arrange lively exotic samples to be experienced in the overseas environments of the metropolis. An inventory can be understood as a workspace arranged for constant managerial return, and—in contrast with a collection or an archive—they allow easy access to items for reordering, removal, or replacement. Just like almanacs used in observatories or taxonomies at museums, inventories play a role in the becoming of computational herbaria as contemporary apparatuses for the production of knowledge, capital, and order.

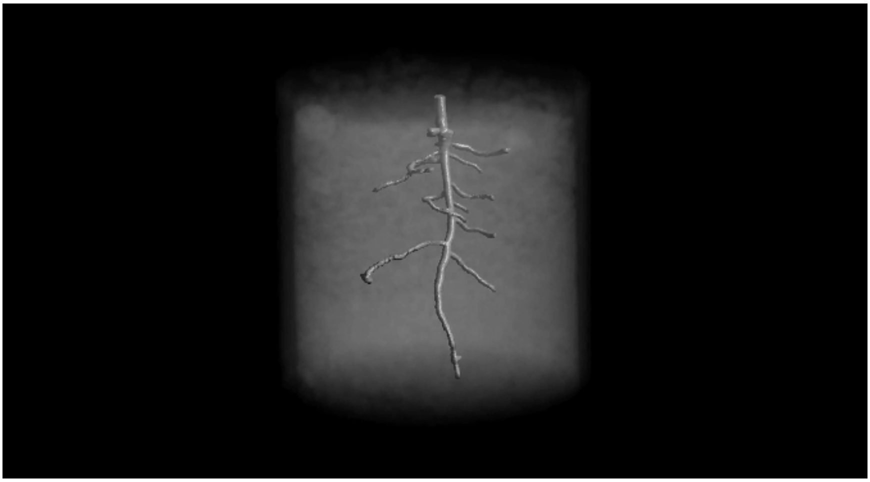
Possible Bodies attends obliquely to the power relations embedded within inventories, because it provides a possibility to open up methods for disobedient action-research. Following trans*feminist (see Glossary) technosciences driven by intersectional curiosity and counter-politics, the inventory attempts to unfold the possibilities of this modern apparatus for probable designation and occupation. Disobedient action-research implies radical un-calibration from concrete types of knowledge and proposes a playful, unorthodox, and "inventive" inhabiting of many disciplines, of learning, unlearning, and relearning on the go. It also plots ways to actively intervene on the field of study and interlocutes with its communities of concern and their praxis of care. In this chapter, we try to relate to the cracks in the supposedly seamless apparatus of 3D. As long as we have not yet abolished the modern, we persist in reorienting its tools in the meantime. This includes the possible misuse of the apparatuses of designation, extraction, and occupation, including volumetrics; considering the misuse of techniques as an active matter of care (Bellacasa 2017). Committed to memories but resisting nostalgia, as proposed by Livia Alga and her thinking with the post-exotic (Alga n.d.) (see Glossary), we are curious about a rearrangement of methods, techniques, and processes in ways that do not reinforce the establishment of volumetrics. This text tries to provide a mode of understanding and engaging with so-called plants not as individual units, but as vegetal forms of computationally implicated existence.

Vegetal Volumetrics

The following two items pay attention to processes of vigilant standardization as a result of collapsing the one with the many. They each apply disobedient volumetrics to resist naturalizing representation as evidence of a universal truth. The items want to cultivate the ability for response-ability within computational presentations of the vegetal.[2] Instead of the probable confirmation of hyperproductive 3D-computation, these items root for a widening of the possible and other computational ways of rendering, modeling, tracking and capturing so-called plants.

En nuestros jardines se preparan bosques ("In Our Gardens, Forests Are Being Prepared") is a thick para-academic publication on political potential by Rafael Sánchez-Mateos Paniagua, alluding to the force of potentiality that is specific to vegetal surfaces, entities, and co-habituating species, which turns them into powerful carriers of political value (Paniagua 2012). Other than productive and extractive, they are informative of the inner functionings, interdependencies, and convivial delicacies of so-called plants.

Item 102: Grassroot rotation is a poetic rendering of demo-videos that accompany a manual for RooTrak, a software suite for the automated recovery of three-dimensional plant root architecture from X-ray microcomputed tomography images. The images we see rotating before us are the result of a layered process of manual and digital production, starting with separating a grass "plant" from its connected, rhizomatic neighbors and, in that sense, it is a computationnally gardened object. The "plant" is grown in a small, cylindrical container filled with extracted soil before being placed in a micro-CT installation and exposed to X-rays. The resulting data is then calibrated and rendered as a 3D image, where sophisticated software processes are used to demarcate



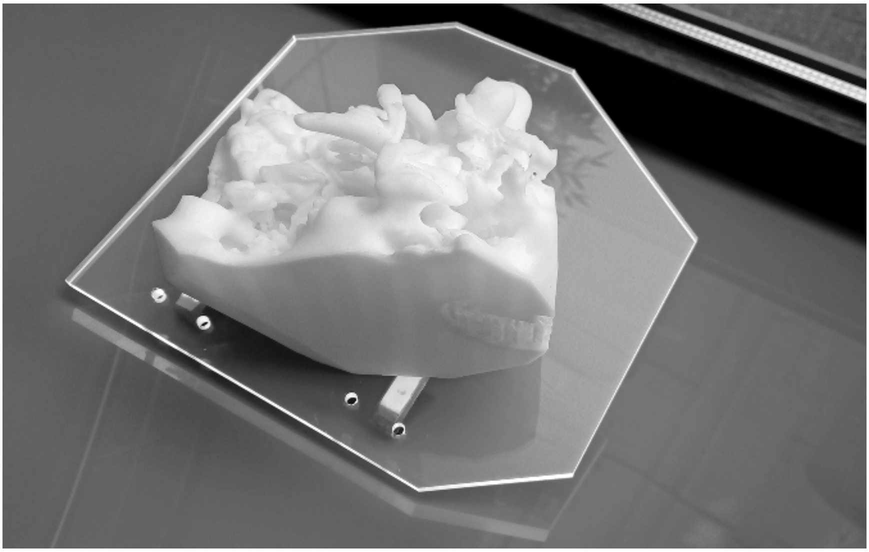
Item 102 Grassroot rotation: segmentation of a tomato root from clay loam using RooTrak (Mairhofer 2015). GNU General Public License. **[Figure 5.1]**

the border between soil and "plant," coloring those vessels that count as root in blood red. The soil fades out in the background.

In collaboration with RooTrak, the software package responsible for these images, X-ray microcomputed tomography (μCT) promise access to the living structure through "a nondestructive imaging technique that can visualize the internal structure of opaque objects" (Mairhofer 2012: 1). But these quantified roots are neither growing nor changing. They rotate endlessly in a loop of frozen or virtual time, which can be counted and at the same time not. The virtualized roots pass through time while the computed loop goes on smoothly … but time does not pass at all. The roots are animated as if lively, but simultaneously stopped in time. Speed and direction are kept constant and stable, providing with an illusion of permanence and durability that directly links this re-presentational practice to the presentational practice of cabinets, jars, and frames. The use of animation has been persistent in the scientific study of life, as a pragmatic take on "giving life" or to technically reanimate life-forms. After first having claimed the ability to own and reproduce life by determining what differentiates it from non-life, all of this is done in an efficient manner, combining positivist science with the optimization mandate of the industrialized world. But how does the 3D animation complex apparatus do the trick of determining life and non-life? While RooTrak prefers to contrast its combination of CT imaging and 3D rendering with *invasive* techniques such as root-washing or growing roots in transparent agar, to us this grassroot rotation seems closer to the practice of fixing, embalming, and displaying species in formaldehyde.

The tension between animism and animation can be studied from the dimension of time and its specific technocultural maneuvers present in *Item 102*. It helps us see how computed representations of the animated vegetable kingdom continue to contribute to the establishment of hierarchies in living matter. What are the consequences of using techniques that isolate entities, which need complex networks for their basic existence? What is kept untold if different temporalities are collapsed into smooth representations of specimens, as if all happened simultaneously?

Item 033 features a work by Brussels-based artist Pascale Barret.[3] A 3D object is printed from a volumetric scan of a flowering bush with an amateur optical scanner. The object has nothing and everything to do with so-called plants, because the low-res camera never went through a machinic training process to distinguish or separate leaves. The software processing the data points then algorithmically renders the vegetation with an *invented* outside membrane, a kind of outer petal or connective tissue that is sneaked into the modeling stage and finally materialized by the printing device. This invention might look hallucinatory to the eyes of a trained botanist, but for us it is a reminder of the need to re-attune digital tools in a non-anthropocentric manner. Barret printed the volumetric file at the maximum scale of the 3D printer she had available, breaking the promise of the 1:1 relationship between scanned object and its representation. Because she did not remove the scaffolding that upheld the soft plastic threads during the printing process, these now "useless" elements flourished as twigs once the object had solidified. The item talks to us about a complex switching of agencies. In the first place, the vegetal groupings in *This Obscure Side of Sweetness Is Waiting to Blossom* are formed by the surfaces that the algorithm computes in between



Item 033 *This Obscure Side of Sweetness Is Waiting to Blossom* (Barret 2017). Artwork by Pascale Barret, photographed by the authors, published by Constant. Free Art License. **[Figure 5.2]**

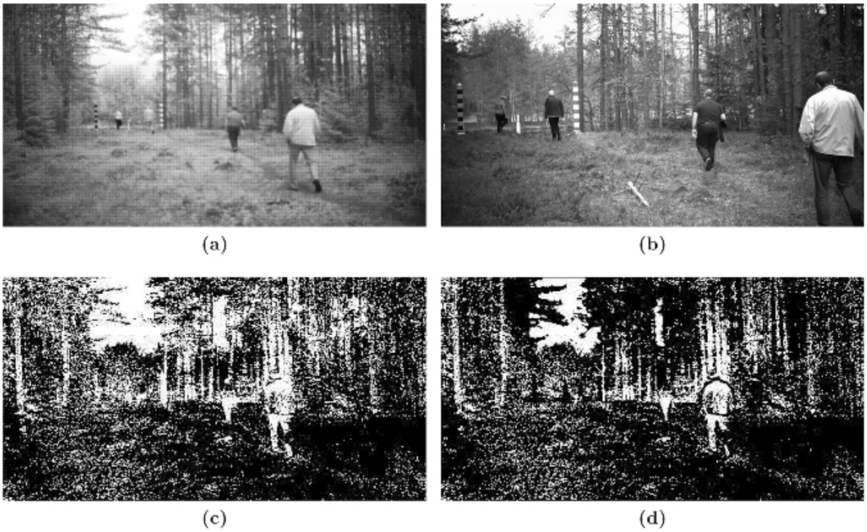
leaves caught by the scanner, trying to connect their wild in-betweens. The leaves defy linear, isolating, and rigid capture by taking on the too obedient mathematics that tries to encapsulate each gap and jump. Their surfaces and their positionality invite the computation of a continuous topological surface, based on straight mathematical axioms and postulates. What interests us here is that the axioms nested in the operations of 3D optics and scanning are stretched towards a *beyond-realistic* materialization. This switching of agencies is operating according to a logic that simultaneously defies the *realistic* establishment of a topological space, while creating a *manifold* that looks Euclidean. "Plants" become computable, accountable, nameable, determined, and discrete, without giving in to the promise of mimesis.[4]

In the way "plants" have been historically described, there is an ongoing attempt to fix the zones where they actually can be, become, and belong. But, looking closely, we can easily identify paranodal spaces (see Glossary) in between the vegetal and other forms of existence, gaps, or porous membranes which exist beyond the positive space of nodes and links. These can be seen as void and sterile spaces in between known entities, but they can also be taken as wide open, inhabitable areas; places to be in-relation that are non-neutral and also not innocent at all: connecting surfaces that provide with the blurring travel from one isolated unit of life onto another, in specific ways. Holes, gaps, or even chasms are zones of the world in and for themselves.[5] Mel Y. Chen's work on interporousness tries to come to terms with the way interspecies interabsorbence is prefigured by more-than-human power relations. "The couch and I are interabsorbent, interporous, and not only because the couch is made of mammalian skin. These are intimacies that are often ephemeral, and they are lively; and I wonder whether or how much they are really made of habit" (Chen 2012: 203). Their work shows how the attempt to separate, segment and identify ontoepistemologically demarcates sharp edges between the mammalian, vegetal, and human modes of existence. The attempt must be considered as damaging due to the persistent cutting apart of dense and complex relational worlds that, as a result, do not show cracks and paranodal spaces as inhabitable anymore. How those damaging representations infuse the contemporary computational take on "plants" is a direct consequence of modern technosciences and their utilitarian, exploitative foundations, based on the fungibility of some matters and the extraction of others. But if we think of seeds blown by the wind, roots merged with minerals, or branches grabbing the whole world around them, then formerly disposable cracks and gaps also have lively potential for ongoingness as areas for circulating matters. From useless to blossoming, from separating borders to articulated and activated cracks, we need a persistent flipping of agencies, ongoing "circluding" (see Glossary) moves that are difficult, but not impossible to uphold in computed spaces.[6]

Systemic Vegetation

In her work on the involution of plants and people, Natasha Myers invites us to consider renaming the *Anthropocene* into *Planthroposcene* as it "offers a way to story the ongoing, improvised, experimental encounters that take shape when beings as different as plants and people involve themselves in one another's lives" (Myers 2017: 1). With her proposition in mind, we now move upwards and sideways from the topological attention to surfaces of vegetal specimens, and the way they are cut together and apart by naturalized modes of (re)presentation, to the quantification and tracking of wide and thick surfaces. From Planthroposcene to Plantationocene, this section pays attention to a set of volumetric operations for predicting, optimizing, and scaling full areas arranged as gardens, forests, landscapes, or plantations in which so-called plants are made part of a system of intensive worlding, not free from similar options of measurement, control, and scrutiny (Tsing 2015).

Item 117 references FOLDOUT, a five-year collaboration between various research departments across Europe on border control in forest areas. FOLDOUT aims to "develop, test and demonstrate a solution to locate people and vehicles under foliage over large areas" (FOLDOUT 2019: n.p.). Dense vegetation at the outer borders of the EU is perceived as a "detection barrier" which needs to be crossed by surveillance technology. The project received €8,199,387.75 funding through the European Union's Horizon 2020 scheme and its central approach is to integrate short-range (ground based), medium-range (drones), long-range (airplane), and very long-range (satellite) sensor techniques to track "obscure targets" that are committing "foliage penetration." FOLDOUT says to integrate information captured by Synthetic-Aperture Radar (SAR), Radio Detection and Ranging (Radar), Laser imaging, Detection, and Ranging (Lidar) with Low Earth Orbit satellites (LEO) into command, control, and planning tools would ensure an effective and efficient EU border management.[7]



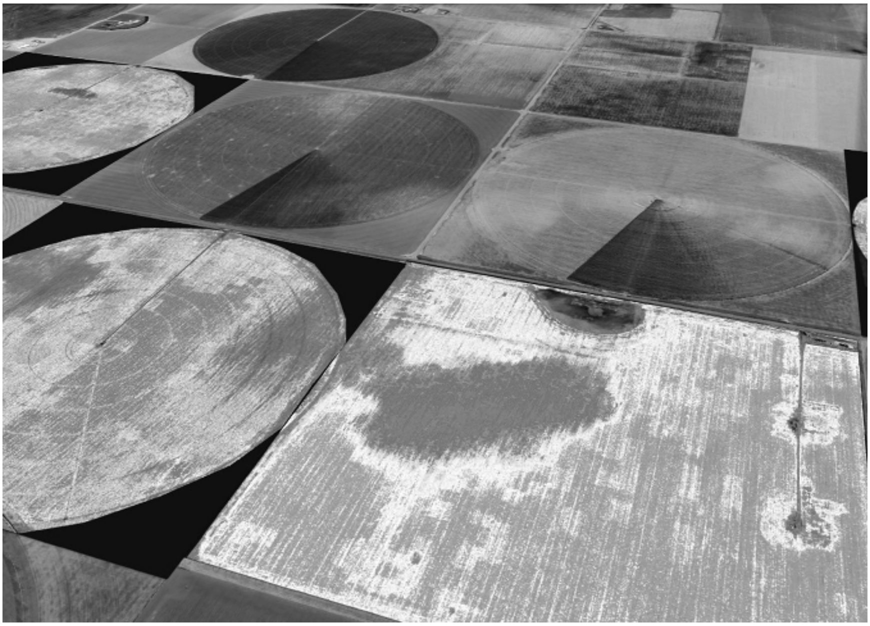
Item 117 FOLDOUT: "Terrestrial scenario (Ground dataset), classification based on radiance: (a) Raw hyperspectral input frame. (b) Corresponding RGB frame. (c,d) Classification without and with spectral overlap suppression, respectively. White: Classified as positive sample. Black: Classified as negative sample" (Papp et al. 2020: 15). Creative Commons Attribution. https://www.mdpi.com/2072-4292/12/13/2111/htm © 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license. [**Figure 5.3**]

To detect "foliage penetration," FOLDOUT relies among others on "foliage detection," a technique now also widely used for crop optimization. In agricultural yield estimation or the precision application of pesticides for example, hyperspectral imaging, and machine learning techniques are combined to localize leaves and tell them apart from similar shapes such as green apples or grapes. Hyperspectral imaging scans for spectral signatures of specific materials, assuming that any given object should have a unique spectral signature in at least a few of the many bands that are scanned. It is an area of intense research as it is being used for the detection, tracking, and telling apart of vehicles, land mines, wires, fruit, gold, pipes, and people (Kapoor et al. 1999: 819–34).

FOLDOUT is a telling example of the way "fortress Europe" shifts humongous amounts of capital towards the entanglement of tech companies with scientific research, in order to develop the shared capacity to detect obscurity at its woody barriers (Frontex Programme of Work 2013). By sophisticating techniques for optimized exclusion, negation, and expulsion, Europe invests in upgrading the racist colonial attitude of murderous nation states. How to distinguish one obscureness from another seems a banal issue, seen from the perspective of contemporary computation, but it is deeply damaging in the way it allows for the implementation of remote sensing techniques at various distances, gradually depleting the world of all possibility for engagement, interporousness, and lively potential. In the automation of separation (of flesh from trunk, of hair from leaves, of fugitive from a windshaken tree) we can detect a straightforward systematization of institutional violence.

> Apples are red,
> leaves are green,
> branches are brown,
> sky is blue
> and the ground is yellow.
>
> Apples are red,
> leaves are green,
> branches are brown,
> sky is blue
> and the ground is yellow.
>
> Mangoes are red,
> leaves are blue,
> branches are green,
> sky is black
> and the ground is yellow.
>
> Almonds are blue,
> leaves are red,
> branches are black,
> sky is blue
> and the ground is white.
>
> Mangoes are black,
> leaves are white,
> branches are yellow,
> sky is red
> and the ground is white.
>
> Fugitives are blue,
> branches are red,
> sky is yellow,
> leaves are black
> and the ground is white.
>
> (Possible Bodies 2020)

Item 118 features the research and practice of Abelardo Gil-Fournier, and with him we learn how agriculture is volumetric. He quotes Geoffrey Winthrop-Young to highlight how elemental "agriculture … is initially not a matter of sowing and reaping,



Item 118 Agribotix™ FarmLens™ Image Processing and Analytics Solution, viewed on WinField's Answer Tech® Portal (Molin, Amaral, and Colaço 2015). https://www.prnewswire.com/news-releases/agribotix-farmlens-image-processing-and-analytics-solution-offered-via-winfields-answer-tech-portal-300269650.html. **[Figure 5.4]**

planting and harvesting, but of mapping and zoning, of determining a piece of arable land to be cordoned off by a boundary that will give rise to the distinction between the cultivated land and its natural other" (Gil-Fournier 2018a: 334). He continues:

> However, this initial two-dimensional demarcation gives rise to a practice that can be further understood when the many vertical layers that exist simultaneously above and below the ground start to be considered. From the interaction of synthetic nutrients in the soil with the roots of the plants, to the influence of weather or the effect of both human and machinic labor, agriculture appears as a volumetric activity.
>
> (Gil-Fournier 2018a: 334)

The massive vertical management of soil, with the aim of fertilizing it, reorients agriculture from an engagement with surface to the affections of scaling up and down the field. To explain the way soil matter is turned into a "legible domain," Gil-Fournier takes as a case study the Spanish inner colonization that organized land and landscapes for plantation and irrigation. Through those studies, it is made materially explicit how the irrigation zones configure a network-like shape of polygonal meshes that distribute and systematize the territory for a sophisticated exploitation of its vegetal potentials. In Francoist Spain, under a totalitarian regime of autocracy, inner colonization was the infrastructural bet which provided the nationalist project with all needed resources from within, as well as with a confident step into the culture of wider Western, modern economies ruled by an obsession with development and growth. Gil-Fournier's work facilitates a departure point for a study of the legacies carried by contemporary hypercomputational applications that are currently being tested, for example, to analyze the seasonal evolution of gigantic agro-operations or to detect the speed by which desertification reveals the diminishing of so-called green areas (Gil-Fournier 2018).

> Recent space imaging developments have given rise to a spread of commercial services based on the temporal dimensions of satellite imagery. Marketed under umbrella terms such as environmental intelligence, real-time Earth observation or orbital insight, these imaging projects deliver the surface of the planet as an image flow encoded into video streams, where change and variation become a commodified resource on the one hand, as well as a visual spectacle on the other.
>
> (Gil-Fournier 2018b: n.p.)

The structural connection between volumetrics and soil observation unfolds when soil itself is treated as a segmentable and computable surface for purposes as different as climate change monitoring, new resource location, or crop growth analysis and maintenance. The big-scale top-to-bottom agro-optimization of vegetal surfaces by hyperproductive means urges us to consider the Plantationocene:

> Plantation as a transformational moment in human and natural history on a global scale that is at the same time attentive to structures of power embedded in imperial and capitalist formations, the erasure of certain forms of life and relationships in such formations, and the enduring layers of history and legacies of plantation capitalism that persist, manifested in acts of racialized violence, growing land alienation, and accelerated species loss.
>
> ("Sawyer Seminar: Interrogating the Plantationocene" 2019: n.p.)

The "enduring layers of history and legacies of plantation capitalism" can be read in the hyper-quantified vegetation praxis that we observed, a continuous flow of similar logics and logistics that forms what we elsewhere termed "The Industrial Continuum of 3D" (Rocha and Snelting 2022c). Scaling up and moving sideways, the Plantationocene joins the Planthroposcene to tell stories of how the systematization of vegetation happens partially through a set of volumetric operations, for the sake of vegetal extraction and intensive multi-planar exploitation. Such ongoing surveillance of growth continues to produce and reproduce systemic oppressions and asks us to stay attentive to and eventually twist the flattening monocultures that 3D tools and devices engender.

Lively Math

In the first two sections, we discussed the paradigm of "capturing" by scanning plants, and the politics of vegetal topology. Now we would like to turn to the particular technocultural conflation of "beauty," "scientific accuracy," and "purpose" that is intensified in the modeling of 3D vegetals. We insist that this type of conflation is cultural because it depends on a classic canon that turns only certain equilibriums and techniques into paradigmatic ones. This section tries to get a handle on the many levels of aesthetic and semiotic manipulation going on in the "push and pull" between botany and computation. It is written from an uncalibrated resistance to the violence inherent in this alliance, and the probable constraints that computation inflicts on the vegetal and vice versa.

Item 119 is called IvyGen, after a small software tool developed in 2007 by a now retired computer graphics professor, Thomas Luft. Luft was looking for a "sample scene" for his work on digitally emulated watercolor renderings: "I was thinking of something complex, filled with vegetation—like trees overgrown with ivy. Fortunately, I was able to implement a procedural system so that the ivy would grow by itself. The result is a small tool allowing a virtual ivy to grow in your 3d world" (Luft 2007). Ten years later, we find Luft's rudimentary code back as the *Ivy Generator add-on* which can

Item 119 IvyGen (screenshot) (Luft 2007). http://graphics.uni-konstanz.de/~luft/ivy_generator/ GNU General Public Licence. **[Figure 5.5]**

be installed into Blender, a free and open-source 3D computer graphics software suite. The manual for *Ivy Gen add-on* reads as follows:

1. Select the object you want to grow ivy on.
2. Enter Edit Mode and select a vertex that you want the ivy to spawn from.
3. Snap the cursor to the selected vertex.
4. Enter Object Mode and with the object selected: Sidebar ▸ Create ▸ Ivy Generator panel adjust settings and choose *Add New Ivy.*

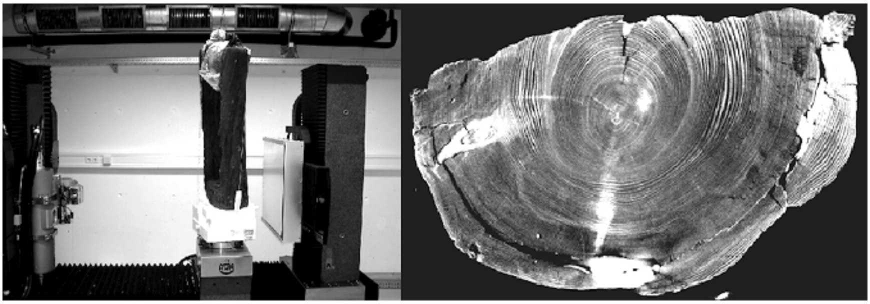
(*Blender 2.92 Reference Manual* n.d.)

The smooth blending of computational affordances with natural likeness that was already present in Luft's original statement promising "ivy that would grow by itself" in "your 3d world" (Luft 2007) is further naturalized in these simplified instructions. The slippage might possibly seem banal because computational vocabulary already naturalizes vegetal terms such as tree, root, branching, seeds, and so on to such an extent that the phrase "Select the object you want to grow ivy on" at first causes no alarm. It is common in modeling environments to blend descriptions of so-called bodies with those of their fleshy counterparts. This normalized dysphoria is considered a shortcut without harm, a blurring of worlds that does not signal any real confusion or doubt of what belongs to what. The use of "plant" when "so-called plant" would be more accurate, effectuates a double-sided holding in place, that ignores the worlding power of modeling so-called ivy in computation, and removes the possibility for these ivies to make a difference.

Non-computational ivy is a clear example of symbiogenesis,[8] meaning that it is materially, structurally, and behaviorally always already implicated in codependence with other structures, vegetal or not, straight or crooked, queer or dead. But the vegetal modeling in *Ivy Gen* takes another route. So-called plants are drawn from one single starting point that then is modulated according to different computed forces. Parameters allow users to modulate its primary direction of expansion (the weighted average of previous expansion directions), add a random influence, simulate an adhesion force towards other objects, add an up-vector imitating the phototropy of so-called plants, and finally simulate gravity. The desire and confidence by which this procedural system makes ivy "grow" itself is not innocent. Technically, *Ivy Gen* implements a Fibonacci sequence complexified by external forces that act as "deviators," and variation is the result of a numerical randomization applied after the fact. The Fibonacci sequence is a string of numbers that describes a spiral that mathematician Fibonacci coined as "golden proportions," and similar ratios can allegedly be found in biological settings such as: tree branching, the fruit sprouts of a pineapple, the flowering of an artichoke, an uncurling fern, and the arrangement of a pinecone's bracts. It became a pet project for nature lovers, math enthusiasts, and 3D-modelers who create an ongoing stream of more or less convincing computer programs and visualizations celebrating algorithmic botany or computational phyllotaxy, the botanical science of leaf arrangements on plant stems. The Fibonacci sequence is a mathematical construct that has just the right combination of scientific street cred, spiritual promise, and eloquent number wizardry to convincingly bring patterns in "nature" in direct relation to math and computation, confirming over and over again that aesthetics and symmetry are synonymous and that simple rules can have complex consequences. The obsession with computed leaf patterns reinforces the idea that dynamic systems are beautiful and predictable. In turn, these programs confirm how spiraling "plant" patterns are not just elegant but also inevitable. They can be decoded like computer software, and in the process computation becomes as stunning as nature itself (Burakoff 2019).

Like many other modeling set-ups for simulating biological life, *Ivy Gen* aligns 3D computation with phyllotaxy without any reservations. It constructs so-called plants as autonomous individuals through "expansion patterns," which are straight at the core. This is not surprising because the procedural conditionings of computation seem to make political fictions of life which provoke technocratic and scientific truths of so-called bodies easier to implement than others (Rocha and Snelting 2022b) whereas *Ivy Gen* reasserts a non-symbiogenetic understanding of evolution and ecology where growth is a deformation of the symmetrical, a deviation after the fact. Queer angles (see Glossary) can only arrive afterwards, and are always figured as disruption, however benign and supposedly in the interest of convincing realism. Luft clarifies that "the goal was not to provide a biological simulation of growing ivy but rather a simple approach to producing complex and convincing vegetation that adapts to an existing scene" (Luft 2007: n.p.). The apparent modesty of the statement confirms that even if the goal has not been to simulate non-computational ivy, the procedural system is seen as a "simplified" approach to actual biological growth patterns, rather than an approach that conceptually and politically differs from it. The point is not to correct *Ivy Gen* to apply other procedures, but to signal that the lack of problematization around that rote normalization is deeply problematic in and of itself.

Dendrochronologists study climate and atmospheric conditions during different periods based on tree-ring growth in wood.[9] This particular scientific way of relating to life has to be individual-centered in order to make trees emerge in their ideal form. Dendrochronology is based on seeing a tree as a perfect circle, assigned to each individual. All variations along that specimen's existence are just the result of modifications radiating outwards from the perfect mathematical zero point. Instead of departing from a complex environment full of forces interlaced in the midst of which a tree grows, dendrochronology reads the aberrations and deviations from the



Item 120 Simulated dendrochronology for demographics? Close-up of ring detection method on Red cedar (Makela et al. 2020). https://arxiv.org/abs/2010.08691 CC BY. **[Figure 5.6]**

geometrical circle as exceptional interventions deforming its concentric expansion, and by doing so time and time again reconfirms and projects the idealized geometry as the desired centered and balanced life-pattern for a tree. This approach confirms the understanding of the plant's growth as a predictable phenomenon (i.e., beautiful), which make it become a vector into the probable (i.e., extractive, exploitative ideology) and distances it from the surprise ontologies of the possible.

Pedro Cruz, John Wihbey, Avni Ghael, and Felipe Shibuya's project, *Simulated Dendrochronology of U.S. Immigration* (Cruz et al. 2018) takes dendrochronology as a visual reference to represent the development of US demographics by visualizing immigration as "natural growth." "The United States can be envisioned as a tree, with shapes and growing patterns influenced by immigration. The nation, the tree, is hundreds of years old, and its cells are made out of immigrants. As time passes, the cells are deposited in decennial rings that capture waves of immigration" (n.p.). The work won a prestigious design prize (*Information is Beautiful Awards* 2018) and seems to be read as a benevolent rendering of immigration as being "in the nature" of the United States. As some of their colleagues note, they make "immigration look positive, natural, and beneficial" (Cunningham 2019). But by visualizing immigration data as a severed tree, the infographic almost literally flattens the lively complexity of demographics: firstly, by essentializing the category of the nation state as formative of population evolution, and secondly, by accounting only for "entrances" and not "exits" (e.g., not accounting for deportations). Last but not least, *Simulated Dendrochronology of U.S. Immigration* imposes a mechanism of naturalization over the social behavior of immigration that is inextricably linked to economic, cultural, and political conditionings.

As an invasive volumetric method that studies growth with the help of cylindrical samples after very precise planar drilling, dendrochronology is also a story of how modern technosciences gaslight the borderline between existence and representation. In other words: the horizontal strata of tree rings present a specific complex and rich worlding, while the disciplinary study of them categorically imposes a view of what ought to be through the application of comparative and quantitative methods that foreground average behavior as well as the measuring of the distance of that specimen from an ideal representation of its species. How could dendrochronology inform on difference, instead of imposing ideals? How might it invite the probable and avoid forgiving comparisons of nation-state demographics as if they were "resembling a living organism" only subjected to climate inclemencies? The worrying benevolence in the data visualization work, trying to naturalize immigration via the greenwashing figuration of a tree trunk cut, alerts us to technocultural leaps. The equation of vegetal symmetry, straightness, and proportionality has "deep implicancies" that we discuss in the next section. The aesthetic and semiotic manipulation which benevolent data visualization accomplishes removes responsibility for the conditions that produce its necessity. The naturalization of the thick damage of migrating experiences in *Simulated Dendrochronology of U.S. Immigration* violently revalidates a world divided by borders and comprising states that kill. We simply cannot afford more deadly simplifications.

Cracks and Flourishings

In a conversation with Arjuna Neuman, Denise Fereira da Silva contrasts her use of the term "Deep Implicancy" with that of "entanglement": "The concept of Deep Implicancy is an attempt to move away from how separation informs the notion of entanglement. Quantum physicists have chosen the term entanglement precisely because their starting point is particles (that is, bodies), which are by definition separate in space" (Ferreira da Silva and Neumann 2019: 23). She insists that by paying attention to the relations between particles, their singularity as entities is reconfirmed. In the very matter of the notion, implicancy or "implicatedness" can be understood as circluding operation (Adamczak 2016) to the notion of entanglement, in the sense that it affirms a mutual constitution from scratch (Barad 2012). When attempting a disobedient action-research in volumetrics oriented towards so-called plants, we try to start from mutuality to understand at least three things. First, what are the cracks in the apparatus of contemporary 3D that is too often presented as seamless? Second, how and where can those cracks be found and signaled, named, and made traceable? Third, how can we provoke and experience a flourishing of volumetric computation otherwise, attentive to its implicancies and its potential to widen the possible? In "Vegetal Volumetrics," those surfaces that provide bridges for jumping from one unit of life to another are made tangible in *Item 033: This Obscure Side of Sweetness Is Waiting to Blossom*. *Item 102: Grassroot rotation* exposed the consequences of contrasting life and non-life all too graphically. These items call for different a-normative interfaces; ones whose settings would not already assume the usefulness or liveliness of one area over the uselessness and backgroundness of another. "Systemic Vegetation" brought two items together to ask how plants are made complicit with deadly operations. *Item 117: FOLDOUT* points at the urgency to resist the automation of separation to block the systematization of institutional violence. *Item 118: Agrarian Units and Topological Zoning* showed how staying with the volumetric traces, keeping memories of and paying attention to certain forms of life and the relationships between such formations might open up possibilities for coming to terms with the systemic alienation going on in plantations. The last section, "Lively Math," investigated the stifling mutual confirmation of math and so-called plants as "beautiful," "inevitable," and "true." *Item 119: Ivy Gen* proposes non-normative dysphoria to queer and hence declutch the worlding power of modeling that keeps both math and so-called plants in place. It is how *so-called* operates as a disclaimer, and thereby opens up possibility for the ivies to make a difference. *Item 120: Simulated dendrochronology for demographics?* points at the need for eccentric desired life-patterns. Once we accept the limits of representation, visualizations of decentralization, un-balancing, and crookedness might make space for complexity.

Nobody really believes that managing plantations through AI is beyond violence, that so-called plants can be generated, that fugitives should be separated from leaves in the wind. In our technocultures of critique it is not rare to share views such as "of course, those techniques are not neutral." Nevertheless, after studying the tricks and tips of volumetrics (from biomedicine, to mining, to sports, to court), we understood that once these complex worlds entangle with computation, the normalized assumptions of Cartesian optimization start to dominate and overrule. The cases we keep in *The Possible Bodies Inventory* are each rather banal, far from exceptional, even everyday. They show that volumetrics are embedded in mundane situations and, once folded into computation, concerns are easily dismissed. These cases show the monocultural power of the probable, as a seemingly non-violent regulator of that what is predictable and therefore proportional, reasonable, and efficient. The probable is an adjective turned into a noun, a world oriented by probabilistic vectors, in the socioeconomic sense of the "normal." We are committed to heightening sensibility about the actual violence of such normality, in order to consider variable forms of opening up cracks for computational cultures that flourish by and for other means. By keeping complexity close, the possible becomes doable.

Notes

1 Database-based cosmologies are modes of understanding and representation which are conformed by the material and imaginary constraints of fields, rows, and columns.

2 "There are no solutions; there is only the ongoing practice of being open and alive to each meeting, each intra-action, so that we might use our ability to respond, our responsibility, to help awaken, to breathe life into ever new possibilities for living justly" (Barad 2007b).

3 See for another discussion of Item 033 (Pritchard 2022).

4 "Representation raised to the nth power does not disrupt the geometry that holds object and subject at a distance as the very condition for knowledge's possibility" (Barad 2007a).

5 This perspective has been practiced with diverse sensibilities by authors as different as Zach Blas (*paranodal spaces*), Karen Barad ("What is the Measure of Nothingness?"), or Gloria Anzaldúa (*Nepantlas*).

6 "Circlusion is the antonym of penetration. What implications would it have, in naming, representing and performing switched-agency-practices, to push onto instead of pushing into?" (Ward 2022).

7 See diagram included in the second periodic project report for FOLDOUT on the Cordis EU Research results webpage ("Periodic Reporting for Period 2.")

8 *Symbiogenesis* is a term that Lynn Margulis uses to refer to the crucial role of symbiosis in major evolutionary innovations. It literally means "becoming by living together" (Margulis 1976).

9 "Tree-rings are easy to observe in the cross-section of most sawn tree trunks. Each ring is one of the many concentric bands surrounding the pith and all are more or less distinguishable from each other" ("Laboratory Procedures: Basic Dendrochronology Procedures of the Cornell Tree-Ring Laboratory" n.d.).

References

Adamczak, B. (2016), "On Circlusion," *Mask Magazine*. Available online: https://web.archive.org/web/20180811000134/http://maskmagazine.com/the-mommy-issue/sex/circlusion (accessed April 9, 2023).

Alga, L. (n.d.), “Postesotica.” Available online: http://postesotica.blogspot.com/ (accessed October 6, 2022).

Ballestero, A. (2019), “The Underground as Infrastructure? Water, Figure/Ground Reversals, and Dissolution in Sardinal,” in Kregg Hetherington (ed.), *Infrastructure, Environment, and Life in the Anthropocene*, 17–44, Durham, NC: Duke University Press.

Barad, K. (2007a), “Diffractions: Differences, Contingencies, and Entanglements that Matter,” in *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, 88, Durham, NC and London: Duke University Press.

Barad, K. (2007b), “Preface and Acknowledgements,” in *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, x, Durham, NC and London: Duke University Press.

Barad, K. (2012), “Visning af: Nature’s Queer Performativity*.” Available online: https://tidsskrift.dk/KKF/article/view/28067/24695 (accessed August 25, 2022).

Barret, P. (2017), “This Obscure Side of Sweetness Is Waiting to Blossom,” *TEMI Edition*, South Korea. Available online: http://www.pascalebarret.com/projects/this-obscure-side-of-sweetness-is-waiting-to-blossom/ (accessed April 9, 2023).

Bellacasa, M. P. (2017), *Matters of Care: Speculative Ethics in More than Human Worlds*, Minneapolis: University of Minnesota Press.

Blender 2.92 Reference Manual (n.d.). Available online: https://docs.blender.org/manual/en/latest/addons/add_curve/ivy_gen.html (accessed April 9, 2023).

Burakoff, M. (2019), “Decoding the Mathematical Secrets of Plants’ Stunning Leaf Patterns,” *Smithsonian Magazine*, June 6. Available online: https://www.smithsonianmag.com/science-nature/decoding-mathematical-secrets-plants-stunning-leaf-patterns-180972367/ (accessed August 25, 2022).

Chen, M. Y. (2012), “Following Mercurial Affect,” in *Animacies: Biopolitics, Racial Mattering, and Queer Affect*, 203, Durham, NC and London: Duke University Press.

Cruz, P., J. Wihbey, A. Ghael, and F. Shibuya (2018), “Simulated Dendrochronology of U.S. Immigration.” Available online: https://web.northeastern.edu/naturalizing-immigration-dataviz/ (accessed April 9, 2023).

Cunningham, R. (2019), “Is Information Beautiful?” Available online: https://fakeflamenco.com/2019/07/22/is-information-beautiful/ (accessed April 9, 2023).

Ferreira da Silva, D. and A. Neumann (2019), “4 Waters: Deep Implicancy,” *Images Festival*. Available online: http://archive.gallerytpw.ca/wp-content/uploads/2019/03/Arjuna-Denise-web-ready.pdf (accessed April 9, 2023).

“FOLDOUT: Through Foliage Detection in the Inner and Outermost Regions of the EU” (2019), Presentation flyer for the Mediterranean Security Event 2019. Available online: https://mse2019.kemea-research.gr/wp-content/uploads/2019/11/FOLDOUT_AKriechbaum.pdf (accessed April 9, 2023).

Fritsch, D. and M. Kada (2004), “Visualisation Using Game Engines,” *Archiwum ISPRS*, 35: B5.

Frontex Programme of Work (2013). Available online: https://www.statewatch.org/media/documents/observatories_files/frontex_observatory/Frontex%20Work%20Programme%202013.pdf (accessed April 9, 2023).

Gao, F., L. Fu, X. Zhang, Y. Majeed, R. Li, M. Karkee, and Q. Zhang (2020), “Multi-Class Fruit-on-Plant Detection for Apple in SNAP System Using Faster R-CNN,” *Computers and Electronics in Agriculture*, 176: 105634.

Gil-Fournier, A. (2018a), “Earth Constellations: Agrarian Units and the Topological Partition of Space,” *Media Theory*, 2(1): 333–51.

Gil-Fournier, A. (2018b), *Landscape Prediction: An Earthology of Moving Landforms*. Available online: https://abelardogfournier.org/works/earthology.html (accessed August 25, 2022).

Haraway, D. (1985), "A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s," *Socialist Review*, 80: 985.

Information is Beautiful Awards (2018). Available online: https://www.informationisbeautifulawards.com/showcase?action=index&award=2018&controller=showcase&page=1&pcategory=most-beautiful&type=awards (accessed April 9, 2023).

Molin, J. P., L. R. Amaral, and A. F. Colaço (2015), *Agricultura de precisão*, Sao Paulo: Oficina de textos.

Kapoor, R., A. Banerjee, G. Tsihrintzis, and N. Nandhakumar (1999), "UWB Radar Detection of Targets in Foliage Using Alpha-Stable Clutter Models," *IEEE Transactions on Aerospace and Electronic Systems*, 35(3): 819–34.

"Laboratory Procedures: Basic Dendrochronology Procedures of the Cornell Tree-Ring Laboratory" (n.d.), Cornell Tree-Ring Laboratory. Available online: https://dendro.cornell.edu/whatisdendro.php (accessed April 1, 2021).

Lange, E. and S. Hehl-Lange (2006), "Integrating 3D Visualisation in Landscape Design and Environmental Planning," *GAIA Ecological Perspectives for Science and Society*, 15(3): 195–9.

Luft, T. (2007), "An Ivy Generator." Available online: http://graphics.uni-konstanz.de/~luft/ivy_generator/ (accessed April 9, 2023).

Mairhofer, S. (2012), "RooTrak: Automated Recovery of Three-Dimensional Plant Root Architecture in Soil from X-Ray Microcomputed Tomography Images Using Visual Tracking," *Plant Physiology*, 158(2): 561–9.

Mairhofer, S. (2015), "Segmentation of a Tomato Root from Clay Loam Using RooTrak," *RooTrak 0.3.2*. Available online: https://sourceforge.net/projects/rootrak (accessed April 9, 2023).

Makela, K., T. Ophelders, M. Quigley, E. Munch, D. Chitwood, and A. Dowtin (2020), "Automatic Tree Ring Detection Using Jacobi Sets." *arXiv*. doi: 10.48550/ARXIV.2010.08691

Margulis, L. (1976), "Genetic and Evolutionary Consequences of Symbiosis," *Experimental Parasitology*, 39(2): 277–349.

Myers, N. (2017), "From the Anthropocene to the Planthroposcene: Designing Gardens for Plant/People Involution," *History and Anthropology*, 28(3): 297–301.

Paniagua, R. S.-M. (2012), *En nuestros jardines se preparan bosques*, León: MUSAC.

Papp, A., J. Pegoraro, D. Bauer, P. Taupe, C. Wiesmeyr, and A. Kriechbaum-Zabini (2020), "Automatic Annotation of Hyperspectral Images and Spectral Signal Classification of People and Vehicles in Areas of Dense Vegetation with Deep Learning," *Remote Sensing*, 12(13): 2111. doi: 10.3390/rs12132111

Pavithra, D. S. and M. S. Srinath (2014), "GSM Based Automatic Irrigation Control System for Efficient Use of Resources and Crop Planning by Using an Android Mobile," *IOSR Journal of Mechanical and Civil Engineering*, 11(4): 49–55. doi: 10.9790/1684-11414955

"Periodic Reporting for Period 2—FOLDOUT (Through-Foliage Detection, Including in the Outermost Regions of the EU)" (2021). Available online: https://cordis.europa.eu/project/id/787021/reporting (accessed December 6, 2021).

Possible Bodies (2017), "Item 074: The Continuum," *Possible Bodies.* Available online: https://possiblebodies.constantvzw.org/inventory/?074 (accessed April 9, 2023).

Possible Bodies (2020), "Item 122: So-Called Plants. Performance at Nepantlas #3," Curated by Daphne Dragona at Akademie Schloss Solitude. Available online: https://www.akademie-solitude.de/en/event/nepantlas-03/ (accessed April 9, 2023).

Possible Bodies (2022), *The Possible Bodies Inventory*. Available online: https://possiblebodies.constantvzw.org/inventory (accessed April 9, 2023).

Pritchard, H. V. (2022), "Clumsy Volumetrics," in Possible Bodies (ed.), *Volumetric Regimes: Material Cultures of Quantified Presence*, 161–71, London: Open Humanities Press.

Rocha, J. and F. Snelting (2022a), "Disorientation and its Aftermath," in Possible Bodies (ed.), *Volumetric Regimes: Material Cultures of Quantified Presence*, 58–73, London: Open Humanities Press.

Rocha, J. and F. Snelting (2022b), "Invasive Imaginations and its Agential Cuts," in Possible Bodies (ed.), *Volumetric Regimes: Material Cultures of Quantified Presence*, 79–101, London: Open Humanities Press.

Rocha, J. and F. Snelting (2022c), "The Industrial Continuum of 3D," London: Open Humanities Press.

"Sawyer Seminar: Interrogating the Plantationocene" (2019). Available online: https://humanities.wisc.edu/research/plantationocene (accessed April 9, 2023).

Stengers, I. (2005), "Introductory Notes on an Ecology of Practices," *Cultural Studies Review*, 11(1): 183–96.

Tsing, A. L. (2015), "Some Problems with Scale," in *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*, 37–44, Princeton, NJ: Princeton University Press.

Ward, K. feat. Possible Bodies (2022), "Circluding," in Possible Bodies (ed.), *Volumetric Regimes: Material Cultures of Quantified Presence*, 187–90, London: Open Humanities Press.

Part Two

Plants—Resistance, Regeneration, and Alliance

The following chapters call for alliances with plants, forests, and agroecologies in modes of solidarity and reciprocity. In her chapter, "Forests that Compute," Gabrys extends our understanding of computing to suggest that forests have always been computers, while also asking how forests vegetalize technology (see Glossary). Gabrys opens an imaginary of computers to propose that, together with vegetal computing fellows, we might challenge the logic of optimization and connect to "communities of ecological flourishing."

In "Watered by Data and Other Bio-Economic Thoughts," the artist Stephanie Rothenberg discusses her relatable installations, and the fiscal intra-actions that underpin them, through an interview with curator Belinda Kwan. Rothenberg's works are created using citizen science-style data viz and biological circuits made of quotidian objects populated with living plants. She refers to evolutionary biology and "biological market theory"; a methodology used to analyze nonhuman life through market analogies. Each of Rothenberg's works is an ecological model that explores the subversive agency of nonhuman actors in contemporary financial models and community gardening projects in the US and France.

Community gardening differently underpins "Tending to 2030 m^3: How to Regenerate Regeneration? How to Unasphalt Asphalt?" This chapter grew from a day-long collaborative workshop held in Växjö, Sweden, for the municipality's earth week series of events in March 2022 and is co-authored by Helen V. Pritchard, Miranda Moss, Daniel Gustafsson, and Eric Snodgrass. Communities gathered together to experiment with the tools of regenerative farming, carpentry, DIY electronics, soil science, and further materials in order to collectively address how a parking lot might be remade into a regenerative space for community agriculture and cultivation.

In their chapter, "Decolonization, Computation, Propagation: Phyto-Human Alliances in the Pathways towards Generative Justice," Ron Eglash, Audrey Bennett, Lionel Robert Jr., Kwame Robinson, Matthew Garvin, and Mark Guzdial describe the network effects of industrial plantations that are integral to many global threats and pressures that create current social and environmental disasters such as global warming, wealth inequality, racism, misogyny, and war. While it seems foolish to think that something as small and fragile as a plant could oppose them, their chapter shows how, by guiding technological innovation through the principles and practices of decolonial computing, phyto-human alliances can reverse the trend towards extraction that produces so many of the social ills listed above.

6

Forests that Compute

Jennifer Gabrys

Computers now seem to reside almost exclusively within the confines of electronics. Composed of silicon and circuitry, metals and plastics, computing takes the form of mobile devices and sensor networks, smart appliances and corporate clouds. These processing devices are dominant logic engines, informing calculative relations and operations. However, as many researchers and practitioners have demonstrated, computing can materialize in a wide range of materials and relations. Abacuses and stone formations, forests and ponds, waves and canyons: these are entities that "constitute a mark that makes a distinction" (Blohm et al. 1987: 15). Distinction typically unfolds through inputs transformed into outputs, in the prevailing von Neumann computing architecture. Yet analogue and biological computing can describe organismal processes, not just as inputs contributing to outputs but also as transformations that extend through and rework space and time. For instance, vegetal operators within forests sense their environments, take decisions about stimuli, signal states of operation, mitigate environmental conditions, and transform surroundings. In this sense, forests perform computational functions. Yet they do this in complex and extended communities over vast stretches of time. In so doing, they rework the scope of what computation is and how it could operate in and on the world. When plants and other organisms assemble into ecosystems such as forests, the complexity and range of computational processes multiplies further.

This chapter examines two instances of plant-computational operations: the first, an account of how forests are transforming into highly digital and "smart" environments through the increasing use of electronics-based technologies that span from embedded sensors to Lidar, robots, and drones; and the second, a reconsideration of the usual diagram of smart forests through a discussion of how analogue and biological computing rework what a computer is or might be beyond electronic circuitry and silicon chips. I consider processes of computing forests and forests that compute by looking at the proliferation of digital technologies that monitor and manage forests while also asking how forests *vegetalize* technology (see Glossary). In other words, the relations and processing that forests and plants perform also vegetalize technologies. In drawing together these instances of plant-computational operations, the chapter broadly considers the diverging and converging processes of digital computing, biological computing, and environmental analogue computing. By extending an understanding of computation as material expression of logic and relation, this chapter contributes to an analysis of pluralistic and vegetal modes of processing.

Computing Forests

Let us travel into the forest to find out more about the flux and transformation of these sensory environments under the sway of the digital. A common way that forests can be encountered is as a thick green expanse where trees and thickets of shrubs, ground layers of ferns and moss gather into a dense surround of vegetation. The occasional animal, bird, or invertebrate might break through an otherwise quiet setting, depending upon the location and diversity of the forest environment. Yet this depiction of the forest as a green and often distant land can be multiply unsettled. Forests are not self-evident entities—they can be composed through scientific measurements and classifications, policy objectives, resource practices, and cosmologies. Forests are as often living spaces where people sustain themselves in relation to many other forest dwellers—human and nonhuman. They are less a remote retreat and more an extended inhabitation. Moreover, forests are composed not just of woody and vegetal strata but also of digital infrastructures that observe, manage, and constitute these spaces in response to the demands of the planetary crises of environmental change. The still and green landscape that would seem to be a place apart—and a zone of unmediated connection—is then necessarily remade when considering these pluralistic re-compositions of forests.

The question of how forests materialize is an important consideration, since they are now in the spotlight as key ecosystems for addressing environmental change. They are undergoing destruction worldwide due to deforestation and climate change. As time-lapse images of deforestation in the Amazon frequently indicate, forests are increasingly being carved up due to often illegal burning for expanded agriculture; extraction of materials for commodities; clear-cutting for forestry; as well as climate change, which can increase diseases and pests while exacerbating drought, making for less robust forest conditions. Given the urgency of addressing environmental change, policymakers, scientists, and communities have identified forests as important spaces to conserve and cultivate. Meeting climate targets requires both halting deforestation and contributing to practices of mass-scale reforestation and restoration. It goes without saying that forests are key environments for preserving biodiversity, absorbing carbon dioxide, filtering and providing water, and enabling livelihoods and much more for multiple forest-dwelling people around the world.

Forests are diminishing, environments are changing, and climates are warming. In response to these challenges, as well as in recognition of the need to protect forests to help address environmental change, forest practices are emerging together with environmental policies and sustainable development goals that attempt to conserve forests as carbon sinks, and to sustain and cultivate forests as green infrastructure. Smart digital technologies are now materializing as key devices to track, manage, conserve, and expand forest environments. Environmental changes become perceptible through digital infrastructures that are mapping, monitoring, and managing forests. Indeed, forest practices are informed and unfold through digital technologies that not only observe and constitute but also govern and act on forest conditions. The digital infrastructures whereby environmental change becomes evident span from remote sensing and Lidar to sensor networks and camera traps, as well as participatory observations of environmental change experienced by forest dwellers. Such forest technologies are digital media devices, networks, and infrastructures. They can be in outer-earth orbits, or installed on tree trunks and embedded in forest soil. Images of deforestation in the Amazon are remotely sensed from satellites that detect and compose forests through aerial views and changing patterns over time. In sensor installations in Canadian forests, researchers recount their ability to see forests "breathe" in real time, so extensive is the instrumentation and immediate is the data this generates (Schaeffer 2014).

Digitalization generates distinct practices and ontologies for addressing changing forests. And yet, digital technologies can also surface forest experiences through different and unexpected registers, as the WaterViz example from the Smart Forests network in the US Forest Service suggests. This project takes environmental data about a stream and sonifies it so that listeners can interpret more quantitative environmental data through other acoustic registers of sensing. Listeners begin to understand not just a sonification of data but also how forest entities such as waterways are computing changing river temperature, salinity, and chemical composition. In this way, forests are an analogue computer and medium through which detection and analysis take place. Testing the soundness of wood, for instance, is a practice that requires arrangements of technical devices, trees, milieus, and sensing actors that tune in to the computational processes of forests. The computational medium includes trees along with their accumulated environmental processes, as they are the sonifying instruments. On the one hand, forests are not usually discussed as technological spaces, or indeed, as computers; on the other hand, there is hardly anything that is not referred to as a technology or medium. While sonifying practices are just one example of how this occurs, I want to turn now to consider a more elaborate and extensive example of this merging, blurring, and remaking of forests and computation through a consideration of how the forest computes. Here, the digitalization of forests gives way to the vegetalization of technology.

Vegetalizing Technology

When listening to patterns within wood, or sonifying forest data, what becomes apparent is how multiple entities are involved in processes of analogue computing. The "wood wide web" (Simard 2021) that has become a popular reference for describing mycorrhizal networks of tree roots, fungi, and soil forming communication pathways could be understood less as a metaphor and more as a description of how computational processes of sensing, actuating, and transforming take place in more than silicon chips and electronic circuits. In a similar way, environmental sensors are often thought of as analogue or digital instruments for measuring pollution or other environmental disturbances. However, sentinel organisms, from plants to marine life, also sense environments and respond to changes in their surroundings (Gabrys 2016). Organisms might be monitored through digital environmental sensors. But at the same time, organismal sensors inform the detection, operations, and actions of digital sensors. Tree rings might be the most obvious way of understanding how a vegetal organism calculates, but such processes are distributed throughout and materialized within forest environments. In the forest that computes, technology is vegetalized: it is recast by attending to the responses and inferences that are already unfolding through multiple entities.

Rather than designate computation as a singular or unitary mode of technology, here computational processes occur beyond a dominating and representational approach to "nature" to instead tune in to the performative potential of entities as they express computational relations (cf. Pickering 2010). Biological computing proposals within the work of Stafford Beer—a British cybernetician who worked extensively on organizational systems—go so far as to imagine a factory that could tap into the complex interactions of a pond to regulate its own assemblage. An industry could be trained in relation to an "organic assemblage" such as a pond (or forest) that would inform the "dynamic equilibrium" of a factory. In the multi-directional feedback and adjustments across management, factory, and ponds, a negotiated homeostasis could then materialize (ibid.; Beer 1962). This proposal forms a diagram of logic and action where ponds and factories co-constitute each other by mutually training their processes in response to one other, as relations of reciprocal action. Rather than one entity serving as the training dataset for a processing and control system, as is commonly described in machine learning, here training is imagined as reciprocity and response, where continual adjustments are made based on the conditions of pond, factory, or other environmental system. Yet the inputs are still selected in such a way as to inform what the processing and organizational capabilities of these systems might be.

Here are biological, chemical, analogue, environmental, and other computers surfacing as performative inputs, outputs, interactions, and transformations that could mobilize the regulatory and computational interactions of other aligned and intersecting systems. A garden pond could even be a site of more complex intelligence materializing interactions and dynamic equilibrium, which a human-manager would not be able to replicate. If systems are self-organizing, they are seen within the logic of Beer (as well as his interlocutor, Gordon Pask) to offer another way of organizing and understanding computers as "logic machines" (Blohm, Beer, and Suzuki 1987). The logic of systems adapting to environmental perturbations materializes within entities such as forests, and can in turn form a dynamic dataset that guides the control and governance of related or intersecting systems.

In these alternate approaches to computing vis-à-vis biological, environmental, and analogue systems and processes, different modalities of "intelligence" surface that are less oriented toward cognitive processing undertaken by a discrete organ of gray matter, and more indicative of detection, response, relations, activation, transformation, and adaptation. Such expanded approaches to intelligence can be found not just in cybernetics and early proposals for biological computing, but also in process philosophy, plant science, and feminist, postcolonial, and Indigenous technoscience. Indigenous futurist filmmaker Nanobah Becker shows in *The 6th World* (2012) how a Navajo scientist and astronaut traveling to Mars must tune in to the space-time bending operations of corn, both as ancestral storage system and instructions for how to travel with vegetal journey fellows. An inability to work within or attend to the vegetal trajectories of corn computers can in turn jeopardize extra-planetary and extra-temporal inhabitations.

Forests can be digitalized and monitored for their processes and changes, with regulation and interventions adopted in response. Yet forests are not just computed, they also perform as computers: processing environmental inputs, transforming these into outputs, bioindicating results, bending and remixing the inheritances of space-time, and enabling or reworking environments and environmental inhabitations. Forests that compute and technologies that are vegetalized could then point to ways of "computing otherwise" (Pritchard 2018) by surfacing the actions, relations, and reciprocal adjustments that generate and inform these other modalities of computers and computing. On the one hand, the computational remaking of forests into smart entities poses significant questions about the social-political impacts of these reconfigurations. On the other hand, the composition and processing of computing can be opened into other operations and relations that incorporate and yet exceed the presentist and mechanical arrangements of inputs and outputs.

In a similar way, the *Phyto-sensor Toolkit* (see Glossary) developed by the Citizen Sense project indicates how electronic sensors can be deployed to study air quality. Yet alongside these devices plants can also act as another sort of environmental sensor that indicates air pollution levels while absorbing particles and gases, transforming pollutants through leaves and roots, remaking air and surrounding milieus, and creating relationships with other organisms and entities that can sustain and transform environments (Gabrys 2022). Plants and forests as computers do not necessarily signal changes in environments as an electronic sensor might, with a relatively immediate reading on an LED, for instance. Instead, parallel environmental relationships and changes materialize over time. Computation in this sense is less a system of real-time alerts and more a dynamic interplay of relations. Indeed, some scenarios even propose to merge these different forms of computing so that electronic computers might monitor and learn from organismal computers, creating not one but multiple types of intelligent environments that combine digital and analogue, biological and electronic, immediate and extended, centralized and distributed processes.

Figure 6.1 Cover of *Phyto-Sensor Toolkit* for making air-quality gardens and monitoring air quality with vegetation (Citizen Sense 2018). Image courtesy of the author. CC4r.

Figure 6.2 *Dustbox 1.0*, a digital sensor for monitoring particulate matter, installed as part of the *Phyto-Sensor Toolkit* (Citizen Sense 2018). Image courtesy of the author. CC4r.

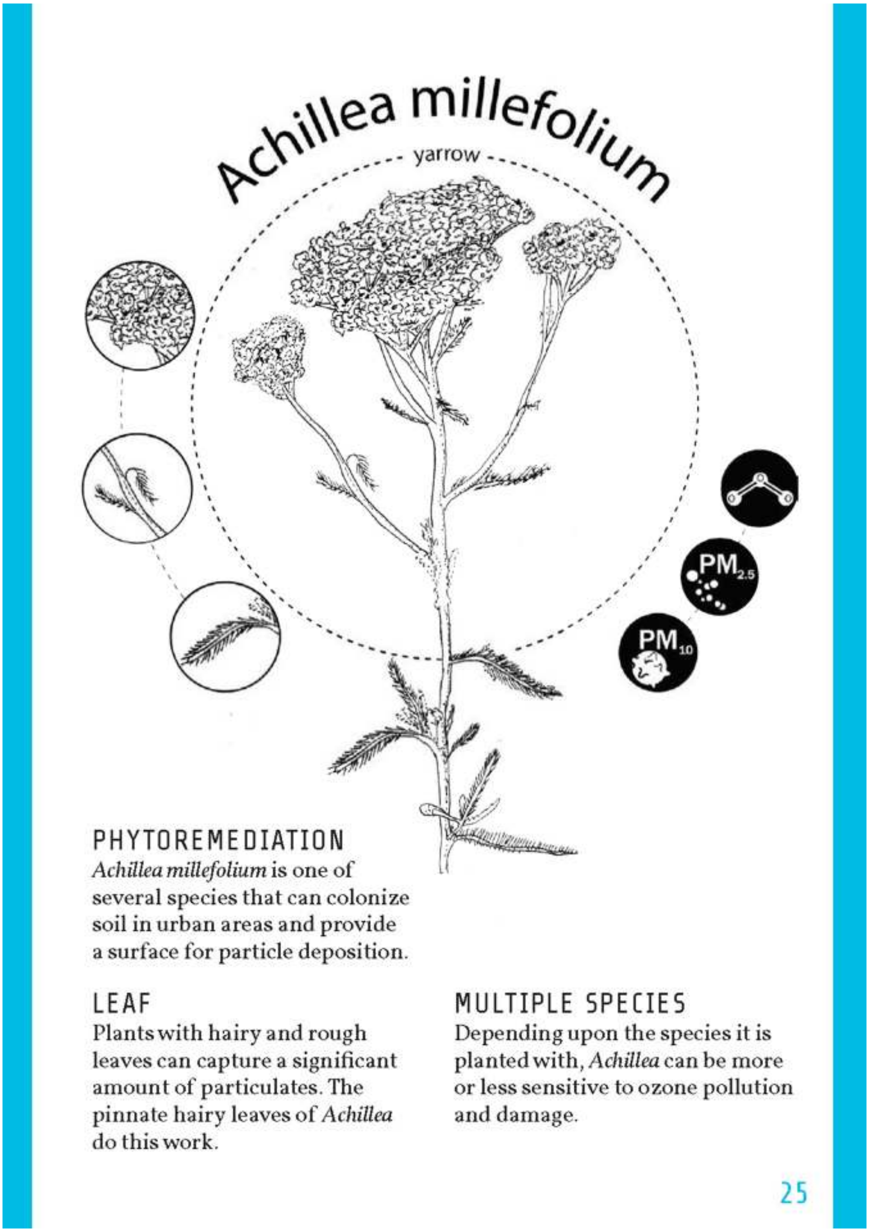


Figure 6.3 *Achillea millefolium*, a plant for phyto-sensing and remediating air and soil. Included in the *Phyto-Sensor Toolkit* (Citizen Sense 2018). Jennifer Gabrys of Citizen Sense and Smart Forests, CC4r.

Unconventional Computing

While the speculative proposals of cyberneticians did not at that time manifest as fully operational biological computers, and ponds were not deployed to ensure the homeostasis of industry, there are now multiple projects underway that engage in practices of "unconventional computing." Fungal computers are now being prototyped that mobilize mycelium networks to join up electrical activity, activate fruits as interfaces, and perform information transfer through fungal networks (Adamatzky 2018). And yet, one could say that computing has always been unconventional, if by this term is meant the materialization of sensing, analysis, actuating, and transformation, whether in silicon chips or slime mold. Indeed, "nontraditional hardware" ranging from frying pans to paperweights are now serving as central processors for neural networks (Hutson 2022). Researchers working in this area suggest that computation extends to all entities (Wright et al. 2022). Yet as this chapter suggests, computation is not a singular process, and the entities involved in computing inevitably inform the decisions, actions, and relations that materialize through these operations. This is the requirement to vegetalize—or indeed, fungalize—computation.

At the same time, and to return to smart forests and forests that compute, the entities that are understood to be computing are often differently constituted depending upon the computational scenarios in which they participate. Stafford Beer's pond will have been designated as a particular type of entity, bounded and operationalized so as to fit within an extended diagram of computation that includes industry and human managers. The objectives of computation can also skew toward diverging and destructive projects. Beer suggests that with ponds and factories co-constituting and regulating each other, human managers could be freed up for more important pursuits such as eugenics (Pickering 2010: 225). The governing logics that humans ascribe to machines then extend not just to regulating factory outputs but also to human populations. The optimization of one system here leads to ever more dire ambitions to optimize others. Computing with a pond does not, in this sense, lead to more just or equitable conditions. Instead, it naturalizes discriminatory logics of efficiency and extermination that certain humans program into the governing logic of extended computation (cf. Benjamin 2019). Indeed, this is a prevailing theme within AI scenarios that come to the conclusion that if AI were truly intelligent then it would inevitably want to rid the earth of humans. Such a planet-as-computer would eliminate humans as an inefficient and damaging glitch in the system. This would be the logical outcome of AI's self-optimizing executing practices (Lovelock 2019).

Computation as a process of regulating toward a seemingly optimal state (whether homeostasis or racial purity) is a pervasive script that projects of computing otherwise seek to disrupt and challenge. As Helen Pritchard (2018) notes in her discussion of "critters on a chip," other modes of existence can surface beyond the commoditized exploitation of computational organisms caught within a circuit of capital. This involves attending to exhaustion, damage, indeterminacy, and unpredictability. Such practices and modes of existence rupture the possibility of a closed loop, homeostatic order, or optimal outcome, to instead point toward the differential transformations in which computing and computational entities participate. In such an approach, a tree, pebble, forest, or planet operate as computers that challenge the logic of optimization, signal toward extended registers of space-time, and connect up and out to communities of ecological flourishing.

Other and possibly more pluralistic practices of computing emerge here. This is not a singular computation toward certain regulatory outcomes, but rather involves different modes of taking account, sensing and actuating, relating and non-relating, connecting and transforming. A smart forest, in this logic, monitors an ecosystem-entity (however diversely defined) undergoing environmental change. It is a descriptive project that as often as not is mobilized toward optimizing forest functions in a time of planetary catastrophe. Yet a forest that computes indicates how it decides to observe and manifest events and relations according to different "logics." These operations and changing registers of experience transform what a forest—and computer—could even be. A forest or a plant does not then simply become an interface for electrical activity or neural networks or training data. It instead becomes a proposition for reworking the parameters and purposes of computation. This is a way to vegetalize technology by tuning in to the forest that computes.

Figure 6.4 Fieldwork in Epping Forest, London, while testing digital sensors to monitor forest spaces (Smart Forests, 2021). Jennifer Gabrys of Citizen Sense and Smart Forests. CC4r.

Acknowledgments

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 866006).

References

Adamatzky, A. (2018), "Towards Fungal Computer," *Interface Focus*, 8(6): 20180029.

Beer, S. (1962), "Towards the Automatic Factory," in H. von Foerster and G. W. Zopf (eds.), *Principles of Self Organization*, 25–89, New York: Pergamon.

Benjamin, R. (2019), *Race after Technology: Abolitionist Tools for the New Jim Code*, Cambridge: Polity.

Blohm, H., S. Beer, and D. Suzuki (1987), *Pebbles to Computers: The Thread*, Oxford: Oxford University Press.

Citizen Sense (2018), *Phyto-sensor Toolkit*. Available online: https://phyto-sensor-toolkit.citizensense.net (accessed February 1, 2022).

Gabrys, J. (2016), *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet*, Minneapolis: University of Minnesota Press.

Gabrys, J. (2022), "Multiple Citizens: How to Cultivate Relations," *Citizens of Worlds: Open-Air Toolkits for Environmental Struggle*, Minneapolis: University of Minnesota Press. Available online: https://manifold.umn.edu/read/chapter-4-multiple-citizens-how-to-cultivate-relations/section/6d7ffd4c-86bf-4f7f-b9c0-d484d8ed303b (accessed February 1, 2022).

Hutson, M. (2022), "Everyday Objects Can Run Artificial Intelligence Programs," *Science*, January 26. doi: 10.1126/science.ada0599

Lovelock, J. (2019), *Novacene*, Cambridge, MA: MIT Press.

Pickering, A. (2010), *The Cybernetic Brain*, Chicago: University of Chicago Press.

Pritchard, H. (2018), "Critter Compiler," in H. Pritchard, E. Snodgrass and M. Tyżlik-Carver (eds.), *Executing Practices*, 261–77, London: Open Humanities Press, DATA browser book series 06. Available online: http://www.openhumanitiespress.org/books/titles/executing-practices (accessed April 7, 2023).

Schaeffer, J. (2014), "Sensors, Big Data Analytics Propel Environmental Monitoring," *A Smarter Planet Blog (IBM)*. Available online: https://web.archive.org/web/20141124043204/https://asmarterplanet.com/blog/2014/11/big-data-environment.html (accessed February 1, 2022).

Simard, S. (2021), *Finding the Mother Tree: Uncovering the Wisdom and Intelligence of the Forest*, New York: Allen Lane, Penguin Books.

Smart Forests. Available online: https://smartforests.net.

The 6th World (2012), [Film] Dir. Nanobah Becker, USA/Navajoland: ITVS FUTURESTATES. Available online: https://vimeo.com/256611676 (accessed February 1, 2022).

WaterViz. Available online: https://www.waterviz.org.

Wright, L. G., T. Onodera, M. M. Stein, T. Wang, D. T. Schachter, Z. Hu, and P. L. McMahon (2022), "Deep Physical Neural Networks Trained with Backpropagation," *Nature*, 601: 549–55. doi: 10.1038/s41586-021-04223-6.

7

Watered by Data and Other Bio-Economic Thoughts: A Conversation between Curator Belinda Kwan and Artist Stephanie Rothenberg

Belinda Kwan and Stephanie Rothenberg

In Stephanie Rothenberg's ecological models and contemporary art installations, chloroplasts have a thirst for philanthropic data; direct investments are powered by the electrolytes of a rotting lemon; *rhizopus stolonifer* spores strain to explain the idea of debt through fungal colonization; micro-green gardens are dependent on the global politics of micro-lending and computer numerical control. As bizarre as these cyber/eco/financial dynamics may be, the components of Rothenberg's installations are familiar and relatable to the everyday person. *Bio-Economic Fairy Tales* explores the subversive agency of nonhuman actors in contemporary financial models using crowd-science-style data viz and biological circuits made of quotidian objects. *Garden of Virtual Kinship* takes the everyday act of gardening and uses it to demonstrate the unsustainability of charitable micro-lending. *Planthropy* taps into the language of self-satisfying tweets about philanthropy and brings them into an interdependent relationship with a few houseplants. These ironic, worldbuilding gestures result in complex but accessible, fictive but candid allegories about neoliberalism and its promises for a better social economy.

In this long-distance interview with curator Belinda Kwan, Rothenberg discusses her recent works and new research regarding the metabolic implications of fiscal crisis; the economics of plant cybernetics; and how liveness differs between organisms, data, and physical infrastructure. Between their differences in generation and place, the conversation traces points of development, open inquiry, and tension in techno/eco/feminist practice and its beef with conventional economics.

BK: In *The Production of Money* (2018), Ann Pettifor notes how the infinite logics of financial mathematics are irreconcilable with the finite logics of earthly life, which are subject to decay and scarcity. She quotes the English radiochemist, Prof. Frederick Soddy, who wrote:

> Debts are subject to the laws of mathematics rather than physics. Unlike wealth which is subject to the laws of thermodynamics, debts do not rot with old age and

> are not consumed in the process of living … on the contrary [debts] grow at so much per cent per annum, by the well-known mathematical laws of simple and compound interest … which leads to infinity … a mathematical not a physical quantity.
>
> (Soddy qtd. in Pettifor 2018: 45)

I think Pettifor and Soddy's points bring great context to a work like *Planthropy* (Rothenberg 2015b), which hybridizes planthood and the idea of global, networked philanthropy to signify a kind of pointed absurdity—one that notes how capitalism and its monetary forms have contributed so much to the destruction of plant-based ecology, at the same time that botanical and ecological metaphors and endeavors serve as frequent motivators for philanthropy and charity work.

In *Planthropy*, a collection of hanging plants each representing a major social cause such as hunger, climate change, breast cancer, etc., hang throughout the gallery as seen in Figure 7.1 and in Plates 14 and 15. Each plant has an automated watering system that correlates to a Twitter hashtag. Whenever someone tweets using the hashtag, plants receive water from IV bags. The tweet also activates text to speech voices explaining why people donate to the cause. The statements, ranging from the banal to the idiosyncratic, create a cacophony of voices as tweets are continually made.

Figure 7.1 Images from the artwork *Planthropy*, 2016, featured in the exhibition *Right Here, Right Now* at The Lowry Galleries, Manchester, UK. Image photo credit: David Lake. CC4r.

There is also a valuable conversation to be had about how the rhizomatic has been separated from its botanical roots and applied to thinking around networks. In botany and dendrology, a rhizome is a modified subterranean plant stem that sends out roots and shoots from its nodes. Rhizomes develop from axillary buds and grow horizontally in multiple directions simultaneously. This kind of plant system has been repurposed for topological and graph-like thinking that abstracts the plant and cuts out the more organic aspects of what allows these botanical systems to continue growing.

I am interested in what brought you to your botanical-mathematical practice—given this prior context, and the disciplinary separation between the botanical, mathematical, financial, and computational.

SR: I have always been interested in the recursive tension and dialectic between the physical/terrestrial and the virtual space of the screen. Prior to working with plants, I focused on new forms of digital labor and the physical bodies that produced virtual gains. I can't quite recall how the shift to plants happened except that I had returned to New Mexico after many years and it was incredibly inspiring to be back in that landscape. I wanted to revive my relationship with the earth and I wanted to garden. But not having a green thumb, I made a robotic one instead! I started reading about evolutionary biology and what is known as biological market theory: a methodology proposed by behavioral ecologists Ronald Noë and Peter Hammerstein for analyzing nonhuman life through analogies of the market (Noë and Hammerstein 1994). For example, the ecologists equated a simple commodity exchange to nonhuman acts of mutualism, symbiosis, and scarcity. Early cybernetics influenced theories of resilience that were initially linked to natural ecosystems and have been more recently coopted by finance. There are some very interesting artworks that look at the botanical in relation to the computational and financial and the excess produced. Gilberto Esparza's *Nomad Plant* (Esparza 2013) is a bio-robotic species that lives off environmental waste. This plant vehicle that is part organism and part robot roams polluted urban landscapes, metabolizing toxins into usable energy which enables it to survive. It is an artwork about symbiosis, rendering visible an ecosystem that moves between human excess incurred through production and remediation enacted by the nonhuman world of micro-organisms.

There has been a long history of biopolitical interaction between economics and biology beginning with Thomas Malthus and Charles Darwin. Malthus's seminal text on population control, written in the late 1700s (Malthus 1798), was well known to Darwin as he developed his theory of natural selection (Darwin 1859). It is highly debated how much Malthus actually influenced Darwin's research and what Darwin was already aware of in terms of biological reproduction and survival within the limitations of the food supply. Malthus viewed ideas of human survival through the lens of economics and supply and demand whereas Darwin viewed biological survival through the strength and what he termed "fitness" of an organism's traits in specific environmental conditions. The exchange of ideas and research between a social economist, Malthus, and a biologist, Darwin, during this time period connected the disciplines—sometimes to positive ends but, unfortunately, his ideas were also negatively interpreted as evidenced by Social Darwinism and Eugenics.

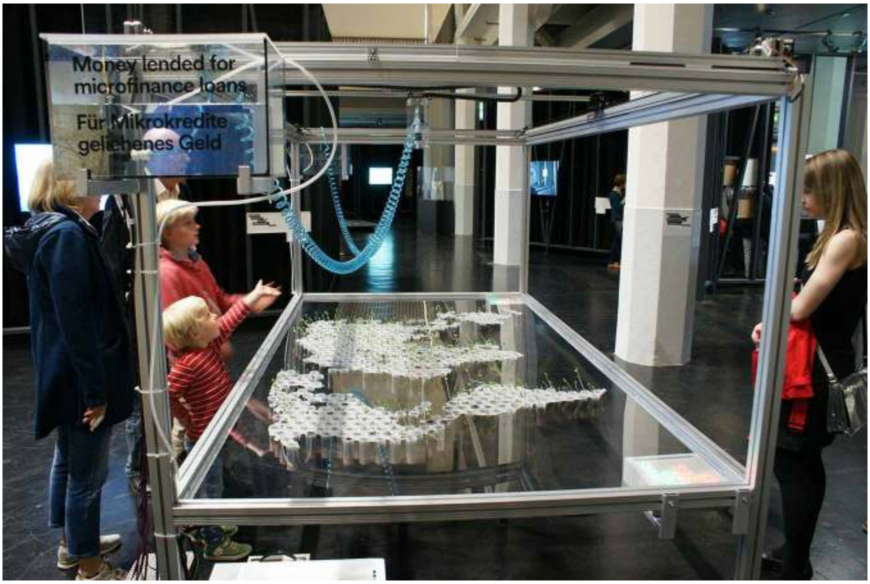


Figure 7.2 Images from the artwork *Garden of Virtual Kinship*, 2015, featured in the exhibition *Globale: Infosphere*, ZKM Center for Art & Media, Karlsruhe, Germany. Image photo credit: Stephanie Rothenberg. CC4r.

In earlier digital labor projects, I was interested in the circulation of labor through the network, enabled by physical, terrestrial bodies. For example, in the large robotic garden, *Garden of Virtual Kinship* (Rothenberg 2015a) as seen in Figure 7.2 and Plates 17, 18, and 19, I became interested in the larger geopolitical framework and its representation, as the bodies now become data points, and their livelihood depends on how the network feeds them via water. This network was mapped to the rhythms of a new emerging online global micro-finance economy created through the rise of crowdfunding platforms in conjunction with humanitarian and development efforts. The artwork examined the relationship between lenders in more affluent Western countries and very low-income borrowers in economically challenged regions located around the world. In the physical installation, borrowers were represented by tiny plants situated in containers that formed an image of a world map. Each time a real-time transaction was performed between a lender-borrower, a plant in a specific geographic location would receive water. I started working with living media because I felt that, as we moved further into a networked society, using living media such as plants and micro-organisms would create a more dynamic underscoring of how virtual and terrestrial interfaces shape and determine our behavior, actions, and sentiments. In this case, the impact of economic growth on human life.

I'm always interested in the underlying mechanisms, technological, political, economic, that move between the ideological and the material and the way they impact each other. *Garden of Virtual Kinship* visually represents the many logics of micro-lending and micro-finance and reveals the tension between these logics. There is the logic of the larger system of global micro-finance in which capitalist accumulation creates a new demographic of debtors. These are the millions of extremely poor people who previously lived on subsistence systems (small-scale farming, foraging, local trade, etc.) and are now given access to bank credit. On a micro-level there is the actual impact of each individual who is now in debt because they have not had the opportunity to gain the financial literacy necessary to effectively use this money. These people don't benefit from this larger system and end up in dire circumstances, owing more money than they borrowed due to lack of financial education and the huge fees and interest the micro-finance industry charges them for these very small loans. The project makes visible the apparatus of capitalism that creates new ideologies in order to justify exploitative accumulation.

BK: I'm trying to read Marx's *Capital* (Marx 1996) cover to cover right now, and in one of his prefaces he mentions how the social sciences can't be studied in a contained environment, *in vitro*, so to speak, like the other sciences, so we have to rely on abstraction to come up with concepts that systematize what we're thinking about. We can think about this kind of abstraction in the context of data visualization, which is a major way to visualize the macro-scale proportions of global capitalism. In pursuing that kind of abstraction, something gets lost … the data can become distant and difficult to empathize or connect with.

SR: People have become accustomed to thinking about data visualization as abstractions and data bits/points as representations so much so that the actual human condition that the data is representing often gets lost. I think it was somewhat shocking for people to see living things as data in the robotic garden installation *Garden of Virtual Kinship*. Ironic because most data are derived from living systems.

BK: Your work makes it clear that the sensory and tactile add a new dimension to data presentation. I think a lot about what art critic Dan Adler (Adler 2018) says about spectacular scale versus human-scale artworks—that in many ways, taking the macro-scale and scaling it down to something more intimate, allows more meaningful engagement with an audience. But I think both types of aesthetic attraction or rhetoric are at play in your work here. The spectacular but also the intimate. In *Garden of Virtual Kinship* (Plates 17–19) there's macro-scale spectacle in the overall data visualization, but also an intimacy with the small plant shoots. I would argue that this results in a stronger approach than one exclusively concerned with the intimate. While it's true that artworks are made for a human audience, it's also important that we understand how much our impact extends beyond us. The human scale, on a one-to-one basis, is micro-scale compared to the human impact of the Anthropocene, which is macro-scale. Because the latter extends so far beyond us, it may seem spectacular beyond comprehension. But we need to understand both, even if just partially. Your work makes that very clear—how tiny living ecologies constitute or gesture toward something bigger.

SR: My interest in the macro-micro relationships of global capitalism is inspired by the Japanese architecture movement "Metabolism" from the 1960s. The Metabolists viewed human society as a "vital process of continuous development from atom to nebula"

(Kikutake et al. qtd. in Lin 2010: 24). These ideas emerged from the destruction of Japan in the Second World War and more recently had a resurgence after 2011 due to the Fukushima nuclear explosion. William Gardner, a Japanese scholar, attributes the movement's reemergence to the way it offers a methodology for better understanding the processes of "construction, growth, sustenance, change, and degeneration" (Gardner 2020) versus solutionism.

I'm interested in how metabolism, and also certain branches of ecological Marxism, speak to the way biological systems can reimagine the inequities/unevenness of our built environment, its networks and infrastructure, but also its reconstruction after disaster. I am intrigued by the parallels of metabolism to theories around resilience.

I think the ability of the artworks to intersect with many discourses, especially those normally unrelated, is what viewers find intriguing. It propels them to make connections they haven't considered before. It can be challenging to determine what aspects of the research to put into a piece because there is so much interesting information. The challenge is how to articulate the essential but not essentialize. I want the forms to be able to speak for themselves and not to overwhelm the piece with too much didacticism. But I also like artworks that offer multiple readings. I think this is also why the workshop has become a popular model as another component to my artworks, as the workshops can be used to disseminate other forms of information relevant to the project.

BK: This is where I become interested in the rhetorical and pedagogical potential of contemporary art beyond aesthetics. For me, your practice allows audiences to think through the distinct components of an ecology, as incongruous or separate as they might typically be seen. You shuffle substrates, materials, and methods of presentation into new semantic assemblages, forcing audiences to recognize and confront the relationships between seemingly disparate components within a given ecosystem. It's not obvious, for example, that a data-based critique of capitalism can come out of a horticultural installation in a contemporary art context. The idiosyncrasies of horticulture, contemporary art, computation, and financial mathematics all seem too distant and irreconcilable. That plus the fact that people don't usually have access to the tools required to navigate all these different considerations at once. And yet your work seems to be able to mesh those disparate vernaculars.

SR: Tactical media has always been a methodology I've used for merging ideas and form, and I like to quote Marshall McLuhan's pivotal idea that "The Medium is the Message/Massage" (McLuhan, Fiore, and Agel 1967). I see it as both a methodology and an ideology. Hacker culture evolved from that artistic movement and is both a belief system and mode of production. I'm interested in how technology—its physical and immaterial manifestations—is a driving force in our lives and yet there is a lack of critical engagement with its role in our lives.

BK: The juxtaposition between the botanical and economic in your work doesn't just *point* to these greater systems; it strategically offers familiar popular entry points, like houseplants, to a public that may otherwise be is less inclined to think systemically. On the flip side, your use of plants may also help folks used to big picture, abstract data visualization to think in sensory and intimate ways.

SR: Yes, and I think your point about making these ideas accessible using plants is very valid. Through the use of more relatable objects such as houseplants, these systems are humanized.

I'm interested in underscoring the cultural trend of the moment and its instrumentalizing power on our everyday life. My creative process is both theoretical and intuitive. I read a lot of theory around the themes I am interested in and I'm also seduced by current technological forms. I'm very interested in the construction of technological ideology, and how through these assemblages, and what you refer to in my work as ontological diversity, I can make visible this process.

For example, I've been reading a lot about what is known as "natural capital" and how this term has evolved into a neoliberal ideology for supposedly saving the planet. This is the quantifying and commodification of nature into "ecosystem services"—goods and services that benefit human needs of sustenance but also lifestyle and well-being. It makes me think of Foucault's *The Archaeology of Knowledge* (Foucault 1972) and the way he describes how the strata and formations of discourses from a multiple of disciplines (education, industry, government, etc.) congeal to form ideologies. This recalls earlier discussions we had via Skype about the incompatibility of numbers with organic systems and capital's need to quantify the living into binary systems. Also, how these political and economic systems converge in order to make nature legible so it can enter the market mechanism. These are some of the ideas I try to make visible and accessible in my work to encourage dialogue around them.

In addition to interdisciplinary dialogue, I use humor and spectacle, and in a recent project about a cyborg oyster, *Aphrodisiac in the Machine* (Rothenberg 2021), a bit of sensationalizing. We are so overstimulated with visual information you have to engage the spectacular to get people to look. My strategy is to use the spectacular in a somewhat self-conscious way so that it becomes rhetorical, for example the title *Planthropy*. This humorous neologism reflects on the merchandising of plants as therapy. We see myriad advertisements depicting a person experiencing euphoria because they are in the presence of a plant they just purchased. Yes, studies have proven that plants have a calming effect, but it might take more than buying a plant to solve one's problems. By underscoring this reductive analogy, I aim to make our actions and the systems that perpetuate those actions and behaviors more visible.

BK: For me, your work is successful in engaging audiences because it sufficiently pays attention to aesthetic value at the same time that it involves in-depth research and well-thought-out critique. The aesthetic dimensions of your works, such as *Garden of Virtual Kinship* and *Planthropy*, have rhetorical power because they offer immediate sensory rewards—they catch the eye and activate the spatial sensibilities of a visitor who may not yet be drawn to your subject matter. In other words, the aesthetic ensures visitor engagement, leading an audience from the moment of intuitive attraction to deeper areas of critical and conceptual thinking.

Earlier, I mentioned how I think your work combines the intimate and the spectacular. As the pandemic, anti-Black state violence, and natural disaster converge, I want to dive further into the conversation around interspecific intimacy as a form of care in response to crisis. Your latest project, *Aphrodisiac in the Machine* (Rothenberg 2021) in Figure 7.2 pitches "the libidinous myth of the oyster" (Rothenberg 2021), a hermaphroditic creature, as offering answers to the biotechnological crises of late capitalism by making way for "a more sentient state of being and empowerment" (Rothenberg 2021). There's this sense of non-heteronormative kinship exuding from this reimagination of the aphrodisiac as something that moves beyond sexual connotations and restrictions in bodily identity and relations. I'm reminded of Elizabeth Freeman's writing on queer kinship and belonging, which evaluates how queerness provides metaprocreative models for social formation and "the caretaking activities that have not been socialized as services for purchase or state entitlements" (Freeman 2007: 298). Primarily using Pierre Bourdieu's notion of the habitus (Bourdieu 1977) to explore the possibilities and limitations of genetic kinship, Freeman proposes a model of mutually beneficial togetherness premised on durable, sedimentary acts "of alliance and inheritance from bygone or not-yet eras and discarded bodily dispositions." Against the idea of kinship as alibi for biological legitimacy, Freeman draws from the procreative register but also turns it on its head. She notes that while kinetic and practical (as opposed to genetic) kinship may be grounded in "shared substance" between bodies, that sociocultural transmission is not limited to biological means. Speaking of queer habitus as *replicative* rather than reproductive, Freeman gestures toward biomimesis as a kind of kinship process. Can you elaborate on how these ideas of kinship outside of genetics are situated in this new work using the oyster as the focal point?

SR: *Aphrodisiac in the Machine* (see Figure 7.3 and Plates 20 and 21) is an environmental science fiction that speculates on a new breed of cyborg oysters able to "cure" climate change by converting toxic waters into a special drinkable fluid they secrete for humans, literally what Freeman might call "shared substance." Oysters have

Figure 7.3 Image from the artwork *Aquadisia* (formerly *Aphrodisiac in the Machine*), 2022, featured in the exhibition *Meta.Morf 2022 Ecophilia: Trondheim International Biennale*, Trondheim, Norway. Image photo credit: Stephanie Rothenberg. Image courtesy of the author. CC4r.

an amazing filtration system and can filter up to 50 gallons of water per day. In the narrative, the cyborg oysters are harvested in unique aquaculture farms near municipal public drinking water reservoirs. The secreted fluid can be accessed from one's faucet somewhat like a home water purifier so drinking the fluid is as easy as pouring a glass of water. But when ingested the water produces an experience that is beyond the sexual limitations of aphrodisia into a new state of what I'm calling *Aquadisia—a Sentience 2.0*. In brief, the work explores sentience as a more agential and empowered state of being influenced by the work of black feminist writer Audre Lorde and her seminal essay "Uses of the Erotic: The Erotic as Power" (Lorde 1984) as well as Donna Haraway's theories of multispecies entanglements (Haraway 2016).

BK: The biomimetic presentation of the oyster as a creature that models solutions to late capitalism can be said to promote interspecies collaboration or kinship in one sense, but also extractive industry in another. That is to say that while *Aphrodisiac in the Machine* carries a hopeful, solutionist air, it does so in a fictional-satirical context; the work makes it obvious that biotechnological solutions are neither perfect nor without tradeoffs. The end goal of enhanced sentience is a noble one, with implications for mutually beneficial modes of interspecific coexistence; paradoxically, the means to this end requires a substantial level of extractive violence. The ethical quagmire presented in *Aphrodisiac in the Machine* thus demonstrates how, in the hierarchies of late capitalism and neocolonialism, the classification of *other-than-human* oscillates between assessments of *less-than-human* and *more-than-human*. Does the celebration or valorization of a nonhuman entity create a mutually beneficial relationship between human and nonhuman when that valorization is preferentially instrumentalized to benefit human goals? The double-edged nature of this question demonstrates how the romanticization, fetishization, or heroization (whatever you may want to call it) of a thing exceeding human skill or intelligence may not be as intercooperative as it may seem.

SR: *Aphrodisiac in the Machine* emerged from my concern with the necropolitics around nonhuman life—the neoliberal, utopian illusions of biotechnology as the new frontier. I began developing the work through a Fellowship at Bowdoin College which is located on the northeast coast of the United States on the Gulf of Maine. The Gulf is warming 99 percent faster than the rest of the ocean, creating dire economic and environmental conditions to this pristine landscape that is also home to an historic fishing industry. Through this experience, I became more aware of contradictions within conservation movements and the capitalist production of nature.

Keeping with the playful nature of my work, I decided to leverage the myth about oysters as aphrodisiacs to explore the queering of new capitalist systems of industrial sea farming. The title references the American idiom to "throw a monkey wrench into the machine." As capitalism turns more and more to our oceans to provide so-called sustainable resources for human future survival, what if humans become more part and parcel of these ecosystem services? It posits an absurd twist on the idea of social reproduction if humans, like nonhuman actors, can also be quantified as "natural capital" assets.

BK: Freeman's discussion of queer/trans and racialized bodies demonstrates how the classification of *other-than-human* fluctuates to rationalize capitalist-colonial exploitation. Queer/trans, racialized, and intersex humans have historically been, and continue to be, subjected to the Janus-faced *less-than-human/more-than-human* binary. The exploitative dehumanization of living things is directly linked to a biopolitical framework that prioritizes the livelihoods of people and creatures that "buy into" and fit neocolonial, capitalist models of merit. Cultural studies scholar Michelle Yates describes this logic as one of "human disposability," in which the "the body of the laborer is used up or wasted at accelerated rates so as to secure the most profit … [or] excreted (as a form of waste) into unemployment or underemployment, creating surplus populations that are separated partially or fully from domains of capitalist exchange and social life" (Yates 2011: 1679). People classified as inferior to the ideal are dehumanized and quickly deemed subservient to the objectives of capitalism—either classified as waste after they've played their role as capitalist agent, or immediately once they have been deemed unuseful to capitalist objectives and means of production. The dynamics of resource status and disposability bind together critical evaluations of the human and nonhuman "Other." Critical explorations of plant intelligence and economics are therefore not just about neutral and binary relations between humans and nonhumans but the production and adoption of targeted classifications that dictate what is considered *less-than-human*. To put it bluntly, exploring the eco-ontological as providing a viable alternative to the current state of the world while avoiding the global histories of environmental racism and biopolitical disposability logics that have led up to this point is nothing short of ecofascism.

These kinds of conversations are dismal, but I don't think they completely decimate the possibility of radical kinship. On the contrary, I think they're a necessary part of ecological liberation and stability. With that said, I'm wondering about some of the more hopeful, non-satirical models of hope and possibility that are driving your practice right now.

SR: I'm hopeful for the younger generation of artists and radical thinkers who are merging the tradition of hacker culture with the politics of care. I see this in projects that engage healing practices to empower rather than shame the large percentage of Americans literally suffering from debt on both a material and emotional basis. These projects hack the institutional structures that reify oppressive power structures and instead offer a more equal playing ground for experimentation and exploration into new ways of "care-full" being in the world. Many of these ideas and projects, or I should say creative collective actions, can be found in the *Pirate Care Syllabus* (Pirate Care Collective 2020) which emerged during the pandemic, although its gears had been put in motion many months prior. The syllabus is an open-source toolkit for sharing ideas and pedagogy about alternative practices and models at the intersection of "care" and "piracy." Use of the word piracy underscores the formations of international solidarity as knowledge production within the gray, autonomous zones that are outside of normative legal structures and systems.

I appreciate your comment on the need for "dismal" conversations in order to disrupt stale thinking and develop new ideas around radical kinship. In an article in the May 2020 issue of *ArtForum*, organizers of Pirate Care specifically state that care isn't always nice: "Caring is not intrinsically 'nice,' and always involves power relations and processes of discipline, exclusion, and harm; it is a necessary and skilled form of labor that is shouldered by workers, mostly unwaged women and migrants, who themselves receive the least amount of care while serving those who take care-labor for granted" (Graziano, Mars, and Medak 2020).

What is exciting is how these new approaches to creative activism extrapolate on earlier advocacy models of solidarity and alternative economy such as the work of J. K. Gibson-Graham. Their model of "Community Economies" envisions a more equitable and humane post-capitalist economy of "surviving well together" (Gibson-Graham 2015: 123). In bridging civil disobedience with ideas around piracy, Pirate Care ignites a new force that has the potential to not only destabilize and decolonize, but equip people with both the intellectual and physical tools needed for creating more just, caring societies. And it's more apparent than ever that is what the world needs right now.

References

Adler, D. (2018), *Contemporary Sculpture and the Critique of Display Cultures: Tainted Goods*, London: Routledge.

Bourdieu, P. (1977), *Outline of a Theory of Practice*, Cambridge: Cambridge University Press.

Darwin, C. (1859), *On the Origin of Species by Means of Natural Selection, or, the Preservation of Favoured Races in the Struggle for Life*, London: J. Murray.

Esparza, G. (2008–2013), [Artwork] Plantas Nómadas. Available online: http://plantasnomadas.com (accessed September 1, 2020).

Foucault, M. (1972), *The Archaeology of Knowledge*, London: Tavistock Publications.

Freeman, E. (2007), "Queer Belongings: Kinship Theory and Queer Theory," in *A Companion to Lesbian, Gay, Bisexual, Transgender, and Queer Studies*, 295–314, Hoboken, NJ: Blackwell Publishing.

Gardner, W. O. (2020), "Liquid Cities," *Places Journal*, May. Available online: https://placesjournal.org/article/liquid-cities (accessed June 5, 2020).

Gibson-Graham, J. K., J. Cameron, and S. Healy (2015), "Pursuing Happiness: The Politics of Surviving Well Together," in C. Nelson, D. Pike, and G. Ledvinka (eds.), *On Happiness: New Ideas for the Twenty-First Century*, 116–31, Perth: University of Western Australia Press.

Graziano, V., M. Mars, and T. Medak (2020), "Pirate Care," *Art Forum*, May 11. Available online: https://www.artforum.com/slant/valeria-graziano-marcell-mars-and-tomislav-medak-on-the-care-crisis-83037 (accessed August 1, 2020).

Haraway, D. J. (2016), *Staying with the Trouble*, Durham, NC: Duke University Press.

Kikutake, K., N. Kawazoe, M. Ohtaka, F. Maki, and N. Kurokawa (1960), *Metabolism: The Proposals for New Urbanism*, Tokyo: Bijutsu shūpansha.

Lin, Z. (2010), *Kenzo Tange and the Metabolist Movement, Urban Utopias of Modern Japan*, London: Routledge.

Lorde, A. (1984), "Uses of the Erotic: The Erotic as Power," in *Sister/Outsider*, 87–91, Trumansburg, NY: Crossing Press.

Malthus, T. R. (1798), "An Essay on the Principle of Population," History of Economic Thought. McMaster University Archive for the History of Economic Thought. Available online: https://historyofeconomicthought.mcmaster.ca/malthus/popu.txt (accessed April 7, 2023).

Marx, K. (1996), *Das Kapital*, ed. F. Engels, Washington, D.C.: Regnery Publishing.

McLuhan, M., Q. Fiore, and J. Agel (1967), *The Medium Is the Massage*, New York: Bantam Books.

Noë, R. and P. Hammerstein (1994), "Biological Markets: Supply and Demand Determine the Effect of Partner Choice in Cooperation, Mutualism and Mating," *Behavioral Ecology Sociobiology*, 35: 1–11.

Pettifor, A. (2018), *The Production of Money*, London: Verso.

Pirate Care Collective. Available online: https://syllabus.pirate.care (accessed June 20, 2020).

Rothenberg, S. (2015a), [Artwork] *Garden of Virtual Kinship*. Available online: http://stephanierothenberg.com/reversal-of-fortune-the-garden-of-virtual-kinship/ (accessed September 1, 2020).

Rothenberg, S. (2015b), [Artwork] *Planthropy*. Available online: http://stephanierothenberg.com/planthropy/ (accessed September 1, 2020).

Rothenberg, S. (2021), [Artwork] *Aphrodisiac in the Machine*. Available online: http://stephanierothenberg.com/aphrodisiac-in-the-machine/ (accessed July 16, 2021).

Yates, M. (2011), "The Human-As-Waste, the Labor Theory of Value and Disposability in Contemporary Capitalism," *Antipode*, 43(5): 1679–95.

8

Tending to 2030 m³: How to Regenerate Regeneration? How to Unasphalt Asphalt?

Regenerative Energy Communities (Helen V. Pritchard, Eric Snodgrass, Miranda Moss, and Daniel Gustafsson)

Overview

This chapter is an account of a day-long collaborative workshop held in Växjö, Sweden, for the municipality's earth week series of events in March 2022. The collaboration was between ourselves as the Regenerative Energy Communities team (a three-year Swedish Energy Agency funded project currently in its first year), the local Hofs Lifs cultural center, and researcher Jorge Zapico's LNU Climate Neutral Växjö 2030 project. Titled *Regeneration 2030 m³*, the workshop was an attempt to work collaboratively with Hofs Lifs's ongoing proposal to transform a roughly 2000 m² parking lot in Växjö city center to a space for climate neutral, community-centered production of food by the year 2030. As announced in the invitation to the event (https://regenerative-energy-communities.org/regeneration-2030), the workshop proposed to do so by working "hands-on with tools of regenerative farming, carpentry, DIY electronics, soil science and further materials in order to collectively address how a parking lot might be remade into a regenerative space for community agriculture and cultivation."

The workshop brought together twelve participants and mixed practices from regenerative agriculture with those of art, design, and citizen science. In giving this account, we have focused on the uncertain complications, tensions, and energies that spilled out of the collaboration, the event, and its crossings. We give voice to what we see as a two-sided unease in our own project that also manifested itself in the planning of this day. The unease is partly one of working practically with technoscientific and technocratic paradigms and imaginaries, but it is also our caution of what it means to work with regeneration and the regenerative as a practice (see Glossary). This account of the framing, planning, and events of the day is an opportunity to share stories about the challenging sedimentations of working with material resistances and of deep, ongoing damages. We describe our speculative attempts at remediation and crossings, as well as the generative prompts and lingering questions that emerged as a queer, open-ended set of collectively made regenerative prototypes loitering in between spaces of a seemingly fixed and sealed present, deep-time past, and future possibility.

Fieldnote (Miranda's)

> *But I am very poorly today & very stupid & hate everybody & everything. One lives only to make blunders.—I am going to write a little Book for Murray on orchids & today I hate them worse than everything so farewell & in a sweet frame of mind.*
> (Darwin 1861: 1)

I misread this, my favorite Darwin quote (the only Darwin quote I like?), and I thought it said "orchards" at the time, and was kinda feeling this way. The sign Hofs made to commemorate the 300-year farm/ten-year parking lot (it was the asphalt's tenth anniversary), was also right next to the mini apple orchard. Also, I cried about the volcanic soil all being removed. I was just feeling a bit emotional at that time. I wonder where that volcanic soil went? Who or what is enjoying this rich, nutrient-dense material now?

Volcano Country, Växjö

As our team stands in and on the windy cold asphalt car park to plan the workshop, we begin to discuss what it might mean to remediate this space of roughly 2000 m^2. Already in an email exchange we have suggested modifying this numerical calculation and designation of space, suggesting a change to 2030 m^3 in recognition of the 2030 goals and a sense of depth we want to add to the concept. In our capacity as the Regenerative Energy Communities project (https://regenerative-energy-communities.org/), we have been brought together for the possibility of running a small workshop on regeneration for Växjö municipality's earth week events in collaboration with the local Hof Lifs cultural center and computer science researcher as well as farmer Jorge Zapico and his LNU Climate Neutral Växjö 2030 project. Leah Ireland, a part-time researcher at Hofs Lifs and one of the founders of the Feminist Farmers collective in Växjö, with whom we have a longer collaboration at VXO Farm Lab, explains that the site was a farm for 300 years and a car park for ten years. Gravelly asphalt stretches from the primary school at one end across to a kitchen training building and on to the Hofs Lifs building, the site of a former brewery manager's grand nineteenth-century timber house, painted in yellow and adorned with masonic symbols, hovering at the other end on its raised and slightly receded perch in the landscape. Slightly farther off, and tallest of all, recently built high-rise apartment blocks can be seen, standing at the top of the graduated hill that makes up the entire area, formerly a water tower and well-loved local landmark and lookout. Before this, reportedly, the site was used by a Bronze Age Swedish sun cult who would gather at the top of the hill. In fact, we are told, this hill and the Kristineberg area it sits on contain volcanic remnants in the soil. Can this

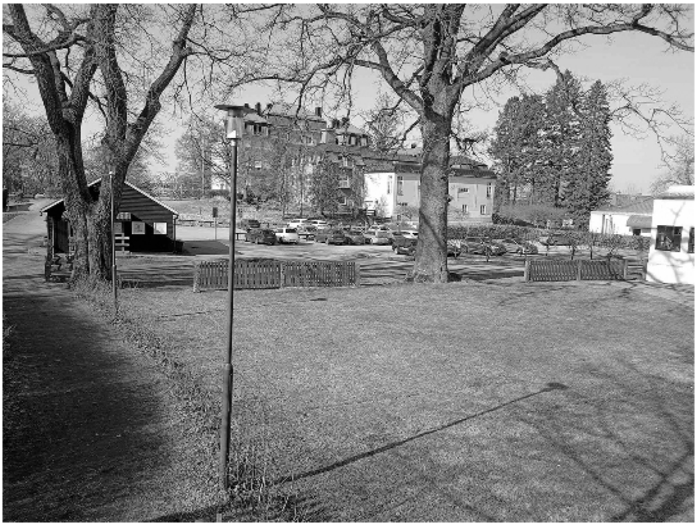


Figure 8.1 View of the car park from the Hofs Lifs grounds, 2022. Courtesy the authors. CC4r.

be possible? Is it just a seductive semi-fabulation? The energies of this site are certainly present—but hard to gauge.

A small section of the garden remains and is rented to a local luxury hotel who use it to produce vegetables for their restaurant. During the summer a worker for the hotel cycles between the hotel and greenhouse with produce in their basket. The greenhouse sits alongside an artwork monument to a former women's prison that was on the site. Abandoned by the out-of-town artist who installed it, the uncared-for garden structure celebrates the prison manager's life and carceral garden design that allowed the incarcerated women in the nineteenth-century prison access to a small outdoor space for gardening. We look up from the artist's garden and onto the large building, once a prison, now a luxury apartment block. As described in the press materials for Hofs Lifs (Hofs Lifs Under Ekarna 2021), in addition to the prison garden and Hofs's own space for growing, there was also a school garden with an orangery. This complicated, multilayered area of land was kept arable and tended by workers at Hofs, teachers at the school, and the prisoners who were mostly socialized as women and whose carceral labor on this 2030 m^3 all helped to keep the land arable for 300 years and this former urban farm site's soils rich.

Energy Imaginaries in 2000 m^2

The farm-now-car-park serves the community association and cultural center. Current actors in the space are Hofs Lifs, the regional theater, an after-school cultural center for music and art lessons, the greenhouse for the luxury hotel, a preschool, and a primary school. The stated purpose of Hofs Lifs and their current three-year Under Ekarna ("under the oaks") project is to work towards "the emergence of a creative centre with an enclosing garden park at Ringsberg/Kristineberg in Växjö" (Hofs Lifs Under Ekarna 2021, authors' translation). In particular, the association has focused on proliferating the imaginary for creating a 2000 m^2 project through holding events and actions in the car park.

The project is part of the "global 2000 m^2 project and agroecology network," which originated in Berlin and has been replicated in similar community projects in Sweden, Switzerland, Turkey, India, and Scotland (cf. https://www.2000m2.eu/). The 2000 m^2 project is based on the idea that if land was divided equally between all people across the world everyone would receive 2000 m^2 and therefore a sustainable life should be designed to fit into the arable space of 2000 m^2, which by their calculations would involve a reduction of 5000 m^2 for the average EU citizen (ibid). The projects encourage communities to experiment with 2000 m^2 to invent practices that grow resources and reduce consumption/energy use. The division of the earth's surface into 2000 m^2 grids which overlay the planet is reminiscent of the development of transparent earth theory of the eighteenth century, which divided the planet into a grid to aid colonial expansion, extraction, and accumulation, a technical imaginary which later formed the basis for GPS. What impacts, one might ask, does this have on a new imaginary for the crossing of agriculture and energy communities?

Although current 2000 m^2 projects mostly focus on getting communities involved in designing and tending locally grown food resources in 2000 m^2, part of the imaginary also considers how the 2000 m^2 might include space for *community energy experiments*, such as "grow[ing] cotton for our clothes, tobacco for smokers, 'bio' gas or diesel, and other so-called renewables on our field" (https://www.2000m2.eu/story/). The project works as a useful bridging and pedagogical device, bringing together practices such as garden planning and smart kitchen methods to calculate and quantify how much energy is gathered from certain crops and how much energy is needed to maintain what Lauren Berlant calls the good life fantasy (Berlant 2011). As many have reflected, the relationship between renewables and agriculture is almost always quantitative, financial, and extractive (cf. Dunlap 2021), and cultivates green grabbing. While we think it is important to critique the numbering practices of the 2000 m^2 imaginary, we acknowledge that it can be a useful pedagogical device that calls in an alternative to the green grabbing of industrial-scale renewables, as it potentially cultivates a more interdependent relationship between energy and agriculture that considers what it might mean to farming for regenerative food and energy practices. But alongside such projects and as a challenge to seamless readings of access to and transformations of space, we would also insist on other examples. Examples such as the Solitary Gardens project (https://solitarygardens.org), which takes the six by nine foot (or smaller) dimensions of solitary confinement cells used by the US prison-industrial complex as an intentional template for the creation of 6×9 solitary gardens ("prison-cells-turned-garden-beds") that put practices of solitary confinement and chattel slave cropping in dialogue with those of permaculture, prison abolition, community organizing, and transformative justice (Solitary Gardens 2019). As we see it, regeneration must always work, carefully, with a continued and inherent question of how to tend to deep-sown damages (e.g., what and whose damages? as defined by which groups?) and their many ongoing momentums in working with any processes and pedagogies of transformation and regeneration.

The global 2000 m^2 project might be understood as a proposition that communities use to gather around, and also as a pedagogy to visualize, spatialize, and invent new economies and practices with soil. As we stood on the asphalt together as collaborators wanting to explore a 2030 m^3 theme for our earth week workshop, we discussed the inescapable colonial logic at work in the original versions of the 2000 m^2 project, in the imaginary of a neutral division of land, measurement, and the optimization of crops and bodies. To some extent, the imaginary of 2000 m^2 works as a unifying of spatial and temporal-material dimension of what Kathryn Yusoff, Kerry Holden, and Casper Laing Ebbensgaard have described as speculative "planetary portals." These portals are replete with "wide-angle dreaming" and the uniform, stabilizing logics that such "imperial imaginings" and "dreaming across continents" commonly involve (Yusoff, Holden and Ebbensgaard 2021).

Indeed, the global 2000 m^2 project reproduces the violence of what la paperson (Wayne Yang) describes as the technologies of settler colonialism—technologies that generate the patterns of social relation to land based on colonialism in transnational arenas (Yang 2017). The imaginary of energy community experiments in projects like 2000 m^2 is potentially one of neocolonialism and late liberalism, namely one that values individual responsibility and individual land ownership. In addition, like many energy community projects that have happened under late liberalism, 2000 m^2 focuses on an imaginary towards reduction, both the reduction of energy use for personal heating, lights, and transport, but also the reduction of life. Instead, how might the bringing together of community agriculture and energy experiments open up towards a plurality of rich full lives, where new imaginaries of renewables and energy use open onto collective practices of pleasure and joy, material resistances to individualism and property? Although the 2000 m^2 project might be understood as returning land or dividing land equally, the quantification of a universal 2000 m^2 for a universal body is based on colonial logics of land ownership and land and bodies as fungible resource. The 2000 m^2 project is bounded by and therefore at constant risk of reproducing a particular settler imaginary, one which uses technologies such as measurement, the science of nutrition, and the measurement of bodies to make land property. Accumulation at the scale of 2000 m^2.

At Hofs Lifs they have titled their own take on this theme *Experiment 2000 m^2*. The leaflet on the project opens with a call of "Asphalt out, topsoil in" (*"Asfalt bort, matjord in"*) and aims "to produce all the food needed for one person for a year in 2000 square meters—and to make it healthy, sustainable, tasty and beautiful. The experiment can then give a concrete picture of what sustainable production and consumption of good food really means" (Hofs Lifs Under Ekarna 2021, authors' translation). The project makes explicit reference to the local Kristineberg and Ringsberg area's history as a space of gardening and cultivation, positioning this history as one that might be regenerated through the project's own vision for the space. The following excerpt from the leaflet gives a flavor to how the spatial vision is expressed: "Kristineberg/Ringsberg appears as a kind of human possibility zone ('mänsklig möjlighetszon') in Växjö. Here it is possible to breathe, think, dream and grow."

Later in the office a researcher, who amongst other tasks has been asked to take the *Experiment 2000 m²* project forward, shows us pictures of this site as an arable space. They are kept in the office, together with a series of unrealized urban planning projects, as objects for imagining a return to farmland from the asphalt car park. Vegetable plants, flax, and fruit trees are in abundance in both the historical images and the urban design speculations. However, the historical context of the carceral labor that underpinned the urban farm of 2000 m³ are largely erased within the green imaginary. As we pass through a little library area on the way to the office, the researcher mentions work they are doing on updating and diversifying the collection. Complications small and large; surfaces and depths of struggle.

Around the table we begin to speculate backwards on the imaginaries of energy capture and storage in the rich volcanic soil that lies under the tarmac. Together, we attempt to open onto an energy imaginary around carbon storage and the materiality of community energy in the soil itself, part of permaculture practice and agroecological soil work as well as carbon trading imaginaries. The soil, we are told by Leah, was taken away somewhere—a sense of deep-time loss that strikes us all. In this moment the complexities around the crossing of agriculture and energy practices are overwhelming and open a space to investigate what Anna Krzywoszynska and Greta Marchesi describe as the importance of researching "[t]he ways in which the carbon ontology of soils may be developed and used to pursue oppressive or, alternately, just human-land relations" (Krzywoszynska and Marchesi 2020: 197).

Regeneration Wants to Regenerate Everything but Itself

Back at the studio we wrestle with the unforeseen complexity of what we have just been presented with and questions of what forms a workshop event in such a setting might take. Superficially, the Hofs Lifs Experiment 2000 m²'s version of permaculture and urban regeneration might seem an easy fit with a project like ours on regenerative energy and agriculture. But we have wrestled throughout our project on what contours, forms, and practices our take on regeneration should cultivate and participate in. The term regeneration has a buzzwordy and zeitgeisty trendiness that is full of potential pitfalls. Some of the popular texts invoking a regenerative practice of one kind or another (Reed 2007; Rodale Institute 2014; Wahl 2016) default to an all-too-seamless, stable, and clean reading of what regeneration can be. From the beginning of this project, we often felt ourselves bashing in between an aesthetics of prepperdom, with its alt-right, individualistic, and ecofascist connotations, and certain practices of permaculture and regenerative agriculture that, while often well intentioned, can nevertheless lack acknowledgments to questions of race and class—not to mention the rich and long-established histories of agroecological practices that many projects often ignore or gloss over in their desire to portray their approach as emergent and new. Instead, following the work and lines of enquiry raised by Afro-Caribbean lesbian writer, teacher, and activist, M. Jacqui Alexander (2005) in her book *Pedagogies of*

Crossing, we ask what could a regenerative "pedagogies of crossing" be for Regenerative Energy Communities? Alexander describes a pedagogy of crossing

> as something given, as in handed, revealed; as in breaking through, transgressing, disrupting, displacing, inverting inherited concepts and practices, those psychic, analytic and organizational methodologies we deploy to know what we believe we know so as to make different conversations and solidarities possible; as both epistemic and ontological project bound to our beingness and, therefore, akin to Freire's formulation of pedagogy as indispensable methodology.
>
> (Alexander 2005: 7)

As highlighted in Kopenawa and Albert (2013), César (2016), Penniman (2018), Altieri (2019), and others, a disregard for, denigration, and/or outright dispossession of the traditions of various Black, Indigenous, and majority world and societies of agroecological practice are not new, and can arise at the intersections of energy and agriculture (e.g., Stock and Birkenholtz 2021). In Western contexts such as Sweden, the UK, Europe, and the US it is imperative that we challenge the prevailing sense that practices such as regenerative farming are the domain of reproduction of white, heterosexual, middle- to upper-class communities. In her inspirational handbook, *Farming While Black* (2018), farmer and community organizer Leah Penniman highlights not only the long histories of thefts of farming land and the ongoing and imposed plight of food apartheid, but also celebrates the often unacknowledged and vibrant roots and histories of regenerative farming and agroecology. For example, Penniman remembers and celebrates Dr. George Washington Carver's work on formalizing principles of organic and regenerative farming in the early 1900s, and the later work of Dr. Booker T. Whatley in establishing some of the earliest, but again, not regularly cited community-supported agriculture in the black American communities in which he was based (Penniman 2018: 3, 101; see also Jordan et al. 2009).

Regenerative agriculture practices, as characterized by Matthew Kearnes and Lauren Rickards in their writing on the political aesthetics of regenerative agriculture, are often accused of both a "naïve" spirituality on the one hand, and of producing quasi-scientific knowledges and approaches (Kearnes and Rickards 2020). Yet, in trying to claim ground in the difficult battles over land and practices of agriculture, regenerative and other alternative forms of agriculture might in some cases have too easily pushed their own brand of a seamless "promissory logic" and "high hopes for a brighter future" (Kearnes and Rickards 2020: 72). This promissory logic is not dissimilar to those of science, smart cities, and corporate fossil fuel companies. As theorists Kodowo Eshun and Kara Keeling describe it, a promissory logic is a practice of producing future scenarios by corporations, agrotech firms, and regenerative farming groups looking to support profitable decision-making and a future industry that "dreams of the prediction and control of tomorrow" (Eshun 2003; Keeling 2019: 4).

These imaginaries are thick at present, even as they are being more regularly questioned, and it feels as if they are the only way to gather attention and support for a project. As we thought about what we might do for the earth week event in the car park space, we too began to slide into discussions of smart sensors and working with quantification and optimization in relation to the question of what could be the most "effective" use of planting and energy harvesting in a space of roughly 2000 m^2. We are technoscientists just as much as we are artists and designers and formed by our past and present projects. We have seen first-hand the immediate appeal to publics of the sensor that measures and quantifies to make data on pollution actionable for political change (cf. Pritchard and Gabrys 2016); a solar panel that generates an imaginary permaculture future that seamlessly regenerates; or a quantifiable kitchen garden farm and energy planning workshop. These imaginaries no longer require significant amounts of translation and are readily digested as palatable inputs in public-facing events in places like Western Europe and America. However, in the context of our planning of 2030 m^3, generating data about pollution or demonstrating renewables did not seem to address the problems or concerns, and therefore those approaches risked becoming performances full of ahistorical, greenwashed technocratic energies.

This location of the car park was an area that had already seen an uptick in gentrification with the relatively recent transformation of the former women's prison into luxury city apartments, and it was hard not to see the inherent risks of further gentrification and the green grabbing that might spill out of a nice permaculture garden in the area—despite all of the environmental benefits and potentials for agroecological learning that might happen in such a space. If we did not take a "smart," data-oriented approach to energy and agriculture in the space—then what? With the rejection of these approaches for this context, what did we have the expertise to do? As Jorge commented, the Växjö municipality approached him about an earth week hackathon and now there will not be a laptop in sight! How might we still activate the space through regenerative practices?

We returned to what defined the space at present in an attempt towards "recruiting matter(s) that perhaps have not participated in previous knowledge projects, or that have not been recognizable as ways of knowing" (Keeling 2019: 16). We considered the sad but also rich history of a space used to park cars for the last ten years, and as a rich but complicated space of collective farming and cultivation 300 years previous to that. We turned our focus away from the glossy future of a finished city farm to a juncture that would necessarily occur before that: the moment when the asphalt was removed. Despite the excitement of learning that new anaerobic bacteria grow and live within soil sealed by asphalt, enduring life in the harshest of conditions—we were concerned about the state of the urban soil that would already have been filled with heavy metals such as lead, chromium, arsenic, zinc, cadmium, copper, mercury, and nickel after ten years of sealing by asphalt with its petrochemical contaminants that leach and drip through the gravel, soil, and deep into the groundwater below. While the *Experiment 2000 m^2* leaflet suggested a simple step of "asphalt out, topsoil in"—presumably simply by bussing in topsoil from some other location—we decided to pause and open up this step in order to consider in what ways the damaged soil might be remediated rather than simply replaced or topped up. How might we bring (back) into the conversation that we live in damaged worlds that are not innocent, not easily redeemed, nor turned back while at the same time recruiting an energy community able to engage with carbon capture and storage in soil?

As described by anthropologist Germain Meulemans in "Reclaiming Freak Soils," "There can be no such delivery of soil without the destruction of soil elsewhere" (Meulemans 2020: 162). In this case, there was the theft of soil that had already transpired when the top layer of rich, centuries-old, volcanic, and cared-for soil was removed for the purpose of laying the asphalt for the car park. There was also the looming question of what would happen to the asphalt if it was to be removed. We wanted to develop approaches that might keep these histories, struggles, and damages at the fore to highlight their presence in cities and bring the stories of the sealed and damaged soils more readily to the present (Pritchard et al. 2020). We planned to highlight the dominant "surfaces of empire" such as concrete, asphalt, and other paved materials that "[participate] in the ambition of silencing all forms of life other than humans" (162). We agreed that our work together would bring to the fore, through different collective experiments with regeneration and bioremediation, what Meulemans describes as "an ecological understanding of soil processes that does not disconnect the material and human histories that make and unmake the city" (159).

Prompts, Orientations, Sedimentations

> *Expect soil imaginaries, dig-ins, sit-ins, plant-ins, microscope-ins, training for breaking up tarmac, techniques for regenerating contaminated soil, solar powered servers, cushions and stargazing, community farm infrastructuring and any further tools and ideas participants brings to the occasion for co-creation.*
>
> (Excerpt from invitation to the event)

Having settled on a general focus to explore the complex histories of flourishings and damages within this site, we began to plan the structure of the workshop. We decided to begin the day with a set of written prompts that might bring participants into some of the multilayered and multisensory elements of the space, what we internally described as the "sedimentations" in the space. We would hide these prompts around the grounds of the Hofs Lifs site and the parking lot for participants to find and then read aloud.

After some morning coffee and tea and introductions, we moved outside for what was part walking tour, part treasure hunt. The first prompt was already blowing away in the Spring wind. After chasing it down and unrolling the paper, a participant read the prompt, that was as follows:

☆. 。.:*・° ☆. 。.:*・° ☆. 。.:*・° ☆. 。.:*・° ☆ ☆. 。.:*・°

Regeneration 2030m^3

☆. 。.:*・° ☆. 。.:*・° ☆. 。.:*・° ☆. 。.:*・° ☆ ☆. 。.:*・°

What could a regenerative practice be in the year 1830, 2130, 2030m^3 for urban farmland? m^3 for the horizontal, the vertical (roof tops, tree lines, clouds, stars), the ground (asphalts, grasses, our feet), the depths (underground cellars, suppressed oppositional histories, dormant volcanoes), the volume of this space (invisible airs, pressures, collective/contagious/compressed/expansive entities, feelings), the deep time all through 2030Kw. How do we not just "maintain" 2030m^3 in the future but work towards actively reviving and enhancing the health and resilience of local ecosystems and communities? Focusing on soil, carbon, biodiversity and living in the ruins of fossil capitalism and big tech together. How do we regenerate soil contaminated by pollutant patriarchal-colonialism? How do we think through regeneration for rich full flourishing lives? What is the governance, community foundations, needed for these spaces? Regenerate with micro ecosystems of deep-time bacteria, nematode crushes, love letters to lively soil, asphalt remediations, sifting through the rubble.

The prompts acted as scripts for us to read to one other and reflect on. Certain words and phrases sank in and others blew past. The expansive oaks at the edge of the Hofs Lifs grounds stretched in our company, upwards to the sky and downwards into the earth, sheltering both sides of the border between Hofs and the parking lot. Leah shared details on the material and cultural histories of each location where a prompt was found. We eventually gathered around a prompt hidden in the parking lot. Smaranda, a design student from Romania, read aloud:

☆. ｡ . :* ･ ° ☆. ｡ . :* ･ ° ☆. ｡ . :* ･ ° ☆. ｡ . :* ･ ° ☆ ☆. ｡ . :* ･ °

Openings and Groundings—Asphalt

☆. ｡ . :* ･ ° ☆. ｡ . :* ･ ° ☆. ｡ . :* ･ ° ☆. ｡ . :* ･ ° ☆ ☆. ｡ . :* ･ °

When I go there tomorrow I want to put my hands on the asphalt. It didn't asked to be put there, my hard friend the asphalt was made to do this work, everyday spilled on, run over with the weight of a society of cars. To touch and acknowledge how asphalt supports us and our ways of life that it never asked to support. But yesterday in addition to cars it was also supporting little strands of hay, small memories of the previous event. It stayed with me. Leaving me wanting to connect with this burdened, entangled surface and all of the ways it is enrolled into life.

How to unasphalt asphalt? How to carefully release and free one another from the burdens of these entanglements? What's under car park? How can we speculate with rubble, petrol spills, and leaching chemicals from the tarmac itself and deep-time heavy metals from the previous life? The lead from urban traffic. The arsenic most likely from the orchard. To test or not to test. When we know without doubt heavy metals are present? Do we spend our energy on remediation or remeasurement? How do we remediate, regenerate, rehabilitate, and respeculate on living with these damages? Regenerate with training for subterranean solidarity, toxic queer loves, asphalt futures, spotting petrochemical spills, seedling planting, mycoremediation.

And so on, from one spot to another. The discussions were thoughtful and not rushed. At one point after a prompt about queering quantification someone whispered to us "thank you," in order not to be seen by those more attached to numbers. This particular audience had some experience with the kind of language and lines of thought in the prompts. It might have been different in another constellation of participants. Amongst some of the participants we eventually sensed a restlessness to get to the "making" elements of the workshop, but the exercise felt important as a way of grounding and deliberately orienting us in the histories and details of the space. As articulated by queer theorist Sara Ahmed in her writings on how "orientations matter," "[w]hat passes through history is not only the work done by generations but the 'sedimentation' of that work as the condition of arrival for future generations. Objects take the shape of this history" (Ahmed 2006: 41). The collective reading and sharing of the prompts seemed to be doing at least some work of orientation, opening up different historical and materialist senses and sensitivities, and, in doing so, creating conditions for what objects and interventions might eventually "arrive" in the space during the workshop.

In looking closer at the space, feeling out its varying textures and the contours of the ground, digging in the brush for prompts, listening to the tones of one another's voices, the swaying of the oaks and other resonant acoustic phenomena in the area, there was also a sense of what science and technology studies scholar Jennifer Gabrys describes as a "sitework" that opens onto the "multiple and different urbanisms that unfold often beyond human points of reference" (Gabrys 2012: 2924). In this instance, a sitework that was notable for the emergent collective exchanges at play and how such exchanges can work "across material, affective, political, socionatural, and imaginative registers" in an "active processing of ecological community" that "is not just about holding sites together, but also about setting differences to work" (2922). The prompts and discussion had done at least some of this sitework. Here was asphalt, ground, soil, and still further sedimentations beneath our feet. Orienting, prompting, and maybe even prototyping us—or elements of a possible "us."

What Does Soil Prototype?

Standing in the car park at Hofs Lifs during the earth week event, one might ask, as Daniel did, what does it mean now to be a designer or artist, citizen scientist, or curious member of the public in such a space and context? The stories surrounding the car park's past, its present, and the arising "what ifs" seemed to leave few untouched, but a sense of subtle frustration lingers in close orbit, though failing to overshadow people's good spirit. We had joked earlier that we could just throw caution to the wind and take a pickaxe or jackhammer to the asphalt and begin working with the soil it sealed right there and then. Leah said members of their team also dreamed of slowly unpicking the car park space several meters or so everyday, casually potting holes here and there, interrupting the flow of cars, perhaps accidentally dropping a few seeds into these holes. These and other fertile thoughts were starting to take shape amongst the participants, but the numbers of emerging ideas did not yet equate to the numbers of white stripes on the pavement.

In preparing to work in one way or another with remediation and regeneration of damaged soils, we had some practices working with soil and bioremediation sketched out and it was to these we turned after lunch. Altogether we were twelve participants and we loosely organized ourselves across the three activities: one working with bioremediation microbial bubble tea, a second with oyster mushroom mycoremediation, and a third with soil-activated microbial fuel cells. We were not quite sure which directions these learn-it-together activities would take, but another of the prompts written in advance of the workshop suggested routes to follow: "How can we work with nematodes, worms, bacteria, fungi and collectively created and cared for tools, practices or rituals for transitioning to futures other than those that dominate the present?"

In the yard, the soil cell group were discussing how to use animal excrement that Jorge had brought from his farm as an MFC (microbial fuel cell) substrate for creating in situ soil cells. This integration of animals into an urban farming and energy experiment echoes similar such intentional integration of animals within regenerative farming practices. Miranda mentions that, when we were visiting the site earlier, a local passer-by, Sara, stopped to see what we were doing. Sara described how she regularly takes a moment to sit down on a bench in the Hofs garden as part of her walks. She knows the space well. In discussing the car park, she mentions that, amongst its many other uses, it is also a meeting spot for selling drugs in the evening. She said that she could easily point out the cars in question if it was later in the evening, showing us yet another layer of activity on top of the many others in this space. She mentioned it would be exciting to get sheep on any future cultivation plot. During the event itself, we wondered if the activities in their current state were a bit too alien, at least for people simply walking into the workshop unprepared, but the

Figure 8.2 Soil cell with animal excrement, 2022. Courtesy the authors. CC4r.

details and inputs, such as those provided by Sara, were much appreciated, expanding our understanding of the function of the site as a soft space for resting and recovering in. In the future, these soil cells might benefit from the poo of grazing sheep and perhaps support a living backdrop to other unplanned-for activities, restful, illicit, or otherwise.

In Hofs Lifs's own on-site wood workshop, the mycoremediation experimenters have settled on making a mycoremediation trebuchet! Having begun by foraging around the site for scattered bits of grasses and twigs as locally sourced substrate for what will be sachets of mycoremediation mushroom projectiles, they are now busy cooking the substrate and sawing bits of wood for the catapult. A smell of boiling bark and an air of woodworking concentration fills the room. Between the poo, soil microbes, urine cells, and the scents of this room, if nothing else, it is clear this future will be ladened with smells.

Back outside, the bioremediation tea group are laughing. After harvesting fresh rainwater from a nearby bird fountain, they have now reached the stage of cupping the bioremediation tea bags made out of cut nylon stockings and filled with a mixture of microbially active compost, sheep dung, and oats. The cupping releases the bioremediation kombucha in small clouds within the large mason jar filled with sugary water, to start its fermentation. They march over to the soil cell group to enquire about borrowing Jorge's solar panel to power a water pump for aerating the tea, and Helen quickly cuts a plug off the aquarium pump and wires it directly into the inverter so that it can receive energy from the solar panel. Someone mentions that the car park is apparently much less busy on the weekends, as it is normally a hub of pickups and drop-offs around the afternoon. A shame for the vernissage but nevertheless the prototypes are creeping into life, spilling over and into one another.

Figure 8.3 Bioremediation station, 2022. Courtesy the authors. CC4r.

In the Regenerative Energy Communities project, we are working to explore what possibilities lie in practices that aim to be regenerative. This involves developing and experimenting with a range of different "regenerative" prototypes together with others. In reflecting back, after the earth week event, on how we decided on and prepared the co-creation prototyping activities around soil remediation for the event, we found it helpful to speak of a hanging, open-ended question of "How does soil prototype …?" This open-ended question had an expansive potential to it and, slowly, we felt new framings of the question arising. How does soil prototype communities? How does soil prototype (regenerative) imaginaries? Critiques of technology? Creative and innovative uses of technology? Alternative histories of energy? Stories of damage? (Overwhelming) refusal and unknowing? Working across time, space, and scales (micro, meso, macro … microbes, ghosts, sedimentations)? In the question's ability to loiter and remake itself we felt a response, or way to carry it forward. Similar perhaps to how the anthropologist Kristina M. Lyons, in writing on human-soil relations in rural farming communities in Columbia, speaks of the ability of the decomposing layers of composting piles (*hojarasca*) to "force thought" via the many different and vital "propositional life-making processes" that gather around and emerge out of them (Lyons 2020: 3).

Whatever else is going on in these prototyping activities, it seems there is a way in which this site and its stories of human-soil relations are forcing something into being. Such a faith in something becoming can constitute what sociologist and urban theorist AbdouMaliq Simone as a "material resistance," a commitment to "the pursuit of particular tacit, collective processes, but whether they will produce anything useful or not, usable or not, remains a question" (Simone 2022: 110).

Eric walks over to the bubbling bioremediation tea and tapes up a napkin inscribed in thick marker pen with the opening of local Växjö author and pioneering ecofeminist thinkers Elin Wägner and Elisabeth Tamm's "At Peace with Earth" (*Fred Med Jorden*): "Earth is not created by human hands—*but human hands have forced themselves into the earth*. And yet the earth does not allow itself to be owned" (Wägner and Tamm 2021 [1940], authors' own translation). What does soil prototype? … Relations, resistance, refusals of redemption (Simone 2022). Human hands forced back, by the earth, into the earth.

Vernissage

next time they come
i hope they bring soil and green soothe for the roots
i hope they bring dirt and depth and plant us in it
we could sure use the grounding for remembering earth

(Gumbs (2018): "Archive of Dirt")

The question, what does soil prototype? shifted again as we gathered in the still empty car park with the different propositions and micro energy imaginaries. At 3 p.m., with the temperature and light dropping, the different groups start to move the prototypes into the empty car park. Each proposition takes up a different parking space. At first glance it looks like a sparse collection of scavenged parts and solar panels, tables, plants, and blankets. However, these material arrangements become propositions (Simone 2022: 108) and at this moment Jorge and Leah add another layer, as they begin flaming wood (which involved burning the edges of wood to disinfect it) in the center of the car park to make a car-sized mobile greenhouse. Different groups are gathering around their 2030 m^3 experiments to activate them. The experiments do not suggest a simple fix or technocratic vision for energy communities, but instead can be understood through what Simone describes as everyday material resistance, "something that requires continuous tending and curiosity" (110). Across the car park people tend to fragile, fugitive regenerative energy experiments that make others curious enough to gather or join in with the practice.

Miranda is kneeling on the asphalt surrounded by the soil fuel cells, terracotta pots filled with soil, sheep, chicken, and worm excrement and human urine, wired together and creating a small amount of energy that is fluctuating between 1 and 3 volts (see Figure 8.4 and Plate 24). Later, Miranda wrote in a fieldnote, "in the end we got a surprising (I mean I was expecting it lol) amount of electricity from these clay, carbon cloth, oats and charcoal cells, making an LED light up, and lots of noise synthesising. Roel noted in a text to Eric that: 'We managed to get 2.4v and 0.3mA, so 8mW from the poop batteries in the end:D'."

Figure 8.4 Bioremediation tea, solar panel, soil cells, car park, 2022. Courtesy the authors. CC4r.

Different people are walking across the car park with glasses of urine to donate to the fuel cells, along with cups of tea to keep themselves warm. Soil is prototyping a urinating future! A chirping from the toy karaoke machine starts from a low energy synthesizer hooked into the soil fuel cells (see Plate 23), sensing the microbial activity, and high pitch chirps followed by lower grumbles echo faintly across the car park, punctuated by the loud roar of Jorge and Leah's wood flaming, and a few more people gather around as if at an impromptu noise performance. Listening. The soil chirps and grumbles, vibrating into bodies and a few people seem to move as if prompted by the anaerobic energy that flows through their bodies into the asphalt and underneath—spreading out through the gravel layer and into the water courses. Rumbling under the former prison and the teachers' school, vibrating some deep-time bacteria deep below the car park. A more-than-human sensing (Gabrys 2022) as what Alexander has framed as a "pedagogy of crossing," releasing the practices of energy communities from modernity's secularized episteme, disturbing and reassembling them (Alexander 2005: 7).

Meanwhile, in another space in the car park, a small group of participants nearby are covered in blankets, having a small file-sharing party on a local bibliotecha library running on a low power server using energy from the solar panels, which have now made their way to the car park. They are uploading books such as *Radical Mycology: An SLF Primer* from Spore Liberation Front (2009) and *Thinking with Soils* (2020) alongside PDFs about the impossibility of removing heavy metals in remediated car parks. However, only one book can be uploaded or downloaded at a time, so in between they are discussing why they are sharing the particular book or how it might open another possibility towards energy futures. Next to them and also sharing the solar panel energy is the jar of bioremediation tea, a glass jar with three sacks made from a pair of tights dangled into it. Tubes go in and out of the jar to a small pump aerating the tea (see Figure 8.4 and Plate 22).

Across the other side of the carpark, Daniel and Andrea emerge with a medium-scale catapult made from two-inch by three-inch wood. Andrea is wearing a sweater with a rainbow and the word "Pleasure" printed across it. Small sachets of mycelium remediation compounds begin to be catapulted across the car park, landing in the edges or the borders, some go into the trees, some on the grassy bank of the school alongside the car park. One goes onto a car entering the car park. The performances of these energy futures seem to breathe energy into the deadness of the car park as a form of queer bioremediation of soil and communities who matter in the imaginations of agriculture and energy, echoing, as Keeling describes, Audre Lorde, for whom poetry is a way of thinking the space/time of politics for those deemed disposable or socially dead (Keeling 2019). Daniel, in a later field note on the event, reflected that from the midst of the parking lot, amongst the trees and plants growing from the damaged parts of the car park, he could empathize with people's immediate response to the 2030 m^3 workshop—ideating on tearing the tarmac up. "We can't quite equal them to the numbers of white stripes but to their defence, the trees already started. Tearing things down made me think of what kind of design holds such qualities? … How is tearing something down embedded in nature?"

Figure 8.5 Vernissage: mycoremediation catapult, file-sharing, etc.! 2022. Courtesy the authors. CC4r.

The scene looks like something from dreamy science fiction, a car boot sale, or an impromptu teenager gathering. The 2030 m^3 vernissage in stark contrast to the glossy images of a smart city or urban regeneration workshop. We might understand these scavenged, impromptu, bodily modes as part of what Keeling describes as stubborn spatiotemporalities of our senses, as a way to intervene in the smooth and seductive assertions of capitalism's inevitability, issued from capitalism's predictable futures. In this case, capitalism's predictable future imaginary of what or who an energy community is and how they might be managed and reproduced. The energy communities imagined by capitalism are not imaged like this joyful, vulnerable, queer, and messy arrangement that gathers on the car park at dusk. What Miranda describes as "humuspunk" (see Glossary). Occupying the asphalt without buying tickets, through the stubbornness of their bodies and their senses, they render these spaces as sites of the redirection of energy imaginaries, "as sites not only of the application of power but also of power's transvaluation or redirection" (Keeling 2019: xi).

In this space without the domination of quantification and scientific measurement or human-centered frameworks focused on usefulness and behavior change, soil seems to be prototyping an eventuality of energy communities. One without resolve but thick with creative inventiveness, regenerations, crossings, and the acknowledgment of practices of attentiveness and curiosity. The deep sedimentations of the site are scavenged and become present through these past, present, and future histories of the asphalt and its soil imaginaries.

References

Ahmed, S. (2006), *Queer Phenomenology: Orientations, Objects, Others*, Durham, NC and London: Duke University Press.

Alexander, M. J. (2005), *Pedagogies of Crossing*, Durham, NC and London: Duke University Press.

Altieri, M. (ed.) (2019), *Agroecology: The Science of Sustainable Agriculture*, 2nd edn, Rugby, UK: Practical Action Publishing.

Berlant, L. (2011), *Cruel Optimism*, Durham, NC and London: Duke University Press.

César, F. (2016), "Mapping Agropoetics of Liberation," in *Agropoetics Reader*, 41–66, Berlin: Savvy Contemporary.

Darwin, C. (1861), *Darwin Correspondence Project*, "Letter no. 3272." Available online: https://www.darwinproject.ac.uk/letter/?docId=letters/DCP-LETT-3272.xml (accessed August 23, 2022).

Dunlap, A. (2021), "End the 'Green' Delusions: Industrial-Scale Renewable Energy is Fossil Fuel," in "Negotiating Climate Change in Crisis," in C. Daggett, B. J. Cohen, and R. G. S. Weisbrot, *Negotiating Climate Change in Crisis*, 127, New York and Abingdon, UK: Routledge.

Eshun, K. (2003), "Further Considerations of Afrofuturism," *CR: The New Centennial Review*, 3(2): 287–302.

Gabrys, J. (2012), "Becoming Urban: Sitework from a Moss-Eye View," *Environment and Planning A*, 44: 2922–39.

Gabrys, J. (2022), *Citizens of Worlds*, Minneapolis: University of Minnesota Press.

Gumbs, A. P. (2018), *M Archive: After the End of the World*, Durham, NC and London: Duke University Press.

Hofs Lifs Under Ekarna (2021), *EXPERIMENT 2000 m²: Ringsberg/Kristineberg Växjö*. Available online: https://underekarna.com/2000-m2.

Jordan, J. L., E. Pennick, W. A. Hill, and R. Zabawa (2009), *Land & Power: Sustainable Agriculture and African Americans*, Sustainable Agriculture and Research Education (SARE).

Kearnes, M. and L. Rickards (2020), "Knowing Earth, Knowing Soil: Epistemological Work and the Political Aesthetics of Regenerative Agriculture," in J. F. Salazar, C. Granjou, M. Kearnes, A. Krzywoszynska, and M. Tironi (eds.), *Thinking with Soils: Material Politics and Social Theory*, 306–20, London and New York: Bloomsbury Academic.

Keeling, K. (2019), *Queer Times, Black Futures*, New York and London: NYU Press.

Kopenawa, D. and B. Albert (2013), *The Falling Sky: Words of a Yanomami Shaman*, trans. N. Elliott and A. Dundy, Cambridge, MA: Harvard University Press.

Krzywoszynska, A. and G. Marchesi (2020), "Toward a Relational Materiality of Soils: Introduction," *Environmental Humanities*, 12(1): 190–204.

Lyons, K. M. (2020), *Vital Decomposition: Soil Practitioners + Life Politics*, Durham, NC and London: Duke University Press.

Meulemans, G. (2020), "Reclaiming Freak Soils: From Conquering to Journeying with Urban Soils," in J. Salazar, M. Kearnes, C. Granjou, A. Krzywoszynska and M. Tironi (eds.), *Thinking with Soils: Social Theory and Material Politics*, 157–74, London: Bloomsbury.

Penniman, L. (2018), *Farming While Black: Soul Fire Farm's Practical Guide to Liberation on the Land*, White River Junction, VT: Chelsea Green Publishing.

Pritchard, H. and J. Gabrys (2016), "From Citizen Sensing to Collective Monitoring: Working through the Perceptive and Affective Problematics of Environmental Pollution," *GeoHumanities*, 2(2): 354–71.

Pritchard, H., J. Rocha, F. Snelting, and L. Benítez Valero (2020), "Queering Damage," in M. Belina (ed.), Magazine—*Sonic Acts Academy 2019: Hereafter*, 72–83, Amsterdam: Sonic Acts Press.

Reed, B. (2007), "Shifting from 'Sustainability' to Regeneration," *Building Research & Information*, 35(6): 674–80.

Rodale Institute (2014), "Regenerative Organic Agriculture and Climate Change: A Down-to-Earth Solution to Global Warming." Available online: https://rodaleinstitute.org/wp-content/uploads/rodale-white-paper.pdf (accessed April 7, 2023).

Simone, A. (2022), *The Surrounds: Urban Life within and beyond Capture*, Durham, NC and London: Duke University Press.

Solitary Gardens (2019), "About the Project," *Solitary Gardens* website. Available online: https://solitarygardens.org/about.

Spore Liberation Front (2009), *Radical Mycology: An SLF Primer*, https://we.riseup.net/assets/287443/radical+mycology.pdf (accessed April 7, 2023).

Stock, R. and T. Birkenholtz (2021), "The Sun and the Scythe: Energy Dispossessions and the Agrarian Question of Labor in Solar Parks," *The Journal of Peasant Studies*, 48(5): 984–1007.

Wahl, D. C. (2016), *Designing Regenerative Cultures*, Axminster, UK: Triarchy Press.

Wägner, E. and E. Tamm (2021) [1940], *Fred med jorden*, Stockholm: The Sublunar Society.

Yang, K. W. (2017), *A Third University Is Possible*, Minneapolis: University of Minnesota Press.

Yusoff, K., K. Holden, and C. L. Ebbensgaard (2021), "Planetary Portals: 'Dreaming in Continents' from East London to the Cape in the Colonial Praxis of Emergence and Extraction," *Gropius Bau Journal*. Available online: https://www.berlinerfestspiele.de/en/gropiusbau/programm/journal/2021/kathryn-yusoff-planetary-portals.html (accessed April 7, 2023).

9

Decolonization, Computation, Propagation: Phyto-Human Alliances in the Pathways Towards Generative Justice

Ron Eglash, Audrey Bennett, Lionel Robert Jr., Kwame Porter Robinson, Matthew Garvin, and Mark Guzdial

The pressures that create current social and environmental disasters—global warming, wealth inequality, racism, misogyny, and war, to name a few—are daunting to contemplate. It seems foolish to think that something as small and fragile as a plant could oppose them. But plants and humans synergistically working together—what we will refer to as phyto-human alliances—have been known to change history. The rubber tree (*Hevea brasiliensis*), for example, gave industry its first durable, flexible material, making possible everything from automobiles to condoms. Rubber tree plantations are also responsible for deforestation, carbon emissions, and biodiversity loss (Warren-Thomas et al. 2018); and they facilitate the concentration of wealth in the hands of a few (Chaudhuri 1972). In other words, they have a particular set of what we can call network effects, creating innovation in technological domains, the concentration of wealth in financial domains, and the destruction of ecological health in biological domains. In this chapter, we will examine the possibilities for designing a different network of relationships. By guiding technological innovation through the principles and practices of decolonial computing, we hope to show how phyto-human alliances can reverse the trend towards extraction that produces so many of the social ills listed above; and that these alternative networks can instead create transitions towards a non-extractive economy, that of generative justice.

What Is Decolonial Computing?

Tiziana Terranova and Ravi Sundaram (2021) detail some of the most important aspects of contemporary oppression in relation to authoritarian and unsustainable structures, and wisely avoid the temptation to demonize technology. More specifically, they warn against thinking about opposition to technosocial colonization in terms of romantic organicism, in which embodied, “natural” life is good and technologized life is bad. It is an error, from their view, to frame the problem as one in which "technology has subsumed and colonized social life, and how this process might be reversed to gain access to a more authentic, embodied sociality." In this caution, we agree. The romantic organicism framework posits that natural things ("embodied sociality") are inherently better (morally, medically, etc.) than artificial things. As we have described elsewhere (Eglash 2009; 2019), the position is frequently used in heterosexist attempts to dictate what constitutes "natural" sexuality; in racist attempts to unite "blood and soil"; in the rising tide of ecofascist movements that link environmental pollution with immigration and "racial pollution," and so on. And romantic organicism is simply naïve: there are plenty of things in nature that are poised to kill us, and plenty of things in the realm of human invention that make life better. But there are other aspects of the argument that can help illustrate more subtle points of disagreement.

In Terranova and Sundaram's view (and here we again agree), there is no separate "social" to disentangle from the technical; the two are co-constructed. Rather than romantic organicism, they posit that since online connectivity created computer-mediated forms of social life, oppositional politics must be located there as well. In support, they point to movements such as Black Lives Matter, the Arab Uprisings of 2011, the Occupy movement of the same year, the 2019 Hong Kong Protests, the Ni Una Menos movement against Latin American femicide, and others in which online networking facilitates physical-world oppositional politics.

But this is not what we have in mind by "decolonial computing." The historical periodization they offer provides a distinct "before computing" and after. This reduces computation to what happens on screens and keyboards. It capitulates to the seductive power of corporate social media platforms, rather than raising awareness of the counter-hegemonic understanding of Indigenous computational forms and processes prior to colonialism. And it detracts from critical analysis of the co-evolution between the particular forms that computing now takes, and the colonized technosocial landscape we inhabit. Without that analysis, the implication is that the technology itself is neutral, and we merely need to use it for good purposes, as implied in slogans such as "AI for social good." From a decolonial view, the challenge is not to merely hijack existing computational forms; it is to transform them at every level.

Various scholars have offered definitions of decolonial computing that move toward this multilevel approach. Syed Mustafa Ali (2016), for example, points out the tendencies of frameworks such as postcolonial computing to remain in the realm of disembodied process, and notes that a decolonial approach requires not only "the turn to embodiment" but also an understanding of what conditions the colonization of the body created in relation to computing. Lilly Irani and Kavita Philip (2018) add to that the challenge of new varieties of ethno-nationalism (e.g., Hindutva in India), such that lands and peoples are still abused as sources of extraction for computational modernity, in the guise of decolonization. Playing with the terminology of the "full stack" software developer as someone who can code at any level from user interface to network server, Indigenous scholar Jason Lewis refers to this deeper alternative as "full stack decolonization" (Lewis 2020; see also the comments (p. 14) on "cycles of being, building up from the smallest to the largest entity" in the decolonial AI framework of Sabelo Mhlambi 2020). In an effort to better flesh out the concept, we consider technology's recursive composition (Eglash and Banks 2014) in which physical components support hardware modules, modules support computer architectures, and computers (both personal and servers) support networks spanning the globe (Figure 9.1).

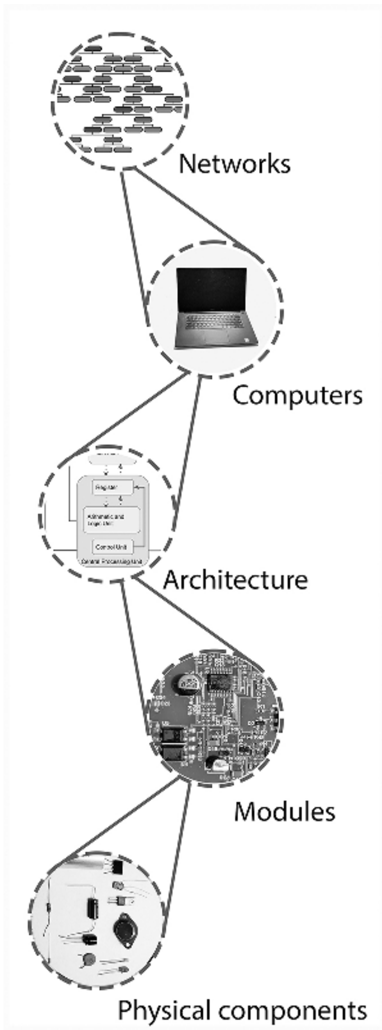


Figure 9.1 The layers in which full stack decolonization needs to engage. Photos and images by Ron Eglash. CC4r.

A Case Study in Decolonial Computing: Mineral Sourcing and Phyto-Human Alliances

At the smallest level one can consider the molecular composition and structure of electrical components. Many crucial materials are derived from conflict minerals, such as tantalum for capacitors, gold for microcontacts, and tungsten in heat sinks. The mines for these minerals are often located in conflict areas, such as those found in the Democratic Republic of the Congo (DRC), where they have been linked to funding for armed militias, the use of child labor and other human rights violations. The kinds of online public campaigns that Terranova and Sundaram recommend were indeed powerfully applied to this issue, and as a result, the 2010 Dodd-Frank act (section 1502) required companies to determine through supply-chain due diligence whether or not their products contain conflict minerals from DRC or neighboring countries. But the tracing system is easily faked and has now been turned into a "mineral laundering scheme" (Global Witness 2022: n.p.). That is not surprising: with so much money and power aimed at mineral extraction, it is unlikely that we can decolonize one thread of the tapestry while leaving the rest intact (Pritchard, Rocha, and Snelting 2020).

At the same time that illegal business dealings and armed militias were creating this mineral laundering system, the DRC, spurred by foreign investors, created large-scale agribusiness "parks" (i.e., plantations), which have been implicated in providing cover for mining violations (Mousseau 2019). The industrial-style agribusiness also displaces smallholder farmers, which can then force them into mining operations. Because the smallholder farms had included subsistence growing, removing them also diminishes the ability of miners to go on strike. Thus, the reason our cellphones and laptops are filled with conflict minerals is not only because of the combined influence of wealthy corporations like Apple, Tesla, and Intel and unaccountable military brutality, but also because a particular configuration of plant-growing, that of industrial agribusiness, was weaponized against the miners and their communities.

But other phyto-human configurations are possible. Prior to the start of the agribusiness parks, the DRC had been headed in the opposite direction: their 2009 "Note de politique agricole" outlined a policy which would "support the organization of the rural world into self-managed structures" (Mousseau 2019: 22). This reflects an earlier Indigenous system, *kalinzi*,[1] which originally circulated the value created by people and land without alienating it from producers or their community (Van Acker 2005). While the agribusiness parks largely supplanted this grassroots empowerment plan, some exceptions illustrate the power of alternative phyto-human alliances.

Shahriar Kibriya and his colleagues (Kibriya et al. 2014) describe the case of ESCO, a farming business in the northern Kivu province of the DRC. In the 1980s they stopped all activity due to coffee plant disease and violent conflict (which included raids on farms to feed armed militants). The business was saved, however, by switching to the cultivation of quinquina trees, *Cinchona officinalis*. The bark of the quinquina tree contains quinine, which is used to treat malaria. Since it is not a food plant and has no value outside of a specific supply chain, there is no point in pillaging. It can be neglected if conflict forces temporary displacement, and only grows in value over time, as the bark accumulates. The tall, rugged tree is structurally resilient, unlike more delicate plants, and, when cut for harvesting, it regrows from the stumps. Because of these properties, it has been referred to as "conflict resilient."

With the rebirth of the business through quinquina, the new financial stability allowed for expansion. Inspired by the example of quinquina (from the Indigenous view, having learned from the plant), they realized that other crops could have conflict resilience, even if not to the same degree as quinquina. Cacao (chocolate) and vanilla beans have been the most profitable, and focusing on organic farming opened higher profit marketing and better worker health. Although funded by external investors, the structure is based on working with smallholder farms, usually about an acre in size (16,000 farmers as of the 2014 report). The success attracted additional economic stability (e.g., Starbucks began importing their coffee). They also attracted nonprofit NGO support, which has been applied to farmer education, and encouragement to diversify income-generating activities and invest in community-based infrastructure and institutions, resulting in new primary schools, secondary schools, and a university.

Despite the success of ESCO, and the disasters caused by agribusiness parks, the DRC continues to plan for park development, insisting that mass production agribusiness is the only path to modernization; and that if they just keep repeating these industrial plantations, eventually they will "get it right" (Ross 2018). We posit that there are parallels between the agricultural world's faith in the plantation, and the computing world's faith in the platform. In neither case do they consider the possibilities for bottom-up alternatives, in both cases they posit some future in which we finally convince those at top (Zuckerberg, Musk, plantation owners; whomever is in charge) to "get it right." In these top-down corporate structures, any return of value to those at the bottom is an added feature, won only through protest, and typically a temporary victory. In the bottom-up alternative, by contrast, the potential for value return is at least nascent from the start, and if nurtured, more deeply embedded. Company policy can change overnight, but 16,000 farmers trained in organic methods and entrepreneurial independence are much harder to uproot. Another way to say this is that the conflict resilience in the quinquina tree is a model for the exploitation resilience that is needed for decolonial pathways.

If agribusiness plantations are acting as a top-down neocolonial force, and empowering smallholder farmers offers a bottom-up decolonial alternative, could the same be true for replacing corporate industrial mining with smallholder mineral organization? Eleanor Fisher and her colleagues (Fisher et al. 2021) make this case through an exploration of artisanal gold mining in Africa. Using the framework of "gold lifeways," they begin by noting the common misconception that industrial mining is the norm, and artisanal mining is a tiny fringe. Artisanal gold mining is active in over eighty countries in the Global South, and approximately 90 percent of all employment in gold mining is based on these smallholder activities, contributing about 20 percent of global gold production. With about 45 million artisanal miners, and another 134 million indirectly dependent on them, it represents an enormous economy in terms of the number of people it supports.

While it is true that artisanal mining is linked to environmental and health problems—in particular the use of mercury and child labor—Fisher et al. point out that these problems are weaponized by industrial interests that offer to eliminate them for the price of corporate ownership and domination of the resources.

> Sustainability narratives pertinent to [artisanal mining] reflect stark asymmetries of knowledge and power. All too often, these narratives reinforce negative, homogenizing and dehumanizing stereotypes that situate miners as environmental pariahs and social deviants.
>
> (Fisher et al. 2021: 191)

For an alternative framing they point to Deborah Bryceson's study of artisanal gold miners' governmentality. She found a striking trend towards egalitarian democracy in their communities, which she attributes to "the collegial ties and occupational integrity of working together on a common occupational footing regardless of class and educational level, and their creativity in devising a modus operandi of shared work practices" (Bryceson 2018: 54).

Other positive potentials reviewed by Fisher et al. (2021) included the ways in which Indigenous cosmologies conceptualized gold as having spiritual, agentic properties. The term "agentic" is used here to convey the limits of human hubris—that disrespecting the natural world will have negative consequences—as well as the unpredictability of nature; that clever schemes or raw power will still fail to dominate it (as global warming is now making evident for industrial powers). Thus, Indigenous cultures and decolonial mining have the potential to play a role in preventing overwork, eliminating the over-exploitation of natural resources, and enacting other generative counters to mass production exploitation (Taussig 1980). Using Anna Tsing's (2015) description of mushroom "lifeways"—her term for the matsutake mushroom-human-forest alliances at the "unruly edges" of capitalism's destructive industrialization—Fisher et al. (2021) call for a recognition of gold lifeways.

Missing from their description (somewhat surprisingly, given the origins of their "lifeways" terminology) are the possibilities for phyto-human alliances as we have described here: a symbiosis between artisanal mining and artisanal growing. Rather than replacing artisanal mining with industrial mass production, a decolonial path to eliminating mining's environmental and human rights problems would entail the formation of an artisanal economy (Eglash et al. 2020a), including state and non-state institutions for recognition of the value of artisanal mining lifeways, support for its positive attributes, and accountability for eliminating its negative impacts. But we join Terranova and Sundaram (2021) in pointing out that the present-day technosociality will have to be a crucial component in this process of decolonization. This is not simply because it is in fashion, or that we are now welded to our cellphones at the hip, but rather because the computational dimensions of generative economies have always been present. We are not moving from a non-computational past to a computing present, but rather allowing extraction, exploitation, and imperialism (which takes forms ranging from racism to patriarchy) to take on the role of designer for these technosocial ecologies. To develop a different transformation—one that allows humans and their nonhuman allies in nature to co-design decolonial computational ecologies—we need a set of principles to guide us.

Underlying Principles for Mutual Support between Decolonial Computing and Phyto-Human Alliances

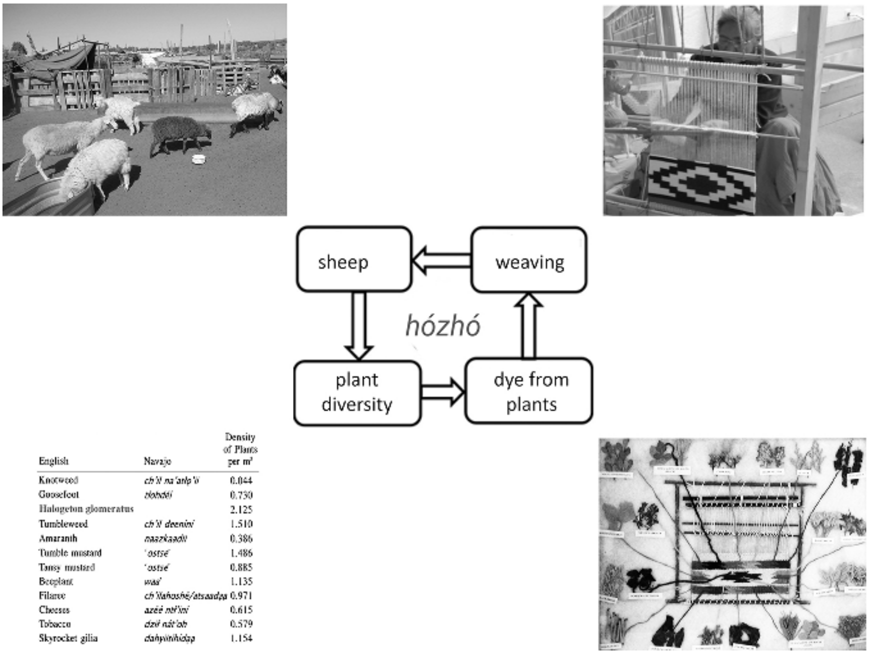
The above case study examines one layer within the full stack of information technology phenomena that must be engaged for decolonial computing. Space does not permit the description of cases for each successive stack, so we will instead attempt to summarize a few of the underlying principles. These are not meant to be exhaustive, merely some preliminary elements of what a fuller analysis might provide.

Entropic Modulation

Donna Haraway's cyborg framework (Haraway 1991) was meant to avoid the historical periodization problem. In her view, "we have always been cyborgs," in the sense that even an ancient technology such as fire is part of us (consider for example how the human jaw evolved in response to our change to cooked foods). But that has come into conflict with her recent comments (primarily in lectures) about the Chthulucene, a sense of earthly worlding created by tentacular beings "before the sky father." The "sky father" phrase nicely invokes the ways that Indigenous religions, more respectful of nature, were supplanted by "religions of the book" that shifted authority to a patriarchal abstraction, and, at least in the Judeo-Christian version, to "fill the earth and subdue it; and have dominion over the fish of the sea and over the birds of the air and over every living thing that moves upon the earth" (Gen 1:26–8). One cannot miss the implied analogy between this sense of spiritual abstraction—from living tentacular life-force to ethereal master in heaven—and the negative consequences of other kinds of abstraction, such as mathematics, science, and computation, and their impact on environmental destruction. How are we to rethink the positive possibilities for abstraction within a decolonial framework? There are, after all, many Indigenous religions that refer to sky father, sky woman, or other beings that at least point in the direction we associate with abstraction in the European tradition. What does it mean to actually do abstraction without exploitation, extraction, reductionism, and similar negative connotations?

Figure 9.2 shows an example from Indigenous economic value flows, in this case Navajo weaving. At the upper left are sheep in one of the corrals. Taken out to pasture, they return with guts full of plant seeds; hence the explosion of biodiversity in the corral areas. As a result, the image in the lower left, a list from Lawrence Kuznar (2001), shows the high entropy[2] (diversity) of plant species around the corral. These in turn are used to create dyes; together with yarn from the sheep's wool and the "heritage algorithms" (Bennett 2016) of Indigenous computation, a weave is created. But the act of weaving imposes order on the chaos; it is because of that order that this becomes a human artifact. The profits from selling the blanket benefit the weaver, as well as the sheep, which is how the loop of value generation comes full circle:

> What the women weave is part of the environment. If you take something from the environment, you must give something back. Navajo weaving is all about



English	Navajo	Density of Plants per m²
Knotweed	*ch'il na'anp'ii*	0.044
Goosefoot	*tłohdéí*	0.730
Halogeton glomeratus		2.125
Tumbleweed	*ch'il deeníní*	1.510
Amaranth	*naazkaadii*	0.386
Tumble mustard	*'ostsé*	1.486
Tansy mustard	*'ostsé*	0.885
Beeplant	*waa'*	1.135
Filaree	*ch'iłahoshé/atsaadąą*	0.971
Cheeses	*azéé nit'iní*	0.615
Tobacco	*dził nát'oh*	0.579
Skyrocket gilia	*dahyiniłhidąą*	1.154

Figure 9.2 Entropic modulation in the circular economy of Navajo weaving. Photos and image by Ron Eglash. CC4r.

> relationships … The weaver has a relationship with the sheep … she must respect them, and she uses the wool in her weaving … and she must respect it too.
>
> (M'Closkey 2004: 108; M'Closkey quoting Harry Walters, Director of the Ned Hatathli Gallery at Navajo Community College)

In the basic structure described above, the traditional economy allows ecological value, labor value, and social value to circulate without alienation (which is the definition of generative justice). But value is not embedded in a single form: it swings from something highly diverse (the plants with millions of variegated proteins, genetic strains, leaf architectures, soil interactions, and so on) to something strictly regulated (the fabric). We refer to these swings as *entropic modulation*. As the system swings from high entropy in plant biodiversity, to low entropy in the orderly stitches of the weave, it generates new value that is circulated (without alienation) back to the high entropy side of the flow once again. This is an oscillation of high and low entropy forms feeding off each other (Figure 9.3); the chthonic tentacles and hand of heaven embracing. Indeed, the Navajo say that Spider Woman instructed them to build the first loom from materials that are the union of earth and sky; that of rock and sheet lightning.

Entropic modulation also happens in colonial economies, but the differences are telling. From the Indigenous perspective, both high entropy and low entropy forms

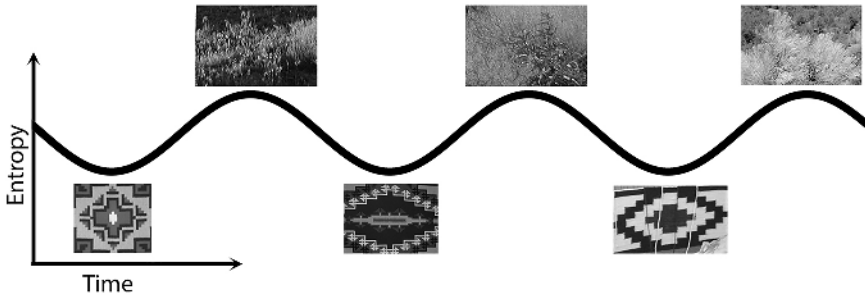


Figure 9.3 Oscillations between high and low entropy value forms in the Navajo generative economy. Photos and image by Ron Eglash. CC4r.

are agentic, computational, and mutually supportive. This can be represented and implemented in very different ways depending on the culture. The Navajo term *hózhó*, which is variously translated as "balance" and "beauty," has been used to describe this: the weavings offer a visualization of that principle. For the Anishinaabe of the Northeast, the concept can be found in the term *bimaadiziwin* ("the good life"); in *wampum* iconography such as "One Dish, One Spoon," and its connection to concepts such as "enoughness" (Babbitt and Lachney 2021). In addition to traditional Indigenous cultures, the concept is foundational to many contemporary decolonization movements based on agroecology, in which humans and nature are in relations of synergy and mutualism while oscillating between low entropy—seed selection, plowing rows, irrigation grids, etc.—and the high entropy of self-organizing ecological diversity (Figueroa-Helland, Thomas, and Aguilera 2018).[3]

From the extractive economy view, only the reductive abstraction of low entropy is aligned with agency, authority, and control. There are two extractive strategies for achieving this. One is to reduce the autonomous diversity of human and natural flourishing to a low entropy state. Haraway illustrates this with the concept of the "plantionocene," a historical epoch marked by an assault on both human and ecological diversity; one in which heterogeneous variation is replaced with uniformity in labor (slavery) and uniformity of species (monocropping). The other strategy is to retain embodied diversity in natural or social forms as a point of extraction for wealth concentration, as in the tourism industry, the entertainment industry, or other corporate appropriations.

Thus, the problem with a simple binary—high entropy good, low entropy bad—is that it is neither accurate for describing Indigenous traditions, nor a decolonized future. Instead, we need to think about how the ebb and flow of concretization and abstraction—entropic modulation in the style of *hózhó* relations—can support agentic autonomy on both sides, in mutually supportive circulations. For example, elsewhere we have described the computing education tool we developed for South American contexts based on this work (Eglash et al. 2020b). Woven Heaven, Tangled Earth (Figure 9.4) (online at https://csdt.org/culture/whte/index.html) is a phrase introduced by Cecilia Klein (1982) to summarize the concept she found through many

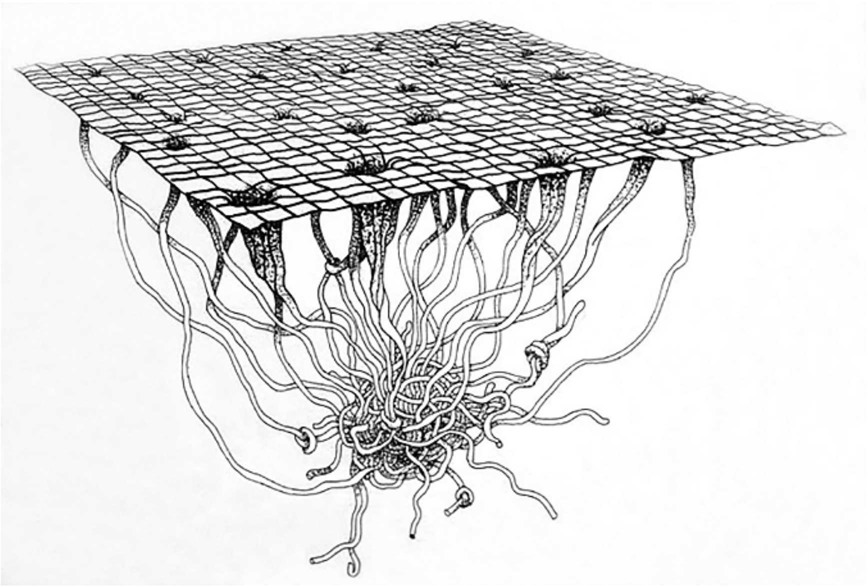


Figure 9.4 *Woven Heaven, Tangled Earth*. Image © Henry Klein, 1981 by permission.

years of ethnographic work in Mayan communities. The illustration in Figure 9.3 is her visualization of what Mayan weavers related to her as a dual cosmology, with fabric-like high gods above, and the tangled trickster gods of the earth below. In our workshops in Ecuador, we found this to be one of the best ways to introduce decolonial STEM to K-12 teachers; using simulation tools to develop heritage algorithms for both Euclidean and nonlinear forms ranging from beadwork to Indigenous face painting (Eglash et al. 2020b).

Agentic Design

Tsing (2015: 152) stresses the unintentional nature of her mushroom-human-disturbed forest assemblage.

> [O]ne could say that pines, matsutake, and humans all cultivate each other unintentionally. They make each other's world-making projects possible. This idiom has allowed me to consider how landscapes more generally are products of unintentional design, that is, the overlapping world-making activities of many agents, human and not human …. As sites for more-than-human dramas, landscapes are radical tools for decentering human hubris.

Audrey Bennett's (2021) agentic design offers a promising negotiation between Tsing's portrait of unintentional survivability and the deliberate design of decolonial pathways. Bennett points out that design disciplines have, at least since the 1980s, promoted the idea of allowing some kind of bottom-up process to democratize design; for example, "participatory design" (Schuler and Namioka 1993), "community-based design" (Constanza-Chock 2020), and more recently the incorporation of Tsing's area of nonhumans in collaboration (Rice 2018). But it is not self-evident how to accomplish that without either making the designers' contributions trivial (because we stepped back to sustain the democratization) or forcing the participants into the performance of collaboration without its substance, as implied by Cooke and Kothari (2001) in *Participation: The New Tyranny?*

Bennett (2021) describes the gradual nurturing of agency that can be seen for students using Culturally Situated Design Tools (CSDTs), an online heritage algorithms suite. These start out with fairly didactic methods, but gradually introduce increasing opportunities for agency in the design activities, leaving room for students to eventually create their own goals and objects for simulation studies; greater agency in physical action through CSDT-based maker activities, and finally action through community-based research.

We propose that this can be expanded beyond STEM to serve as a model for rethinking participatory design. That is to say, agency itself can be nurtured. By starting with community-based assets, such as heritage algorithms, ecological knowledge, local physical resources, and so on, the design intervention becomes a process of facilitating agency rather than the "tech-fix" approach that has (justifiably) been the target of so much criticism. But how to convey this explicitly to participants? In several projects we have used the metaphor of plant roots and water (Eglash 2018). Water trickles through soil, finding its own way around rocks, moving faster where it hits sand, etc. Plant roots similarly inch forward, exploring the terrain. Eventually the two meet up. This invites participants to think about both sides—academics and locals—as having their own sets of resources and goals; asking both sides to investigate that as they see fit, and collectively finding where they meet up, just as fingers of water and plant roots will meet up at the points of mutual convergence. What grows from there, ideally, offers a mutually supportive facilitation of agency. The metaphor is common enough that one does not need a course in postmodern metaphysics to understand, but still conveys the sense that agency is something nurtured, not merely tolerated.

Advocating for recursive agency (Lachney et al. 2016) is not a resolution of all tensions; quite the contrary. Roots disturb soils, soils have impacts on roots. There must be a commitment to relinquish control of the process in the midst of these tensions, but that too is something that can be embraced. In Ghana, for example, we developed an open-source condom vending machine in collaboration with students at Creativity Group, a network of maker-space collectives. The idea was to address both the AIDS crisis (respondents reported embarrassment at buying condoms in the highly moralistic Ghanaian society), and simultaneously develop localized production and income generation. We did indeed start with our root-and-water metaphor, and that had consequences. Although the device began with a highly localized design—a cover that was created by local artisans, using Indigenous iconography—the Ghanaian students eventually created their own version that invoked a universalized modernity, replacing the Indigenous elements with corporate-looking sleekness and dubbing it “the venus machine” (referencing the European goddess of love, rather than Indigenous sources).

Often universalism is demonized in social justice critiques. But in keeping with “full stack” decolonization, it is worth considering how we might understand layers of universalism and localism as a kind of meta-level entropic modulation. For example, given that the goal was to increase access and acceptability of condoms, the African students may have been envisioning that by associating condoms with Western modernity, they could make it more acceptable socially. Thus there are parallels between Spivak’s (1993) “strategic essentialism” and what we might call strategic universalism. But most importantly, their new version was not simply cosmetic: they adjusted the interior dimensions to accommodate other reproductive technology products that also had social stigma barriers, which broadened both the social benefits and economic viability. Nurturing agency is a crucial aspect in the self-propagation of generative justice.

Self-Propagating Threats and Phyto-Modeling Alternatives to Authority from Above

Gilles Deleuze and Felix Guattari (1980) introduced the vocabulary of self-propagating plants in their essays on “rhizomatics,” using the image of plants that send out roots under the soil and pop up as a new plant some distance away. Here they launched an entire sub-literature of poststructuralism, one that often invoked networks of localized autonomous resistance that would spread like crabgrass, bringing down capitalist domination because it would be decentralized and acephalous. “The Rhizome, the Multitude, the wisdom of crowds and peer-produsage all rest on an ideal of a latent affective human connectivity, that passes between bodies in cyberspace, enabling new decentralized forms of resistance and democracy” (Jutel 2017: n.p.). But this was before the greatest threat to democracy was a decentralized alt-right and its amorphous online clouds of misogynist nerd nazis.

When domination rises from below, as a viral or rhizomatic spread of bigotry or fascism, it can seem unstoppable. Hence the seduction of authority from above; perhaps a psychological echo of many of our childhoods when someone helped protect us. The idea that social media should have authorities censuring and expelling those who do not meet certain criteria might sound appealing to anyone disturbed by alt-right hate speech. But it is easy for the political left to forget the McCarthy era of the 1950s, when it was their speech that was censored, their jobs and social networks from which they were expelled. Humanity cannot have it both ways. We cannot demand more democracy when elites engorge themselves on wealth and power and demand less democracy when populist sentiment trends in the wrong direction. How is it possible to foster nurturing environments without top-down control? Again, learning from plants is a useful metaphor, as well as (in some cases) a literal example.

One fruitful area of inquiry is to examine how Indigenous phyto-human alliances managed such issues. The egalitarian structure of some hunter-gatherer groups such as the Agta of the Philippines, the Ju/'hoan of southern Africa, and the Awá of the Amazon are extraordinary, but others have more limited forms. As noted by Brian Hayden and his colleagues (Hayden et al. 1986) this variation shows ecological correlations: the most egalitarian societies tend to be in the most biodiverse environments. But Hayden et al. do not point out the reciprocal nature of this relationship: Indigenous land management (even in precolonial times) promotes biodiversity, they are "engineered landscapes" such as controlled burns, clam gardens, stream sculpting, etc. (Smith 2011; Schuster et al. 2019). So, the relationship is not passive: indeed, we can also find examples of egalitarian relations in Indigenous groups which do not have hunter-gatherer economies, such as certain horticultural societies.

In many Indigenous horticulture economies, what is practiced is not agriculture (mass production by seed) but rather vegeculture. That is, many plants can propagate by vegetative growth, such as the tradition of cutting a yam root into pieces to create more yam plants. While this potential existed prior to humans, centuries of unnatural selection have allowed humans to influence the most preferred characteristics (Scarcelli et al. 2019). Simultaneously, yams have spurred human cultural evolution: for example, Samuel Nortey (2012) describes a case study in which a yam festival emerged in a West African community, which in turn created health, psychological, and social benefits. The vegeculture propagation method is, from a modern engineer's view, inefficient: planting chunks of yam is an artisanal method that resists mass production, but for that very reason it is exploitation-resistant, conducive to agroecology gardening methods that promote higher species diversity and more localized ownership. Again, the value is thus in high entropy states for biodiversity, and lower for human representations such as yam festival arts; another example in which entropic modulations circulate both ecological and social value without alienation. Such agroecology systems have minimal water use and a carbon negative profile, due to the smaller, denser plots, as well as more localized profits and labor control.

In contrast to that style of vegetative propagation, the seed-based agriculture typical of the US requires enormous space, utilizes enormous amounts of irrigation water, and contributes a whopping 25 percent of annual greenhouse gas emissions (Shukla et al. 2019). Unlike agroecology, it is notorious for using underpaid labor and exposing them to health hazards (Figueroa-Helland, Thomas, and Aguilera 2018). Unlike vegetative propagation, seed propagation is conducive to mass production methods. The reduction in biodiversity means that insect predators cannot be used to rid the garden of pests; instead, chemical inputs of pesticides are utilized. Even its geometry is reductive: most Indigenous gardening traditions have a 3D structure, because biodiversity means climbing plants, ground-hugging plants, tree-like plants and so on. The reductive process of Haraway's Plantationocene is not only species reduction but also a geometric reduction, from 3D to 2D, which allows mechanized mass harvesting and planting, and also its massive evaporation and greenhouse gas emissions.

If we are to utilize this contrast to help us think about the dilemmas of authority in social media, concepts of scale have an obvious and immediate application. Every business instruction or mandate will include the question: "does it scale?"; every software application or server-side platform will boast about its scalability; the phrase "at scale" is synonymous with success. At first that may seem like an unquestionable truth: surely we want justice and sustainability "at scale" as well? But these examples of vegetative propagation contrast with agriculture's mass production in ways that disrupt the very definition and methods of the scale concept. Flattening 3D to 2D; turning a variegated landscape and biodiverse soil ecosystem into a million-acre petri dish for seed-based genetic replicants is not actually bringing science to the world; it is reducing the world to the uniformity and control of a lab; a process Bruno Latour and others in science and technology studies refer to with terms such as "immutable mobiles" and "configuring the user" (Latour 1987; Woolgar 1990). Here we will use the term "unidominant," meaning that widespread use came at the cost of replacing pluralism with uniformity. Spreading without unidominant conformity has been referred to by Arturo Escobar (2020) as "pluriversal."

The ways that agroecological plant propagation is communicated, borrowed, exchanged, and (meta)propagated is thus not a version of industrial scaling; it is a pluriversal alternative to scaling. It is a means of striving towards just and sustainable practices that are developed bottom-up, and thus can spread as diverse forms; that is, scaling without being unidominant. When Nortey (2012) describes the yam festival he is documenting the ways in which nontraditional and traditional practices find mutually beneficial exchange without converting one to the other. More extreme examples—that is, more fraught with contradictions and higher stakes outcomes—can be found in the history of mutual support between enslaved Africans and colonized Native Americans, ranging from shared plants (sweetgrass, a Native craft plant, used to recreate African patterned baskets in the Americas) to shared political resistance (Weaver 2008; Tracy 2009). But there is as yet no computational equivalent of this pluralistic meta-propagation. Even in cases where a politically vibrant resistance creates alternatives, as in platform cooperatives opposing platform capitalism (Scholz 2016) the impulse is always to "fight fire with fire"; to make a unidominant oppositional platform, because we assume the validity of industrial concepts of scaling implicitly; indeed, without seeing it as a concept at all. There is work to be done here, new kinds of praxis that are needed to address the intertwined challenges of the Plantationocene and the Platformocene.

In 2021 we received a new research grant from the National Science Foundation, "Race, Gender and Class Equity in the Future of Work: Automation for the Artisanal Economy." The ultimate goal of the grant is to run experiments in developing an economic ecosystem from the bottom-up, one in which AI, digital fabrication, and other automation techniques can facilitate unalienated value generation and flow, rather than extraction. Here, too, plants play a role. For example, one of our textile artisans in Detroit, Daune Smith of Visual Noise, is using simulation software and AI assistance to develop new patterns that draw on her African heritage as well as urban fashion sensibilities. She sends those patterns to fabricators in Ghana, some of whom use a sustainable tree-derived dye whose manufacture we facilitated with solar heat production (https://generativejustice.org/solar-dye-in-ghana/). They then market their own styles locally (https://africanfuturist.org/afrofuture-fashions/) as well as ship cloth back to Smith. The shipment e-fulfillment is carried out by a local cosmetologist who was already shipping hair extensions.

In Lawrence Lessig's 1999 classic *Code and Other Laws of Cyberspace* he advanced the hypothesis that the internet's underlying software architecture acted as a set of legal affordances, constraining some activities and enabling others. But the giddy sense of cyber-escape from that era has now been tempered with the physical reality of data servers' carbon footprint; global warming's impact on supply chains and other matter and energy considerations. A decolonial democracy needs not only "jurisgenerativity"—the specific ability of citizens to make their own laws (e.g., Carpenter and Riley 2014)—but more broadly generative justice; in which law is only one of many kinds of egalitarian value creation, in which creators control their own conditions of production, and in which the value is circulated back to them in unalienated forms rather than extracted. Cutting out Amazon for e-fulfillment, eliminating mass production for textiles, and substituting tree bark for toxic dye chemicals, as we have outlined above, is just one example in which we can plug the leaks of extracted value across multiple formations. Our next goal is to examine the possibilities for online systems that avoid unidominant platforms, and rather spread a pluriversal grassroots economy across ecological, labor, and social domains.

Conclusion

We have endeavored to draw parallels between the kinds of phyto-human alliances that best exemplify Indigenous traditions of generative justice, and those that can help us with thinking and acting in more pluralistic modes in future endeavors to decolonize computing. We need methodologies such as design agency that can nurture community independence from top-down practices; forms of entropic modulation that can allow for localized agency over things like data, and forms of artisanal server gardens rather than the plantation-like server farms (Eglash et al. 2021). Decolonization can be full stack, and phyto-human alliances can be both metaphor and method for this work.

Acknowledgments

This material is based upon work supported by the National Science Foundation (NSF) Future of Work at the Human-Technology Frontier under Grant No. 2128756.

Notes

1 The *kalinzi* system was not utopian; it required a hierarchy. But Van Acker notes that it was not a feudal system where royalty owned land, and peasants were frozen into social immobility. Rather, it followed the basic structure for Indigenous common-pool resources (Ostrom et al. 1994) with reciprocity such that land was available to

all who wanted to use it, and responsibility for contributing to value distribution was integrated at every level. It was destroyed under the Mobutu dictatorship in 1973, when all land became the property of the state. The *kalinzi* system also declined due to population expansions that made land less available; an outcome influenced by immigration, New World crops, and missionary suppression of Indigenous fertility control (Moroole et al. 2020).

2 The use of entropy to measure diversity is integral to its definition. Shannon and Weaver defined the measurement of information as the log of the inverse of the probability of a symbol. For example, if I told you the results of a coin flip, since the odds are 50 percent it has the value of $\log_2(1/0.5)=1$ bit. Hence the more diverse the symbols, the lower the probability of encountering any one of them in particular, and (because it is the inverse of probability) the higher the entropy of that symbol system (the weighted geometric mean of the individual symbol entropies). The word "symbol" can be replaced with "species" in an ecosystem, or "mineral" in rock, or "color" in a tapestry, or "ethnicity" in an institution, or any other property that can be said to have variety. For Indigenous computation of entropy, see Eglash 2002.

3 Indeed, entropic modulation need not include humans at all: all life on earth is composed of swings between low entropy genotype (DNA of a single seed) and high entropy phenotype (adult form with its diverse life history). And if biology is not fundamental enough, consider how physics predicts quantum fluctuations between the uniform (low entropy) "real" particles and the high entropy clouds of virtual particles when they interact with each other.

References

Ali, S. M. (2016), "A Brief Introduction to Decolonial Computing," *XRDS: Crossroads, The ACM Magazine for Students*, 22(4): 16–21.

Babbitt, W. and M. Lachney (2021), "Two Concepts of Enoughness as Organizing Design Principles for Generative STEM Education and Culturally Situated Design Tools," *New Design Ideas*, 5(1): 81–93.

Bennett, A. G. (2016), "Ethnocomputational Creativity in STEAM Education: A Cultural Framework for Generative Justice," *Teknokultura*, 13(2): 587–612.

Bennett, A. G. (2021), "Agentic Design: An Emergent Approach to Generative Justice," *New Design Ideas*, 5(1): 5–20. Available online: http://jomardpublishing.com/UploadFiles/Files/journals/NDI/V5N1/BennettA.pdf (accessed April 7, 2023).

Bryceson, D. F. (2018), "Artisanal Gold Rush Mining and Frontier Democracy: Juxtaposing Experiences in America, Australia, Africa and Asia," in K. Lahiri-Dutt (ed.), *Between the Plough and the Pick: Informal, Artisanal and Small-Scale Mining in the Contemporary World*, 31–61, Canberra: ANU Press.

Carpenter, K. and A. Riley (2014), "Indigenous Peoples and the Jurisgenerative Moment in Human Rights," *Calif. L. Rev*. 102(173). Available online: https://scholar.law.colorado.edu/articles/65 (accessed April 7, 2023).

Chaudhuri, J. P. (1972), "British Reaction to the Firestone Investment in Liberia," *Liberian Studies Journal*, 5(1): 25–46.

Constanza-Chock, S. (2020), *Design Justice: Community-Led Practices to Build the Worlds we Need*, Cambridge, MA: The MIT Press.

Cooke, B. and U. Kothari (eds.) (2001), *Participation: The New Tyranny?* London: Zed Books.

Deleuze, G. and F. Guattari (2004), "A Thousand Plateaus," trans. Brian Massumi, London and New York: Continuum.

Eglash, R. (2009), "Oppositional Technophilia," *Social Epistemology*, 23(1): 79–86. doi: 10.1080/02691720902741407

Eglash, R. (2018), "A Generative Perspective on Engineering: Why the Destructive Force of Artifacts is Immune to Politics," in *Engineering a Better Future*, 75–88, Cham: Springer.

Eglash, R. (2019), "Anti-Racist Technoscience: A Generative Tradition," in R. Benjamin (ed.), *Captivating Technology: Race, Carceral Technoscience, and Liberatory Imagination in Everyday Life*, 227–51, Durham, NC: Duke University Press. doi: 10.1215/9781478004493-014

Eglash, R. (2022), "Computation, Complexity and Coding in Native American Knowledge Systems," in J. Hankes and G. Fast (eds.), *New Perspectives on Mathematics Teaching: NCTM 2022 Yearbook*, 251–62, Reston, VA: National Council of Teachers of Mathematics.

Eglash, R. and D. A. Banks (2014), "Recursive Depth in Generative Spaces: Democratization in Three Dimensions of Technosocial Self-Organization," *The Information Society*, 30(2): 106–15.

Eglash, R., L. Robert, A. Bennett, K. P. Robinson, M. Lachney, and W. Babbitt (2020a), "Automation for the Artisanal Economy: Enhancing the Economic and Environmental Sustainability of Crafting Professions with Human–Machine Collaboration," *AI & Society*, 35(3): 595–609.

Eglash, R., A. Bennett, W. Babbitt, M. Lachney, M. Reinhardt, and D. Hammond-Sowah (2020b), "Decolonizing Posthumanism: Indigenous Material Agency in Generative STEM," *British Journal of Educational Technology*, 51(4): 1334–53.

Eglash, R., A. Bennett, L. Cooke, W. Babbitt, M., and Lachney (2021), "Counter-Hegemonic Computing: Toward Computer Science Education for Value Generation and Emancipation," *ACM Transactions on Computing Education (TOCE)*, 21(4): 1–30.

Escobar, A. (2020), *Pluriversal Politics: The Real and the Possible*, Durham, NC: Duke University Press.

Figueroa-Helland, L., C. Thomas, and A. P. Aguilera (2018), "Decolonizing Food Systems: Food Sovereignty, Indigenous Revitalization, and Agroecology as Counter-Hegemonic Movements," *Perspectives on Global Development and Technology*, 17(1–2): 173–201.

Fisher, E., S. Luning, L. D'Angelo, C. H. Araujo, L. A. de Balme, J. Calvimontes, and R. Twongyirwe (2021), "Transforming Matters: Sustaining Gold Lifeways in Artisanal and Small-Scale Mining," *Current Opinion in Environmental Sustainability*, 49: 190–200.

Global Witness (2022), *The ITSCI Laundromat: How a Due Diligence Scheme Appears to Launder Conflict Minerals*. Available online: https://www.globalwitness.org/en/campaigns/natural-resource-governance/itsci-laundromat/ (accessed April 7, 2023).

Irani, L. and K. Philip (2018), "Negotiating Engines of Difference," *Catalyst: Feminism, Theory, Technoscience*, 4(2): 1–11.

Haraway, D. (1991). "A Cyborg Manifesto," in *Simians, Cyborgs and Women*, 149–81, London: Routledge.

Hayden, B., M. Deal, A. Cannon, A., and J. Casey (1986), "Ecological Determinants of Women's Status among Hunter/Gatherers," *Human Evolution*, 1: 449–473. doi: 10.1007/BF02436620

Jutel, O. (2017), "The Alt-Right and the Death of Counterculture," *Overland Literary Journal*. Available online: https://overland.org.au/2017/07/the-alt-right-and-the-death-of-counterculture/ (accessed April 7, 2023).
Kibriya, S., V. Partida, J. King, and E. Price (2014), "Conflict Resistant Agribusiness in Democratic Republic of Congo," *International Food and Agribusiness Management Review*, 17, Special Issue B. Available online: https://core.ac.uk/download/pdf/232287904.pdf (accessed April 7, 2023).
Klein, C. F. (1982), "Woven Heaven, Tangled Earth: A Weaver's Paradigm of the Mesoamerican Cosmos," *Annals of the New York Academy of Sciences*, 385(1): 1–35.
Kuznar, L. A. (2001), "Ecological Mutualism in Navajo Corrals: Implications for Navajo Environmental Perceptions and Human/Plant Coevolution," *Journal of Anthropological Research*, 57(1): 17–39.
Lachney, M., A. Bennett, A., G. Appiah, and R. Eglash (2016), "Modeling in Ethnocomputing: Replacing Bi-Directional Flows with Recursive Emergence," *International Journal for Research in Mathematics Education*, 6(1): 219–43.
Latour, B. (1987), *Science in Action: How to Follow Scientists and Engineers through Society*, Cambridge, MA: Harvard University Press.
Lessig, L. (1999), *Code and Other Laws of Cyberspace*, New York: Basic Books.
Lewis, J. E. (ed.) (2020), "Indigenous Protocol and Artificial Intelligence Position Paper," *Honolulu, Hawai'i: The Initiative for Indigenous Futures and the Canadian Institute for Advanced Research (CIFAR)*. doi: 10.11573/spectrum.library.concordia.ca.00986506 Available online: https://spectrum.library.concordia.ca/986506 (accessed April 7, 2023).
M'Closkey, K. (2004), "Towards an Understanding of Navajo Aesthetics," *SEE: Semiotics, Evolution, Energy*, ed. P. Harries-Jones, 4(1): 1–91.
Mhlambi, S. (2020), "From Rationality to Relationality: Ubuntu as an Ethical And Human Rights Framework for Artificial Intelligence Governance," *Carr Center for Human Rights Policy Discussion Paper Series*, 9.
Moroole, M. A., S. A. Materechera, W. Otang-Mbeng, and A. O. Aremu (2020), "African Indigenous Contraception: A Review," *African Journal of Reproductive Health*, 24(4): 173–84.
Mousseau, F. (2019), *The Bukanga Lonzo Debacle: The Failure of Agro-Industrial Parks in DRC*. Available online: https://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/bukanga-lonzo-debacle-small.pdf (accessed April 7, 2023).
Nortey, S. (2012), "Artistic Evolutions of the Ga Mashie Twins Yam Festival and its Cultural Omplications," *Art Design Studies*, 2: 1–9.
Ostrom, E., R. Gardner, J. Walker, J. M. Walker, and J. Walker (1994), *Rules, Games, and Common-Pool Resources*, Ann Arbor: University of Michigan Press.
Pritchard, H., J. Rocha, and F. Snelting (2020), "Figurations of Timely Extraction," *Media Theory*, 4(2): 159–88.
Rice, L. (2018), "Nonhumans in Participatory Design," *CoDesign*, 14(3): 238–57. doi: 10.1080/15710882.2017.1316409
Ross, A. (2018), "Africa's Green Revolution Stumbles at Congo Project to Solve Food Shortages," *Reuters*. Available online: https://www.reuters.com/article/us-congo-agriculture-idUSKCN1IN0IJ (accessed April 7, 2023).
Scarcelli, N., P. Cubry, R. Akakpo, A. C. Thuillet, J. Obidiegwu, J., N. N. Baco, and Y. Vigouroux (2019), "Yam Genomics Supports West Africa as a Major Cradle of Crop Domestication," *Science Advances*, 5(4). Available online: https://www.science.org/doi/10.1126/sciadv.aaw1947 (accessed April 7, 2023).

Scholz, T. (2016), *Platform Cooperativism: Challenging the Corporate Sharing Economy*, New York: Rosa Luxemburg Foundation.

Schuler, D. and A. Namioka (eds.) (1993), *Participatory Design: Principles and Practices*, London: Lawrence Erlbaum Associates.

Schuster, R., R. Germain, J. Bennett, N. Reo, and P. Arcese (2019), "Vertebrate Biodiversity on Indigenous-Managed Lands in Australia, Brazil, and Canada Equals that in Protected Areas," *Environmental Science & Policy*, 101: 1. doi: 10.1016/j.envsci.2019.07.002

Shukla, P. R., J. Skeg, E. C. Buendia, V. Masson-Delmotteh, O. Pörtner, D. C. Roberts, and J. Malley (2019), *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*. Available online: https://www.ipcc.ch/site/assets/uploads/sites/4/2020/02/SPM_Updated-Jan20.pdf (accessed April 7, 2023).

Smith, B. D. (2011), "General Patterns of Niche Construction and the Management of Wild Plant and Animals Resources by Small-Scale Pre-Industrial Societies," *Philosophical Transactions of the Royal Society of Biological Sciences*, 366(1566): 836–48.

Spivak, G. C. (1993), *Outside in the Teaching Machine*, London: Routledge.

Taussig, M. T. (1980), *The Devil and Commodity Fetishism in South America*, Chapel Hill: University of North Carolina Press.

Terranova, T. and R. Sundaram (2021), "Colonial Infrastructures and Techno-Social Networks," *e-flux Journal*, 123, December. Available online: https://www.e-flux.com/journal/123/437385/colonial-infrastructures-and-techno-social-networks/ (accessed April 7, 2023).

Tracy, B. S. (2009), *Transcultural Transformation: African American and Native American Relations*, Lincoln: The University of Nebraska-Lincoln.

Tsing, A. L. (2015), *The Mushroom at the End of the World*, Princeton, NJ: Princeton University Press.

Van Acker, F. (2005), "Where Did All the Land Go? Enclosure & Social Struggle in Kivu (D.R.Congo)," *Review of African Political Economy*, 32(103): 79–98. doi: 10.1080/03056240500120984

Warren-Thomas, E. M., D. P. Edwards, D. P. Bebber, D. P. P. Chang, A. N. Diment, T. D. Evans, F. H. Lambricj, J. F. Maxwell, M. Nut, H. J. O'Reilly, I. Theilade, and P. M. Dolman (2018), "Protecting Tropical Forests from the Rapid Expansion of Rubber Using Carbon Payments," *Nature Communications*, 9: 911. doi: 10.1038/s41467-018-03287-9

Weaver, H. N. (2008), "Boiling Pot of Animosity or an Alliance of Kindred Spirits—Exploring Connections between Native Americans and African Americans," *Journal of Sociology & Social Welfare*, 35: 115.

Woolgar S. (1990), "Configuring the User: The Case of Usability Trials," *The Sociological Review*, 38(suppl. 1): 58–99.

Part Three

Becoming-with Plants

In this part, the chapters and artworks document our becoming-with plants and computation; that is, how human life is inseparable from plants. In this section, we mobilize Haraway's (2008) concept of "becoming-with" to consider the politics of relationality and interdependence of living with plants. The chapters outline how "becoming is always becoming with, in a contact zone where the outcome, where who is in the world, is at stake" (2008: 3).

Jane Prophet's chapter accounts for the development of her collaborative augmented reality artwork, *Pocket Penjing*, which simulates the growth of 3D trees from live environmental data and human intra-action. The project grew in the contact zone of Hong Kong, where plants and humans are entangled with questions of governance. She describes her particular use of "phytographia"—writing beside plants—that extends to the computer coding of algorithms with plants. Prophet's chapter offers a "writing beside" of her works with plants that go beyond the use of computation to measure, manage, or control plant growth; rather, works in which computation is part of complex relations that open up potentialities and create new affordances for virtual plants.

In "Tehran of Trees," Sina Seifee tells the stories of "becoming-with" as a "becoming-worldings," recalling a series of meetings and talks with friends in Tehran about their memories and experiences of trees—a nonnegotiable indebtedness—which shapes city life. The ethnographic stories inform a series of computer-generated animations and poetry that form a "counter-memorial mediated practice"—the computer remembering the plant.

"Becoming-worlding" is also central to sound artist Joel Ong's case study of his ice-crystal forming work, *Terra Et Venti* (Between the Earth and the Wind), made with the plant bacterium *Pseudomonas Syringae.* Ong's artwork depends on encoding algorithmically derived poetry into the DNA of *Pseudomonas Syringae*, a microbe that is implicated in planetary-scale anthropogenic weather modification.

In "*Sunbot Swarm*: Absurdist Cyborg Systems for House Plants," Kathleen McDermott's media art investigations result in artworks, where plant-based cyborgs move freely to seek out the sun. McDermott prompts us to consider the future of the relationship between technology and bodies through a less anthropocentric lens.

The book's final chapter is a lullaby based on a script for a performance by the artist-duo Breakwater, Youngsook Choi and Taey Iohe. They work with the dandelion as a healing agent and a witness that counts the damages of traumatic incidents, such as the 2011 Morecambe Bay cockling disaster and the 2021 Atlanta spa shooting, to Asian bodies. They activate collective healing through performative acts that describe their installation *Fermented Flower*.

Reference

Haraway, D. (2008), *When Species Meet*, Minnesota: University of Minnesota Press.

10

Codely Phytographia: An Artist's Material History of Writing Code with Trees

Jane Prophet

Introduction

In the sunlit green highest reaches—flames!
A morning in early June the outer islands and clouds
pass and we turn into your yielding rows,
and you demand seeing beyond genus and species.
[…]
How does something simply change colors?
Must green always mean tolerance? Red
revolution? No. Symbols
are mostly limitations. I must avoid categorizing.
The longer I look at you, the more I want to see.
Do your green tangles go on sacrificing red-orange blossoms, wide open, to
white clouds, or do your stamens and pistils also laugh till they shake
at the unending games of creeping branches and flirting leaves?
This until, in mid-gaze, my bus
turns the corner and the scene alters
into yet another way of seeing you and your world.

("The Flame Tree" by Leung Ping-kwan, 1991; Leung 2012: 143)

This chapter began as a reflection on the development of an app, *Pocket Penjing*, that simulates the growth of a tree to express air quality and pollution. I made the initial prototype for *Pocket Penjing* (see Figure 10.1) with my long-term collaborator, software developer, Mark Hurry, when I lived in Hong Kong in 2012–2016 and worked at City University in the School of Creative Media. We iteratively developed that prototype through a research practice that later included a co-design process facilitated by my Singaporean colleague, Yong Ming Kow (Kow and Nardi 2010) with over sixty Hong Kong and Chinese students. Elsewhere, I have described the co-design process through which the app emerged (Prophet, Kow, and Hurry 2018b) and discussed how it was designed to engage publics with science (Prophet, Kow, and Hurry 2018a). *Pocket*

Figure 10.1 Left, the app's opening screen; middle, the simulated globe players spin to "plant" their virtual tree; right, a simulated tree grows from the graphic marker laid on top of a real flowerpot. *Pocket Penjing*, 2016. Courtesy the author. CC4r.

Penjing takes its name from "penjing," or "penzai," artistically formed miniature trees and landscapes, planted in shallow trays, that originated in China and predate bonsai.

Leslie McCall, writing on intersectionality, notes that research practice "mirrors the complexity of social life, calling up unique methodological demands" (McCall 2005: 1772). To account for the complexity of social life in works like *Pocket Penjing* I reflected on some of the intersecting frameworks of multiple, interacting forms of oppression that are part of *Pocket Penjing*'s co-design process and these became the new focus of this chapter. In a paper on intersectionality, identity politics, and violence against women of color, Kimberlé Crenshaw wrote, "[t]hrough an awareness of intersectionality, we can better acknowledge and ground the differences among us and negotiate the means by which these differences will find expression in contracting group politics" (Crenshaw 1990: 18). Crenshaw's intersectionality was developed in the context of anti-Black racism in the US. Race, colorism, and intersectionality play out differently in the UK and Hong Kong in the co-design process and my work with trees in significant ways. I start by looking back on my childhood and my older artworks to situate myself and the works in intersecting frameworks of multiple, interacting forms of oppression.

My Life in Trees

My lifelong entanglements with plants and trees, both virtual and real, are best situated via a preamble, a relaxed walk amongst trees and plants, with my younger self. The saying "the apple doesn't fall far from the tree" seems appropriate because as a baby

I was immersed in plants. My mother laid me in bushes of lavender to surround me with scent, and placed me down for naps in clumps of yellow flowers (see Plate 25), convinced that immersing me in the scent and color of plants would enrich my world. I grew up loving our gardens, my mother's suburban greenhouse (Plate 25), and, later, the expansive gardens at the large house we moved to in the Cotswold countryside. To write this chapter I asked my mother, who spends most of her time with plants, how she would describe her background and her movement between social classes. She grew up in a working-class family in Birmingham, an industrial city in the UK. An autodidact, her lifelong passion for plants and garden design prompted her to learn Latin to better understand plant names. Her later (and relatively brief) upper middle-class life afforded her beautiful landscapes and these are what she misses most about that time of privilege: she renovated a neglected Gertrude Jekyll garden and went to horticultural college when she was fifty, though she still identifies with her working-class roots and values.

I was raised in an economically privileged family that lived in a rural area and later fell on hard times. In the 1970s, I spent hours in the countryside near my home, climbing trees, wading through ponds, swimming in rivers, sometimes with a dog or pony, usually with no humans in sight. My adored maternal grandfather, a retired metallurgist, had a stroke while doing a yoga headstand and, as a result, came to live with us when I was five. We spent a lot of time together and, although uneven garden paths were tricky for him to navigate after his stroke, he would walk slowly with me and point out plants, always telling me something about their healing or poisonous properties; "that small yellow flowering plant is aconite, used to make the homeopathic remedy of the same name. And *that* is belladonna, which means 'beautiful lady', because women used it to dilate their pupils, but it can be poisonous." My fascination with plants' forms and chemistry flourished through his explanations, our scrutiny of plants (sometimes with a magnifying glass), and the hours we spent together reading plant entries in *Encyclopedia Britannica* while we waited to watch the Saturday afternoon wrestling match on TV.

In her opening to *Through Vegetal Being* (Irigaray and Marder 2016), Luce Irigaray talks movingly and eloquently of her love of the vegetal world from infancy onwards, recounting times she sought refuge in the vegetal world. After writing *Speculum of the Other Woman* (Irigaray 1985), she describes being rejected both professionally and by many of her friends, and how she found sanctuary in nature, "I was outside, and I could attempt to recover my breathing first to survive and, then, to discover how to cultivate life" (Irigaray and Marder 2016: 20). As a tween and teenager, my family life was fractured by domestic violence and increasingly our house felt unsafe. I took sanctuary outside in our garden and the surrounding countryside.

Despite the threat of violence having gone, I remained an insomniac after my father's death when I was sixteen. I often crept out of the house if I was still awake at 4 a.m., and walked a mile across fields, navigating by moonlight or with a torch, to the top of a hill. Those were psychologically dark days and lack of sleep made me despondent and jumpy, but I felt better being outside. Irigaray describes the vegetal world as a "mothering place" and the air as "placental" (Irigaray and Marder 2016: 21), which is different from my experiences which were characterized by a physical and sensory shift, away from my racing thoughts to a heightened awareness of all outside me. I did not experience boundary-blurring blending with the myriad of vegetal beings, nonhuman animals, and weather but I became more aware of myself in the world. This may be closer to Irigaray's comment that breathing also reminded her of "the difference between the outside and the inside … the difference between the other and myself" (Irigaray and Marder 2016: 23) For me, being there was therapeutic, in keeping with findings that the health and well-being of young adults improves if they have increased access to wooded landscapes (Milligan and Bingley 2007). For Irigaray, breathing in nature, drawing the air of nature in, and breathing while-in-nature are acts of universal sharing from vegetation, especially trees that give the "gift of breathable air by releasing oxygen in the process of photosynthesis" (Irigaray and Marder 2016: 130). On the one hand, I empathize with Irigaray's feeling of finding solace in nature, while, on the other hand, I balk at presenting trees and the vegetal in terms of what they afford humans, such as oxygen. The belief that trees are the earth's dominant oxygenators is speciesism, a misconception that places trees, easily sensed by humans, above phytoplankton. These microscopic marine plants are less apparent to humans but produce roughly 80 percent of the world's oxygen ("World's Biggest Oxygen Producers Living in Swirling Ocean Waters" n.d.). During my difficult teenage years, it is certainly true that my breathing often deepened when I was outside, but as significant as my visceral breathy experience were the feral adrenaline rushes in response to the movement of a swooping owl or a sudden rustle in the undergrowth. I spent many pre-dawns sitting against a tree, sensing the night, soothed by watching the silhouettes of branches against the night sky, black on black. In winter I observed branching structures as the light gathered, in summer I watched leaves move. The reduction in stress I felt, sitting against one tree, gazing at the silhouettes of others, is supported by research showing that even experiencing virtual environments modeled on everyday urban natural environments reduces stress (Hedblom et al. 2019). In the hours before dawn, when my sight was weakest, sound and touch were the primary senses through which I experienced the world around me: the occasional startling call of a screech owl, the more common rustling of mice and insects, the feel and sound of wind through foliage and wheat, the cold ground beneath me. As dawn started to break my eyes discerned more definition and color, and, once again, sight became my dominant sense. Those nights, sitting with trees at the edge of a field, gave me a feeling of belonging that I could find almost nowhere else, certainly not amongst humans. These embodied experiences of trees are part of my sensibility that led to the production of the app, *Pocket Penjing*.

Pocket Penjing grew from the affinity I feel with trees, imprinted through the ones I climbed as a tomboy and my sharpened observation of them through insomnia. However, I realized that the gritty virtual soil in which *Pocket Penjing* is planted was created over eighty years ago, from the ground-down traces of my father and paternal grandparents and their colonial connection to Hong Kong, the city where I worked on *Pocket Penjing*. My father was born in Hong Kong in 1937, the son of a Scottish accountant and a Devonshire physical education teacher who met there. He left with his mother as a six-year-old, just before the 1941 Japanese invasion. My paternal grandfather stayed behind, a soft-handed white accountant with little military training, who joined the

Hong Kong Volunteer Defence Corps and numerous Hong Kong Chinese, British, Indian, and Canadian soldiers who fought the powerful Japanese army. Discussing his war experience was taboo in our family but I learned he had fought in Hong Kong's wooded subtropical hills, been captured, and spent three years and eight months in a prisoner of war (POW) camp at Sham Sui Po, and survived, though severely damaged. One of the few stories he told was that Japanese guards took the prisoners' Red Cross food parcels, leaving them with almost nothing but the tinned tomatoes that they did not like to eat. From 1943 until they were liberated, the prisoners were allowed to garden and planted tomato seeds from those tins and improbably grew scraggly plants that bore fruit. Their communal gardens supplied almost the only fresh vegetables they had and were fertilized with their feces (Schwarzkopf 2019). My grandfather believed the tomatoes' vitamins were one of the things that saved the prisoners who survived. But it may equally have been the therapeutic effect of creating these "defiant gardens" (Helphand 2006). Kenneth Helphand details numerous examples of "barbed wire gardens" that are still created by internees, POWs, and refugees held in camps. At the end of the Second World War my grandfather returned unexpectedly on a hospital ship to the UK, emaciated and diseased, and testified in the subsequent war crimes tribunal ("Hong Kong's War Crimes Trials Collection," n.d.). As soon as he was fit enough, he and my grandmother returned to live and work in Hong Kong for another decade, leaving my father in a British boarding school. They returned to the UK before I was born, but that family history played a part in my decision to relocate there sixty years later. I hoped that being in Hong Kong would help me better understand my tough-as-nails, paternal grandmother whose house was full of Chinese mementos, and the grandfather who died when I was too young to remember him.

Phytography: Vegetal Writing with Trees

I mainly wrote this chapter during COVID-19, inside, working at my computer in Michigan, looking at urban trees on the street. Nevertheless, this chapter is what Irigaray terms a feminist vegetal writing—it emerges from the author's ongoing encounters with plants and trees. Patricia Vieira, scholar of comparative literature, postcolonial studies, and ecocriticism, expands Irigaray's concept of vegetal writing, offering the term "phytographia," combining the Greek words "phyto," meaning "plant," and "graphia," meaning "writing or drawing," in her focus on human cultural productions. In Vieira's phytographia the vegetal has more agency in processes of inscription. She defines phytographia as "the encounter between the plants' inscription in the world and the traces of that imprint left in literary works, mediated by the artistic perspective of the author" (Vieira 2015: 205). As a visual artist, the activity of *writing* something like this chapter is not "an intransitive activity, a variation on breathing, an end in itself" as Rosi Braidotti (2014: 163) describes writing in her life; however, coming up with ideas and writing/drawing them into artworks using computer code is an end in itself for me. Like Vieira, I write/draw beside plants, specifically trees, and so I have found it useful to borrow Vieira's term, phytographia, and expand the idea of writing to include writing-code-beside-trees. Over the last thirty-five years I have made a series of artworks beside trees. This began when, as a first-year undergraduate, I composed abstract images with tiny pieces of detritus from the forest floor using tweezers to arrange them between the panes of 35 mm glass slides (Plate 26). I then projected the results onto piles of leaves and hanging texts.[1]

Now, thirty years later, I use text differently, creating art inscribed through writing computer code with human and arboreal collaborators. This, I suggest, extends Patricia Viera's idea of vegetal *writing with plants*, her "phytography," to *computer coding with plants*. For me, phytographic writing with code "is an affective and geometrically rigorous mode of inscription into life" (Braidotti 2014: 163). Since the mid-1990s I have created idealized fractal landscapes and trees (Plate 27) with computer programmer Gordon Selley, using variations of his algorithms that simulate trees (Selley 1991). For Viera, plants' inscription "depends primarily on their physical configurations that shape both the contours of a landscape … and of their relation to animals" (Vieira 2015: 208). Selley and I took a similar approach as we researched the morphology of English oak trees and their location in landscapes, amongst animals who often impacted their branching structures. The resulting artworks owed a lot to the time we spent walking and driving around the UK observing trees, especially after the oaks lost their leaves in the autumn and we could see their branching structures. The artworks we created were a kind of biotechne that emerged as part of an "active, technical process," a matter of techne, or mattering through techne (Walters 2002) in relation with biology. The mundane and largely ignored practices that enabled us to inscribe these trees, to simulate these realities, included reading scientific papers and consulting with arborealists to understand how location, animals, weather, and injury impact oaks' forms, or as Vieira might say, how they were inscribed and concurrently how they inscribed. We used those practices to develop a formal model, a description written in plain English, of how oak forms grew, which Selley translated into mathematical rules—an algorithm, a numbering. The rules controlled our computer code to form virtual 3D computer models of oak trees. Writing with the computer code we produced images (Plate 27) and 3D-printed objects (Figure 10.2) that approximated the look of oak trees, specifically, *Quercus robur*, the English oak. Braidotti says, "writing is the visualization of ethical relationality through the in-depth critique of Power" (Braidotti 2014: 165) and our choice to computer code with plants with *Quercus robur* enabled an exploration of how the English oak inscribed, and was inscribed by, power. The projects are not inscriptions *of* trees *by* humans, instead each is a phytographic *computer coding with plants*, a co-constituted, co-evolutionary process. Co-constituted processes are not necessarily equitable, though a vegetal writing of human lives can offer a freer, less oppressive, relationship with the landscape. These artistic inscriptions with trees are entangled with the gauging, or numbering, of landscapes to draw attention to the trope of relating to them as resources; for example, instrumentalizing oak trees by focusing on what they afford, from oxygen to aesthetic pleasure.

England's national tree, *Quercus robur*, is significant to me beyond my English identity. It is the species that I most often climbed, that I sat against during many of those pre-dawn interludes on the hill, the same species under which Druids gathered.[2] At school I was taught that, by the mid-sixteenth century, hundreds of thousands of English oaks had been felled and used to build the Royal Navy fleet (Richards 2003).

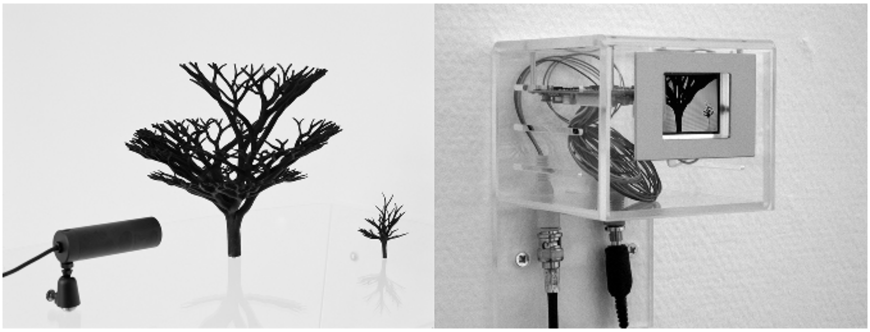


Figure 10.2 Left, 3D printed tree form generated from code with a small camera pointed at it; right, camera image of the same model seen in a miniature screen, both from *Model Landscapes*, 2004. Courtesy the author. CC4r.

The oak became integral to both Britain's ongoing independence and its colonial expansion. From the 1660s onwards British landowners were urged to plant oaks as a patriotic duty for future shipbuilding, including ships that Britons forced enslaved Africans onto (Glickman 2015). In the late eighteenth century, huge numbers of oaks were planted by landowners like Colonel Thomas Johnes, legendary for planting 3 million trees between 1782 and 1813 on his Welsh estate in Ceredigion (Linnard 1971). Landowners benefited from oak's commodification and folklore inscribed oak woods as sites of class war. Like many woods, Sherwood Forest was taken from common ownership, closed off for elite and royal sport, and used by rebels as a base from which to rob the rich. The ongoing association of oaks with power drew national attention in 2006, when the British right-of-center Conservative political party scrapped their thirty-year-old flaming torch logo and replaced it with an oak tree to symbolize traditionalism, strength, endurance, renewal, and growth. But the new logo confused voters, with many associating it with an eco-consciousness that they felt was at odds with Tory branding (Pich and Dean 2015). Welsh and Scottish Conservative party members, mindful of the association of the oak with England, called for different regional logos with other trees better suited to their national identities. The Conservative Party's deployment of the oak as a cultural artifact problematically conflated Englishness with Britishness. The logo was read as inscribing centralized power, a phytographia of English privilege.

Co-constituted Landscapes in China and Britain: Garden Designers Phytographia with Painters

While I was artist-in-residence at the National Trust (Prophet 2001), foresters and parkland custodians shared a lot about the design and production of eighteenth-century pleasure gardens. Through archival research at the National Trust Slide Library, I noticed that pleasure gardens in different places in England looked similar. A distinctive genre had emerged in the 1700s, through the redesign of many English parklands and gardens to look like the scenes depicted in paintings that often incorporated oak trees as key compositional elements. English oaks were inscribing privilege as designers either deliberately placed them in the English landscape or privileged some mature oaks by leaving them in place while felling other species. The enduring inscription of the elite's taste and their power through materializing scenes from paintings in actual landscapes became clear in 1999 when I visited the Holkham Hall estate, designed by Humphry Repton. Paintings in the aptly named Landscape Room, after which I named my subsequent series of photographs, include twenty-two Old Master pictures hung in the eighteenth-century manner, one above the other. The poet George Mason attributed the contemporaneous innovation of English pleasure grounds' designs to Claude Lorraine's landscape paintings that had been seen by wealthy English tourists, who "Bring back to Britain; there give local form/To each Idea" (Mason 1783: 68–9). I stood in Holkham Hall's Landscape Room and looked at seven Claude Lorraine paintings, then turned 180 degrees and opened a wooden shutter to see a very similar scene instantiated in the Repton-designed parkland, a picturesque phytographia, that inscribed privilege and power with landscapes and trees. Contemporaneous plans reveal that creating painterly views across landscapes might be violent inscriptions of power, removing "unsightly" hills and workers' villages, or planting woodlands to obscure visual evidence of a neighbor. This "view-borrowing" is often misattributed as a British approach, but view-borrowing originated in China (Liu 2003). *Pocket Penjing* depends on view-borrowing as, using augmented reality, each simulated tree seen on the mobile device running the *Pocket Penjing* app is seen over the top of the live view of whatever the player's camera is pointing at, as seen in Plate 28. To borrow from the scenery means, as Ji Cheng says in his famous seventeenth-century gardening book,

> that although the interior of a garden is distinct from what lies outside it, as long as there is a good view you need not be concerned whether this is close by or far away … Wherever the view within your sight is vulgar, block it off, but where it is beautiful, take advantage of it.
>
> (Ji Cheng 1988: 39–40)

As I looked for an appropriate tree species to write code with to create *Pocket Penjing*, I learned that the influence of Chinese painters and paintings on Chinese garden designers predated the picturesque movement in Britain by over a hundred years. Working in the late Ming dynasty, Zhang Lian (b. 1587), also known as Zhang Nanyuan, created gardens for wealthy landowners (Hardie 2004). His designs were co-constituted with contemporaneous avant garde landscape painting (Dunzhen and Wood 1982). The poet Wu Weiye, Zhang's close friend, wrote a biography of Zhang, in which he emphasized Zhang's relationship with leading art critic, Dong Qichang (1555–1636) and the painter Wang Shimin (1592–1680), for whom Zhang "designed or renovated several gardens" (Hardie 2004: 137). During the late Ming period there was a more self-conscious discourse on how creators of gardens take their models and inspiration from paintings and poetry. In 1631, the Chinese garden designer, Ji Cheng (b. 1582), wrote in the preface to his treatise, *Yuan Ye* (*The Making of Gardens*), "Since my youth I have been known for my paintings. By nature enamored of seeking out the wondrous, I especially love the style of Guan Tong and Jing Hao [both of the tenth century], often upholding them as models" (Liu 2018: 317). In the design of these gardens and in Chinese paintings, blossom trees appeared again and again and, following discussions with Chinese students, I was prompted to simulate the cherry blossom tree in *Pocket Penjing*. The British cultural appropriation of Chinese painting and gardening was piecemeal, for example, focused on the beauty depicted in ink paintings of cherry blossom, and studiously ignoring other key elements of Chinese garden design, notably Chinese designers' habit of introducing the terrible and damaging aspects of nature into their gardens:

> Their scenes of terror are composed of gloomy woods, deep vallies [*sic*] inaccessible to the sun, impending barren rocks, dark caverns, and impetuous cataracts rushing down the mountains from all parts. The trees are ill formed, forced out of their natural directions, and seemingly torn to pieces by the violence of tempests.
>
> (Chambers 1773: 39)

Chambers had many discussions with the Chinese painter and garden designer, Tan-Chet-Qua who visited England in 1769–72. Tan-Chet-Qua suggested that English gardens could be greatly improved by adopting the more superior Chinese approach, noting that:

> England abounds with commons and wilds, dreary, barren, and serving only to give an uncultivated appearance to the country, particularly near the metropolis: to beautify these vast tracts of land, is next to an impossibility; but they may easily be framed into scenes of terror, converted into noble pictures of the sublimest cast, and, by an artful contrast, serve to enforce the effect of gayer and more luxuriant prospects.
>
> (Chambers 1773: 131)

During the participant design sessions we ran as we developed *Pocket Penjing*, a number of the participants suggested modeling violent typhoons and the damage they might cause to the simulated cherry trees.

Privileged Inscriptions: Economy, Colonialism, and Gardens

Vegetal writing takes place at the intersection of species with human privilege so profound and multilayered it is impossible to account for it fully, as in every written account humans speak for plants. If, as I do, one believes in the observer effect—that an observed system is disturbed by the act of observation whether the observation is by human or an instrument—then even phytographic experiences with no touch, where humans "only" observe, are impacted by the act of human observation, mediated or not, and observation is intersectional. Writing/drawing with Hong Kong plants, and observing them, is a process entangled with British colonialism very differently from the colonial entanglement when writing with the English oak. In the UK, working with the oak, the intersection of gender and class were most profound, especially in relation to the disparities that women and all people of lower and middle classes lived under in the eighteenth century. As a middle-class woman artist working with computation, the privilege of my class and education intersected with the relative lack of privilege afforded by being a first-generation graduate and my gender, though with the advantages of being cis-gender and heterosexual. In Hong Kong intersectionality played out differently for me. I occupied a place of multiple intersecting privileges afforded to me unearned through my whiteness, Britishness, English being my first language, my UK passport, and my well-paid job as a full professor. My place at the intersection of race, color, gender, nationality, and class were all part of my relations with the local vegetation.

Pocket Penjing emerged at a very significant time in Hong Kong, during times that were troubled and cloudy (Haraway 2016), both literally and metaphorically. *Pocket Penjing* was inspired by the daily habit of gauging the meaning of clouds over Hong Kong: were they formed of wet tropical air, or pollution particulates, or a combination of the two? Should I wear a mask or just carry an umbrella on my commute? In his nuanced ethnographic writing on environmentalism in Hong Kong, Timothy Choy has said, "Air mattered powerfully in Hong Kong. It mattered in deeply felt, variegated, and variegating ways" (Choy 2011: 142). When he first lived in Hong Kong in 1999, two years after Britain "handed over" Hong Kong to China, Choy observed that it was predominantly "expatriate businesspeople from the United States" (ibid.: 141) who complained about poor air quality and therefore he largely kept quiet about his own concerns to avoid aligning himself with them. A comparative study of about one thousand Hong Kong people randomly selected from a telephone directory showed 93 percent Hong Kong respondents rated the problem of air pollution as serious or very serious in both 2000 and 2008, about twice the percentage of other Asian societies (Wong and Wan 2011). These findings exist at the same time as the othering of pollution and of Hong Kongers by white American foreigners that Choy flags up. In Choy's discussion of positioning air pollution in relation to the local economy and to China, he draws attention to another othering, this time of China, seen in his description of people's tendency to deflect attention from local causes of pollution towards polluted air coming from China's industrialized Pearl River delta. The American expats to whom Choy refers, speaking from the intersection of multiple intersecting elite migrant privileges, explicitly or implicitly criticized and othered mainland China, connecting Hong Kong's air quality to airborne pollutants from the mainland beyond Hong Hong's border. Such verbal inscriptions of pollution perpetuate a superior colonial attitude towards so-called "newly industrialized" countries like China. Towards the end of the period that I lived in Hong Kong, when we were co-designing *Pocket Penjing*, residents' concerns over pollution were superseded by demands for a fully functioning electoral democracy and resistance to the People's Republic of China's (PRC) colonization of Hong Kong. Resistance was expressed through street protests, art, and the reworking of the Hong Kong flag. The political movement that emerged during the Hong Kong democracy protests of 2014 demanded the right for more citizens of the territory to pick their leaders and was known as The Umbrella Movement, named for the umbrellas that protesters used to protect themselves from tear gas.

Flags as Phytographia

In 1997, after governing Hong Kong as a colony for one and a half centuries, Britain handed Hong Kong over to China. In its controversial deal with Britain, China promised Hong Kong a fifty-year period as "One Country, Two Systems," agreeing to govern Hong Kong as a Special Administrative Region (SAR) of China, with Hong Kong people ruling and, in the early days of One Country, Two Systems, enjoying a high degree of autonomy in comparison with other regions in mainland China. However, "colonial consciousness" persists (Leonard 2010) after colonizers depart and the design of the Hong Kong flag can be examined as a phytographic writing that reflects changing relations to the colonialisms perpetuated by Britain and China on Hong Kong. The British Conservative Party's choice of an oak tree as its logo was a phytographic inscription of English privilege and, similarly, Hong Kong's postcolonial flag, featuring the five-petaled flower of a Hong Kong orchid tree as its central emblem, shows the persistence of colonial consciousness. The phytographia that is the current flag (Plate 29, left) was intended to inscribe "One Country, Two Systems." Its petals mimic the five stars of the Chinese national flag that supposedly represent the Communist Party and the four social classes outlined by Mao Zedong. The flag's architect-designer, Tao Ho, arranged the petals in a clockwise motion, "The stylized flower is asymmetrical, and therefore its form implies movement, alluding to Hong Kong's democratic energy and economic vitality … The red background represents China and the five stars … hint at the integration of the 'one country, two systems' policy" ("Taoho Design Art Design—Graphic Identity of Hong Kong" n.d.)

The Hong Kong orchid tree's Chinese name is "洋紫荊," but it was renamed in the 1960s after seventeenth-century French-Swiss botanists Gaspar and Jean Bauhin and Sir Henry Blake, Governor of Hong Kong from 1898 to 1903. While the orchid tree predates British colonialism, this particular hybrid is most commonly referred to by its Latin name, *Bauhinia blakeana*. Scholars of toponymic research, who analyze placenames and how they change to reconstruct the way successive societies leave their cultural imprints on a place, provide insights to the renaming of 洋紫荊 as *Bauhinia blakeana*. The name change canonizes a British colonist in a biopolitical act that claimed the tree species using Linnaeus's system that treats climatic, soil, and ethnographic environments as irrelevant and whereby plants are examples of "[a]ll natural bodies [that] form as it were an extended Empire, governed by the unalterable laws imposed on them by the Creator" (de Ortega and y Verdéra 1785 in Lafuente and Valverde 2005: 136). There were numerous other indigenous trees that could have been chosen to adorn Hong Kong's new flag that retained their precolonial names. The attention paid in postcolonial Singapore to naming streets and using symbols shows an alternate decision-making that could have taken place in Hong Kong. Singapore took a clear stance against canonizing prominent public figures, especially colonists, through naming streets and places after them (we can usefully extend that thinking to naming plants), noting that prevalence in colonial days (Yeoh 1996). While acknowledging the power relations at play in taxonomy, Timothy Choy reminds us that the process of naming by one botanist in respect of another is entangled with friendships, "beneath their explorer surface lie expressions of intimacy and expert care" (Choy 2011: 54).

Blake and his wife were keen botanists, and this tree embodies colonial botany—every known *Bauhinia blakeana* is believed to be a clone descended from a single, sterile specimen "discovered" around 1880. Molecular biologists such as Kwan Hoi-shan, a core member of the Bauhinia Genome Project, have said it is not even a species (Lo 2019). Taking this as her cue, Hong Kong artist Ellen Pau mapped the genome of a *Bauhinia blakeana* and turned its DNA into sound to make "a positive identification of the first segment of its genome that becomes physical evidence of its less than complete form" (Lee 2019). The choice of a non-native tree's sterile hybrid as a national emblem has been described as awkward and inauspicious (Ku and Pun 2011). Despite this, it was chosen reportedly because its hybrid nature best reflected the mixed colonial heritage of the colony itself, the taxonomic inscription of British colonialism in the tree's renaming balanced as it went through a graphic hybridization with the Chinese flag, taking on that flag's colors and incorporating its five-pointed star pattern. The precursor to Taoho's flag design was the Hong Kong Urban Council logo that used the same flower on a magenta background similar to the flower's actual color, rather than Taoho's red background, which is the same color as that used on the PRC flag, reflecting the mixed heritage and "two systems" of contemporary Hong Kong. But what is this mixed heritage that is so poorly represented in this choice of tree as an emblem?

When we designed *Pocket Penjing*, we did not model the tree species *Bauhinia blakeana*, instead, following conversations with Hong Kong and Mainland Chinese students, we decided to model a different non-indigenous tree, the cherry tree, because of its local popularity and its prevalence as a subject of numerous artworks going back thousands of years in Chinese cultures. It is notable that none of the sixty local participants who co-designed the second version of the app suggested modeling the Hong Kong orchid tree. While the cloned Hong Kong orchid trees that flower today are in effect the same trees from colonial Hong Kong, 2019 saw the rise of the Black Bauhinia flag (Plate 29, right). This variant of the flag of Hong Kong replaces the flag's PRC red background with black, and the modified white flower often has wilted or bleeding petals to represent the erosion of freedoms and rights. The new Black Bauhinia flag has become synonymous with the Hong Kong pro-democracy movement and gained popularity during the 2019–2020 Hong Kong protests, after I had left Hong Kong.

Hong Kong Phytographia

In July 2012 I took a taxi from Hong Kong airport to my apartment to start my new job at City University on the mainland part of Hong Kong. In those first minutes, I was physically struck by the differences, in comparison to the UK and east coast US where I had been living, in both my immediate and the larger environment. I experienced the immersive sensation of hot humid air that enveloped me like a blanket and filled my lungs as I left the airport with my bags. Sociologists describe this sort of experience as the embodiment of foreignness—the visceral differences felt by newly arrived, in my case white British, workers—that unsettle and disrupt our sense of "self-control and superiority" (Walsh 2006: 116). Looking outside, I saw many exciting and unsettling unfamiliar tree species in formations that were reminiscent of British civic planting, interspersed with familiar favorites that grow smaller, indoors, in the UK.

In Hong Kong, importing "native" English gardening ideas and planting was both frontier cultivation and enculturation. British colonial rule included over a decade of intense afforestation, with over a million trees a year planted from the early 1870s through to its peak in the 1880s (Dudgeon 1996) to green Hong Kong's so-called "barren rock." Not all colonists viewed Hong Kong as barren, as this picturesque description by English architect and topographical illustrator, Thomas Allom reveals:

> Few areas so limited include so many scenes of sylvan beauty as the sunny island of Hong-kong. The country immediately behind Queenstown is peculiarly rich in romantic little glens, or in level tracts, adorned with masses of rocks, in the fissures of which the noblest forest-trees have found sufficient soil for their support.
>
> (Allom 1843: 33)

The predominant view of landscape as separable, commodified, in terms of what it affords humans, is exemplified in the colonial gaze and in unacclimatized colonists' use of the "barren rock" descriptor. They wanted trees for shelter from unsettling strong sun and monsoon downpours. Planting trees also imprinted colonial aesthetics onto the rocky landscape, obscuring its existing beauty according to feng shui that appreciates the mineral alongside the vegetal world. Most of this multi-million colonial tree planting of one native pine species, *Pinus massoniana* (Dudgeon 1996) were cut for fuel during the Japanese Occupation and the hard post-war years. After the Second World War fast-growing non-natives were planted to replace those losses (Zhang and Jim 2013) and non-native planting continued with 16.5 million trees planted over the last thirty years. The enculturation of Hong Kong through planting in the European style reflected the tripartite colonial and Enlightenment attitudes towards nature: as picturesque, or sublime, and as the ground for improvement, against which inferior figures, defined according to race, socioeconomics, and taste, were set. Enculturating Chinese land extended to garden city designs and to private gardens that "were evoked as enclaves of peace and domesticity in an otherwise sterile and hostile land" (Peckham 2015: 1185). City University's faculty housing, where I lived for the first year I was working in Hong Kong, is located on the mainland portion of Hong Kong in Kowloon Tong. Once known as Kowloon Tong Garden Estate, it was founded as a garden city in 1922 by the Briton, Charles Montague Ede, who wanted to develop Kowloon Tong into a high-class residential area. Toponymic analysis reveals the power of renaming Hong Kong's streets by British colonial immigrant groups (Hsieh 1980) that extends to retaining politically sensitive canonizations even after the Chinese handover. Elgin Street (伊利近街) in the Central district honors James Bruce, the eighth Earl of Elgin and the British High Commissioner to China, responsible in 1860, during the Second Opium War, for the order to loot and destroy the Summer Palace in Beijing and for extending Hong Kong Territory by persuading China to add the Kowloon Peninsula (which includes Kowloon Tong and the adjacent area occupied by City University) to the British crown colony of Hong Kong. Subsequent post-British colonial mutations of Anglicized names, by Hongkongers, is "an ideological tool to divest the landscape of its colonial associations and achieve political legitimation" (Yeoh 1996: 299) but far fewer streets have been renamed in Hong Kong than, for example, in postcolonial Singapore. Colonial-era street names that persist after Hong Kong's reunification to China in 1997 include seventeen streets in Kowloon named after trees like ash, beech, elm, or oak, trees common in the UK but which do not grow in Hong Kong (Dewolf 2016).

After my first year in faculty housing, I moved to Fo Tan (火炭), a light industrial area interspersed with artists' studios. It was full of concrete multistory industrial units, with car repair shops and recycling centers on the ground floor, a few remaining textile producers (though most had relocated to China) and food preparation and distribution units higher up. The streets had almost no litter but were dirty, there was little water-based cleaning of the pedestrian areas, nor civic beautification in this largely non-residential area. But everywhere I looked there were plants. Local shop owners and workers cared for shrubs and small trees planted in all sorts of vessels (Figure 10.3 and Plate 30). Upside-down traffic cones, discarded cooking oil cans, chemical drums, and plastic buckets filled with soil became plant pots, lined up on the pavement, stacked outside garage doors, and clustered around lamp posts. These residents and workers reordered space with the plants they loved, to create a new ecology. If Hong Kong's forestation and planting "illuminates the social and political processes taking place in the 'contact zone,'" where colonial and native Chinese subjects were "constituted in and by their relations to each other" (Peckham 2015: 5) then such plantings around Fo Tan instantiate a contact zone that resists the legacy of colonial order. Might the unsanctioned street plantings in Fo Tan be a form of contemporary

Figure 10.3 Street planting in Fo Tan (火炭), Hong Kong, 2015. Courtesy the author. CC4r.

penjing where nature thrives in recycled containers refashioned as *penjing* planting trays? Their idiosyncratic placement is a new equation of a "green" landscape with economic (re)production and postcolonial order that blurs simple differentiation between public and private space.

Conclusion

In this personal account of the situated material histories of phytographia I have tried to shift what we might understand phytographia to be. These histories grow from, and rot down to be part of, the compost of colonial oppressions, inscribed with and by plants and gardens. Inscribing one version of my history here, I then dug in to expose some of its roots, looking at some of the history of British and Chinese gardens design that each differently inscribe power relations with plants. Phytographia is a colonial practice, an intersectional writing/drawing, and I explored my part in that by extending Patricia Vieira's exciting definition of writing with plants, to coding with plants, reflecting on my own work and lived experience. While *Bauhinia blakeana* is named after botanists, it is not simply the Latin renaming of this tree, after a colonist, that is loaded with colonial power disparities; every sterile cloned tree is itself a phytographic invention of colonial privilege. Through the codely phytographia of *Pocket Penjing* and this account of them, 洋紫荊, the Hong Kong orchid tree, *Bauhinia blakeana*, has become as potent for me as the English oak.

Notes

1 "Summer 84, … Was teaching in art college in Hull (1st time in his life in art college), watched a female student (Jane Prophet) doing performances in front of slides projected on the wall, but she put rubbish from her pockets (scrapings of charcoal) in the slide mount, light passing through; it was very beautiful, incredibly powerful incredible random black marks with white light around them projected on the wall; reminded me of Ian McEver pictures (Show at Arnolfini): simplicity of passing of light through almost nothing. Why not try?" Gary Fabian Miller interviewed by Mark Haworth-Booth and Martin Barnes.

2 "In Irish the word for oak is 'daur,' and in Welsh 'dar' or 'derw,' probably cognate with the Greek 'drus.' Some scholars consider this the origin of the term 'Druid,' since Druids have always been associated with sacred groves, and particularly oak forests" (The Order of Bards, Ovates & Druids, n.d.).

References

Allom, T. (1843), *China, in a Series of Views, Displaying the Scenery, Architecture, and Social Habits of that Ancient Empire*, Vol. 1, Frankfurt am Main: Fisher.

Braidotti, R. (2014), "Writing as a Nomadic Subject," *Comparative Critical Studies*, 11(2–3): 163–84. doi: 10.3366/ccs.2014.0122

Chambers, W. (1773), *A Dissertation on Oriental Gardening. The Second Edition with Additions to Which is Annexed An Explanatory Discourse by Tan Chet-Qua, of Quang-Chew-Fu, Gent*., London: W. Griffin. Available online: https://www.google.co.uk/books/edition/A_Dissertation_on_Oriental_Gardening/kupDwgEACAAJ?hl=en&gbpv=0 (accessed April 6, 2023).

Choy, T. (2011), *Ecologies of Comparison: An Ethnography of Endangerment in Hong Kong*, Durham, NC: Duke University Press.

Crenshaw, K. (1990), "Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color," *Stanford Law Review*, 43(6): 1241–99. Available online: http://www.jstor.org/stable/1229039 (accessed April 5, 2023).

Dewolf, C. (2016), "Solving the Mystery of Hong Kong's Foreign Tree Streets." Available online: https://zolimacitymag.com/solving-the-mystery-of-hong-kongs-foreign-tree-streets/ (accessed April 6, 2023).

Dudgeon, D. (1996), "Anthropogenic Influences on Hong Kong Streams," *GeoJournal*, 40(1–2): 53–61.

Dunzhen, L. and F. Wood (1982), "The Traditional Gardens of Suzhou ('Su zhou gu dian yuan lin')," *Garden History*, 10(2): 108–41. doi: 10.2307/1586743

"Flag, Arms and Graphic Identity of Hong Kong" (n.d.). Available online: https://taohofoundation.org/portfolio/public-commercial/hong-kong-flag/ (accessed April 6, 2023).

Glickman, J. (2015), "A War at the Heart of Man: The Structure and Construction of Ships Bound for Africa," *Open Access Master's Theses.* doi: 10.23860/thesis-glickman-jessica-2015

Haraway, D. J. (2016), *Staying with the Trouble: Making Kin in the Chthulucene*, Durham, NC: Duke University Press.

Hardie, A. (2004), "The Life of a Seventeenth-Century Chinese Garden Designer: 'The Biography of Zhang Nanyuan,' by Wu Weiye (1609–71)," *Garden History*, 32(1): 137–40. doi: 10.2307/1587318

Hedblom, M., B. Gunnarsson, B. Iravani, I. Knez, M. Schaefer, P. Thorsson, and J. N. Lundström (2019), "Reduction of Physiological Stress by Urban Green Space in a Multisensory Virtual Experiment," *Scientific Reports*, 9(1): 1–11. doi: 10.1038/s41598-019-46099-7

Helphand, K. I. (2006), *Defiant Gardens: Making Gardens in Wartime*, San Antonio, TX: Trinity University Press.

"Hong Kong: Population Breakdown by Language 2018" (n.d.). Available online: https://www.statista.com/statistics/329051/hong-kong-population-breakdown-by-language/ (accessed October 21, 2020).

"Hong Kong's War Crimes Trials Collection" (n.d.) [Archive]. Available online: https://hkwctc.lib.hku.hk/exhibits/show/hkwctc/documents/item/61 (accessed August 22, 2022).

Hsieh, C. M. (1980), "Sequent Occupance and Place Names," in R. G. Knapp, *China's Island Frontier: Studies in the Historical Geography of Taiwan*, 107–14, Honolulu: University of Hawaii Press.

Irigaray, L. (1985), *Speculum of the Other Woman*, Ithaca, NY: Cornell University Press.

Irigaray, L. and M. Marder (2016), *Through Vegetal Being: Two Philosophical Perspectives*, New York: Columbia University Press.

Ji Cheng (1988), *The Craft of Gardens: The Classic Chinese Text on Garden Design*, trans. A. Hardie, London: Yale University Press.

Kow, Y. M. and B. Nardi (2010), "Culture and Creativity: World of Warcraft Modding in China and the US," in *Online Worlds: Convergence of the Real and the Virtual*, 21–41, Berlin and Heidelberg: Springer.

Ku, A. S. and N. Pun (2011), *Remaking Citizenship in Hong Kong: Community, Nation and the Global City*, Abingdon, UK and New York: Routledge.

Lafuente, A. and N. Valverde (2005), "Linnaean Botany and Spanish Imperial Biopolitics," in L. L. Schiebinger and C. Swan (eds.), *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*, 134–47, Philadelphia: University of Pennsylvania Press.

Lee, C. (2019), "In Hong Kong, What is Home? Ellen Pau Tackles the Question in Her 30-Year Retrospective." Available online: https://zolimacitymag.com/hong-kong-home-ellen-pau-tackles-the-question-in-her-30-year-retrospective/ (accessed April 6, 2023).

Leonard, P. (2010), "Work, Identity and Change? Post/Colonial Encounters in Hong Kong," *Journal of Ethnic and Migration Studies*, 36(8): 1247–63. doi: 10.1080/13691831003687691

Leung, P. (2012), *City at the End of Time* 形象香港*: Poems by Leung Ping-kwan* 梁秉鈞詩選, Vol. 1, Hong Kong: Hong Kong University Press.

Li, D. C. S. (2018), "Two Decades of Decolonization and Renationalization: The Evolutionary Dynamics of Hong Kong English and an Update of its Functions and Status," *Asian Englishes*, 20(1): 2–14. doi: 10.1080/13488678.2017.1415517

Linnard, W. (1971), "Thomas Johnes (1748–1816)—Pioneer of Upland Afforestation in Wales," *Forestry: An International Journal of Forest Research*, 44(2): 135–43.

Liu, Y. (2003), "The Importance of the Chinese Connection: The Origin of the English Garden," *Eighteenth-Century Life*, 27(3): 70–98.

Liu, Y. (2018), "The Real vs the Imaginary: Sir William Chambers on the Chinese Garden," *The European Legacy*, 23(6): 674–91. doi: 10.1080/10848770.2018.1470382

Lo, Z. (2019), "How Did the Bauhinia, a Sterile Flower, Become the Symbol of Hong Kong?," Available online: https://zolimacitymag.com/how-did-the-bauhinia-a-sterile-flower-become-the-symbol-of-hong-kong/ (accessed April 6, 2023).

McCall, L. (2005), "The Complexity of Intersectionality," *Signs*, 30(3): 1771–1800. doi: 10.1086/426800

Mason, W. (1783), *The English Garden: A Poem*, London: A. Ward, in *The English Garden: A Poem*, Classic Reprint, London, Forgotten Books, 2008.

Milligan, C. and A. Bingley (2007), "Restorative Places or Scary Spaces? The Impact of Woodland on the Mental Well-Being of Young Adults," *Health & Place*, 13(4): 799–811.

Peckham, R. (2015), "Hygienic Nature: Afforestation and the Greening of Volonial Hong Kong," *Modern Asian Studies*, 49(4): 1177–1209.

Pich, C. and D. Dean (2015), "Political Branding: Sense of Identity or Identity Crisis? An Investigation of the Transfer Potential of the Brand Identity Prism to the UK Conservative Party," *Journal of Marketing Management*, 31(11–12): 1353–78.

Prophet, J. (2001), [Artwork] *Decoy*, London: Film and Video Umbrella. Available online: https://www.fvu.co.uk/read/shop/decoy (accessed April 6, 2023).

Prophet, J., Y. M. Kow, and M. Hurry (2018a), "Cultivating Environmental Awareness: Modeling Air Quality Data via Augmented Reality Miniature Trees," in *International Conference on Augmented Cognition*, 406–24, Berlin and Heidelberg: Springer.

Prophet, J., Y. M. Kow, and M. Hurry (2018b), "Small Trees, Big Data: Augmented Reality Model of Air Quality Data via the Chinese Art of 'Artificial' Tray Planting," in *ACM SIGGRAPH 2018 Posters*, 16: 1–2. doi: 10.1145/3230744.3230753

Richards, J. F. (2003), *The Unending Frontier: An Environmental History of the Early Modern World*, Vol. 1, Oakland: University of California Press.

Schwarzkopf, M. (2019), "The Second Mission: Canadian Survival in Hong Kong Prisoner-of-War Camps, 1941–1945," PhD, Université d'Ottawa/University of Ottawa. Available online: https://ruor.uottawa.ca/bitstream/10393/38898/1/Schwarzkopf_Matthew_2019_thesis.pdf (accessed April 6, 2023).

Selley, G. (1991), "TWIGS—Trees and Woods Image Generation System," PhD, Coventry (Lanchester) Polytechnic. Available online: https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.305956 (accessed April 6, 2023).

So, A. Y. (2011), "'One country, two systems' and Hong Kong-China National Integration: A Crisis-Transformation Perspective," *Journal of Contemporary Asia*, 41(1): 99–116.

The Order of Bards, Ovates & Druids (n.d.), Available online: https://druidry.org/druid-way/teaching-and-practice/druid-tree-lore/oak (accessed April 6, 2023).

Vieira, P. (2015), "Phytographia: Literature as Plant Writing," *Environmental Philosophy*, 12(2): 205–20.

Walsh, K. (2006), "'Dad Says I'm Tied to a Shooting Star!' Grounding (Research on) British Expatriate Belonging," *Area*, 38(3): 268–78.

Walters, W. (2002), "The Power of Inscription: Beyond Social Construction and Deconstruction in European Integration Studies," *Millennium*, 31(1): 83–108.

Wong, T. K. and P. Wan (2011), "Perceptions and Determinants of Environmental Concern: The Case of Hong Kong and its Implications for Sustainable Development," *Sustainable Development*, 19(4): 235–49.

"World's Biggest Oxygen Producers Living in Swirling Ocean Waters" (n.d.). Available online: https://eos.org/research-spotlights/worlds-biggest-oxygen-producers-living-in-swirling-ocean-waters (accessed January 20, 2022).

Yeoh, B. S. A. (1996), "Street-Naming and Nation-Building: Toponymic Inscriptions of Nationhood in Singapore," *Area*, 28(3): 298–307. Available online: https://www.jstor.org/stable/20003708 (accessed April 5, 2023).

Zhang, H. and C. Y. Jim (2013), "Species Adoption for Sustainable Forestry in Hong Kong's Degraded Countryside," *International Journal of Sustainable Development & World Ecology*, 20(6): 484–503.

11

Tehran of Trees

Sina Seifee

In 2020, together with Goda Palekaitė, I undertook an artist residency that was organized by Bozar in Brussels and the Embassy of Germany in Tehran. It was here that we realized *Tehran of Trees* (see Figure 11.1 and Plate 31) a hyper field-notebook on the trees that make Tehran. By hyper field-notebook what I mean is an extensive, diffracted reportage of our thoughts and trajectory, a diary about an artificial journey. During the residency we tried to get our hands syntactically dirty with the history of writing about plants—God forbid, humans would be the only makers of the city. *Tehran of Trees* was created through interviews, computer-generated animation, writing, and poetry. We collaborated with many others to get our imagination to a place we could not travel to, due to both pandemic and political complications. Funded by the European economy,[1] our project now exists as an online platform among a host of stories and soundscapes that constitutes our endeavor to work as artists in a transnational and virtual environment.[2]

For myself, the project became an excuse to parse Iran with Goda's pathfinder talents as she had never been there. The motto was simple: *go to the foreign with the friend, check out the plants, find out what they are up to.*[3] I had wanted for a long time to talk with my old friends about their trees—our trees—in Tehran. Of course, as modern urban subjects of a megacity it is rare for anyone to own a tree. So, talking about *your* trees implies intimacy and importance through touch, play, looking, or bumping into larger-than-you perennial erections, in public or semi-public spaces. Trees that you grew up with, lived with, or watched again and again in a monster film. From the imprint of the moving branches on the street at night, to a single leaf becoming a world, to the animated beans twirling up to soar the seventh sky in the animation, *Jack and the Beanstalk* (1974); or from the flower monster in the Japanese sci-fi drama *Godzilla vs. Biollante* (1989) invading the world, to the neighbor's grape tree invading your garden over the wall … one way or another, invasion becomes worlding.[4] Like little boys who are allowed to enter the hammam during forbidden hours and hang out in the women-only areas, trees cross the boundary of private and public, precisely because of their nonhuman status. It turned out that almost every one of my friends had trees building up their memories and experiences in their youth. These stories were not clichés but precise and strong memories.

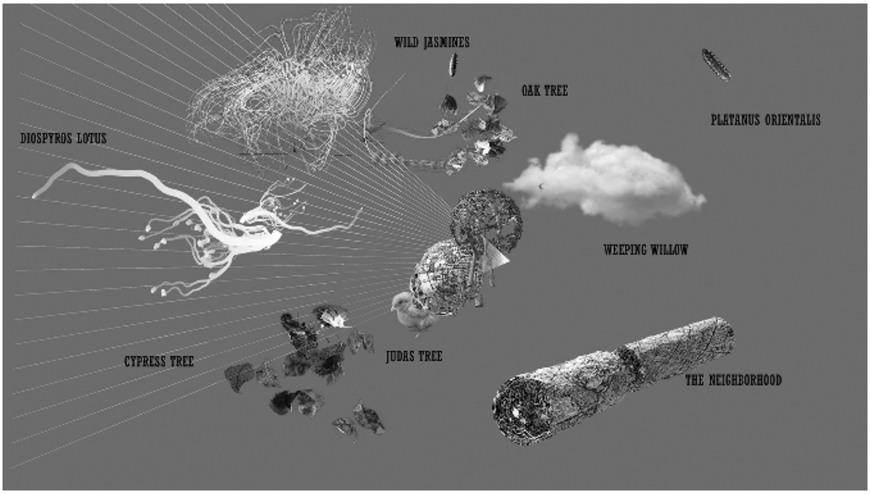


Figure 11.1 Sketch for the homepage of *Tehran of Trees* by Goda Palekaitė and Sina Seifee; HerMap phase 1, 2020. Courtesy of the artists. CC4r.

Two points: one, when I say memory I am talking about *Gedächtnis* (memory, recall), something that has to be learned in German. *Gedächtnis* refers to the technological memory that is not situated in the *heart* but is a supplement or prosthetic device whose job is to remind you, a concept of memory that is almost mechanical—on the side of death and forgetting.[5] Two, remembering is talking to the dead. Try not to situate remembrance as mourning for that which is lost, and you will find out how difficult it is. Especially in Iran, the concurrence of remembering and mourning sometimes happens almost automatically. I hoped that, by sojourning in memories of people's alliances with their plants, I could somehow wishfully grow my interest in technology, welfare, and politics (always on the side of death) in my home world and have it coincide with that which links beings and places in a semi life-death-affirming way. If discontinuity (of life, consciousness, etc.) is at stake with remembering, then trees, due to their slower-than-human processes, are the materialization of continuity. Everyone knows that, if you carve the shape of your burning heart on a tree, it does not just disappear the next day, nor stay intact by temporality. It will be there in ten years mnemonically metabolized with the tree (i.e., the tree remembers your love, but changes it through its own processes).[6]

In *Tehran of Trees*, aside from fulfilling artist duties, I had a secret agenda, to learn to "think ethnographically"[7] about the image of aspiration in Tehran. Following Bhrigupati Singh's (2011) ethnographic insight, aspiration means how do people imagine a better life? How do people conceive of vitality? Which forms render life thinkable and become imitated in mini worlds that proliferate there? Is it vegetal? Does it look like a tree? Or is it more lush, like the wedding finale of *Cinderella*? Does aspiration start where mourning stops? Or do aspiration and mourning reside and surface in the subject at the same time? This is perhaps a question of the limitations

Figure 11.2 Tehran, a random location, 2020, photo by Ehsan Barati. Courtesy of the artists. CC4r.

of imagination when it comes to a place like Tehran.[8] What forms does aspiration take in an urban environment that is like a phantom-sphere of death drives, abject politics, televised operations, emergent "wilderness," technologically mediated stories, and rumors that populate its milieu?

To think of Tehran not as a city, but as a phantom-sphere, invites a different set of sciences—namely hauntology, demonology, and bestiary, to get to know its noise and to inhabit its plenitude of life that in my view the political consciousness of contemporary Tehran fails to grasp. Talking about trees, I was hoping I would start conceptualizing what Singh names "varying thresholds of life" (Singh 2019). *Thresholds* imply thinking of those participants among the living, a memory, a dream, a haunting figure, that are imminent across phases of life and may refer to varying degrees of intensity, as Singh points out. Tehran's range of moods and intensities each need their own attention: amazing ghost stories, hidden colonies of cannibalistic mice that live in the city's underworld, the transformative dimensions of damage such as Tehran's earthquake as an immanent affect, a dormant neighboring volcano, the Tehran of mobile phones, the Tehran of trees, of dogs, of rats, of moms, of thugs, and so on.

In the arts you are immediately persuaded to ask pragmatically: *how to recruit others?* How to invite others in the indexing of a Tehran that, using Norah Campbell's words, experiments with organizational forms of justice, ethics, politics, and reason.[9] Tehran needs something more like a demonological bestiary, rather than journalism. Demonology is not just an ecclesiastic discipline, but a genre of writing phantasm, a mode of curiosity fundamentally interested in the variational aspects of the nature of causality itself. Demonological curiosity (highly commodified for consumption and proliferating in popular media) is a mode of aesthetic verification of hybrid human-animal creatures from long-standing popular conceptions of a shared augmented reality. Demonology and demonic curiosity are also part of a vast repertoire of composite and cross-disciplinary networks of nonhuman causality and transmedia writing, a technology of writing that I tentatively call *bestiary*. Bestiaries are the premodern practices of discovery, interpretation, and production of the real itself. They are categorized rumors of animals, lists of the strange and wonders of nature, most popular around the twelfth century.[10]

When we ask each other (at least among Iranians) about the past, we go to a complex place—of striving, of failure, of fantasy, of defeat, of breaking and building. Instead, asking about trees in the past tense is a way of signaling a resistance regarding what Iran has become in the rise of collaborative media—a country of pure abject politics, where spectatorship (necessary for art) becomes mere witnessing (necessary for testimony). After I moved out of Iran it became more perceptible to me how many voices life had in Iran. I could perceive how only oppositional voices tend to get amplified as a medium in which the story of the ruling system is refuted, and what role this image plays in the landscape of international politics. However, there must be imagination and curiosity where I think there is only disaster-journalism, juridical information, and forensic aesthetics (techniques of justice). In order to resist stories that render life in a place unthinkable, I have to learn to be attentive to my own imagination's stopping-points. I must learn to be attentive to what happens when we cannot differentiate between what is a critical question and what is a juridical question. As someone whose head is in the clouds, in recent years I have been feeling an increasing need for need for what Kathleen Stewart calls a "mode of precision" (Stewart 2016), driven by the desire for experimentation when it comes to Iran.[11] How can we tell non-apocalyptic stories about the otherworldly hauntingly familiar faces of life in Iran? Like many other contemporary artists, I am trained in (and ready to rush into) the mobilization of desire, turning it into work. Different from anger, desire is a process of production with little reference to exterior agency.[12] From Plato to Lacan, desire is frustrated by the real, while in Spinoza, Nietzsche, and Deleuze, desire is the producer of reality. From the latter we learn that striving implicates the individual in the world. I understand it as such, when writing about a world that you desire—you write yourself into it.[13]

Tehran of Trees approaches trees through their human constituent knowers. Contrary to our project question (which was: *how can a tree tell you what is important to them?*), asking people about their trees instead creates a palette for painting an unavoidably anthropogenic landscape. Nonetheless, this landscape can help us to learn something about the worldly objects of Tehran that are deeply entangled with human actors. These worldly objects are highly plastic and are constructed by memory and the study itself, they are not just out there available to be experienced. If I have learned something about Tehran, it is that "the real" is translocal (a local that is virtual) and technologically mediated. This situation demands that *Tehran of Trees* be more like a creative play that aims for enabling a technologically augmented ecosystem and a translocal exchange.

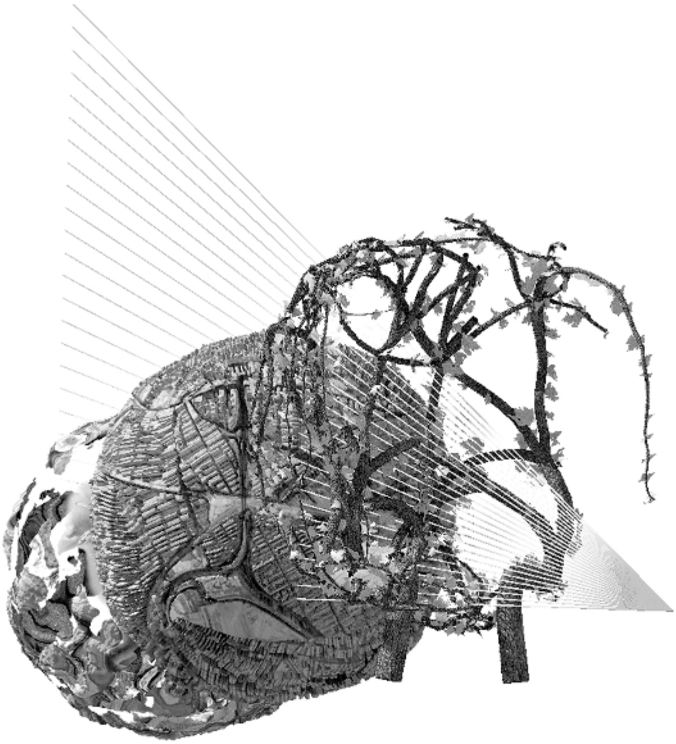


Figure 11.3 Snapshot of the poem-image *NEIGHBORHOOD*, part of *Tehran of Trees* by Sina Seifee and Goda Palekaitė; HerMap phase 1, 2020. Courtesy of the artists. CC4r.

Computer animation technology enacts a system of lenses that resolves a semi-image. If remembering is an extremely creative and imaginative practice, then CG (Computational Gesture but also Computer Graphics)—as a technology of writing phantasms, of death—can prosthetically help with the ontological indeterminacy of *Gedächtnis*. When we talk about our trees, we do not remember them as species, trees are never tree-like, they are not filial vs. rhizomatic, they are not vertical vs. lateral, arborescent vs. reticulated. You have to make fun of them. In *Tehran of Trees*, when memory objects get cooked by poetry and CG into an interpretation of tentatively scenic spaces, image becomes something perspectival and an intensely cognitive response, while representation becomes a flickering screen of things and trunks. So, in the artwork one element lies nested or wedged within the embrace of another element. Our animations are CG jokes—experiments with forms of trees that are rather ungraceful; a plastic bag textured with a cartoon for children called *Chlorophyll* from the 1980s appearing in curling roots; a trunk mimicking a bird; flower buds that shiver into an awkward shape; a tree awfully snapping into a sphere; something nervously seeks to grasp and be grasped, and so on. Because of this way of joking with the indeterminacy of memories (related to forgetting and writing) and the social aspects of remembering nonhumans (related to loss and sympoiesis) we also generated images through thinking with the logic of phantom limbs. Phantom limb is a technique of cognitive prosthesis. It allows for the creation and addition of artificial limbs to the "body image." The body image, simply put, is the picture of our own body which we form in our mind. It is experienced viscerally and is always anatomically fictive and distorted.[14] Phantom limbs can be defined as the sensation of missing or amputated parts of the body image. Elizabeth Grosz, in her discussion about the problematic status of the body in biology and psychology, has argued that phantasmatically lost limbs are persistently part of our hermeneutic-cultural body (Grosz 2020). Following Grosz, we approached the trees of Tehran with the logic of the phantom limbs. We asked, is it possible to change the body image via engagement with the phantom limb? How does experimental fluency in computer graphics animation technology help the artificial limb take the place of the lost limb? And what is the lost limb in the ecologies of reflection and diffraction that enact[15] the resolutions of nature in Iran? The 3D animations that we made had to submit to the logic of the phantom limbs. Remembering is stretching limbs phantasmatically, your missing limbs helping you (instead of haunting you). By extensively using computer media as a mode of *talking to the talks* that we had, we proposed embodiment through CG technologies as an engagement with the phantom limb. In other words, the techno-perceptual habituation of the 3D software was suggested as one way of examining—or perhaps getting attached to—the ambivalences of the body image of the city.

The following paragraphs grow from my notes from the interviews that I conducted with my friends who are living in Iran at the moment. The idea was that I would "do the talks" and later deliver the notes to Goda. She would then take them as hints and use

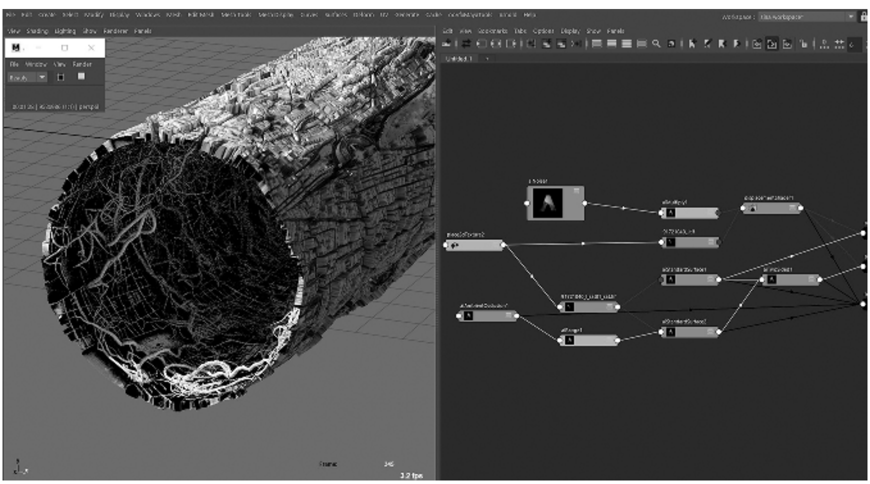


Figure 11.4 Making the tube map of the city with roots filling the underground, Interface of software. *Tehran of Trees* by Sina Seifee and Goda Palekaitė; HerMap phase 1, 2020. Courtesy of the artists. CC4r.

them to create a scene where she could construct a perspective in poetry from which a tree speaks in Farsi. This chain of translations and speculative fiction is what we call normal work.

My proposal to my interlocutors is an old Iranian existential realism. Without formulating it as such, I am suggesting that reality is not always a matter of confrontation, but a matter of interest. By that I mean to locate their desire, and plants do exactly that, they translate the desire for living—call it aspiration.[16] In talking to my friends about their memories of relationships that they had and sometimes continue having with trees, I encountered a non-static picture of aspiration and relation with life itself. Through long-distance calls, feedback loops on things we saw when we were children, a biographical poetry called remembering, browsing in a virtual reality space called Gedächtnis, and invisible camera eyes of the child's imagination, we noticed a non-negotiable indebtedness to trees. I was surprised to hear how much of our subjectivity was inalienably bound with sensorially detailed games we had with trees. Games of touch, of perception, and of flirtation.

My friend Elmira, for instance, spent a lot of her childhood in Tafresh, a city of deep mountain snow, where the winters are so cold your shadow will freeze to the ground. Elmira spent plenty of time in her uncle's farm, where she learned the connection to earth and its cycles, and there she tuned into the rich boredom of childhood. Though I have known her for many years, I had not recognized that she is a child of a farm: throwing dirt in the air, knowing how to separate stone from soil, and so on. Elmira's relation to distance developed in Tafresh. Something that one can see in her artwork. In Tafresh you look out the window, you think about what is happening behind the curtain, behind those trees, behind that hill. Like her, I also love and flourish with *distance* and its immaterial matterings, its conduct aesthetics. This is an aesthetic that is specific to distance, something that must go through conductive matter to be experienced, like looking at thunder in the distance versus being in a storm. In Tafresh, Elmira extends the gesture of looking: look behind that mountain, behind the space, behind the event, and so on. The behind-beyond association becomes literal, goes from first layer, to second layer, to third layer, and so on. This was not a matter of climbing mountain adventure-peaks. For her, the story of the tree related to the renewed and the reconstructed. Due to the harsh winters of Tafresh and the autumn that is short and unpredictable, the trees are perceived as going through rapid changes. She posed a metaphysical question: is the being of tree *sakht* (a hard substance سخت)? Elmira's use of the word *sakht* shows how she was intrigued by the sense of perpetuity in the identity of trees. She thus formulated a riddle: what is it that is a symbol and not a symbol? Later she said, "in autumn trees demonstrate themselves, as if showing off, as if to get attention, they take the breath away, they flirt, *del-e adamha ro mibarand* (they steal the hearts of humans دل آدمها را می برند)." Is flirting (between plant and human) a mode of signification that is both symbolic and not?[17]

Talking with Foad, we dug into the image of growth and overgrowth in Tehran, the toxins and species of overing and overgrowing (*roshd-e biraviye* رشد بی رویه). This points to an increasingly important register in the image we have of aspiration. Foad spent his early youth in a big *baghche* (باغچه). *Baghche* is an Iranian idea of a modest planted space within houses, literally meaning small garden. In Farsi the word for

Figure 11.5 The growing beans in *Jack and the Beanstalk* directed by Gisaburō Sugii.

garden, *bagh*, often refers to much bigger green spaces. The difference is not just in size—*baghche*, the opposite of a designerly public park, is your refuge. Foad had his own kingdom there, a sort of childhood hiding house made heuristically in the middle of the forest's infinity (*khane jangali* خانه جنگلی). The *baghche* triggered a story about colored chicks. During the New Year's celebration in Iran the markets explode for a few weeks with hawkers who sell, among other things, colored chicks. They are sold not as pets but purely as colorful moving little things. Most of them die immediately after purchase, even if they find a careful human companion. Children mourn them. Foad had one, which did not die. The chick continued flourishing in the house garden; despite the trauma of toxicity and the imminent danger of Tehran's cats, the chick grew old under Foad's custody.

For Foad, resensitizing the memory-images of trees into consciousness was deeply bound in the way he perceives the moods of the urban environment in his youth. The luminous scene of the secret garden, where the love affair of seeing and not seeing an uncurtained window filters the neighbors through the sociality of branches. Asking Foad about trees did not reveal a search for an arresting presence, but a method of worlding coming out of responses to the environment. A worlding that, despite knowing him for years, I would not have noticed had I not asked about his trees. This was also a "line of flight"[18] along which he insisted on a sense of *ezmehlal* (collapse and vanish اضمحلال), a word referring to a state of devastation, irreversible loss, non-creative destruction with no return. We traced a correlation between the articulation of overgrowth of urban plants and the disarticulation of urban growth itself. After the Iran–Iraq war, there was in the 1990s the so-called "Renovation Era" with prime ministers Rafsanjani, later Khatami, and Tehran's mayor Karbaschi among others. Foad suggested that, before the Renovation Era, the green spaces had an emergent and wilder quality. It was normal for a plant to grow illegally alongside the more planned green urban spaces. For example, the abundance of Convolvulus and jasmine in Tehran, growing around the fences, were not considered invasive weeds. Tehran's Renovation Era for Foad registers the image of outlaw urban growth, of structurelessness.

An overgrowth of a shadow of people, lacking the old characters (who supposedly have environmental virtues and sensibilities, or even a commitment to some sort of ideal geometry). He proposed a riddle: what is it that is orderless but not chaos, not anarchy, not dystopian? He later coined the concept of *zed-e shahr* (the anti-city ضد شهر), referring to the agential force of *besaz-befrush* (land developers بساز و بفروش) in the transformation of the urban environment. *Besaz-befrush* in the Iran of the 1990s was almost a swear word, a sign of descent into lesser forms of existence, a species of invasive monsters. This is precisely the opposite of the utopia of the industrial city in modernist architecture with the promises of classlessness that one might find in Soviet architecture, Foad suggested. Then how does one think about the city for habitation (مسکن شهر) and not for (monumental gestural) ideation?

I have known Foad for many years. His depth of care for nonhuman and inhuman spaces (not identities) is bottomless. In his artistic work the space of the relation between experience and abstract are explored by means of a perceptual logic. Like Elmira, I recognize in him an engagement with the ambiguities of visual attentiveness via the desymbolization of perception. If you look at his paintings you see "in the rough" not more than two textures have been added to a color; there is a suggestion of a place that does not seem urban or domestic, but of age. Although we were talking about trees, our conversation became more about verifying the disparate ensemble of odd natural assets in Tehran—such as colored chicks and urban trees as privacy veils—which provoked questions of governance. Call it complaining, a vivid subgenre of protest and grievance. The arresting images of neighborhood and trees expressed a hybrid ecosystem that was not so much to augment life, but a way to write a short history of Tehran from the point of view of the body that touches a small token of it. At the end of our conversation, Foad ironicized the notion of tree by suggesting that, within our talk, if you replace the term "tree" with anything else (art, love, shopping mall, economy, etc.) it would, all the same, make sense. It would still describe the contemporary social political conditions in Iran, the displacement of priorities and the *ezmehlal* of identity, an invaded identity. Let us ask Elmira's question again, what is it that is both a symbol and not a symbol?

With another friend, Maryam, the gestural syntax of trees registered a mystical richness. Where she grew up they had a big, beautiful garden with a big, beautiful pomegranate tree that came over the wall. Rooting "there," fruiting "here." Unlike many other middle-class Tehrani families and me, they lived in the same house that she was born in. She grew up with this tree and its processes. She said, "it is under my skin." Maryam can identify a pomegranate tree in an instant from miles away, she does not need to think about it. Her intimacy with every inch of this tree was a matter of becoming-with, not of encounter—notwithstanding how urgent and important *encounter* is for our time. She knew the tree's "attitudes." She called it in plural *sheitanat* (شیطنت). In Farsi, *sheitanat*, coming from the word *sheitan* (the devil), means little mischievous acts, fancy form-makings, baroque, the queerness of something. How to describe this? If you have lived with a cat, for example, you know that they are very *sheitan*. You are conversing with a cat and they suddenly twist and deform and start licking themselves; they turn into a 3D animation. The pomegranate was making jokes like that. Elmira's memories generated a *jesmiat-shenasi* (speculative physiology

جسمیت شناسی), while for Maryam they created an *andam-shenasi* (speculative organology اندام شناسی). She describes that nourishing a childhood's proto-scientific curiosity, she used to dissect pomegranate fruits in different stages of their growth, before they became the raven's lunch. Together with her grandmother (who is alive) they participate in loving the tree, something that she calls *ghorboon sadaghe derakht raftan* (قربون صدقه درخت رفتن). If you try to translate it in English, it is like a sort of verbal cuddling, using language to hug something. Along with coloring and merching newborn chicks, *ghorboon sadaghe* with plants is part of the circulation of intelligence in an Iranian ecological consciousness. Like Elmira, Maryam is also an observer of trees dying back in the winter. The wonder of seeing them coming to life again in spring intrigues a process, not of flow, but of metamorphosis. Her riddle: how does one understand a fruit? Maryam proposed an interesting understanding of the pomegranate fruit. One of synesthesia. Using the word *dark* (apperception درک), signifying long-term cognitive and affective intimacy with something, she suggested that the smell of the pomegranate is synesthetically tuned to the forms of the tree. You can literally see the smell.

The Italian-Swiss animated series that came up in my conversation with Maryam refers to an adaptation from the book of the same name for children by Bianca Pitzorno. Dubbed in Farsi and broadcast on the Iranian national television in the 1980s, the story centers on Milan and Venice and on the adventures of two little boys who know a plant girl, Clorofilla.

The extracts above, from conversations with Elmira, Foad, and Maryam, are part of longer conversations that took place and they are only a few of the people we spoke with whilst making *Tehran of Trees*—I did not include all the protagonists, and I deviated from what I conceived together with Goda. Having an interview is entering a mini world. The *talks* revealed for me a mode of, using Kathleen Stewart's concept, "atmospheric attunement" (Stewart 2011) in my riddle-thinker friends. Did this happen because we asked them about the past? It is too easy to assume relations between the historical and the environmental, and this risks overdetermining these relationships. Instead, learning from Singh's notion of threshold, we can attend to how one aspect of life leads to another. Indeed, asking my friends about their

Figures 11.6 and 11.7 *Clorofilla dal Cielo Blu*, directed by Victor Tognola. © Frama films, RTSI 1985. All rights reserved.

memories was a way to resist applying a category of totality to my interest, namely trees and friends. However, asking about memories about trees is not doing history, or making a map. The interview was not a way to organize memory or to install a reminder, but it was rather used as a counter-memorial mediated practice (an energetic and synthetic remainder), which we translated and enacted in our CG animations. We used heavy computer animation technology to gesture what we mean. The art of talking is itself such a tool. So, I propose my riddle: what is the opposite of a map?

Following up the wonderological tracks of technology, Avital Ronell concisely and beautifully states what we already knew: there is no outside to technology, there is no off-switch (Ronell 1989). We are implicated, inscribed, disarticulated, and resignified by technological prosthesis. If we accept Ronell and Grosz's proposal (and many others who have argued similarly in the last century) that parts of our selves extend beyond the skin in every imaginable way, not just now but throughout human history, then the phantom limb is part of our patterns of accepting and giving. In other words, to be social means one must learn how to sustain the rhythms of the limbs, including one's phantom limbs, and of others, more and more in different conceptual and techno-material resolutions. As children of cyberspace, you respond necessarily with prosthetic skills of the phantom limb to yours and the others' phantom worlds.

Later, Goda wrote short poems based on the notes from the interviews, which I haphazardly translated for her from Farsi to English. While she was experimenting with the language, I did the same with our visuals. I did hundreds of tests within the 3D software, playing with residues of the images that came from our

Figure 11.8 Pomegranate trees in summer from Maryam's house, coming over the neighbor's garden. Image courtesy of Maryam Farshad 2021. CC4r.

Figure 11.9 Deleted scene from *Godzilla vs. Biollante*, directed by Kazuki Ōmori. © Toho Co., Ltd., Dimension Films 1989. All rights reserved.

research: governmental beautification of the urban space, idealized Persian carpets, botanical landscapes of Tehran with its pests, underworld, and charismatic old trees, the molecular world of one person's relation to a tree, chimeras of Xanthogaleruca insects and elm trees, and so on. At the end, we mixed the text and the images with a series of audio tracks that musician Chriztian Hanzen produced for each of the poem-images. We created a digital carpet, which was later translated and put online by a different team who were hired by our host to make the website of the project.

What I have learned from bestiaries is that memories, like rumors, cannot be proven. We just get affected and moved by them. The things recollected as such are *re-past-ed*, as I call it, instead of represented. Like when somebody describes a dream from the night before, recollective practices allow the one who remembers room and inventiveness for precision and expression in regard to the given topic, in our case, trees. The question "what is your first memory of a tree?" received by our phantom limbs invites Gedächtnis to be imagined as a prosthetic technology, a performative and social gesture to draw traces of aspiration, and can happen only when somebody else asks you. In the end it is the computer that is remembering the plant in our project, highlighting the problematic and technological nature of memory.

Notes

1 The artistic research residency program was part of *HerMap Iran—Cultural Heritage Management Project*, a five-year project aiming to promote cultural heritage in Iran. Co-funded mainly by the European Commission (DG Partnerships), the project was led by The Heritage Management Organization—HERITAGE (Greece)

in partnership with the Goethe-Institut (Germany) and Bozar (Belgium). For more information, visit the website of the first phase of the project, https://phase1.hermapartprojects.org/info.

2 To visit *Tehran of Trees* go to https://phase1.hermapartprojects.org/en/projects/goda-palekaite_sina-seifee.

3 This was also the same formula I used in a previous project, *Difficult Forests* (2016, https://seifee.com/difficult-forests): explore a world that is new to you, but do it with your significant other. I wondered for a moment, was I having déjà vu, did I do the same project before?

4 It seems to me that we live in a world where invasion (unwelcomed entry) cannot be avoided. We are invaded left and right, conquered slowly or aggressively, by plants, by technologies, by ideologies, by affects, by bad objects, by products, by Others, and so on.

5 For more on mnemon and technological ontology of memory, see Ronell (2010).

6 For a discussion on how consciousness and memory are mutually exclusive, go to Rosalind Morris's ongoing and brilliant study of mediumship (2014).

7 What is meant by "thinking ethnographically" in this text is not the discipline that produces ethnographic content, but an exercise in a mode of attention that I am trying to learn from the works of ethnographers such as Singh and Taneja. This mode of attention is directed to (1) the social relations that include nonhumans and (2) the productive tensions within its own apparatus, namely the distance between analysis and storytelling. As an artist I am trained to recognize and engage with alterity based on curiosity and attachment. At the same time, we live in a time that demands us to seek and describe multiple situated worldings and multiple sorts of translations that are needed to converse with them. Ethnography is extremely helpful in showing how forms of writing change the way those worlds are enacted and realized.

8 During the talks I began to feel a difference in the nature of my questions, how non-Iranian they are. I realized within myself a fading sensibility towards an artistic radicalism, a mode of cruelty in an Artaudian sense, which was signing off in our tree question. Artaud would have never considered aspiration. He would have been interested rather in breaking points, a cruel yet necessary act upon both the artist and spectator to shatter our "false reality." This theatrical valuing of an unnegotiable relation to the status quo is an Artaudian tradition, which has been one of the sources of my artistic upbringing in Iran.

9 For a fantastic take on the organizational notion of framing and models for viewing reality, see Campbell, McHugh, and Dylan-Ennis (2018).

10 For a fancier exploration of the question of the links between demons and computerized media, go to Seifee (2022).

11 A point of precision in Kathleen Stewart's impressive act of definition refers to an artistic empiricism, a mode of description that starts by deliteralizing things. It is the moment when something becomes a call to writing. A point of precision might be the outcome of a strange faithfulness to the spirit of the unnamed thing, a semi-event that is half-witnessed "brings into relief a background, a zone, a worlding in which things become perceptible" (Stewart 2016: 34).

12 I am here borrowing Elizabeth Grosz's (1994) recapitulation of the contradictory nature of desire in the West.

13 I am taking lessons from the anthropologist of the jinn; for more, see Anand Vivek Taneja (2013).

14 The concept of body image was coined by psychoanalyst Paul Schilder and neurologist Henry Head (Schilder 2013) as a schema, a spatiotemporally structured model, which mediates between the subject's position and its environment.
15 *Enactment*, as Karen Barad (2003) mobilizes it in her thinking about "mattering," refers to the interactive reconfigurings of the entanglement of cause and effect. In her rhetoric, "enact" abounds in contrast to or instead of "to make" or "to have." *To enact* is a ritual of causality, where boundaries between cause and effect are "agentially" cut, and it may or may not involve humans.
16 Even when they are horrific, plants translate desire. For an artistic undertaking with the idea of mutual exploitation between humans and plants, see *The Horror Garden* (2019) by Belgium-based artist Gosie Vervloessem. https://wpzimmer.be/en/projects/the-horror-garden.
17 This move from the plant-human flirtatious relationship to redefine what is a symbol in a new way, is a moment of what I call *the metamorphosis of meaning*. Elmira's definition of "symbol" is a form of metamorphosis that is produced by the acts of flirting.
18 *Line of flight* is a concept proposed by Deleuze and Guattari (1987), and for me refers to a moment when an often both unbearable and normal condition is brought into an affective state with a creative possibility of escape internal to it. The line of flight is precisely the opposite of rebellion. It is more like literature, which brings a condition into a state of being where its forces can be felt, attested, or flee as a mode of cure.

References

Barad, K. (2003), "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs: Journal of Women in Culture and Society*, 28(3): 801–31. doi: 10.1086/345321

Barad, K. (2020), "Invertebrate Visions: Diffractions of the Brittlestar," *The Multispecies Salon*, 221–41, Durham, NC: Duke University Press. doi: 10.1515/9780822376989-012

Campbell, N., G. McHugh, and P. Dylan-Ennis (2018), "Climate Change is Not a Problem: Speculative Realism at the End of Organization," *Organization Studies*, 40(5): 725–44. doi: 10.1177/0170840618765553

Clorofilla dal Cielo Blu (1985), [Film] Dir. Victor Tognola. France: Frama films and RTSI.

Deleuze, G. and F. Guattari (1987), *A Thousand Plateaus: Capitalism and Schizophrenia*, Minneapolis: University of Minnesota Press.

Godzilla vs. Biollante (1989), [Film] Dir. Kazuki Ōmori. Japan: Toho Pictures.

Grosz, E. (1994), "Experimental Desire: Rethinking Queer Subjectivity," in J. Copjec (ed.), *Supposing the Subject*, 133–57, Brooklyn, NY: Verso.

Grosz, E. (2020), *Volatile Bodies*, London and New York: Routledge. doi: 10.4324/9781003118381

Horror Garden (2019), [Film] Dir. Gosie Vervloessem. Available online: https://vimeo.com/368824244 (accessed December 15, 2022).

Jack and the Beanstalk (1974), [Film] Dir. Gisaburō Sugii. Japan/USA: Group TAC and Nippon Herald Films/Columbia Pictures.

Morris, R. (2020), "On the Subject of Spirit Mediumship in the Age of New Media," in *Trance Mediums and New Media*, 25–55, New York: Fordham University Press. doi: 10.1515/9780823253838-004

Ronell, A. (1989), *The Telephone Book: Technology, Schizophrenia, Electric Speech*, Lincoln: University of Nebraska Press.

Ronell, A. (2010), "The Call of Technology," in *The uberreader: Selected Works of Avital Ronell*, Lincoln, NE: University of Illinois Press.
Schilder, P. (2013), *The Image and Appearance of the Human Body*, London and New York: Routledge.
Seifee, S. (2022), "Rigging Demons," in J. Rocha and F. Snelting (eds.), *VOLUMETRIC REGIMES: Material Cultures of Quantified Presence*, Open Humanities Press. https://volumetricregimes.xyz/index.php?title=Rigging_Demons (accessed December 15, 2022).
Singh, B. (2011), "Agonistic Intimacy and Moral Aspiration in Popular Hinduism: A Study in the Political Theology of the Neighbor," *American Ethnologist*, 38(3): 430–50. doi: 10.1111/j.1548-1425.2011.01315.x
Singh, B. (2019), "Hunger and Thirst: Crises at Varying Thresholds of Life," in *Living and Dying in the Contemporary World*, 576–98, Oakland: University of California Press. doi: 10.1525/9780520961067-035
Stewart, K. (2011), "Atmospheric Attunements," *Environment and Planning D: Society and Space*, 29(3): 445–53. doi: 10.1068/d9109
Stewart, K. (2016), "The Point of Precision," *Representations*, 135(Special Issue: Description across Disciplines): 31–44. doi: 1525/rep.2016.135.3.31
Taneja, A. V. (2013), "Jinnealogy," *HAU: Journal of Ethnographic Theory*, 3(3): 139–65. doi: 10.14318/hau3.3.007

12

Writing in the Wind: Ecopoetics and Geoengineering

Joel Ong

Introduction

The year is 1987. Tyvek-suit clad researchers with tanks on their backs walk slowly through a field of strawberry seedlings. Each line of dainty green yielding to heavy boots as they wave black wands over the field, fan spraying a mist of coating over the new leaves. Today's mix is different, not the usual concoction of pesticides and water, but a new microbial brew, the flavor for the month. In some plants, small white and yellow flowers have begun to emerge, signaling a new generation of strawberries on the way, the first to adopt a new synthetic microbial ecology. Nearby, a line of suits watches on, with small gadgets they anxiously monitor the surrounding air. A slight breeze arises, pausing activity as the researchers look around for confirmation to continue. When the wind eventually subsides, they continue until all the seedlings are doused, their tanks emptied. They have chosen the right day for the test, despite the mounds of dirt and seedlings ripped out by protesters in preceding months, it is an auspicious day, a breakthrough as it was called.

Transgenic organisms are increasingly unwitting allies in our quest for dominion over the natural world—the products of technoscientific industry, the ideological fusion of biology and engineering. While most remain isolated in specialized habitats of the lab or within closed factory settings behind multiple layers of safety restrictions, the first open-air testing of a genetically modified organism (GMO) occurred in 1987. A strain of the plant bacterium *Pseudomonas Syringae* (*P. syringae*), engineered to have its ice-nucleation domains knocked out, was released in a field in Contra Costa County, about 50 miles northeast of San Francisco. Dubbed Frostban, it would displace native *P. syringae* colonies that had been causing extensive frost damage to the leaves of crops, addressing a $1.5 billion-a-year agricultural crisis. Despite being approved by the US Environmental Protection Agency (EPA), the experiment was met with criticism from environmental groups that organized widespread protests and lawsuits. While the experiment was eventually considered a success in reducing frost damage to the test crop, Advanced Genetic Sciences (AGS) was never able to bring their product into circulation amidst the controversy.

AGS faced far less resistance with their project Snomax that was introduced into the North American ski industry in the same year Frostban underwent open-field testing (Henderson 1986). Snomax was derived from the same micro-organism *P. syringae*, though in this case its ice-nucleation proteins were extracted and dried into a seemingly innocuous powder that could be loaded into commercial snow blowers. That year, Snomax blanketed nine ski resorts. With a projected annual revenue in the millions, Snomax went into international circulation, with the recent 2022 Beijing Winter Olympics being the first to exclusively use artificial snow on all its sites. While Frostban had proposed the release of a living, genetically modified strain of bacteria to compete against existing ones, Snomax's strategy was simply to extract the target protein from the bacteria, then encase it in a freeze-dried bacterial cell as a sort of optimized but inert capsule. This contrasting reception of AGS's two products was to be found in the distinction of one entity as "living," and the other as supposedly dead with little to no harmful consequence. Despite these, a growing amount of literature is documenting Snomax's unintended consequences on the ecology, arising mostly from its runoff from slopes into groundwater (Lagriffoul et al. 2010; Siegwald and de Jong 2020), undergirding questions of the true extent of anthropogenic effect in the environment. Evidently, the issues at the core of the environmental concern around Frostban—the unintended and potentially acute consequences on the local ecology—also apply to Snomax.

P. syringae has also been implicated in another controversial experiment, this time in climate geoengineering. In emerging policy recommendations targeting climate collapse, particles such as Snomax (Huang et al. 2021) have been studied for injection into the atmosphere as cloud condensation nuclei that would raise the density and reflective quality of clouds, a process of cloud-seeding proposed under the umbrella strategy of climate geoengineering—defined by the University of Oxford's geoengineering program as "the deliberate large-scale intervention into the Earth's natural systems to counteract climate change" (Neyrat 2019). Given the planetary consequences of modifications to the atmosphere, such interventions engender significant social and humanitarian concern and necessitate a global strategy for public discourse and decision-making. To date, while most research is being funded in the Global North, increasing emphasis and support is also being sought for countries in the Global South to engage in hyperlocal interventions to alleviate local climate tensions. Such community science activities put into focus the ability of grassroots-based organizations to build communities around shared goals and develop long-lasting sustainable practices. It is also where community art practices can become a catalyst for public imagination. While providing an overview on current discourses in geoengineering, this chapter introduces the work *Terra Et Venti* (Between the Earth and Wind) that engages with multi-site sense making and community-building. Through a series of lab and field experiments structured as *in vivo*, *in vitro*, and *in silico* forms of engagement (Peters 2014), it develops conversations with both specialists and laypeople around the role that synthetic biology may play in the future enactment of weather modification strategies.

Air at Work

In 1988 the first Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations and the World Meteorological Organization. Progressive IPCC reports since then have recommended reducing global carbon emissions by at least 20 percent. In 2014, the IPCC report identified 204 scenarios to meet climate goals, with 184 of them proposing extensive climate modification through geoengineering. This is done through a combination of two main strategies—Greenhouse Gas Removal, and Solar Radiation Management. In the former, techniques aim to remove greenhouse gases from the atmosphere by creating more carbon sinks (such as forests, soil) or through direct carbon capture from the air; in the latter, strategies are focused on negative radiative forcing by reflecting the sun's heat with space-bound mirrors, or through stratospheric injection of aerosols to reflect heat (reflective particles such as diamond-silica aerogels (Vukajlovic et al. 2021)) and/or to seed clouds that increase the earth's overall albedo. Currently, the most viable approach is that of stratospheric injection of sulfate particles at a scale similar to the 1991 Mount Pinatubo explosion in the Philippines that saw 15 million tonnes of sulfur dioxide rise into the atmosphere and circulate the planet, causing global temperatures to drop temporarily by 0.5 °C. Injecting particles into the atmosphere is reflexively dangerous, especially sulfate particles, that are known to destroy the ozone layer and produce acid rain. Such activities bring up what Peter Slotedijk famously termed *atmoterror* (2009), a form of atmospheric "terrorism" that began in the gas attacks by the German army in the First World War aimed not at enemy soldiers, but at the atmosphere around them. As a medium of violence and *violation* on the bodies of the victims, the extent to which this contamination infiltrates and remains within the body effects a new level of inter-generational trauma. Indeed, with toxic pesticides such as Agent Orange and Roundup still percolating in bodies and the bodies of our children, conversations around the release of bioengineered products in the atmosphere are reflexively difficult to get behind.

In 2010, the UN Convention on Biological Diversity agreed to a de facto moratorium on geoengineering, halting all open field trials of geoengineering technologies and limiting such research to small-scale scientific studies and computer modeling. In 2015, with the formation of SCoPEx: Stratospheric Controlled Perturbation Experiment led by atmospheric scientist Frank Keutsch, Harvard's Solar Geoengineering Research Program (led by climate specialist David Keith), backed by illustrious donors such as Bill Gates, became the largest-funded program in the world. In 2017, China invested \$3 million in a geoengineering research unit, in 2019, \$4 million were awarded to the chemical sciences division of NOAA's Earth System Research Laboratory. Other government-funded geoengineering research efforts exist in Europe, including the German Research Foundation Priority Programme, and the European Union-backed Implications and Risks of Engineering Solar Radiation to Limit Climate Change project, the Oxford Geoengineering program, that developed the Oxford Principles of Geoengineering Research. The collateral impact of these major players may provide the kind of pressure on governments to reverse these moratoriums abruptly. In fact, SCoPEx may become the first since Frostban to begin open-air testing again. The risks are obvious if any one nation dominates the research on climate geoengineering, because it could also "come to dominate the debate on how, when and whether to ultimately deploy such technology" (Temple 2017). As Oliver Morton writes, such moratoriums may sideline urgent problems of how these technologies might be "justifiably and appropriately deployed" (2015: 161).

How are the humanitarian concerns embedded within such research being addressed? One particularly encouraging example is Keith's (2021) paper on developing a shared taxonomy for concerns to support "constructive disagreement" around geoengineering. In it, he considers how a network of journalists, science writers, community-based stakeholders, and experts can come together to unpack policy recommendations to correct what he terms a "conflation of judgement" where expert valuations often are implicitly loaded with the researchers' values and biases (815). Similarly, Holly Jean Buck's book, *After Geoengineering: Climate Tragedy, Repair and Restoration*, considers the global drives towards collaborative and industry-funded research less important than consultative practices and infrastructure development for those that such drastic measures would ultimately affect the most. Buck's concern with geoengineering is that it is not only about the event, the specialist, and its moment of climax, but also that such intervention involves the entire sociopolitical sphere of atmospheric influence and the sustenance of the communities that are at risk. She writes that the task of geoengineering must entail "compensation or insurance for people who suffer loss and damage, working out ways to protect vulnerable people … and … a reckoning with colonial histories of land appropriation, dispossession and exploitation" (Buck 2019: 27).

Writers such as these expose the way prevailing geoconstructivist thought sees the earth as a system to be engineered through a mode of thinking based on practicality, utility, and successful management of a "problem" or operating system. By considering geoengineering as an act of intervention already in progress at different scales, we may begin to prioritize the impact and assiduous care that needs to take precedence as opposed to a technocratic saviorhood that reverses or nullifies the damage caused. The current rhetoric around geoengineering often neglects aspects of community science where contributions from grassroots organizations and environmental groups typically fall outside particular disciplinary "engineering" specializations. Climate modeling with stratospheric aerosol injection has shown how mitigation strategies that involve blocking out the sunlight would cause considerable damage to the sustenance and practices in the Global South such as the farming of Indian nut (Yang et al. 2016) and the management of drought and drought-risks in African river basins (Abiodun et al. 2021). The urgency of climate impact on countries in the Global South have pushed them to adopt modes of climate modification that are not branded necessarily as *engineering* but are focused on smaller-scale interventions into the hyperlocal environment of the environment, activities that expand and extend from site-specific ecological practices (Furuhata 2019). This highlights the historical and geographical asymmetry of geoengineering research, almost 90 percent of which is conducted in the Global North, a situation exacerbated by the low representation of researchers from the Global South in the climate science community. But local interventions also include established systems of expert knowledge that include Indigenous and long-standing communities with generations of lived experiences of responding to the urgencies and particularities in the immediate environment. The 2021 IPCC Report refers to pairings of contemporary scientific research *and* traditional Indigenous knowledges as crucial to combating climate change, echoing previous reports such as the International Labour Organization's "Technical Note: Indigenous Peoples and Climate Change: From Victims to Change Agents through Decent Work," where "climate smart agriculture" (CSA) such as shoreline reinforcements, farming techniques, climate forecasting, and community-based disaster risk reduction are highlighted.

Whether we see geoengineering as a continuation of a desire for dominion and control over the environment, or as the inevitable consequence of generations of neglect, there is a clear need for anticipatory policy, risk assessments, and codes of ethics on a global scale. Grassroots organizations like the Action Group on Erosion, Technology and Concentration (ETC), and the Degrees Initiative, that works with local partners to run Solar Radiation Management workshops across the Global South and provides funding for scientist to work on SRM management projects in their communities, all resist the large investment capitalist models. It is our responsibility to amplify the voices of such organizations and their work.

Creating Artificial Clouds

> *If clouds were the mere result of the condensation of Vapour in the masses of atmosphere which they occupy, if their variations were produced by the movements of the atmosphere alone, then indeed might the study of them be deemed an [sic] useless pursuit of shadows, an attempt to describe forms which, being the sport of winds, must be ever varying, and therefore not to be defined.*
>
> (Howard 1803: 1)

> *You can't construct clouds. And that is why the future you dream of never comes true.*
>
> (Wittgenstein 1998: 48)

I watched clouds for countless hours in my youth, finding meaningful shapes within them and speculating on the distances between them. I noticed their movement across the sky in the wind, tracing them with my finger and imagining how it would feel to fall through a cloud. From marveling at sky-written messages in the air, to gazing at aircraft contrails tracing lines across the sky, we are now deeply conscious of the way the skyscapes are impacted by a mixture of anthropogenic and natural activities.

The way clouds are formed is a combination of its sculpting by the wind and its particulate composition—a diverse, rich, and lively amalgam of migratory particles. Apart from the occasional monolithic cloud "pillars" that are easily recognizable, clouds are incredibly transient and move between shapes, constantly growing and shrinking, stretching and collapsing, appearing and disappearing. Luke Howard, a dark horse in the field of atmospheric science at the turn of the nineteenth century, was the first to classify clouds according to their shape, detailing their activity, relation to rain and wind and their evolution in the sky. His distinctions of "Cirrus," "Cumulus," "Stratus," and "Nimbus" clouds are still mostly in use today, though variations in their intermediaries exist. Amongst the various cloud-seeding approaches embedded within geoengineering are Marine Cloud Brightening (MCB), which involves seeding low altitude clouds with particles such as sea salt to expand their cover and reflectivity, and Cirrus Cloud Thinning (CCT), aiming at reshaping high altitude wispy clouds, which empirically reflect less radiation than they absorb, to become pseudo-cirro-stratus clouds that stretch out onto a more reflective cover (Lawrence et al. 2018). In the wake of such dramatic cloud modifications, how might we imagine a new taxonomy for the shapes, density, reflectivity of artificially seeded clouds?

In fact, experiments on the atmosphere began as early as 1915 when scientists proposed and marketed several facetious weather control strategies to enable "rain for a penny" (Fleming 2010). Self-proclaimed "moisture accelerators" (Tuthill 1954) such as San Diego legend Charles Hatfield "the Rainmaker" were audacious charlatans who even signed contracts with city councils to bring rain with varying amounts of success. By the 1940s, research into laboratory-based atmospheric cloud-seeding had begun at General Electric Laboratories, led by American chemist and pioneering meteorologist Vincent Schaefer. Introducing dry ice into a freezer of supercooled water, he was able to produce streaks of snow apparently out of thin air. Along with his colleagues, Bernard Vonnegut and Irving Langmuir, they launched the first successful open-air cloud-seeding experiments in 1946, transforming a 30 mile long cloud into snow by seeding it with dry ice from an aircraft over Massachusetts. Almost immediately, the work, named Project Cirrus, was militarized and reframed as a classified effort by the US military. The project's applications now included "bogging down energy troops in snow and rain, clearing airfields of fog at lowest cost, and infecting induced storms with bacteriological and radiological materials" (Fleming 2010: 150), but it was also a time where other particles were being developed as cloud-seeding agents, such as silver iodide and common salt. On October 13, 1947, 400 miles northeast of Orlando, the Project Cirrus team bombed the heart of the storm with 80 pounds of dry ice and dropped 100 pounds more into two embedded convective towers, inaugurating what the press called "history's first assault by man on a tropical storm" (ibid.), an experiment with energies of nature far greater than those unleashed by the atomic bomb.

Schaefer's work to develop stratospheric cloud-seeding techniques contrasted the more industrial and commercially oriented motivations of his crew. His account of the test flight of 1946 that preceded the militarization of this technology emphasized the wonder and excitement at the discovery of a new paradigm in scientific knowledge and aesthetics:

> I was on the plane with Curt with a camera, 6 pounds of dry ice and plans for attempting the first large scale test of converting a supercooled cloud to ice crystals … I looked to the rear and was thrilled to see the long streams of snow falling from the base of the cloud which we had just passed, moving through a

> mass of glistening snow crystals! We then swung west of the cloud and observed draperies of snow which seemed to hang for 2–3000 feet below us and noted the cloud drying up rapidly … While still in the cloud we saw the glinting crystals all over.
>
> (Fleming 2010: 38)

Schaefer was also able to preserve snowflake crystals in plastic film, a metaphor for how the ornamentation and conservation of beauty was a crucial motivation in his exploration. Was this moment in 1946, flying through an artificially seeded cloud and witnessing the birth of a new form of human-aided nature, a profound moment in Schaefer's research, and more broadly in the lineage of scientific *and* artistic exploration? Parallels can be drawn to Luke Howard's motivation to classify the clouds in the eighteenth century and the symbolic, lyrical prose he developed to describe them based on his aesthetic appreciation. If the experiments in stratospheric injections are eventually approved, how might such accounts of aesthetics and atmospheric wonder support the consultative and collaborative use of this technology? As Anna Tsing says, "We need new kinds of storytelling … we need to tell empirically grounded stories of particular times and places and positions, and we need to tell them with some curiosity and wonder" (Tsing 2011).

Terra Et Venti (Between the Earth and the Wind)

Prelude *in vivo*

Terra Et Venti follows a trajectory of research-creation projects exploring the liminal spaces between the ground and the atmosphere above, the potent metaphors of the elements in creating narratives (and new mythologies) of travel and connectivity, and the way microbes such as *P. syringae* migrate between them. Its artistic process began in the field, with air balloons, environmental sensors, and community science activities (Plate 32), thinking about the way aerial vehicles like balloons, drones, and aircrafts could help extend our imaginations into the air and develop site-specific narratives for an aerial world that is diverse, multispecies, borderless, and post-gravitational. We asked workshop participants to imagine and find what lives in the air, and to explore how these particles (whether organic or inorganic) could be protagonists in new narratives and fictions around atmospheric living. An emphasis on the wind necessitated a close read of clouds, water, and soil, as Tim Ingold (2007) considers—the environment and natural formations exist in a series of knots made by what is above and what is below, where the ground is "raised by the swelling of the earth" as the weather "drags the earth's surface, conspire(ing) to erase it" (64); and along with my collaborator Mick Lorusso, we held workshops to visualize microbes on our skins, soil, and broader environment, working with diverse tools and strategies to grow interesting microbial colonies (Ong and Lorusso 2019).

The weather balloon was for us an historical symbol of a floating utopia to be experienced that valorized the "ascent" as a form of progress both metaphorically and physically manifested in human history. Pioneering aeronaut James Glaisher wrote:

> Above the clouds the balloon occupies the centre of a vast hollow sphere … No isolated clouds hover above this plane. We seem to be citizens of the sky, separated from the earth by a barrier which seems. We are free from all apprehension such as may exist when nothing separates us from the earth. We can suppose the laws of gravitation are for a time suspended, and in the upper world, to which we seem now to belong, the silence and quiet are so intense that peace and calm seem to reign alone.
>
> (Glaisher 2019: 94)

Gaston Bachelard in his book *Air and Dreams* comments on this vertical differential by saying "Vertical valorization is so essential, so sure—its superiority so indisputable—that the mind cannot turn away from it once it has recognized its immediate and direct meaning. It is impossible to express moral values without reference to the vertical axis" (10). We have been taught that "ascent" should be associated with the celestial and a positive valence; and that descent implies a journey downward, a "fall," demise. More surreptitiously, the actions of looking "down" a microscope and the "descent" of man through an evolutionary tree imply a hierarchy of power that has been instantiated by notions of seeing and visibility. Instead of these associations, Bachelard offers a multiplicity of metaphors. For instance—to examine the notion of ascent through a dialectical play of vertigo and victory. In the same way, the valorization of aircraft, weather balloon, drone, or airborne vessel headed for messianic injection of bioaerosols into the clouds cannot be seen without its converse—a vertiginous downward spiral of acid rain, uncontrollable snow, and debris, back down into the earth.

While not explicitly discussed in current proposals around geoengineering, an anticipatory future of bioengineered aerosols may become a large part of climate remediation in the near future. David Keith affirms this, predicting that by 2070 the geoengineering project will have "switched from sulphuric acid (or silver iodide) to an engineered particle with fewer environmental impacts" (Keith 2013: 7). It is not far-fetched to consider the way *P. syringae* and other organic particles like spores or pollen may be coopted into optimized forms for this purpose. In a research paper published in 1989 (Ward and DeMott 1989), Snomax was assessed and supported as an artificial ice-nucleation for stratospheric injection when compared to conventional cloud injection with inorganic particles. Given its powdered form, it had exhibited a superior dispersion in the clouds and higher efficacy in cloud-seeding than its non-organic counterpart like silver oxides and sulfates. Manufacturing a new strain of *P. syringae* specifically for stratospheric injection would also bring another complex and controversial technique—synthetic biology—to the ethical quandary of geoengineering. Synthetic biology, as Frédéric Neyrat says, "is highly compatible" with the ideas of geoengineering in the way it warms to a technocratic solution to reverse and nullify the issues it hopes to address. While already typically found in experiments on biodiversity conservation and disease prevention (Redford and Adams 2021), as well as the burgeoning agricultural industry of GMOs, synthetic biology presents a possible climax to controversies around geoengineering where we may be looking at the open-air testing and deployment of transgenic bacteria. Clouds are incredibly dynamic habitats, supporting both non-organic particles and organic extremophiles (Delort et al. 2017) and modeling the impact of such bioengineered organisms *in vivo* may be incredibly difficult. In fact, Harris et al. (2013) have revealed that sulfate particles (the leading candidate for stratospheric injection) are oxidized and lose their buoyancy on contact with transition metal ions in the clouds common above industrial cities with high concentrations of mineral dust in the air. This previously unexamined oxidative process would make this strategy much less effective in growing cities such as many in the Global South, making the whole program that much more asymmetrical.

The field of transgenic arts has also become a place where much work has been, and is being, done to bridge the gaps between specialist and amateur, and to introduce creative disruptions or provocations to the industry. Early works like *Genesis* (1999), by transgenic art pioneer Eduardo Kac, where a biblical verse was coded through a cipher onto the DNA of a bacterium and subjected to mutating effects of UV light triggered by remote visitors, critically highlighted the dubious claim of humanity's supremacy over nature. The *Transgenic Bacteria Release Machine* (2001–2003) by the Critical Art Ensemble presented an installation of ten petri dishes assembled around a circular mount; at the touch of a button, a robotic arm would randomly open one of the dish covers. The Tissue Culture and Art Project's work *Victimless Leather* (2004) exhibited a working lab chamber that held and nourished a sculpture of a dress made with living tissue. Its use and display of the technological assemblage around the sustenance of life *in vitro* explored the "future consequences and potentials of using tissue engineering to develop consumer products" (Catts and Zurr n.d.). More recently, Marta de Menezes has been conducting workshops on CRISPR technologies (2017–2017) aimed at introducing the concepts of the new and obscure technique of genetic modifications to artistic and non-specialist audiences with the hope of generating multi-disciplinary and multi-stakeholder conversations at the onset of the technology. Menezes herself is a pioneering bioartist whose seminal work *Nature?* (2000) introduced a scarified pattern in the wing of a butterfly by conducting a micro-cauterization of the pupa, an invasive operation considered routine in the evolutionary sciences laboratory. Though not a genetic intervention (the resulting patterns were non-hereditary), the work was a powerful and contentiously beautiful reminder of the cycle of cause and effect of human intervention in living systems.

In the way that these projects have catalyzed conversations both within the specialist fields of biology and the diverse groups of arts and culture, *Terra Et Venti* aspires towards what Robert Mitchell (2010) calls "vitalist bioart"—art that operates with the biological materials, life-forms, and processes within the web of relationships in research environments, lab environments, corporate culture, and the public.

In vitro

The project initiated a collaboration with the Guttman Lab for Pathogenic Genomics and Evolution at the University of Toronto in 2017, aiming to explore what effects speculative genetic modification/synthetic biology technologies may have on the morphology, specifically related to its ice-nucleation domains, of *P. syringae*. Building

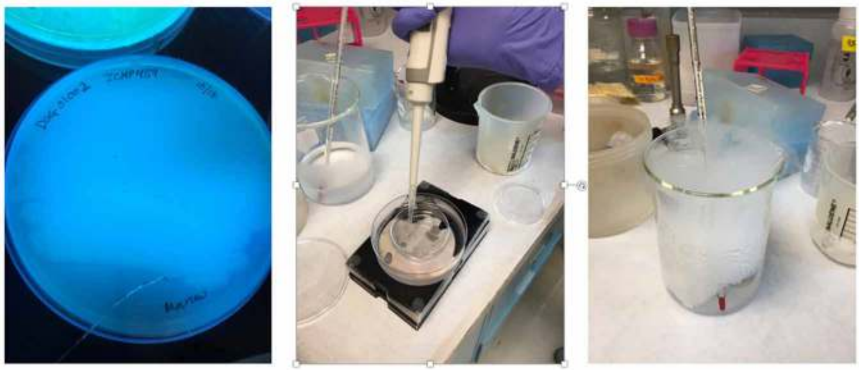


Figure 12.1 Lab work: preparing the elements for bench top ice-nucleation at the Guttman Lab at the University of Toronto. Courtesy the author. CC4r.

on the lab's routine experiments in bacterial genomics, we added lines of text into the DNA of *P. syringae* to observe the ways its ice-nucleation activities might change, hypothesizing that such changes would lead to differential folding of the Ice Nucleating proteins (INPs) that could eventually catalyze an array of ice formations in different shapes and sizes. As a thought experiment towards creating a new taxonomy for geoengineered clouds, this process made visible the layers of mediation and computation involved in artificially synthesizing them. It was done also to speculate on possible workflow in not-too-distant biofutures where clouds and rain would be user-customizable**.** Although not conducted in an ideal simulation, these benchtop tests in nucleating ice were satisfying initial forays into observing the almost magical and dramatic spread of ice from the particle drop (Figure 12.1).

Initially, a list of test words was randomly generated for the process, then a preexisting AI-based text generator trained on the writing of Jorges Luis Borges, was utilized to develop prose from those text fragments that were chosen. These fragments were put through a cipher, derived from Canadian poet Christian Bök, that matches three letter RNA codons to the conventional symbol of its resultant amino acid e.g., Methionine—"M" to the codon—"AUG." (Bök 2015: 97). The sequences were reviewed through the Basic Local Alignment Search Tool (BLAST) online to ensure biologically viability for their host, and then a fragment of this sequence was brought and inserted into a plasmid before bacterial transformation and uptake of the gene of interest in its DNA. The penultimate transgenic bacteria produced contained the phrase "Terra Et Venti" or "Between the Earth and Wind" that had a fragment sequence of "ACAGAACGCCGUGCUGAAACAGUAGAGAACACGAUU."

In 2018, I was invited to a duo exhibition with sculptor Chad Gunderson at the Kittredge Gallery at the University of Puget Sound. Chad's sculptures fuse additives to clay to amplify flavor, color and texture, resulting in artifacts and unpredictable blooms of contrasting colors after the firing process. Inspired by Lego bricks, 8-bit video game sprites and vintage Tupperware, Chad's work is lively and fun, but is also a productive form of intervention that further reveals the interactions between the

Figure 12.2 Terrarium filled with *A. thaliana* and seeded with modified *P. syringae* with closeup view of dew bubbles forming over the leaves, 2018. Courtesy the author. CC4r.

earth, wind, and the hand of the artist. We discussed the revelatory nature of kiln-fired sculpture that seemed to bear some similarities to transgenic art—phenotypic changes would only appear after one generation—and how arbitrary additives to the base materials of both clay and genetics could yield wildly creative results. We named the show *Terra Et Sonus* (Between the Earth and Sound) in a nod to the resonant cavities of his sculptures and the vibratory resonances of the cell.

For this exhibition, the transgenic bacteria featured in two separate installations. In *Mound (for Hans Haacke)*, an acrylic cube was placed in the middle of the gallery, loaded with a mound of soil that had tiny *Arabidopsis thaliana* seedlings. Prior to sealing the terrarium, these seedlings were sprayed with the modified *P. syringae* bacteria (Figure 12.2). The plants were a host to aid the uptake of the bacteria into the micro-atmosphere within the terrarium since there was no external wind to carry it upwards. Within a day, condensation had begun to form on the insides of the cube. Drawing on the aesthetic similarity to Hans Haacke's earlier *Condensation Cubes*, this piece invited visitors to observe the invisible, systemic processes brought about by the respiration of living organism and the terrarium's changing micro-climate. *A. thaliana* plants were also seeded in an open mound in the center of the gallery that extended about 7 feet across, and grew into a small green cover at the three months that the exhibition was up (Figure 12.3). In a separate room, the installation continued with the work *Sculpting a Cloud*. Inspired by Vincent Schaefer's anecdotal description of flying through a cloud releasing dry ice and watching snow crystals begin forming around him, this work attempted to reinterpret the experience as an immersive sound installation. Within a quadrophonic soundscape of atmospheric sounds and wind, the space was punctuated with sounds of ice cracking, directed into points in the room by

Figure 12.3 *A. thaliana* plants were seeded in an open mound in the center of the gallery, about seven feet across, and grew into a small green cover during the three months that the exhibition was up, 2018. Courtesy the author. CC4r.

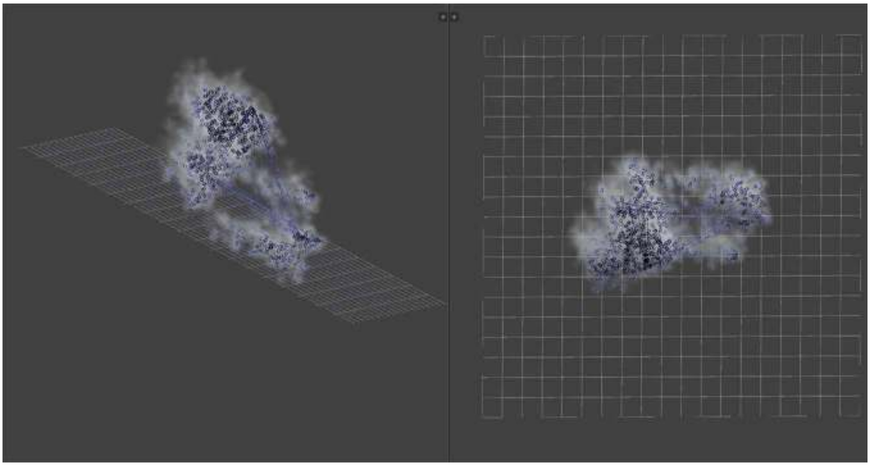


Figure 12.4 Computational animation of a cloud formed by particle mechanics, 2018. Courtesy the author. CC4r.

parametric, hyper-directional speakers set on pan-tilt motors. A video screen shows the visualization of a cloud forming with an overall experience of that approaching immersion within a cloud in the process of its own formation (Figure 12.4). Later iterations of these have been presented at the Ontario Science Centre and the Museum of Contemporary Art in Toronto.

Art's Work in the Age of Biotechnology (Gregg Museum of Art and Design, NCSU, 2019–2020)

In 2019 I was invited to participate in an exhibition at the North Carolina State University's Gregg Museum for Art and Design and the Hunt Library as part of the exhibition *Art's Work in the Age of Biotechnology: Creating our Genetic Futures* (2019–2020) curated by Hannah Star Rogers. This major exhibition was produced with support from the NCSU Genetic Engineering and Society (GES) Center, an international hub for the examination of the "technical, ethical and societal dimensions of the products and impacts of biotechnology" (NCSU Genetic Engineering and Society website n.d.). The works displayed in the exhibition addressed a broad range of topics, including the role that art, speculative fiction, and ecopoetics could play in alternative views of the future, but the icing atop the cake was the symposium that came with the exhibition that brought together artists, humanists, social/natural scientists, and members of the public, using the exhibition as a departure point for conversations about the future of biotechnology and genetics. Beyond the usual schedule, time was allocated for a pre-selected pairing of scientists and social science experts with each artwork for a specialist response to the artworks from a different discipline. As curator Rogers (2019: 4) says,

> If we propose to study life, we must insist on visions from both art and science, and it is these categories that Art's Work aims to complicate: divisions between bodies and experiences, between the public and experts, and between a belief in a technical and biological deterministic view of our genetic futures and the social choices we are free to make.

For the exhibition, I worked with graphic designer Natalie Plociennik on a triptych of pseudo-scientific visualizations of the activity of *P. syringae* in the atmosphere. Inspired by early experiments of cloud-seeding with Snomax (Plate 33), the visualizations embedded the bacteria symbolically at the nucleus of an ice crystal in one, and a snowflake in another. In a third, we created a stylized view of the bacterial cell surface to visualize its activity at the molecular level (Plate 34). In addition, a small setup of *Sculpting a Cloud* was installed at the Hunt Library on another side of the campus.

Terra Et Venti received a poetic intervention by Dr. Darrell Stover, an anthropologist who connected with the piece on the level of clouds, his mention of spores, seeds, and shower cycles reminiscing on the global migration of aerosols and the complex ecosystems that thrive in the atmosphere. In this poem, his use of the refrain "drop up" beautifully depicted the way the rainmaker *P. syringae* was deeply connected with the earth and its cyclical motion above and below ground beyond the natural gravitational pull of the earth, recasting the water cycle in a circularity of aggregative "mini gods" that inhabit "atmospheric churches" that "plop to earth." Reminiscent of Tao Sambolec's *Virtual Mirror: Rain* (Vrhovec Sambolec 2009) in which raindrops flew up to a catchment in the ceiling, triggered by actual rain intensity from sensors placed outdoors on the grounds adjacent to the gallery, Stover's poem catches the totality of the activity, aspirations, and fears in the project, and the way it invites its viewers and participants into a position of discomfort, deviating from, and queering atmospheric positionality:

Cloud 'Crobes
Jungles float above us
Heaven in air life
Microscopic rain forests
On high
Come down
All around
Millions of minigods
Microniche atmospheric churches

Testaments cast on overcast days
No smiles and silver linings
Only shadows of disappointment
Yet tears of approbation build

H 2 O coated cells
Mystery surfaces
Fuel condensation
Water blessings
Wet gods plop to earth

New genesis
Drizzle spores
Rise again in hot winds
Sun lifted
Sun lifted
Evaporation thwarts sin

Drop up seeds
Cherubic bacilli
Super cool
Power shower cycles

Drop up
Drop up
Whirl and transpire
Rise and bypass
Judgement
Yet again
Drop up

(Stover 2020)

Biofrictions Residency (2021–2022)

In a residency with the Biofrictions program hosted by Cultivamos Cultura in Portugal in 2021, I was interested in tracing the genetic ancestry of *P. syringae* to discover within its phylogeny extinct genetic traits that could be reintroduced to consider the future of its role as an "on-demand" rainmaker. Considering *P. syringae*, which is an incredibly diverse species with thirteen phylogenetic groups and over sixty pathogenic variants (Baltrus, McCann, and Guttman 2017), my search also aimed towards a conceptual "re-wilding" of the bacteria to locate its genetic wild-type cast as the penultimate microbial sage. I was paired with micro-biologists Ligia Martins and Vânia Brisso from the Instituto de Tecnologia Química e Biológica, Universidade Nova de Lisboa, and we discussed the ways synthetic biology could lead to both utilitarian and poetic effects in the atmosphere through directed evolution of *P. syringae*, and reintroducing genetic fragments of its own ancestral history. We considered the variety of historical morphologies (such as antibody resistance, color, texture, shape) that could improve the capacity of the bacteria in climate geoengineering. Inspired by the collegiality experienced at NCSU, this residency was for me an experiment in collaborative optimism and accountability between scientists and artists. Considering its timing at the height of the pandemic, we held regular meetings virtually and shared the workload of our investigations and took time to sit with some ideas that were brought in from different cultural and disciplinary backgrounds. We also held honest discussions around broader topics of art/science such as reading (literature and DNA) and death (in the laboratory and in life).

Using the base model of *P. syringae* as a hypothetical living chassis, I created a character creation/customization page similar to the front page of a typical RPG game that explored preliminary speculations on modifying form and function through reading its phylogenetic ancestry (Plate 34). The options were:

1. "Ice-nucleating+"—This mutant derives enhanced ability to nucleate ice through the insertion of DNA sequences that code for optimized INPs on the surface of the bacteria, and further energy conservation for growth through designed avirulence for terrestrial plants (e.g., tomato). A higher affinity for lower temperature environments would also support the bacteria's suspension in the atmosphere. These phenotypes are adapted from parental strains *P. vulgaris* and *P.fragi*.
2. "Mucosa+"—This mutant catalyzes the formation of mucus on its surface through the addition of gel-forming mucins in its genetic library. An opportunistic bacterium, this mutant is able to develop micrometer thick membrane-like biofilms that create arrays of micro bubbles in the atmosphere. While being able to attract other organisms in the air into commensal relationships within these micro-habitats, it is also able to direct microbial antagonism to protect itself and its habitat through the production of specific antibodies/poisons. These micro bubbles can be used for bioremediation of the air. These phenotypes are adapted from parental strains *P. flourescens*, *P. chlororaphis*, *P. aeroginosa*, and *P. abietaniphila*.

3. "Co2-fixing+"—This mutant not only promotes photosynthesis and carbon fixation in hyper-accumulator plants, it has also been infrastructurally conditioned to consume CO_2 as a fraction of its daily diet and contribute to atmospheric bioremediation. This mutant is also able to form internal biopolymers from its raised carbon consumption that contribute to host immunity. These phenotypes are adapted from parental strains *P. alcaligenes*, *P. aeruginosa*, and *P. abietaniphila*.

Conclusion: Is Art Grief Work?

As more and more artists seek to produce radical artworks with life as their medium and site for critical engagement, the question of art's efficacy within the urgent conversations of conservation and climate mitigation are as important as ever. In the intermingling of natural and unnatural, engineering or intervening on the climate is a reflexively dangerous endeavor, even as our planet itself becomes more and more dangerous for us to live on. As Timothy Morton says, "We are losing a fantasy—the fantasy of being immersed in a neutral or benevolent Mother Nature … art in these conditions is grief work" (Morton 2016: 8). Climate geoengineering shifts the scale of engagement with the weather, the climate, and other planetary imaginations to the scale of the immediately perceivable—the wind and breath—through its proposed agenda of stratospheric injection—invisible particles both inorganic and organic seeding within the stratosphere to work against global warming and accumulate in planetary circulation. As we wait to see when and how policy makers, industry leaders, and scientists proceed with such activities, how might we decide who of us are allowed to participate in discussions, engage in debates, critiques, and "constructive disagreements" with them? Additionally, how might the keenest attention be given to the voices of the underserved, subaltern, and Indigenous communities such as in the Global South that will bear the largest cost of these ventures?

Gilbert Simondon describes the state of supercooled water in liquid form as an equilibrium with latent potentials that are actualized dramatically with the introduction of a single particle that nucleates and forms crystals around itself, becoming the medium upon which more crystals can form. For Simondon, this provides the metaphor for the impact of the individual in the physical, biological and cultural domains, in which a small seed may serve as the medium that "introduces a new regime of the system" (Mitchell 2007: 136). As a case study, I have presented the research-creation project *Terra Et Venti* that builds on the role of *P. syringae* as an ice-nucleating catalyst, cloud condensation nuclei, and venerable sage microbe, exploring the interscalar expansion of its role in planetary-scale geoengineering and weather modification practices in the future. While examining the tradition of intervening within genetic sequences as computational and mutable parameters, the project has provided a counterweight of artistic expression through activities across *in vivo*, *in vitro*, and *in silico* forms. William Myers (Myers 2019: 46) has described *Terra Et Venti* as "akin to stamping a floral pattern on the bridle of a workhorse—a gesture of appreciation for aesthetic pleasure all the more potent in its unlikeliness and invisibility," saving a moment for the potential of an artistic connection in the face of such urgent environmental discourse. My hope is that art such as this may at best be disruptive to regimes of geoconstructivist thought that continually intervene on natural systems, and at the very least, as climatologist Judith Curry describes, becomes a strategy for "smuggling some serious topics into the consciousness" of specialist and layperson alike (Scheider-Mayerson 2018: 475).

In providing a conceptual trope through these distinct lineages of biotechnology, weather modification, transgenic art, my aim has been to invite the reader into the complexities and multidisciplinary conversations that engender the notion of climate geoengineering. Recognizing that this is less a comprehensive summary of the main arguments as it is a provocation to learn more, I have aspirationally chosen reach instead of depth, and on occasion may have not sufficiently "dissociated" the conflation of ideas across disciplines. In a similar way, aspects of research that provide relevant contexts for my artwork have been highlighted and form a relatively limited scope of the rich field and current research in geoengineering. The interested reader will find more wholesome discussions, strategies, and industry examples in books like Burns and Strauss (2013), Herzog (2018), and Kolbert and Lowman (2021) in addition to the ones already referenced in this chapter.

As technology gets more and more sophisticated, exerting a similar pressure on the development of human behavior and perspectives, an unprecedented reliance on technology will draw more capital funding for innovations in this area than we have ever seen before, leading to increasingly porous boundaries between industrial, military, and commercial technologies. How might humanitarians, artists, designers, social scientists, and community leaders work together to create a progressive series of checks and balances? Ever the most steadfast of proponents for climate engineering, David Keith has expressed his apprehensions at the way these affordances may be repurposed inappropriately in the long term, reflecting on the "screen" of geoengineering's efficiency and low cost that has often been used to obscure the capitalist motivations behind these. As he says, "Human desire expands like a gas to fill the bottle defined by resources and technology" (Keith 2013: 167). How we manage these contentious relationships, and establish collaborative networks, is the challenge for the future—a role that art, fiction, and creative storytelling to build communities might support and ultimately succeed in. We are after all looking not at the control of nature, but, as Elizabeth Kolbert and Rebecca Lowman write, the "control of the control of nature" (Kolbert 2021: 3).

Acknowledgments

I would like to thank my collaborator Mick Lorusso for his time, energy, and collaborative spirit in developing many aspects of this pieces together. I would also like to thank Solon Morse and Paul Vanouse for hosting us at the Coalesce Centre for Bioart, Marta De Menezes and Cultura Cultivamos and the Biofrictions program, Hannah Star Rogers, Molly Renda, and Fred Gould from NSCU for the invitation to be part of the seminal exhibition *Art in the Age of Biotechnology: Shaping our Genetic Futures*, and to Dr. Darrell Stover for the ekphratic response to *Terra Et Venti*. I would also like to thank Peter Stanley at the Kittredge Gallery, Peggy Muddler and David Guttman (University of Toronto), and Mark Gordon (York University).

References

Abiodun, B. J., R. C. Odoulami, W. Sawadogo, O. A. Oloniyo, A. A. Abatan, M. New, C. Lennard, P. Izidine, T. S. Egbebiyi, and D. G. MacMartin (2021), "Potential Impacts of Stratospheric Aerosol Injection on Drought Risk Managements over Major River Basins in Africa," *Climatic Change*, 169: 31. doi: 10.1007/s10584-021-03268-w

Baltrus, D. A., H. C. McCann, and D. S. Guttman (2017), "Evolution, Genomics and Epidemiology of *Pseudomonas syringae*: Challenges in Bacterial Molecular Plant Pathology," *Molecular Plant Pathology*, 18(1): 152–68.

Black Vault (n.d.), *Project Cirrus, Final Report on Contract W -36-039-SC-32427.* Available online: https://documents.theblackvault.com/documents/weather/CirrusFinal.pdf (accessed February 2, 2022).

Bök, C. (2015), *The Xenotext: Book 1*, Toronto: Coach House Books.

Buck, H. J. (2016), "Rich Man's Solution? Climate Engineering Discourses and the Marginalization of the Global South," in J. Chilvers and M. Kearnes (eds.), *Remaking Participation: Science, Environment and Emergent Publics*, 167–86, London: Routledge.

Buck, H. J. (2019), *Against Geoengineering: Climate Tragedy Repair and Restoration*, London: Verso.

Burns, W. and A. Strauss (eds.) (2013), *Climate Change Geoengineering: Philosophical Perspectives, Legal Issues, and Governance Frameworks*, Cambridge: Cambridge University Press. doi: 10.1017/CBO9781139161824

Catts, O. and I. Zurr (n.d.), [Artwork] Victimless Leather. Available online: https://tcaproject.net/portfolio/victimless-leather/ (accessed April 7, 2023).

Delort, A. M., M. Vaïtilingom, M. Joly, P. Amato, N. Wirgot, A. Lallement, M. Sancelme, M. Matulova, and L. Deguillaume (2017), "Clouds: A Transient and Stressing Habitat for Microorganisms," in C. Chénard and F. Lauro (eds.), *Microbial Ecology of Extreme Environments*, Cham: Springer. doi: 10.1007/978-3-319-51686-8_10

Fleming, J. R. (2010), *Fixing the Sky: The Checkered History of Weather and Climate Control*, New York: Columbia Press.

Furuhata, Y. (2019), "Of Dragons and Geoengineering: Rethinking Elemental Media," *Media+Environment*, 1(1). doi: 10.1525/001c.10797. Available online: https://mediaenviron.org/article/10797-of-dragons-and-geoengineering-rethinking-elemental-media (accessed August 24, 2022).

Glaisher, J. (2019), *The Aeronauts: Travels in the Air*, New York: Melville House.

Gordon, D. R., G. Jaffe, M. Doane, R. Doria, A. Glaser, T. M. Gremillion, and M. D. Ho (2021), "Responsible Governance of Gene Editing in Agriculture and the Environment," *Nat Biotechnol.*, 39: 1055–7. doi: 10.1038/s41587-021-01023-1

Harris E., Sinha, D., Van Pinxteren, A., Tilgner, K. W., Fomba, J., Schneider, S., Mertes, Roth, A., Gnauk, T., Fahlbusch, B., Mertes, S. and Lee, T.(2013), "Enhanced role of transition metal ion catalysis during in-cloud oxidation of SO2", *Science*, 340(6133): 727–730.

Henderson, N. (1986), "Biotech Firm Heads for the Slopes," *Washington Post*, February 18. Available online: https://www.washingtonpost.com/archive/business/1986/02/18/

biotech-firm-heads-for-the-slopes/ff0d74f4-26a4-44f6-bad6-b627ddc43259/ (accessed January 2022).

Herzog, H. J. (2018), *Carbon Capture*, Cambridge, MA: MIT Press.

Howard, L. (1803), *Essay on the Modifications of Clouds*, London: Luke Hansard & Sons.

Huang, S., W. Hu, J. Chen, Z. Wu, D. Zhang, and P. Fu (2021), "Overview of Biological Ice Nucleating Particles in the Atmosphere," *Environ Int.*, 146: 106197. doi: 10.1016/j.envint.2020.106197

Ingold, T. (2007), *Lines: A Brief History*, London: Routledge. doi: 10.4324/9780203961155

IPCC (2021), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge: Cambridge University Press.

Keith, D. (2013), *A Case for Climate Engineering*, Cambridge, MA: MIT Press.

Keith, D. (2021), "Towards Constructive Disagreement about Geoengineering," *Science*, 374(6569): 812–15.

Kolbert, E. (2021), *Under a White Sky: The Nature of the Future*, New York: Crown.

Lagriffoul, A., J. -L. Boudenne, R. Absi, J. J. Ballet, J. M. Berjeaud, S. Chevalier, E. E. Creppy, E. Gilli, J. P. Gadonna, P. Gadonna-Widehem, C. E. Morris, and S. Zini (2010), "Bacterial-Based Additives for the Production of Artificial Snow: What Are the Risks to Human Health?" *Sci. Total Environ.*, 408: 1659–66.

Lawrence, M. G., S. Schäfer, H. Muri, V. Scott, A. Oschlies, N. E. Vaughan, O. Boucher, H. Schmidt, J. Haywood, and J. Scheffran (2018), "Evaluating Climate Geoengineering Proposals in the Context of the Paris Agreement Temperature Goals," *Nat. Commun.*, 9: 3734. doi: 10.1038/s41467-018-05938-3

Mitchell, R. (2007), "Sacrifice, Individuation, and the Economies of Genomics," *Literature and Medicine*, 26(1): 126–58. Available online: https://muse-jhu-edu.proxy.lib.umich.edu/article/230549 (accessed April 12, 2023).

Mitchell, R. (2010), *Bioart and the Vitality of Media*, Seattle: University of Washington Press.

Morton, O. (2015), *The Planet Remade: How Geoengineering Could Change the World*, Princeton, NJ: Princeton University Press.

Morton, T. (2016), *Dark Ecology*, New York: Columbia University Press.

Myers, W. (2019), "May Matriarchal Mayhem Manifest," *Art's Work in the Age of Biotechnology*, Chapel Hill: University of North Carolina Press.

NASA Earth Observatory, *Global Effects of Mount Pinatubo*. Available online: https://earthobservatory.nasa.gov/images/1510/global-effects-of-mount-pinatubo (accessed January 10, 2022).

NCSU Genetic Engineering and Society (n.d.) [website]. Available online: https://research.ncsu.edu/ges/about/ (accessed April 7, 2023).

Neyrat, F. (2019), "The Screen of Geoengineering," *The Unconstructable Earth: An Ecology of Separation*, New York: Fordham University Press, 27–33. doi: 10.1515/9780823282609-003

Ong, J. and M. Lorusso (2019), "Umwelt Microbana," *Public*, 59: 179–89.

Peters, J. D. (2014), *The Marvelous Clouds: Toward a Philosophy of Elemental Media*, Chicago: The University of Chicago Press.

Redford, K. and B. Adams (2021), *Strange Natures: Conservation in the Era of Synthetic Biology*, New Haven, CT: Yale University Press.

Rogers, H. S. (2019), "What Artists Offer: Shaping our Genetic Futures," *Art's Work in the Age of Biotechnology*, Chapel Hill: University of North Carolina Press.

Scheider-Mayerson, M. (2018), "The Influence of Climate Fiction: An Empirical Survey of Readers," *Environmental Humanities*, 10: 2.

Siegwald, L. and C. de Jong (2020), "Anthropogenic Impacts on Water Quality in a Small, Forested Mountain Catchment: A Cast Study of the Seebächle, Black Forest, Southern Germany," *Sustainability*, 12: 9022. doi: 10.3390/su12219022

Slotedijk, P. (2009), *Terror from the Air*, Cambridge, MA: MIT Press.

Stover, D. (2020), [Unpublished work] originally performed at Art's Work/Genetic Futures Exhibition Symposium, October 18, 2019 at Gregg Museum, NC State (13:21). Available online: https://research.ncsu.edu/ges/arts-work-in-biotech/#symposium (accessed April 12, 2023).

Temple, J. (2017), "China Builds One of the World's Largest Geoengineering Research Programs," *MIT Technology Review*. Available online: https://www.technologyreview.com/2017/08/02/4291/china-builds-one-of-the-worlds-largest-geoengineering-research-programs/ (accessed January 1, 2022).

Tsing, A. (2011), "Pluralizing the Anthropocene: The View from Feral Atlas," YouTube, uploaded by fundacaoserralves, March 11. Available online: https://www.youtube.com/watch?v=EzlA-5_soh0&t=24s (accessed January 1, 2022).

Tuthill, B. (1954), "Hatfield the Rainmaker," *Western Folklore*, 13(2/3): 107–12. doi: 10.2307/1520588

Vrhovec Sambolec, T. G. (2009), *Virtual Mirror Rain*. Available online: http://www.taogvs.org/VirtualMirrorRainMain.html (accessed June 20, 2022).

Vukajlovic, J., J. Wang, I. Forbes, and L. Šiller (2021), "Diamond-Doped Silica Aerogel for Solar Geoengineering," *Diamond and Related Materials*, 117: 108474. doi: 10.1016/j.diamond.2021.108474

Ward, P. J. and P. J. DeMott (1989). "Preliminary Experimental Evaluation of Snomax (TM) Snow Inducer, Nucleus *Pseudomonas syringae*, as an Artificial Ice for Weather Modification," *The Journal of Weather Modification*, 21: 9–13.

Wittgenstein, L.(1998), *Culture and Value*, ed. Georg Henrik von Wright, rev. edn, London: Wiley-Blackwell.

Yang, D., J. Au, M. Chan, Z. Dai, and M. H. Thiemens (2018), "Atmospheric SO2 Oxidation by NO2 Plays No Role in the Mass Independent Sulfur Isotope Fractionation of Urban Aerosols," *Atmospheric Environment*, 193: 109–17.

Yang, H., S. Dobbie, J. Ramirez-Villegas, K. Feng, A. J. Challinor, B. Chen, Y. Gao, L. Lee, Y. Yin, L. Sun, J. Watson, A. K. Koehler, T. Fan, and S. Ghosh (2016), "Potential Negative Consequences of Geoengineering on Crop Production: A Study of Indian Groundnut," *Geophysical Research Letters*, 43(22): 11786–95. doi: 10.1002/2016GL071209

13

Sunbot Swarm: Absurdist Cyborg Systems for House Plants

Kathleen McDermott

In this chapter I will explain the process of creating *Sunbot*, a robotic platform for taking a houseplant into the sun, and the questions, iterations, and findings that emerged out of this investigation. I am a visual artist with a practice of working with robotic and wearable electronics that is driven by material exploration and iteration. I produce objects and hardware-based performances as a way of thinking, and sometimes as a way to delay thinking. When the objects are complete, I observe their existence and behavior in relation to bodies, and this is often the phase when more questions, rather than conclusions, emerge. In the case of the *Sunbots*, each version brought new questions, the most pernicious of which persisted throughout: 1) How can the practice of creating absurd wearable designs for nonhumans allow a productive conversation to emerge around issues of technology, embodiment, and agency? 2) In technological investigations with nonhuman collaborators, how can the human investigator decenter themself when approaching design decisions, or can they?

These questions began as playful propositions. Humor is a coping mechanism that I have used to interrogate the ubiquity of technology, the pace of its expected adoption, and the anxiety associated with these entanglements. As an enthusiastic nonprofessional designer of electronics, I might also call myself a "professional amateur," a term borrowed from Shumon Basar, who casts the amateur as a playful figure that "generates knowledge by elision, contingency and exacting luck" (2006: 34). Basar's amateur can be related to Lewis Hyde's definition of a trickster: a boundary-crosser, "creative idiot," and "wise fool" (2010: 6–7) which he identifies among Dada and Fluxus artists who used absurdity and humor to subvert binaries and reveal complexity. My understandings of boundary-crossing are also indebted to feminist theory, most recently, Legacy Russell's *Glitch Feminism*, which argues for vastness as a counter to dualism (Russell 2020). In the second half of the chapter I provide a technical account and conceptual reflection of *Sunbot Swarm*, a series of investigations which directly followed my findings from working with the *Sunbot*.

I created the first version of the *Sunbot* while at a residency at the Tides Institute and Museum of Art in Maine. In the year prior to the residency, living alone and in the early phases of completing my PhD, I began keeping houseplants for the first time and slowly learned how to care for them, which I found very fulfilling. When I was given the opportunity to spend a month focusing on my work in a remote area, I felt the best course of action would be to take my plants with me and so I loaded them onto the floor and seats of my car for the nine-hour trip. They made pleasant travel companions and this was on my mind later as I read Valentino Braitenberg's *Vehicles*, a theoretical work which describes photocell-based robots as a lens through which to discuss the structure of the human brain. One of Braitenberg's assertions is that "analysis is more difficult than invention" (2000: 20) and that humans tend to ascribe more complexity to both synthetic and organic systems than may actually be warranted. In Braitenberg's analogy, a robot programmed to move toward the color red may be described by a human observer as having an affinity for the color red, or as "liking it," an analogy which would greatly overstate the intelligence of the system. While Braitenberg's point is toward the difficulty of reverse engineering systems due to a human tendency to assume greater complexity, the affinity example he uses also demonstrates anthropomorphism—a tendency for humans to see things in the natural world and built environment through their own image. I wanted to model the behavior Braitenberg described in a real robot to see it for myself, and I felt compelled to involve my plants in the investigation, in part so they could get more scenic enjoyment out of the trip, and also because I found the idea of their mobility humorous.

The first *Sunbot* (Figure 13.1) is a very simple robot that takes a houseplant into the sun. It uses two photocells (light-sensitive resistors) to detect ambient light levels and control the movement of two wheels, which are attached to the grill of an old electric fan. A houseplant sits on top of the fan grill, which is serving as the robot chassis. If a low level of light is detected, the wheels receive a HIGH signal

Figure 13.1 *Sunbot Version 1*, 2016. https://vimeo.com/178359991. Courtesy the author.

and the plant moves forward until enough light is found, at which point the plant will stop. One sensor is mapped to each wheel, which allows for a little variety in the plant's movement. For example, if the sensor on the right side of the plant receives enough light, the right wheel will stop; but if the left sensor is still in shade, the left wheel will continue to move forward until the sensor receives enough light, often causing the plant to gently turn as it slows down. This simple responsiveness and ability to self-adjust created, as Braitenberg had supposed, an appearance of greater complexity and intelligence than the system actually comprised. When showing video documentation to the general public (strategically cut to show the *Sunbot* at its moments of highest performance) a common analysis is "it is looking for light." However, that is not exactly true. The robot is moving forward indiscriminately, it does not even have obstacle-avoidance capability, and is simply stopping when it senses enough light. The system is not proactive, it is responsive. This distinction runs parallel to questions in robotic design in general. Should robots move through the world in a proactive, calculated way, carefully analyzing data before making any decisions? Or should they be equipped with a more decentralized intelligence, moving through the world with a network of sensors that may be more parallel to the human experience of embodied cognition?

Cartesian Dualism in Robotic and Wearable Design: A Brief Overview

Upon further research, I found that the *Sunbot* was a simplified descendant of William Grey Walter's "tortoises," which have been described as "the first biologically inspired robots" (Holland 2003: 351–63). Grey Walter, a neuroscientist, built the robots primarily in his home in 1949, with contributions from his wife Vivian Joan Dovey, a trained radiographer and EEG researcher (Saunders 2018) who co-authored eight papers on electroencephalography (EEG) with William under the name V. J. Walter. Grey Walter's tortoises, dubbed "Elmer and Elsie," utilized a single photocell attached to a shaft in the front of the robot that was also attached to the driving wheel. This alignment of the photocell with the driving wheel meant the robot could gather data from the direction in which it was moving, and allowed it to constantly scan the area it was driving toward for light. If enough of a light response was detected, the motor causing the front wheel to turn and scan would disengage, allowing the robot to move straight toward the area where the light response was detected (Holland 2003: 356).

Larissa MacFarquhar has noted in a profile of the cyborg philosopher Andy Clark that "although [the tortoise robots] were mechanically simple, they were surprisingly unpredictable. Because the world that Walter put them in was complicated, their behavior was complicated. They seemed like animals" (MacFarquhar 2018). If Elmer and Elsie were humans, they would be navigating the world instinctively based on sensory information such as touch or smell, as opposed to operating based on top-down decision-making or logic. This model of robotic design stands in contrast to later experiments, such as Stanford Research Institute's 1965 robot "Shakey," a tall robot with proportions more similar to a human. Before its wheels allowed it to move in any direction, Shakey utilized an onboard camera to survey its surroundings and sent the data to a remote processor for analysis. Kuipers et al. describe Shakey as a grandfather of the self-driving car (2017: 88–103). However, Shakey required a lot of time to process data before it made its careful movements, and in comparison to the tortoise robots it seemed slow and inorganic (MacFarquhar 2018).

The design differences between the tortoise robots and Shakey relate to Cartesian dualism, René Descartes's seventeenth-century theory that the mind could be separated from the body, because the body was a non-thinking entity (Rozemond 2002). Descartes's ideas helped proliferate the belief that humans could use the power of their minds (generally in applied forms of math and science), to control their bodies and surroundings, a position which devalues the body's role in human intelligence. Wander Eikelboom explains, "Sensitivity to the embodied human experience was lost during the Enlightenment. Descartes separated body and mind and in this act created the modern human subject that can perceive, know and rule the world by the power of the ratio" (2018: 139). Cartesian dualism has been critiqued through feminist lenses for its implied dismissal of embodied and lived experience, and for perpetuating gendered hierarchies. On the "ontological distinction between soul (consciousness, mind) and body" feminist theorist Judith Butler writes, "The mind not only subjugates the body, but occasionally entertains a fantasy of fleeing its embodiment altogether. The cultural associations of mind with masculinity and body with femininity are well documented within the field of philosophy and feminism" (1990: 12). Applied to technology design, particularly in the area of wearable and cyborg technology, the implied subjugation of the body inherent to Cartesian dualism is further amplified through commercial design trends such as "quantified self" and philosophical debates on posthumanism.

N. Katherine Hayles, Donna Haraway, Rosi Braidotti, and others have offered pertinent, feminist alternatives to posthuman theory that is human-centered and/or rooted in dualism. As Ella Brians states, rather than imply that "the body is obsolete and must be transcended," feminist posthuman theory "explores and pushes the boundary of our relationship to technology, without ever forgetting or effacing the body" (2011: 128–9). Legacy Russell has pushed the conversation further, arguing for the validity of both digital and physical lived experience and identity formation, and seeking to "revisit, occupy, and decolonize," the poet Walt Whitman's famous proclamation, "(I am large, I contain multitudes)" (2020: 37). Russell highlights the fluidity of the digital/physical body in the context of race, sexuality, and gender, asking, "*Who defines the material of the body? Who gives it value and why?*" (2020: 9).

Despite these feminist counters, reductionist conflations between humans and machines persist in cultural memory and can be observed through values that emerge in commercial technology design trends such as quantified self—a movement which encourages users to study and track their bodies and habits through technologically aided data collection, with an implication that, through self-knowledge, users may optimize their bodies and habits. Cultural anthropologist Natasha Dow Schüll argues that quantified self products set up passive relationships between users and devices, leading users to cede control of their schedules and bodily functions to technology

(2016: 317–33). Where early cybernetic theory led to a belief that a brain could be disassociated from an obsolete body, quantified self outsources control of the body to computational devices.

Parallels can be found in the way the body is simplified in online sign-up systems, to fit quantified data input. Jaron Lanier argues that by accepting the terms of multiple-choice check boxes which could never reflect the complexity of their identity, users are "reducing themselves in order to be able to use the services" (2010: 39). Russell also points to the omnipresent surveillance capitalism that users are required to consent to in online spaces, "every day we make a choice whether or not to rob ourselves" (2020: 32) and offers glitch feminism, illustrated through the work of queer and women-identifying artists of color, as a tool for refusing, encrypting, and evading reductive understandings of bodies across digital and physical spaces.

Plants as Emblematic of an Embodied System

In looking for models of human-machinic relationships and robotic design beyond dualism, plants are excellent examples of complex systems with no known central processing system—no clear place for division between sentience and body. Anyone who cohabitates with houseplants may observe the way in which plants grow naturally toward light, sometimes twisting and leaning in the process, seeming to show an awareness of where the light is and how to adjust themselves to reach it. Plants also have methods for keeping time, and have "evolved sophisticated mechanisms for anticipating predictable environmental changes that arise due to the rotation of the Earth on its axis. These mechanisms are collectively termed the circadian clock" (Gardner et al. 2006: 15–24). Importantly, circadian clocks in plants are decentralized (Shimizu et al. 2015: 1126), presenting a very different model of culling information from the world than the centralized human brain. Although their processing systems appear to be decentralized, researchers and artists have shown that plants have communication systems akin to synapses in the human brain (Wang et al. 2009: 1–11); the artist Miya Masaoka reads the electrical pulses from plants as part of a performance practice (2018) and evolutionary biologist Monica Gagliano contends that plants such as *mimosa pudica* can exhibit learning behavior (Gagliano, Abramson, and Depczynski 2018: 29–31).

In what ways can wearable or robotic systems be designed to emulate or benefit the unique decentralized intelligence systems of plants? Precedents can be found in several interdisciplinary art projects, each of which has a different conceptual framing. Katherine Behar's *Roomba Rumba* (2015), features a pair of rubber trees each sitting on top of a Roomba automatic vacuum, roaming around an artificial field in a gallery while instrumental music plays. Behar's playful investigation relates to her philosophical engagement with the field of feminist object-oriented ontology. According to Behar, the installation "aims to upset distinctions between natural and artificial, biological and machinic, behind-the-scenes service work and performative display, and to prompt solidarities across these categories" (2015). In Behar's piece, the Roomba robots and their relationship to domestic labor are equally important actors as the plants. The presence of the vacuum robots also casts the plants as domestic objects and draws attention to the way in which keeping potted plants indoors is inherently human-centered.

IndaPlant Project: *An Act of Trans-Species Giving* (2013), by Elizabeth Demaray in collaboration with Dr. Qingze Zou and other researchers at Rutgers University, "is designed to facilitate the free movement and metabolic function of ordinary houseplants" (Demaray 2014b). *IndaPlant* led Demaray to coin the term "floraborg," to describe an "entity that is part plant and part robot" (Demaray 2014a). *Indaplant* is similar to *GARRy* and *Sunbot* in that it consists of a small wheeled robot, adapted to suit a plant. In addition to allowing the plants to seek the sun, *Indaplant* allows plants to drive themselves to a water dispenser when their soil is dry. On her blog Demaray observes the ways in which the research began to include presence and cohabitation, writing that as the *Indaplants* took up residence in the lab, they became part of daily life, "When my collaborator on the project, Dr. Qingze Zou, comes to work in the morning he is greeted by the IndaPlants, which jostle with one another to exit his office in search of sun in the adjacent hallway" (Demaray 2014a).

GARRy (2015), a project by Byron Rich and Heather Brand, uses a small, GPS-enabled robotic chassis to carry ragweed, an invasive species, toward the direction of its place of origin, or "ancestral land." Rich writes, "The work problematizes what it means to relocate an entity back to its home, for on the journey it interacts with local ecosystems that may or may not be already affected by its presence," and draws a parallel to human histories of colonization (Rich 2015).

While these investigations were co-produced with plants in very different ways, through their status as artworks they share in common an ability to reflect back on human relationships and behavior, illustrating the way in which humans gain meaningful knowledge through design engagements with nonhuman actors.

Climate Change, Anxiety, and Absurdity

Through the process of creating, observing, and conducting post factum research on the precedents of the first iteration of the *Sunbot*, my motivations for contributing to the field of plant-related robotics shifted from an original curiosity at visualizing a behavioral phenomenon explained by Braitenberg, to a larger interest in plant performance in public space, and the meaning it reflects to human observers. An interpretation of the *Sunbot* video that has interested me among audiences (online and in cultural institutions such as The Museum of Art and Design in New York, where I repeatedly showed the video to rotating tour groups as part of a residency program) is the absurd implication that the plant has become migratory, or is a tourist. In many ways this was my original intention, because I had roped my plants into my journey eastward. But if I were taken out of the equation, what would motivate a plant to become mobile? The question can be related back to Hayles's assertion in *How We Became Posthuman*, that "The sense that the world is rapidly becoming uninhabitable by human beings is part of the impetus toward the displacement of presence by pattern" (1999: 37). In other words, the threat of climate change and the anxiety this causes may increase human interest in retreating to a virtual reality. We can also add the human interest in retreating off-planet, illustrated by the boom of billionaires financing private space travel (Koren 2021). If humans will use technology to flee the consequences of our reckless development, where will this leave plants and animals?

Considered in the context of the Anthropocene, a term for a new epoch in the history of earth marked by human alterations to the earth's climate (Raffnsøe 2016; Davies 2016: 2), further technological intervention into plant life seems fraught. Therefore, it becomes important to acknowledge the futility of attempting to "know" a plant's desires and augment its well-being through technology in a way that is not marked by my own values, even when considering efforts to improve plant survival. If the *Sunbots* succeed at destabilizing humans from the center of a robotic investigation, it is primarily through the sheer absurdity of the images they help produce, of mobile plants roaming an outdoor landscape. Absurdity as a tactic for destabilizing viewers and challenging conceptions of technology is rooted in the practices of Dada artists who presented Readymades, byproducts of industrial production practices, in galleries as art objects, undermining the idea of the human artist as a sole author of an artwork (Hyde 2010: 123–4). David Hopkins describes Duchamp's Readymades as "part of an ongoing enquiry; a series of experimental propositions as to what art might look like freed from the artists' touch …" (2016: 150). Hannah Höch's collage work similarly challenged the hierarchy of relationships between human bodies and objects, leading Matthew Biro to explore her work through the lens of the term "cyborg," despite the fact that her work predated the emergence of the term (2009: 202). Although these precedents primarily explore the relationship between people and technological objects, a similarly absurdist approach to designing with plants could be effective in raising questions regarding hierarchies of value in contemporary interspecies technology design.

Further, absurdity was shown by Dada artists to be particularly useful in moments of high anxiety. Many Dada artists witnessed the disastrous effects of technology applied to warfare in the First World War, and noted how these events did nothing to disturb the prevailing bourgeois faith in logic and technology as representative of progress. According to Jennifer Higgie, Dada artists used absurdity in their work as "an aptly alienated response to a culture that could sanctify such horror" (2007: 13). While it is possible to consider absurdist gestures in a climate of despair as "rebelling for rebellion's sake," Elizabeth Benjamin argues that there is a positive affirmation of humanity through these gestures, because they represent a "quest for authenticity" (2016: 12). Further, Jed Rasula argues that the roots of the word Dada come from a Rumanian phase, "*da, da*, meaning, 'yes, yes'" (2016: 9). These productive understandings of absurdity in creative practice have been echoed in contemporary reimaginings of Dada, such as Adam Pendleton's *Black Dada Reader*, which explicitly embraces Dada as affirmative, and as a productive tool for drawing parallels between Dada and Black Arts Movement leaders' responses to racism, "… Black Dada is a way to talk about the future while talking about the past" (2017: 333).

With these framings in mind, I felt that creating absurd electronic inventions to mobilize houseplants in public space could allow productive or unusual dialogue to emerge around the anxiety-ridden space of the Anthropocene, with the *Sunbots* producing a visual narrative of robotically enabled plant migration. Plants, specifically networks of trees, have been found to migrate in response to climate shifts, over the course of many years (Kolbert 2014). *Sunbot Swarm* imagines accelerating this process, out of necessity for the plants' survival. To explore this possibility effectively I felt I needed to create multiples of the *Sunbot*, to produce a mass of mobile plants with low-level communication abilities. What follows is a technical account of these attempts, and brief analysis of their successes and failures.

Sunbot Swarm Case Studies

First Iteration

Entering into the territory of making multiples, I wanted to develop a system to make reproduction of the robots easier. I also wanted to improve the overall performance of the robots. Rather than controlling each DC wheel motor through a transistor circuit as I had done in the first version, which allowed me to simply turn the wheels on and off, I laid out a motor control circuit, which allowed me to turn the wheels on and off as well as backward and forward. Writing the wheels backward is useful for helping the robot back away and turn to avoid obstacles. Further, I added an ultrasonic sensor to help the robot detect obstacles in front of it, as well as an infrared emitter and receiver to allow the robots to communicate, a method utilized in swarm robotic experiments (Rubenstein et al. 2014: 966–75). Admittedly, my decision to build all the robots myself placed some limitations on my technical decisions. On the other hand, maintaining the role of sole designer and builder of the *Sunbots* allowed me to refine my understanding of the impact of design decisions on robot behavior, while also privileging a system that was simple and easily reproducible, qualities which I consider important for promoting broader dialogue and the emergence of weird technology. To that end, I have documented the technical aspects of building the *Sunbots* at https://plantbots.org/. Further, I have found that revealing the way uncanny technological objects work (in line with Braitenberg's prediction, it is almost always simpler than people think), can be a way to invite audiences into a deeper and more inclusive consideration of technological design.

The first iteration of *Sunbot Swarm* was produced in collaboration with participants in a workshop at Open Source Gallery in Brooklyn, in which attendees produced bodies for the robots out of recycled materials and populated them with circuits I had prefabricated. In addition to approaching technology design as a collaborative conversation, my goal with this workshop was to explore the impact of the different structure designs created by participants on the robot behavior. At the beginning of the workshop I demonstrated how a fully assembled *Sunbot* behaved. Then I distributed circuit boards and showed participants how the copper traces connected components together on the boards. I asked the students to plug in the wheels, sensors, and batteries, to check that their boards functioned properly. This was an important step in helping participants understand the functionality of the different components. Then, participants designed bodies to house the components of the

Figure 13.2 *Sunbot* workshop at Open Source Gallery, 2018. Courtesy the author.

robots, primarily utilizing recycled materials that had been collected by Open Source Gallery (Figure 13.2). The materials utilized included a cassette tape player, a juice bottle, a printer, a salad container, a milk carton, and a tin can. Most of the participants were able to fully assemble their robots to a degree which allowed them to test their behavior. The students using the tape cassette and printer experienced the most challenges in assembly, because they were using harder plastic that was difficult to cut through and modify. Throughout the workshop, we talked about robot functionality. Participants were able to test their robots and make modifications to their design, such as placement of the wheels, in real-time. I later produced a video of all of the robots together, which I shared with participants.

After the workshop, I collected the robots and filmed them in my apartment over the course of several hours. The resulting video showed that the variation in the robots' designs, including the different placement of their ultrasonic sensors and wheels, meant that some of the robots were more stable than others. Further, the different placement of their sensors and the different heights of the robots, meant they could not all "see" each other. Their sensors often failed to detect the other robots, and they frequently ran into each other. This became more and more common as the morning progressed, because my apartment is East-facing, and as the sun rose above the building, the area of direct sunlight decreased. In the time-lapsed video documentation it is possible to observe the area of direct sunlight diminish, causing the robots to become restless and to crash into each other at a higher rate. In the resulting video, this behavior appears aggressive, it is as if the *Sunbots* are competing for the light, rather than behaving in a collaborative way (Figure 13.3). Again, this analysis is a more complex description of the behavior

Figure 13.3 Still from *Sunbot Swarm v.1* video, 2018. https://vimeo.com/277725450. Courtesy the author.

than what is technically occurring, which is simply an issue of the sensors being placed at heights that do not allow them to detect each other. Nonetheless, I found the results interesting and was motivated to investigate the idea of the swarm further.

Second Iteration

Approaching the second iteration, I wanted to standardize the robot bodies, so that I could observe how this affected their behavior. I thought that hiding the wheels, to give the impression that a regular potted plant had begun to move, would create an uncanny feeling in viewers and maximize the absurdity of the experiment. Citing the German psychiatrist Ernst Jentsch, Freud attributes uncanny feelings to uncertainty over whether something is alive or not, claiming the feeling can happen with recently dead things, as well as with inanimate objects (Liu 2010: 208). (Freud also believed women were more susceptible to uncanny feelings than men. I wonder whether Freud took an overly simplistic or binary view of what makes something animate.) I also wanted to continue to ensure that the project would be replicable, and to attempt to use low-impact materials. In earlier tests I had experimented with mold-making and casting materials such as latex, mycelium, and "bio-plastic" which I made from common pantry items based on recipes I found online. The results were poor, for several reasons. One is that the mold shape was based on a classic flowerpot. However, many plant pots taper at the bottom, leaving a narrow base and wider top. This was not useful for distributing a load and making a stable robot, and I found many of my robots were too tall/vertical, causing them to easily tip over. Further, the complexity of the shape I envisioned made for a difficult and expensive mold.

I next shifted to a technique called "slicing," which is available in 3D software. I sliced a 3D model to generate files for laser cutting 2D slices. I first tried generating the files based on the thickness of Amazon boxes, hoping to use recycled cardboard; however, I quickly found that factors such as tape and, more importantly, a lack of flatness, made recycled boxes more difficult to laser-cut than new materials. It is not impossible, but extra time is required to find a good waste stream (lots of large boxes in good condition), and then to prepare the waste stream for cutting (flattening under evenly distributed weights might help). In the interest of time, I switched to sheets of two-ply cardboard which I purchased from a craft store.

The robot chassis, the section that the wheels attach to and the circuit board sits on, presented a different challenge because my original design had proposed a vacuum-formed piece that would be integrated into the base of the robot body. Using the slice-form technique for constructing this was not a good equivalent, because the resulting waffle structure did not yield a flat surface for attaching the wheels. Instead, I referenced other chassis I had purchased in the past and seen online, to make a custom design that would allow space for the electronics to sit beneath the robot body. I also made this out of cardboard, over a course of several iterations. Once I had a version of the robot that appeared stable, I began making multiples, initially creating six.

I tested the six robots in my apartment, using fake plants, in a format that echoed the previous swarm test. However, the video of this test was less interesting. All of the bots were more still than in the last test, perhaps because I had pulled up my rug and the varnished, wooden floors were allowing more light to bounce around the room. Improved obstacle avoidance also meant that when the robots were moving, they were better at avoiding each other. This was good in theory, but for the purposes of the video, it really only left two possibilities for the robot behavior. They either had enough light, and were still, or they did not have enough light and were slowly (seemingly "carefully"), moving. There was only one "correct" location for the light, which was near the window, so the behavior was very predictable. The uninteresting video which resulted was partially indicative of the simplicity of the lighting condition I had provided. When comparing the original *Sunbot* video, taken outdoors in Maine, to the indoor *Sunbot Swarm*, the outdoor video is more interesting because the variable lighting conditions enabled a wider variety of robot behavior, as well as more fantastic implied narrative—that a plant robot was on the run in the wild. For the third iteration, I decided it was important to take the robots back outside.

Third Iteration

Taking the robots outside would require a more reliable and stable chassis, because sidewalks and roads, though flat in a general sense, have much more surface variation than the floor in my apartment, and I did not want the wheels to pop off every time the robot encountered a crack in the sidewalk. I also wanted the robots to carry real potted plants, which are much heavier than fake ones. I switched to laser-cut acrylic to create a more rigid chassis, which I assembled using an acrylic-bonding agent. I also began to consider how to conduct the test in a way that could more directly allude to the necessity of plant migration. Through feedback at various phases, I had found that audiences were often struck by the usefulness of the design, and whether it would make a good product, and less likely to critically consider the implications of plant-based robots. To help make the *Sunbots* more fantastical, I wanted to reference a cyborg or a spacesuit more directly in the design, so I made a digital collage in which the robots were enclosed in plastic domes within a bucolic landscape (Plate 35).

I purchased clear plastic hemispheres with the intention of making a dome cap, similar to the rendering in Plate 35; however, I ultimately found that using two hemispheres together to create a sphere allowed more space for the plant to sit comfortably. A challenge was that the sphere shape was more difficult to secure to the robot body. Through testing I have found that having all the elements of the robot tightly secured to each other greatly improves its performance. If elements are shifting their weight around while the robot is moving, it is much more likely to fall over, or lose a wheel. To anchor the dome, I used threaded rods to pass through the chassis, secured with a nut at the base. The rods pass through the waffle structure of the cardboard body and finally through the plastic domes, which I drilled holes in and secured with more nuts at the top. This was a fairly stable system, though over the course of sustained testing the vibration of the robot movements caused some of the nuts on the rods to loosen, allowing the chassis to shift out from under the plant dome and destabilizing the whole robot. This problem was somewhat improved by using silicone thread-stopper and likely would have been further improved by using higher quality lock nuts.

I documented the *Sunbot Swarm* in Prospect Park (Figure 13.4), with the help of the director of Open Source Gallery and two teen volunteers from a local high school, on a fairly warm and sunny Saturday morning in March, 2019. The park was crowded and the bots attracted a lot of attention. Some highlights include a man who approached to tell me about his love of plants, and how he had gotten a "people plant," that he believed led to his in-laws moving in with him, by attracting people to his home. He was considering getting rid of it. An older man saw the plants slowly moving from afar and asked me if they had turtles under them. I liked that analysis, and the way it related to the tortoise robots which helped inspire this iteration. A child nearby shouted "robots!" and the man reflected on how quickly the child, the product of a different technological context, had made the correct guess. In the majority of interactions there was an immediate reaction in bystanders to demand to know how the plants were moving, with many people guessing they were motivated by light or temperature. Within human audiences, there was a persistent desire to understand and assess the intelligence of the robotic plant system.

Final Iteration: Room on Mars

A consistent rule in my past experiments with wearables for humans has been that the garments respond to stimuli in the environment and from the wearer's body, and cannot be controlled by the wearers directly. In the context of humans, I considered this an absurdist subversion of the logic of control present in commercial technology design, and an attempt at extending the power of embodied knowledge. However,

Figure 13.4 *Sunbot Swarm v.3*, 2019. Courtesy the author. All rights reserved.

when designing wearables for nonhumans, questions of control shift. There is an irony in implying agency within plants through a robotic system that has been dictated by a human designer. For the final iteration of the *Sunbots* I sought to trouble this question of control further, particularly in regard to the power dynamic between myself and the *Sunbots*, to acknowledge that beyond the complex interplay of machine | body (plant) | body (human), the assemblage also exists within a broader environment that must be accounted for if the plant robots were to be self-sustaining.

I was also completing a summer residency at Wayfarers Gallery in Brooklyn, and I was confronted with the challenge of how to best present the *Sunbots* in a gallery setting, because the earlier tests left me disinclined to show the robots in an indoor space. Wayfarers was on the street level with a large window to the sidewalk. After conversations with other artists in the space, I decided to build a holding pen out of plywood on the sidewalk, disguised as a construction site, which in New York City are always painted a similar shade of green. The pen would allow those inside the gallery to view the *Sunbots* through the window and would also allow people on the street to view the *Sunbots* through a porthole (Plate 36).

Inside the wooden pen, I wallpapered the plywood with printouts of a digital collage combining images from NASA's Mars Rover with visions of Mars from the public imaginary—science fiction films and landscapes from the American Southwest. I mounted an old CCTV camera inside the pen to transmit video of the *Sunbots* exploring the Mars simulation into the gallery. I was interested in the way in which images of the robots and of Mars, both real and imagined, would become more or less realistic through the degradation of the CCTV image. In some ways, this was an extension of the manipulated account of the *Sunbots* I began through my initial video documentation processes, wherein cutting together moments of the robot at its most functional implied a higher intelligence than it comprised. Inside the gallery, I also projected a video which combined shots from the live feed with prerecorded video and excerpts of transcribed conversations, building a narrative between the plant family and myself in which we argue and complain, "I was also under the impression there would be more space."

A question I posed at the top of this chapter was in regard to whether it is possible to decenter the human from the design of a technology for plants. By describing the plants as a family, I lean decidedly away from this objective, finding myself in the company again of William Grey Walter, who both gendered his tortoise robots and made parallels between them and children (Holland 2003). I am reticent to repeat these tropes because Walter's ideas of gender and family were heteronormative and narrow, with his female robot demonstrating "neurotic" behavior (Hayward 2001). As my plant robots reference children they play obviously into plaintive media analysis of the millennial generation: left without resources to care for others but caring still (Gander 2017). But the plant robots are a family not in a patriarchal sense of robots brought to life by a human hand, but in the sense of robots acting as stewards of life, absurd though that might be, to consider where we are now: in an entangled relationship between the ecological, machinic, and human, with each element dependent on the other.

Figure 13.5 *Room on Mars*, CCTV feed, 2019. Courtesy the author. All rights reserved.

This final version of the *Sunbots*, featuring its most technically advanced and expensive build, probably functioned the worst of all the tests. Created with help from undergraduate students at NYU's Tandon School of Engineering (who bear no responsibility for the robots' shortcomings, that lies firmly with me), the robots have clear acrylic bodies and more robust domes that were meant to function as terrariums. We extensively researched suitable plants to create a self-contained habitat within the domes, along with upgrades to the plants' communication system and structural design to include mounts for solar panels, to eliminate the need for charging batteries (Plate 37). While I loved the visual of the planted terrariums, the weight of the extra soil and the heavier domes was too much for the small motors, which frequently stopped functioning under the strain. The clear acrylic exoskeleton was brittle and easily broken. Finally, the enclosed plants outside in the sun for hours at a time in the baking summer heat of Bushwick, New York (a remarkably good representation of Mars), were essentially cooked and eventually died. They could have been programmed to seek shade, but in that particular site they would have found none.

The failure sheds light on the complexity of the plant, which makes a self-sustaining robotic system so difficult. In addition to sunlight they need water, soil drainage, access to nutrients, and interactions with other plants and insects. In urban areas, we see plants interacting with the built environment all the time, growing through cracks in the pavement and around buildings. Recently, I stood on a sublevel subway platform and looked upward at a concrete overpass covered in vines. It was lightly raining, which made the greenery pop triumphantly against the gray surroundings. Why should plants not interact with robots, when they succeed in so many other unlikely

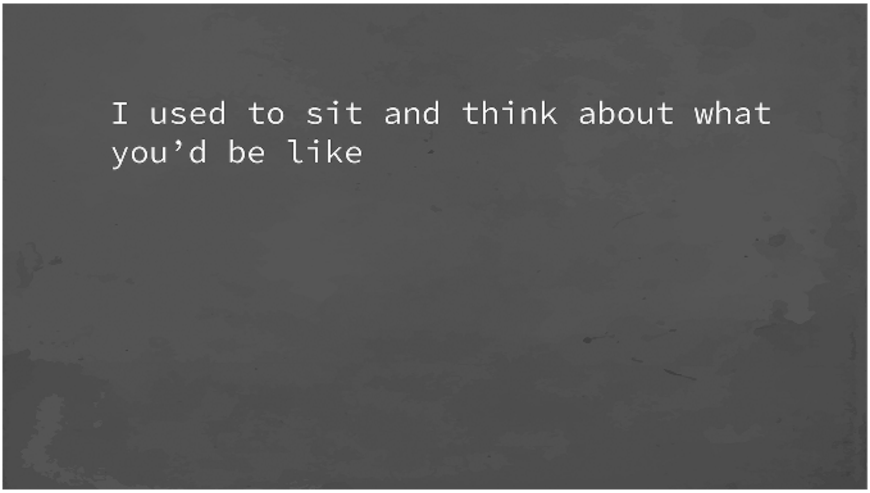


Figure 13.6 *Room on Mars* text: I used to sit and think about what you'd be like, 2019. Courtesy the author. All rights reserved.

environmental interactions? A difference between my plant robots and the subway vines is that the vines set the terms of that relationship/interaction. The simple robot I designed was too narrow to help my plants succeed, revealing the complexity of their survival.

As we consider this complexity, and the difficulty of making a mobile, self-contained ecosystem as an individual working under limitations, an obvious (too obvious?) parallel is drawn to humans, to the precarity of our situation on earth, and to past biosphere experiments (Severinghaus et al. 1994). While the billionaires may be rehearsing their departure from the planet, we know humans are not the only player in this story. Manfred E. Clynes and Nathan S. Kline introduced the word cyborg in 1960, to refer to a body that, "deliberately incorporates exogenous components extending the self-regulatory control function of the organism in order to adapt it to new environments" (1960: 27). The practical need they were identifying, for assistive technology to allow astronauts to survive outside the earth's atmosphere, was later filled by the spacesuit. However, survival extends beyond a binary—alive or not, sheltered or not, fed or not—survival intersects with broader systems. I can "will" an image of my free-roaming plant family into being but I cannot force their survival. In my imagined simulation, I apologize.

References

Basar, S. (2016), "The Professional Amateur," in Markus Miessen and Shumon Basar (eds.), *Did Someone Say Participate? An Atlas of Spatial Practice*, 129–41, Cambridge, MA: MIT Press.

Behar, K. (2015), "High Hopes (Deux) Statement," *katherinebehar.com*, May 1. Available online: http://www.katherinebehar.com/art/high-hopes-deux/index.html (accessed August 10, 2019).

Benjamin, E. (2016), *Dada and Existentialism: The Authenticity of Ambiguity*, London: Palgrave Macmillan.

Biro, M. (2009), *The Dada Cyborg: Visions of the New Human in Weimar Berlin*, Minneapolis: University of Minnesota Press.

Braitenberg, V. (2000), *Vehicles: Experiments in Synthetic Psychology*, Cambridge, MA: MIT Press.

Brians, E. (2011), "The 'Virtual' Body and the Strange Persistence of the Flesh: Deleuze, Cyberspace, and the Posthuman," in L. Guillaume and J. Hughes (eds.), *Deleuze and the Body*, 117–43, Edinburgh: Edinburgh University Press.

Butler, J. (1990), *Gender Trouble: Feminism and the Subversion of Identity*, New York: Routledge.

Clynes, M. E. and N. S. Kline (1960), "Cyborgs and Space," in *Astronautics* (September): 27.

Davies, J. (2016), *The Birth of the Anthropocene*, Oakland: University of California Press.

Demaray, E. (2014a), "IndaPlant Community Goes Live," elizabethdemaray.org, July 21. Available online: https://elizabethdemaray.org/2014/07/21/indaplant-community-live-on-webcam/ (accessed September 1, 2020).

Demaray, E. (2014b), "FloraBorg Community Update: 3 IndaPlants Up and Running," elizabethdemaray.org, July 31. Available online: https://elizabethdemaray.org/2014/07/31/floraborg-community-update-3-indaplants-up-and-running/ (accessed May 1, 2019).

Eikelboom, W. (2018), "Ethereal Scent," in R. Braidotti and M. Hlavajova (eds.), *Posthuman Glossary*, 139, London: Bloomsbury.

Gagliano, M., C. I. Abramson, and M. Depczynski (2018), "Plants Learn and Remember: Let's Get Used to It," *Oecologia*, 186(1): 29–31.

Gander, K. (2017), "Millennials are Obsessed with Houseplants because They Can't Afford Kids," Independent.co.uk, November 17. Available online: https://www.independent.co.uk/life-style/millennials-houseplants-children-kids-money-families-succulent-cactus-bonsai-how-to-dying-a7937021.html (accessed July 1, 2021).

Gardner, M. J., K. E. Hubbard, C. T. Hotta, A. N. Dodd, and A. A. R. Webb (2006), "How Plants Tell the Time," *Biochemical Journal*, 397(1): 15–24.

Hayles, N. K. (1999), *How We Became Posthuman*, Chicago: The University of Chicago Press.

Hayward, R. (2001), "The Tortoise and the Love-Machine: Grey Walter and the Politics of Electroencephalography," *Science in Context*, 14(4): 615–41.

Higgie, J. (2007), "Introduction," in J. Higgie (ed.), *The Artist's Joke*, xiv–xxi, London and Cambridge, MA: Whitechapel Gallery and MIT Press.

Holland, O. (2003), "The First Biologically Inspired Robots," *Robotica*, 21: 351–63.

Hopkins, D. (2016), "New York Dada: From End to Beginning," in D. Hopkins (ed.), *A Companion to Dada and Surrealism*, 70–89, Hoboken, NJ: Wiley-Blackwell.

Hyde, L. (2010), *Trickster Makes This World: Mischief, Myth and Art*, New York: Farrar, Straus, and Giroux.

Kolbert, E. (2014), *The Sixth Extinction: An Unnatural History*, New York: Henry Holt and Company.

Koren, M. (2021), "Jeff Bezos has Reached his Final Form," in *The Atlantic*, June 9. Available online: https://www.theatlantic.com/science/archive/2021/06/jeff-bezos-blue-origin-musk-branson/619140/ (accessed July 1, 2021).

Kuipers, B., E. A. Feigenbaum, P. E. Hart, and N. J. Nilsson (2017), "Shakey: From Conception to History," *AI Magazine*, 38(1): 88–103.

Lanier, J. (2010), *You are Not a Gadget: A Manifesto*, New York: Alfred A. Knopf.

Liu, L. H. (2010), *The Freudian Robot: Digital Media and The Future of the Unconscious*, Chicago: The University of Chicago Press.

MacFarquhar, L. (2018), "The Mind Expanding Ideas of Andy Clark," *New Yorker*, March 26. Available online: https://www.newyorker.com/magazine/2018/04/02/the-mind-expanding-ideas-of-andy-clark (accessed October 6, 2020).

Masaoka, M. (2018), [Artwork] *O, Plant!* Available online: http://miyamasaoka.com/installations-performances/2018/o-plant-2/ (accessed October 6, 2020).

Pendleton, A. (2017), "Black Dada Manifesto," in A. Pendleton (ed.), *Black Dada Reader*, 9–17, London: Koenig Books.

Raffnsøe, S. (2019), *Philosophy of the Anthropocene: The Human Turn*, Basingstoke: Palgrave Macmillan.

Rasula, J. (2016), *Destruction Was My Beatrice: Dada and the Unmaking of the Twentieth Century*, New York: Basic Books.

Rich, B. and H. Brand (2017), [Artwork] *GARRy*. Available online: http://byronrich.com/G-A-R-R-y-Work-in-Progress-2015-2017 (accessed May 1, 2019).

Rozemond, M. (2002), *Descartes's Dualism*, Cambridge, MA: Harvard University Press.

Rubenstein, M., C. Ahler, N. Hoff, A. Cabrera, and R. Nagpal (2014), "Kilobot: A Low Cost Robot with Scalable Operations Designed for Collective Behaviors," *Robotics and Autonomous Systems*, 62(7): 966–75.

Russell, L. (2020), *Glitch Feminism: A Manifesto*, London and New York: Verso.

Saunders, D. (2018), "Wired-Up in White Organdie: Framing Women's Scientific Labour at the Burden Neurological Institute," *Science Museum Group Journal*, 10. doi: 10.15180/181003/001

Schüll, N. D. (2016), "Data for Life: Wearable Technology and the Design of Self-Care," *BioSocieties*, 11(3): 317–33.

Severinghaus, J. P., W. S. Broecker, W. F. Dempster, T. MacCallum, and M. Wahlen (1994), "Oxygen Loss in Biosphere 2," in *EOS, Transactions American Geophysical Union*, 75(3): 33–7.

Shimizu, H., K. Katayama, T. Koto, K. Torii, T. Araki, and M. Endo (2015), "Decentralized Circadian Clocks Process Thermal and Photoperiodic Cues in Specific Tissues," *Nature Plants*, 1: 1–7.

Trianni, V. (2008), *Evolutionary Swarm Robotics: Evolving Self-Organising Behaviours in Groups of Autonomous Robots*, Berlin: Springer-Verlag.

Wang, Z. Y., Q. Leng, L. Huan, L. L. Zhao, Z. L. Xu, R. F. Hou, and C. Wang (2009), "Monitoring Systems for Electrical Signals in Plants in the Greenhouse and its Applications," *Biosystems Engineering*, 103(1): 1–11.

Wiener, N. (1961). *Cybernetics, or control and communication in the animal and the machine* (2nd ed.). John Wiley & Sons, Inc.; Boston Review. https://doi-org.proxy.lib.umich.edu/10.1037/13140-000.

14

Yellow Furry Lullaby

Breakwater: Youngsook Choi and Taey Iohe

This chapter consists of the script of the storytelling performance *Yellow Furry Lullaby* and the images of the installation *Fermented Flower*[1] (Plates 41–3). Both works bring awareness of the lineage of trauma amongst East and Southeast Asian (ESEA) diaspora communities by posing a dandelion as a counting witness, healing agent, and holder of resilient power.

Yellow Furry Lullaby interweaves the traumatic incidents of the 2011 Morecambe Bay cockling disaster and the 2021 Atlanta spa shooting with the depiction of hunting and heroic sacrifice of a children's folk song, and the Korean mythology of a bear woman Ung-Nyeo. The performance text from the children's folk song had to be redacted here, and has been replaced with white space, for copyright reasons and to mark its erasure. *Yellow Furry Lullaby* offers a tender moment of collective healing by activating the installation *Fermented Flower*, which "threads" the relationship between the colonialism of botanical science, the history of indentured labor, and the ongoing extractive operation of the migrant workforce. In the installation, dandelion liquor, made from dandelions harvested from multiple sites, Korean working-class drink Soju, and honey, is half buried in the soil underneath the embroidered tapestry. Burying the flower liquor is based on one particular Korean shamanic ritual which uses flowers to lure harmful madness, locks it up in an alcoholic beverage and buries it together with the flowers underground. "Half" burying signifies the excavation of the trauma within ESEA diaspora communities that is still in process. After the storytelling, *Yellow Furry Lullaby* ends with the sharing of the dandelion liquor with the participating audience as a gesture towards digesting interspecies solidarity to heal trans-generational trauma and overcome the damage of racial violence in colonial operations.

Note

1 Both the installation *Fermented Flower* and the performance *Yellow Furry Lullaby* were featured in the group exhibition *Future Ages Will Wonder* at FACT Liverpool in 2021.

Figure 14.1 Breakwater performing *Yellow Furry Lullaby* at FACT Liverpool, 2021. Photo by Kayt Hughes.

Let us tell a story of how bears signaled the beginning of human history. According to Korean legend, about 5,000 years ago, a tiger and a bear wished to be human, so they prayed. Finally, a god of the mountain advised them: "if you eat only garlic and mugwort in a dark cave, without seeing any light for 21 days, you will become a woman." They started a journey of transformation together. The tiger gave up soon after. But the bear managed to endure, and walked out of the cave as a woman. Not only that. The son of god, who came to the earth to build his holy kingdom, was attracted to this bear woman. Between this heavenly spirit and the bear woman, the first king was born.

Well, that's the story we grew up with. Yes, we are the descendants of this hybrid. We have been holding the future since the very beginning. However, we also have our suspicion—why did the bear woman not become the first queen of the nation? She's the one who endured god's horrible test, not her hybrid son. Where is her glory? The story of the human king continues, but we don't know much about what happened to the bear woman. She seemed to exist only to be the bearer of a great man. Giving birth to a holy manchild, and her story ends there! This feels like unfinished business.

We Are Going to Find Her!!

As soon as I gave birth, holy spirits and humans took my child away from me, saying I am still a bear in a human body. They dismissed me as primitive, uneducated and inferior, and expelled me from their kingdom. I was deeply despondent. Yet I was excited about going back to the forest I had missed so much. You know, we bears are true nomads after all—we know where to find delicious fruits and mushrooms. But the forest was no longer there. Instead, an unbearable horror was waiting. All the trees were cut down. My fellow bears had been hunted down for their skins, gallbladder, and feet, or just for the thrill of hunting down a beast. My life depended on escape. I became an exile.

Figure 14.2 The dandelion liquor and post-bloom dandelion flowers, Breakwater, 2021. Courtesy of the authors. CC4r.

I arrived in the land of dreams and opportunities. Looking down on me, people in uniform said, "Tawny skin, thick dark hair, you must be a bear in a human body!" But they did not expel me. They saw how useful my resilience and patience could be for their empire-building. They gave me a loan and contract. The deal was written in black and white.

Sailing down the river and across the ocean, I traveled to all the continents. First, to the gold mines in South Africa. I was one of the 64,000 Chinese indentured laborers, called coolies. We could not leave the mines without permission, we could not interact with local people. The government considered us to be criminals if found outside the mining camps. It reminded me of the dark cave I endured. But worse. Instead of twenty-one days, we were locked in for eight years and another eight years for many. I heard the most dangerous destinations were the guano mines on the islands, off Peru, where toxins burned the eyes, throat, and lungs. Very few ever returned to home.

Then I went off to the sugar plantations in Cuba, Hawai'i, and Mauritius. In Cuba, about 6,000 Chinese workers arrived every year. We were sold for between $100 and $500 per head. We were chained without committing any crime. We were humiliated by being stoned on the street. We had no choice but to work day and night, day and night, and day and night. At the farm, at the railroad, we built cities and bridges. For many of us, this hard-working life and public despair simply continued all the way to the twenty-first century.

My back was about to break from long hours of harvesting cockles. In Morecambe Bay, cockles are called the shells of gold. I had to collect 25 kg to get paid £5. Still, this was better than getting paid 18 pence a day for working in extremely dangerous mining pits, in my hometown Fujian on southeast coast of China. I thought of the family I left there and worked through the dark, cold, and misty winter night in February. I was too tired to notice the incoming of the 8 meter tide. Local fishermen warned me the low tide is turning, so I must escape. But they were not my boss. The overwhelmingly fast high tide swallowed me up and washed me away. I tried to run, but the tides were faster. I still remember all the shells of gold I picked that night and how they all scattered through the water bubbles and foam. They looked shinier than ever.

A few days later, the Chinese embassy in the UK announced a warning message. The statement claimed that there had been an incident, involving a group of Chinese tourists. They went to the seaside to watch the sunrise and drowned by miscalculating the time of the rising tide. Allegedly, there is no longer poverty in China, so I became a tourist in the official news. No country for the poor. The poor belong nowhere in this world.

(fierce bell ringing)

[silence]

Bang! Bang! Bang! We were just a bunch of hard-working women who were doing our best to survive and support our loved ones. Then, came this man with a lot of anger. He pulled out a pistol. The rain of bullets … He claimed my Asian body induced him to a dirty desire. In his eyes, I was a slut, I was an evil who should be eliminated for keeping his Christian body white clean. Bang! Bang! Bang! The gunfire carried on. The police officer announced it was not a racially motivated attack. The poor boy had a really bad day, the poor boy is a sex addict. Bang! Bang! Bang! The gunfire gets louder and closer. Agony, screaming, so much blood and loss of love. It reminded me of the horror in my home forest where my family and friends were hunted down for their skin, gallbladder, and feet, or just for the thrill of hunting. The massage parlors in Atlanta looked exactly like that.

I became an exile and wandered the world to find out what it means to be a human. It was a journey of fear and despair. Yet, I endured all the tears and sweat. My back and shoulders are aching from excessive labor and full of scars from my master's whipping. My breath is toxified. My hands are rough and dirty. My bones are broken into pieces by fierce high tidal waves. My stomach is bleeding heavily from gunshots. And I am, I am really tired … It all started here in this cave with my dream to become a human. Was it worth it? I don't know. I just endured. And I am walking out of the cave again.

This time, I don't dream to be a human. Instead, I will follow the gentle smell of old spring. There, can you see? The bright yellow dandelions are swaying and waving at me.

우리아기 착한아기 소록소록 잠들라
하늘나라 아기별도 엄마품에 잠든다
둥둥아기 잠자거라 예쁜아기 자장

우리아기 금동아기 고요고요 잠든다
바둑이도 짖지마라 곱실아기 잠깰라
오색꿈을 담뿍안고 아침까지 자장

Glossary

Afro-now-ism

A term created by Stephanie Dinkins in 2019, meaning a willful practice that imagines the world as one needs it to be to support successful engagement—in the here and now. Afro-now-ism is taking the leap and the risks to imagine and define oneself beyond systemic oppression. It values ancestral knowledge. For Black people, in particular, it means conceiving yourself in the space of free and expansive thought and acting from a critically integrated space instead of from opposition, which often distracts us from more community-sustaining work. Afro-now-ist cultural narratives are acts of resistance and community-building that foster self-determined wholeness and care in the technological future.

—Stephanie Dinkins

Circluding

A term by German feminist writer Bini Adamczak,

> A new term, one that has been missing for a long time: "circlusion." It denotes the antonym of penetration. It refers to the same physical process, but from the opposite perspective. Penetration means pushing something—a shaft or a nipple—into something else—a ring or a tube. Circlusion means pushing something—a ring or a tube—onto something else—a nipple or a shaft. The ring and the tube are rendered active. That's all there is to it.

(Adamczak 2016)

Entanglements

Entanglements are distinct from a blended mass. "Entanglement does not mean that what are entangled cannot be differentiated, discussed or remedied, only that the different entangled strands cannot be adequately dealt with in isolation, as if they were unrelated to the others" (Hammarström 2012: 43). An intra-active understanding of entanglement also demands that individual strands are not understood as self-subsistent entities, but as continuously and co-constitutionally refigured in, and through, their mutual interdependence (Hammarström 2012). Barad uses entanglement to discuss all scales of relationality from the entanglements of ontology and epistemology to those of the observed and observer (Barad 2007).

Feminist Vegetal Writing

In their feminist approach to plant life, Prudence Gibson and Monica Gagliano conflate "vegetal writing" with "phytographia" (Vieira 2017: 215–33). They describe this as

> a form of feminist writing. It requires a development of the plant world as outside of heteronormative values and outside a generalist community … In this context, vegetal writing sits alongside the growth of plants, it acknowledges the wealth of knowledge and capabilities of plant life, it does not operate within an authoritative hierarchy, it appreciates active co-species qualities and it understands that all species thrive when they function as communities.
>
> (Gibson and Gagliano 2017: 132)

See also "Phytographia."

Humuspunk

Building on the trajectory of the suffix "-punk," where futuristic genres of fiction grapple with alternative technologies and their effects on societies, Regenerative Energy Communities offer "humuspunk" as an attempt to name a break away from present takes on the -punk genre, such as "solarpunk" and its often overly clean, ordered, Computer-Aided Designed and systematized ecomodernist futures. Humuspunk grounds any imagined futures in the living, breathing, drinking, eating, farting, composting matter we call soil (humus: Latin for earth, ground). It is a space for embracing grimy creativity and the fermenting revolt of punk makings as they can emerge in a plurality of forms and spaces, where the aesthetics and practices of *jugaad*, kludges, *gambiarra*, and Appropriate Technologies acknowledge their rootedness in the soil. "Jugaad" is a colloquial Hindi, Bengali, Marathi, Punjabi, Sindhi Urdu word, for a non-conventional, frugal innovation or hack, innovative fix or simple work-around. "Kludges" are improvisations often put together from an ill-assorted collection of parts. "Gambiarra" are Brazilian practices of idiosyncratic and smart improvisation to repair and/or problem-solve.

—*Regenerative Energy Communities*

Industrial Topology

A term which pays attention to the interconnectivity and interdependence between agents involved in volumetric computation. As a topology, it is invariant under any continuous deformation (Rocha and Snelting 2022a). As a figuration, it makes a statement about the sociopolitical that are produced by means of industrial exploitation and profit-making. The arrangement of continuous surface matters, as well as the foil with very little outside: often deformed, never abolished. The agility with which the industrial topology flows, summons a type of space-time that is both fast and ubiquitous while relegating the naturecultural implications of its industrial operations to a blurry background (Rocha and Snelting 2022b).

—*Jara Rocha and Femke Snelting*

Machine Garden

A hybrid living system that involves human and machine labor in the maintenance of plants. Water pumps, sensors, electronics, and other powered tools are employed as prosthetics or amplifiers for human/plant entanglements.

—Amy M. Youngs

Paranodal Space

Metaphors such as "tree-structure," "nesting," and "rhizomes" mimic vegetation to naturalize nodes as cornerstones of network topologies. The term "Paranodal Space" shifts attention to the space that networks leave out, the negative space of networks, the noise between nodes and edges (Mejias 2013). The term was also used by artist Zach Blas in his installation *Counter Internet*, for making comprehensible and imaginable that which is beyond the network form (Blas and Browne 2017). Paranodal space makes room for intersectional infrastructures formed by bastards, the adopted, the viral, the grafted, the non-aligned.

Phytographia

Patricia Vieira, scholar of comparative literature, postcolonial studies, and ecocriticism offers the term "phytographia" in her focus on human cultural productions. She defines phytographia as "the encounter between the plants' inscription in the world and the traces of that imprint left in literary works, mediated by the artistic perspective of the author" (Vieira 2015: 205). Jane Prophet extends Patricia Vieira's exciting definition of writing with plants, to coding with plants, reflecting on her work and lived experience to point to ways that phytographia is often a colonial practice. See also "Feminist Vegetal Writing."

Phyto-Sensor

A term that describes how plants perform as sensors of environments, signaling pollution, climate change, and the presence of harmful organisms. Similar to molluscs, lichens, canaries, and multiple other organisms, plants can be understood as sentinels that signal changes in environments. Yet the sensing and signaling that plants undertake is often different than the real-time operations of computational systems. Instead, they show environmental events over time and space, and as they are distributed throughout ecological communities. See also: https://citizensense.net/kits/phyto-sensor-toolkit.

—Jennifer Gabrys

Plant Noticing

A method of knowing plants designed to help us become aware of their importance in our shared world. Described by Amy Youngs, this regular practice encourages experiences with plants that are open with possibilities and do not necessarily privilege human language. The steps are as follows: 1) when you feel the urge to look at media on your phone, point it at a plant instead; 2) see the plant through your camera and notice what you notice; 3) every day, take a minute to notice a plant; 4) practice doing it without your phone camera; 5) look for new plant friends indoors or outdoors.

—Amy M. Youngs

Post-Exotic

A term coined by feminist ethnographer and geo-poet Livia Alga:

> In the common sense, nostalgia is the malady of return, an attraction that in itself is paradoxical: it is the urge to return to a place to which one cannot stay or cannot imagine parts of one's life to be. Nostalgia fuels 'tourist' or 'duty' returns, and is linked to the idea of having moved inexorably forward. Forward also means forgetting: nostalgia is half-remembering; when you need forgetting it allows you to do so. Memory is constant, we need it wherever we move. In this sense you could say that nostalgia is exotic, memory is post-exotic.

(Alga 2020)

Queer Angles

A possible geometry, for and with the vegetal, which moves beyond the cubic realities formed by its antonym, "Square Angles." "Queer Angles" deviate from Euclidian geometry, a paradigm with its own straight system of truth, stipulating that parallel lines will always be parallel. Within Euclidanism, non-straight relationships (corners, vertexes, or angles) can only be formed by two lines that meet at a common endpoint, or when a single line deviates from its trajectory. Angles, seen like this, are relational entities that produce their own qualities and quantities but that are still bound to the core paradigm of parallelism. For reasons of efficiency, hardware optimization, path dependency, and compatibility, Euclidean geometry has become the standard for any spatial analysis, including in algorithmic vegetation modelling, growth orientation measurement, and irrigation planning. But more-than-human modes of existence are affected by many which are constantly and partially renegotiated. These modes necessitate relational options beyond sameness and straightness require expanded possibilities for obliqueness. Queer Angles are a mathematical basis for the theory and practice of hyperbolic relations, multiple transversality, open-ended askewness, and overt crookedness.

—Jara Rocha and Femke Snelting

Regeneration

As with many other potentially transformative concepts hijacked within past and present regimes of racial capitalism, regeneration, as concept and practice(s), is itself in need of regeneration. "Urban regeneration" projects gentrify and scatter once vibrant centers of community and living. Regenerative agriculture practitioners too easily ignore rich global histories and practices of agroecology in a promissory desire to portray their approaches as emergent and new. A flattening form of settler colonial imagining that ably prepares the ground for further acts of dispossession. Is it worth fighting (back) to reclaim any transformative potentials held in a term such as "regeneration"? If so, then only by keeping such ongoing damages and dispossessions as a grounding within which to collectively define and cultivate a plurality of material practices of resistance, reclamation, recovery, generosity, flourishing, and joy. See also: https://regenerative-energy-communities.org/.

—Regenerative Energy Communities

Symbiosis and Obligate Symbionts

A close relationship formed between species that benefits one or both of them. Biologist Lynn Margulis expanded the importance of this concept through her research showing that evolution is guided by symbiosis—by relationships formed between organisms, even at the cellular level. She upended the notion that competition, or "survival of the fittest," was the driver of evolution. Organisms involved in a symbiotic relationship are described as "symbionts," and those whose lives depend on the relationship are "obligate symbionts." This applies to some species of fungi who rely upon living plants to feed them. The plants benefit from the relationship through the minerals and information provided by the fungi; however, since they have the ability to survive without these, plants in this relationship are called "facultative symbionts."

—Amy M. Youngs

Totalitarian Innovation

A provocative shortcut which calls to mind the rampant hegemonic continuities between sovereignty, domination, and absolutism and how they play together in the ongoing naturalized acceleration of technologies and techno-ecologies. Innovation assumes a particular one-directional relation to futurity, and relies heavily on solutionism, optimization, techno-fix, and limitless growth. Totalitarian innovation actively imposes "developmentalism" as the only option, and technically prohibits emerging experiments with organizing life in ways that are complex, renegotiable, or non-aligned (see more on the term "Informatics of Domination" coined by Donna Haraway (1991) and Zach Blas (2018)). Totalitarian innovation leads to the persistence of monocultural forms, and paves the way for the elitist formulas of eco-fascism. This term fires up a public conversation on the need to disinvest innovation and to instead organize with the latencies, discontinuities, recursions, and absences of techno-nature entanglements.

—Jara Rocha and Femke Snelting

Trans*Feminist

A denomination which convokes all necessary intersectional and intrasectional aspects around that star (*). In non-Anglo-Saxon cultures, it provides a more grounded notion than the English term "queer," which usually remains untranslated. Siding with trans-gender struggles and against trans-exclusionary forces, the star provokes a halt for the reader, to start a conversation about the distribution of privileges and oppressions in which a specific situation or case is implicated (Halberstam 2018). The star is a powerful element for thickening complexity in the diverse and mutating experiences of needily plural feminisms, walking side-by-side with anti-racism, anti-colonialism, anti-classism, anti-capitalism, anti-specism, anti-ableism, and anti-ageism.

Vegetalizing Technology

A process that Jennifer Gabrys describes within the context of smart forests, whereby plants and forest communities remake the configurations and operations of technology. Even more than plants and forests being monitored with computational devices, they also demonstrate different modalities of calculation, measurement, relation, and connection that exceed the usual operating conditions of digital computation. Vegetalized technology extends over space-time, signals collective conditions, and unfolds through reciprocity rather than dominance.

—Jennifer Gabrys

Volumetric Computation

Describes the calculative technologies, infrastructures, and techniques for tracking, capturing, modeling, and scanning volumes. In contemporary computation, volumemetrics are usually naturalized as "3D." The implications of the material culture of metrics are increasingly hard to escape, given its proliferating applications in climate prediction modeling, advanced biomedical imaging, monitoring crop irrigation, or throughout the gamify-all approach of overarching industries, from education to agro-engineering (Possible Bodies 2022).

—Jara Rocha and Femke Snelting

References

Adamczak, B. (2016), "On Circlusion," trans. S. Lewis. *Mask Magazine*. Available online: https://web.archive.org/web/20180811000134/http://www.maskmagazine.com/the-mommy-issue/sex/circlusion (accessed April 7, 2023).

Alga, L. (2020), "There Is Always Someone Coming from the South," *Postesotica*, October 6. Available online: http://postesotica.blogspot.com/ (accessed April 7, 2023).

Barad, K. (2007), *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, Durham, NC: Duke University Press.

Blas, Z. (2018), *Contra-Internet: Jubilee 2033*, Los Angeles: Semiotext(e).

Blas, Z. and S. Browne (2017), "Beyond the Internet and All Control Diagrams," *The New Inquiry*, January 24. Available online: https://thenewinquiry.com/beyond-the-internet-and-all-control-diagrams/ (accessed April 7, 2023).

Gibson, P. and M. Gagliano (2017), "The Feminist Plant: Changing Relations with the Water Lily," *Ethics and the Environment*, 22(2): 125–47.

Halberstam, J. (2018), *Trans*: A Quick and Quirky Account of Gender Variability*, Berkeley: University of California Press.

Hammarström, M. (2012), "(Mis)understanding Intra-active Entanglement—Comments on René Rosfort's Criticism of Karen Barad's Agential Realism," *Kvinder, Køn & Forskning*, 4. doi: 10.7143/kkf.v0i4.28152

Haraway, D. (1991), "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in *Simians, Cyborgs, and Women: The Reinvention of Nature*, 180, New York: Routledge.

Mejias, U. A. (2013), *Off the Network: Disrupting the Digital World*, Minneapolis and London: University of Minnesota Press.

Possible Bodies (ed.) (2022), "Volumetric Regimes: Material Cultures of Quantified Presence," *Data Browser*, Vol. 9, London: Open Humanities Press. Available online: http://www.data-browser.net/db09.html (accessed April 7, 2023).

Rocha, J. and F. Snelting (2022a), "Somatopologies," in "Volumetric Regimes: Material Cultures of Quantified Presence,"" *Data Browser*, Vol. 9, London: Open Humanities Press.

Rocha, J. and F. Snelting (2022b), "The Industrial Continuum of 3D," in "Volumetric Regimes: Material Cultures of Quantified Presence," *Data Browser*, Vol. 9, London: Open Humanities Press.

Vieira, P. (2015), "Phytographia: Literature as Plant Writing," *Environmental Philosophy*, 12(2): 205–20.

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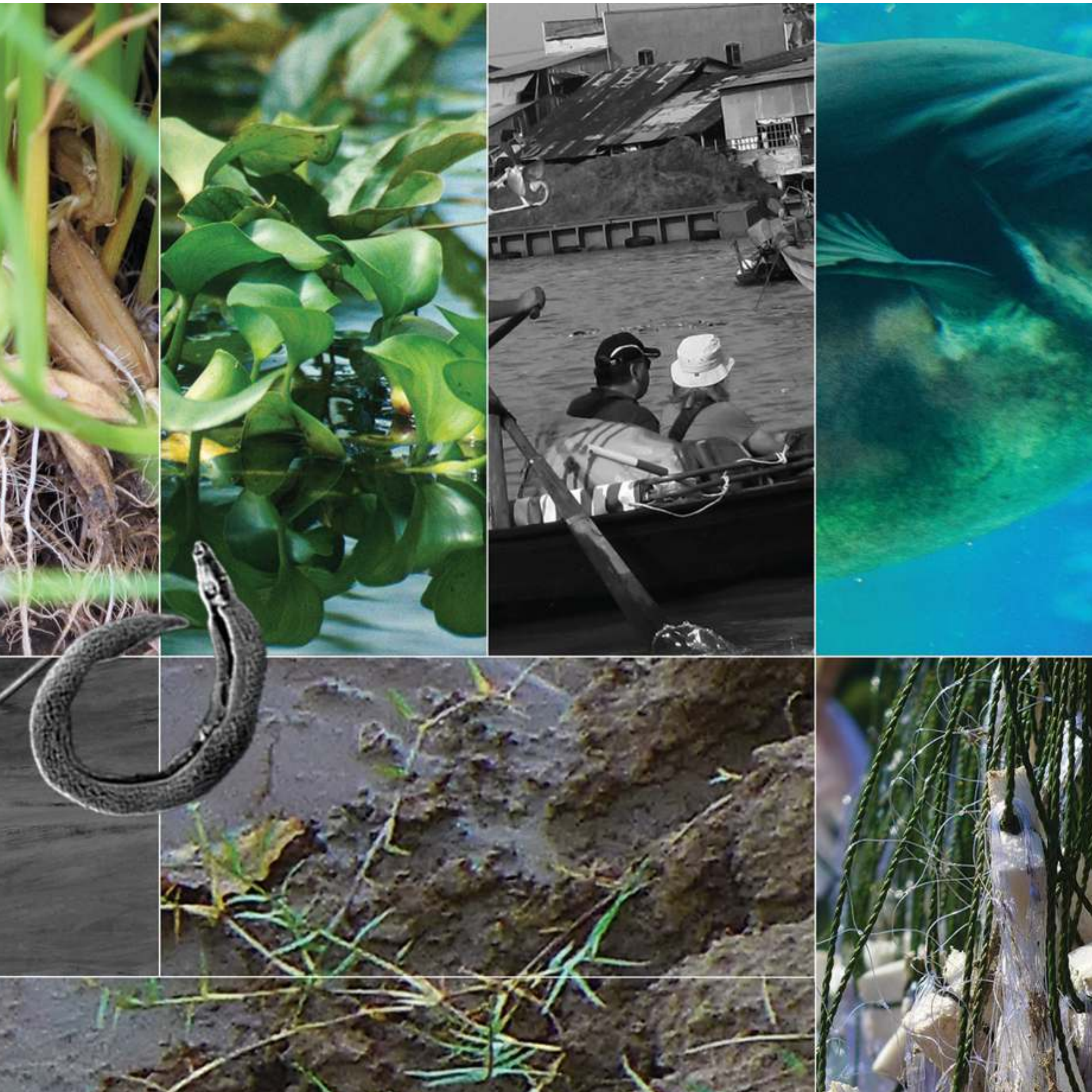
Plate 1 Installation view, Stephanie Dinkins, *Secret Garden*, 2020–1, Stamps Gallery, 2021. Courtesy of UM Photography, photo credit: Eric Bronson.

Plate 2 Installation view, Stephanie Dinkins, #*SayItAloud*, Queens Museum. Courtesy of Queens Museum, photograph by Hai Zhang. CC4r.

Plate 3 Installation view, Stephanie Dinkins, *Conversations with Bina48, Fragments 7,6,5,3*, 2014–ongoing, Stamps Gallery, 2021. Courtesy of UM Photography, photo credit: Eric Bronson.

Plate 4 *Oscillation: When Rain Falls Along The Mekong*, Elaine Gan, 2016–17. Courtesy of the author.



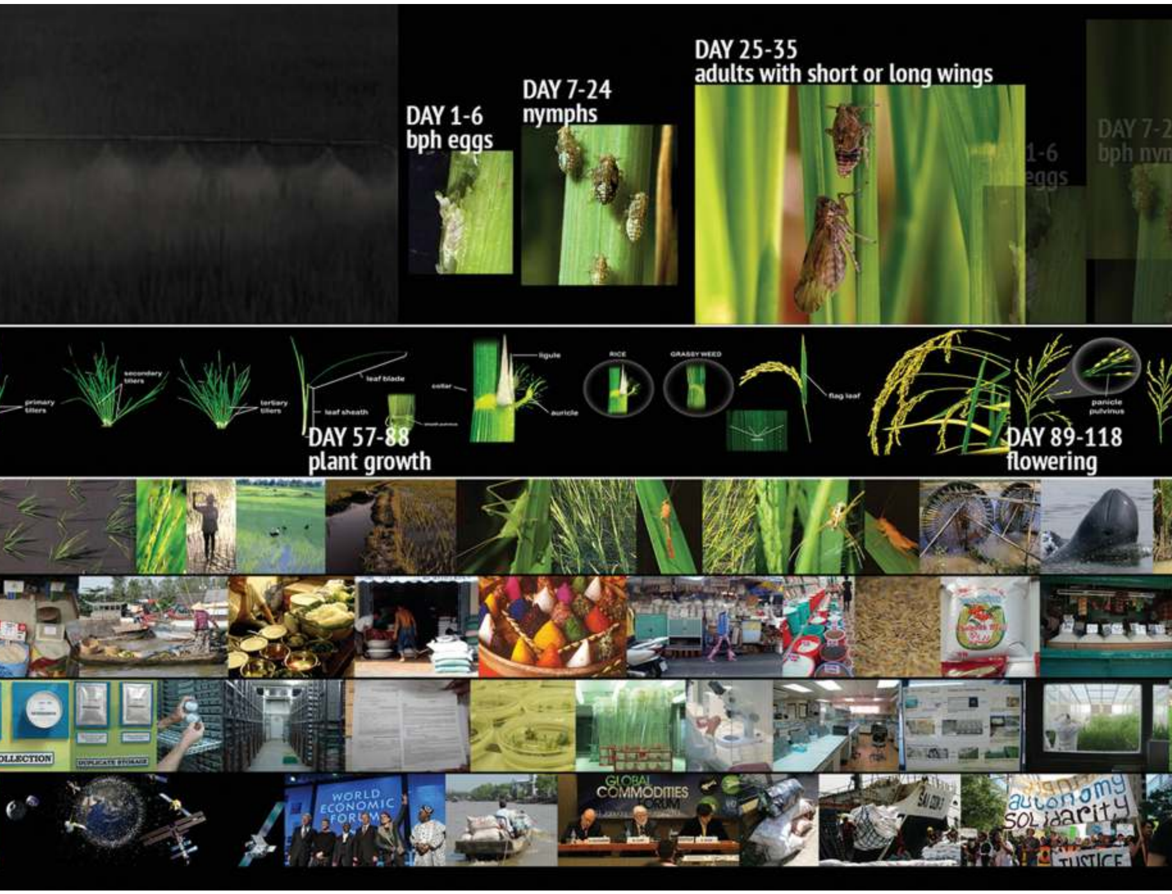


Plate 5 *Invasion of Sap-Sucking Planthoppers*, Elaine Gan, 2020. Courtesy of the author.


DAY 25-35
adults with short or long wings
DAY 7-24
bph nymphs
DAY 1-6
bph eggs
floret
pedicel
rudimentary glumes
sterile lemmas
rachilla
floret
palea
lemma
pistil
Stigma
Style
Ovule
stamens
endosperm
embryo
DAY 119
grain harvest

Plate 6 *Artists' Footprints,* an exhibition at Redline Gallery, Denver, CO. Installation in foreground, *River Construct* by Amy M. Youngs, 2010. Photo courtesy of the author. CC4r.

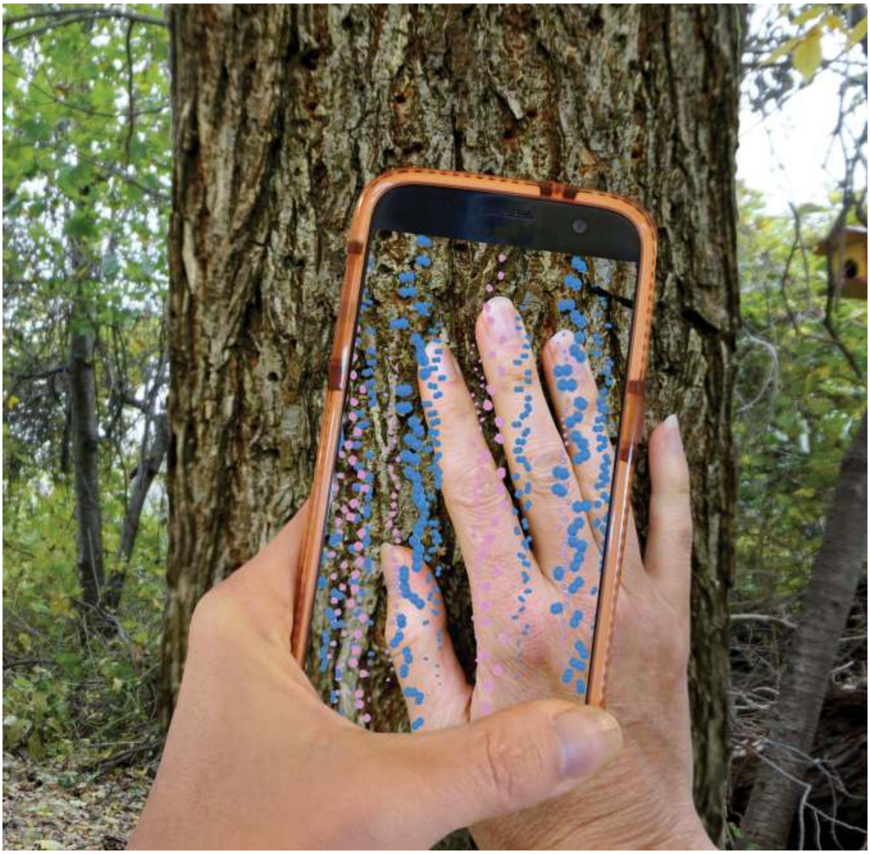


Plate 7 *Becoming Biodiversity*, 2019, by Amy M. Youngs, with Joshua Rodenberg, Danielle McPhatter, and Jayne Kennedy. Photo courtesy of the author. CC4r.

Plate 8 Still image from multimedia website, *Vegetal Entangling*, 2021, by Amy M. Youngs. Photo courtesy of the author. CC4r.

Plate 9 One of the many drawers with arranged diatom slides from J. D. Möller. Photograph by Jef Schoors 2014. All rights reserved.

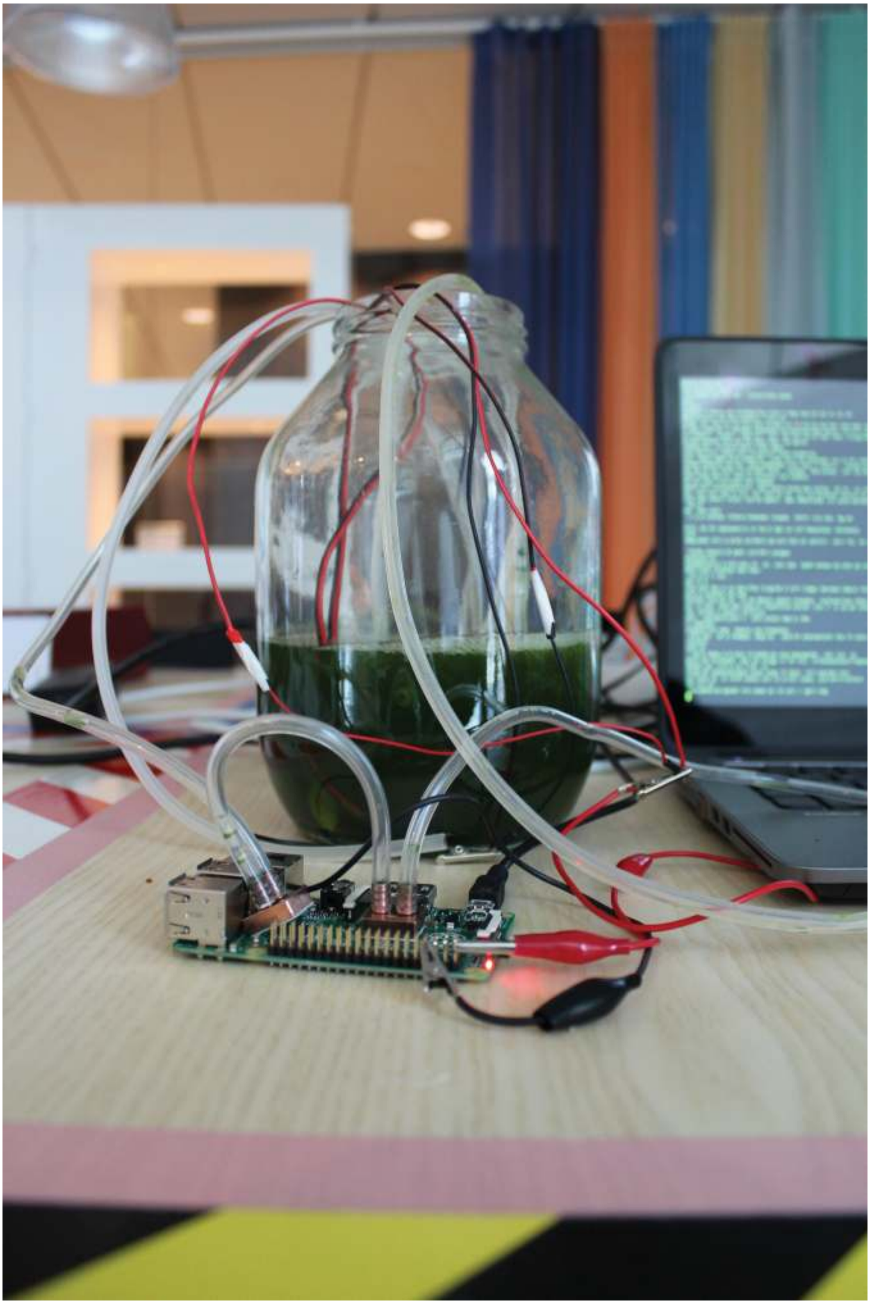


Plate 10 *Critter Compiler Prototype*, Helen V. Pritchard, 2016. Photo courtesy of the author. CC4r.

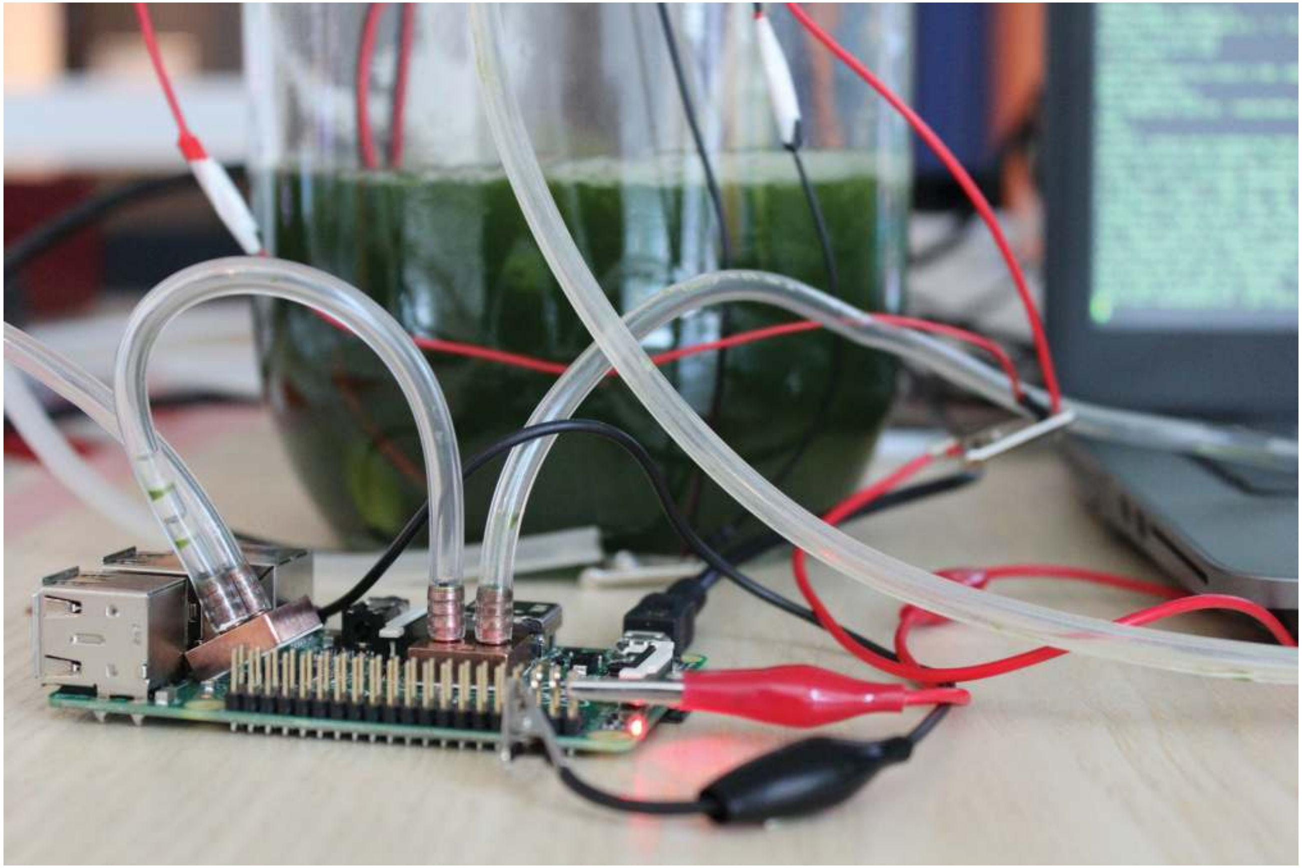


Plate 11 *Critter Compiler Prototype*, Helen V. Pritchard, 2016. Photo courtesy of the author. CC4r.

Plate 12 Forest sensor installation, James Reserve, California, Jennifer Gabrys, 2008. Image courtesy of the author. CC4r.

Plate 13 Phyto-sensor garden installation with *Dustbox* particulate matter sensor and air-quality plants, Jennifer Gabrys. Museum of London, 2018. Image courtesy of the author. CC4r.

Plate 14 Images from the artwork *Planthropy*, Stephanie Rothenberg, 2016, featured in the exhibition *Right Here, Right Now* at The Lowry Galleries, Manchester, UK. Image photo credit: David Lake. CC4r.

Plate 15 Images from the artwork *Planthropy*, Stephanie Rothenberg, 2016, featured in the exhibition *Right Here, Right Now* at The Lowry Galleries, Manchester, UK. Image photo credit: David Lake. CC4r.

Plate 16 Images from the artwork *Garden of Virtual Kinship*, Stephanie Rothenberg, 2015, featured in the exhibition *Globale: Infosphere*, ZKM Center for Art & Media, Karlsruhe, Germany. Image photo credit: Anatole Serexhe. CC4R.

Plate 17 Images from the artwork *Garden of Virtual Kinship*, Stephanie Rothenberg, 2015, featured in the exhibition *Globale: Infosphere*, ZKM Center for Art & Media, Karlsruhe, Germany. Image photo credit: Anatole Serexhe. CC4R.

Plate 18 Images from the artwork *Garden of Virtual Kinship*, Stephanie Rothenberg, 2015, featured in the exhibition *Globale: Infosphere*, ZKM Center for Art & Media, Karlsruhe, Germany. Image photo credit: Stephanie Rothenberg. CC4r.

Plate 19 Images from the artwork *Garden of Virtual Kinship*, Stephanie Rothenberg, 2015, featured in the exhibition *Globale: Infosphere*, ZKM Center for Art & Media, Karlsruhe, Germany. Image photo credit: Stephanie Rothenberg. CC4r.

Plate 20 Images from the artwork *Aquadisia* (formerly *Aphrodisiac in the Machine*), Stephanie Rothenberg, 2022, featured in the exhibition *Meta.Morf 2022 Ecophilia: Trondheim International Biennale*, Trondheim, Norway. Image photo credit: Zane Cerpina. CC4r.

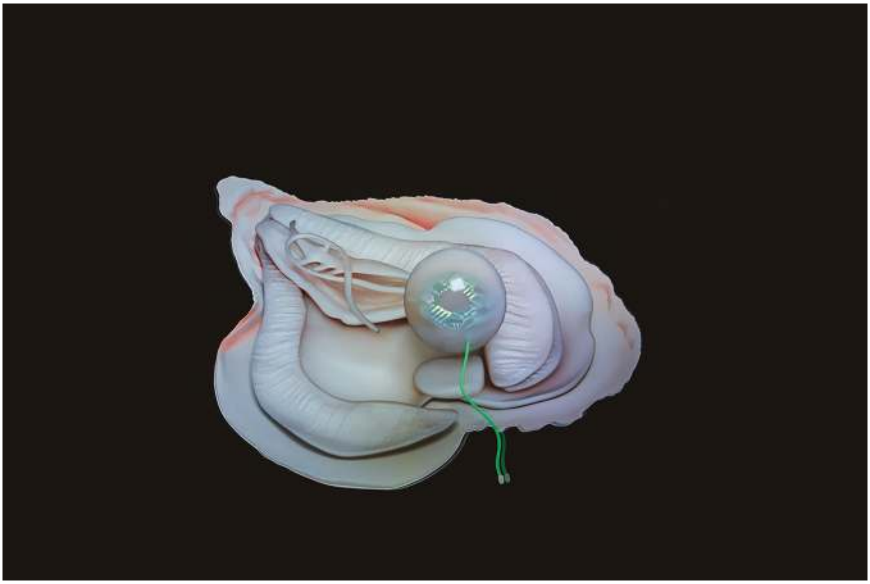


Plate 21 Images from the artwork *Aquadisia* (formerly *Aphrodisiac in the Machine*), Stephanie Rothenberg, 2022, featured in the exhibition *Meta.Morf 2022 Ecophilia: Trondheim International Biennale*, Trondheim, Norway. Image photo credit: Juliane Schütz. CC4R.

Plate 22 Smaranda tending to solar-powered bubbling of bioremediation tea, mobile meadow under construction. Camilla Uhlén, 2022. CC4r.

Plate 23 Jamming with the fertilizer synthesizers in the car park. Leah Ireland, 2022. CC4r.

Plate 24 Generating 500 millivolts from a mixture of soil and chicken poo, 2022. Roel Roscam Abbing. CC4r.

Plate 25 Left, the author as a baby in her mother's garden, c. 1964; right, the author as a child in her mother's greenhouse, c. 1969. Courtesy of the author. CC4r.

Plate 26 Close-up of two slides created by sandwiching plant and soil fragments between glass, 1984. Courtesy of the author. CC4r.

Plate 27 One of six digital photographs from *The Landscape Room*, 2001. Courtesy of the author. CC4r.

Plate 28 On the screen of the phone held in the author's right hand a simulated tree "grows" from the graphic marker held in the author's left hand. The live view of the location is borrowed as a setting for the simulated tree. *Pocket Penjing*, 2016. Courtesy of the author. CC4r.

Plate 29 Left, flag of Hong Kong, July 1, 1997; right, the Black bauhinia, a flag used at the 2019 Hong Kong protests (black and white). Left: Designed by Tao Ho. Credit: CC BY-SA 3.0. Right: Author jyy. Credit: CC BY-SA 3.0.

Plate 30 Street planting in Fo Tan (火炭), Hong Kong, 2015. Courtesy of the author. CC4r.

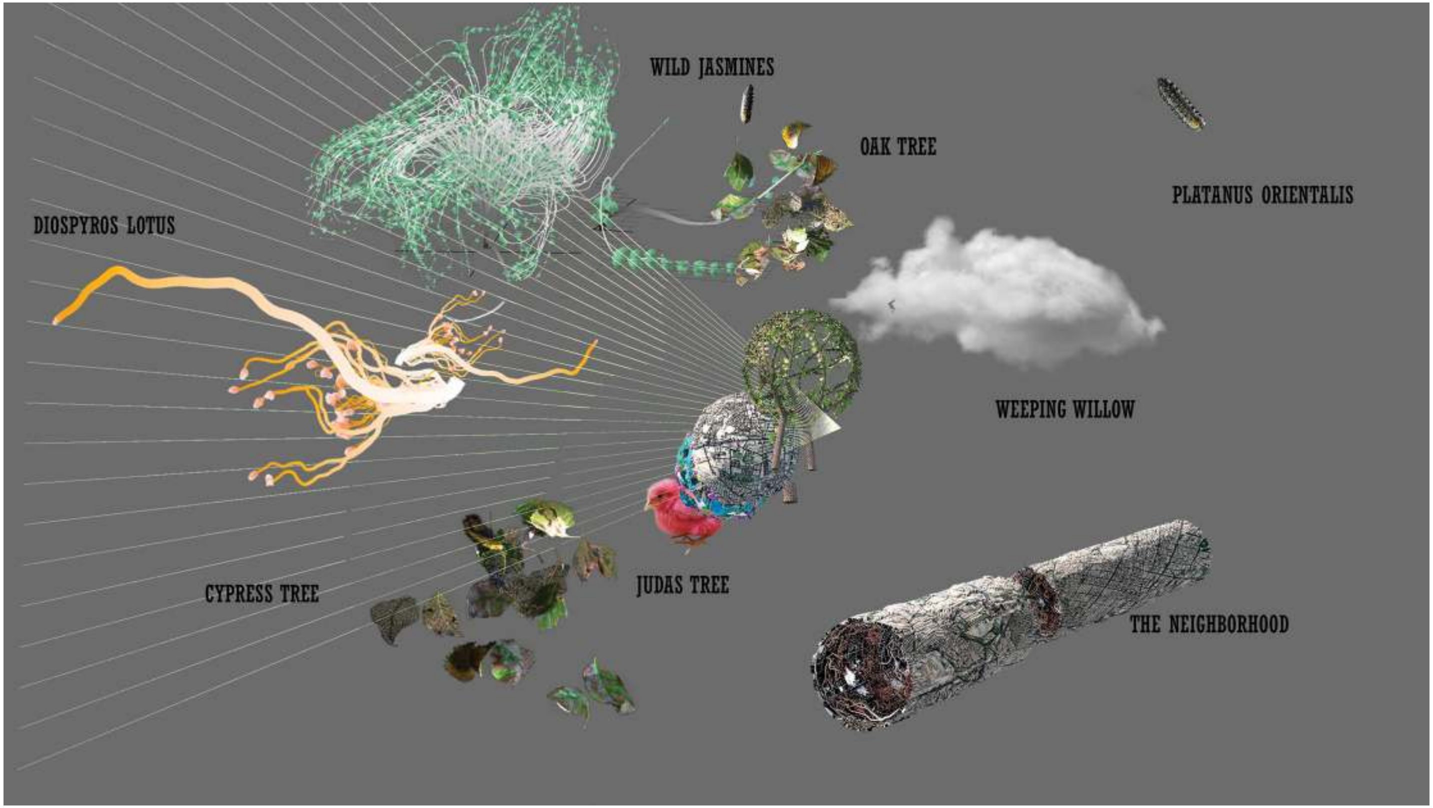


Plate 31 Sketch for the homepage of *Tehran of Trees* by Goda Palekaitė and Sina Seifee; HerMap phase 1, 2020. Courtesy of the artists. CC4r.

Plate 32 *Terra Et Venti,* Joel Ong. Artistic process in the field, working with air balloons, environmental sensors, and community science activities. Courtesy of the author. CC4r.

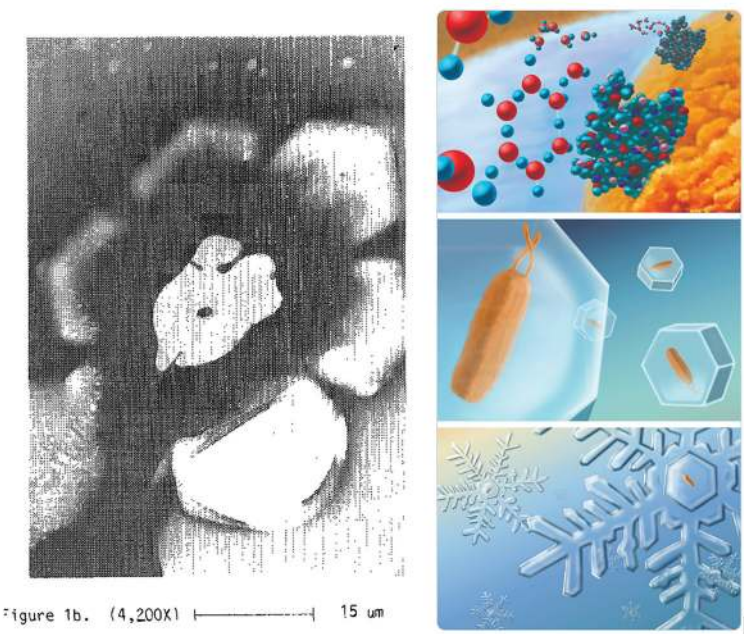


Plate 33 Joel Ong and Natalie Plociennik, triptych of stylized visualizations of ice nucleation activity of *P. syringae* in the atmosphere. Courtesy of the author. CC4r.

Plate 34 Joel Ong, a stylized view of the bacterial cell surface to visualize its activity at the molecular level. Courtesy of the author.

Plate 35 Kathleen McDermott, *Hills Alive with Sunbots*, 2018. Courtesy of the author.

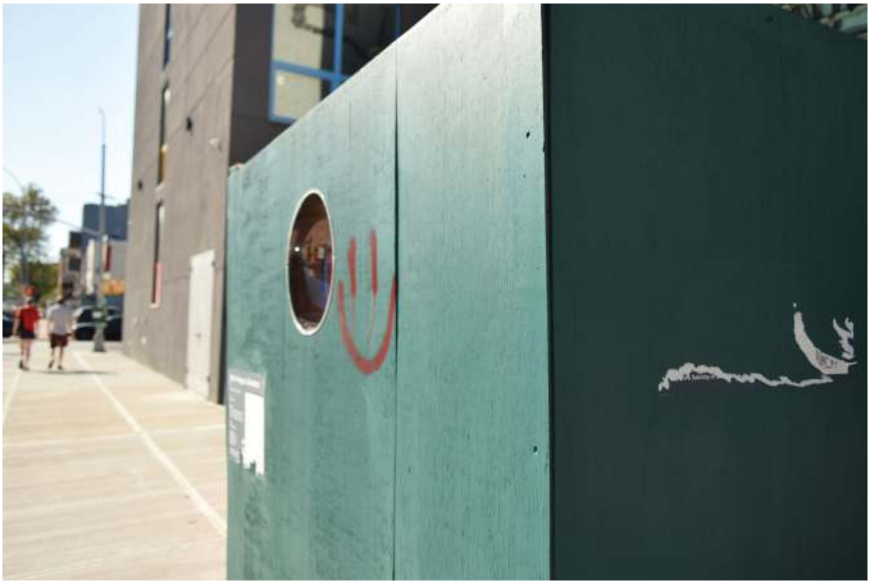


Plate 36 Kathleen McDermott, *Room on Mars* exterior installation view, 2019. Courtesy of the author.

Plate 37 Kathleen McDermott, *Room on Mars* installation view, 2019. Courtesy of the author.

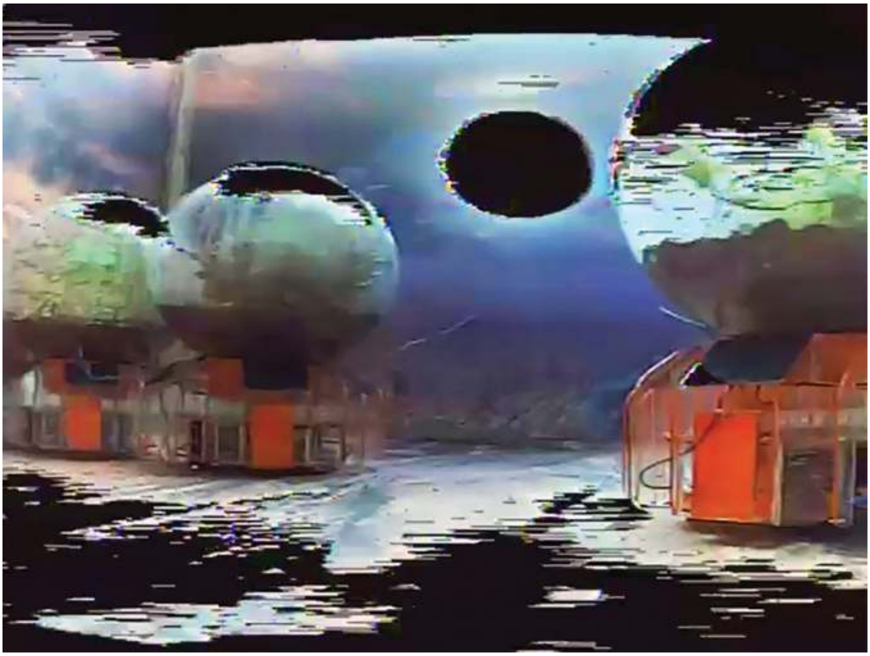


Plate 38 Kathleen McDermott, *Room on Mars* video still, 2019. Courtesy of the author.

Plate 39 Breakwater performing *Yellow Furry Lullaby* at FACT Liverpool, 2021. Photograph by Kayt Hughes.

Plate 40 The dandelion liquor and post-bloom dandelion flowers, Breakwater, 2021. Breakwater. CC4r.

Plate 41 *Fermented Flower,* full view of the installation at the exhibition *Future Ages Will Wonder* at FACT Liverpool, Breakwater, 2021. Breakwater. CC4r.

Plate 42 *Fermented Flower*, part view of the installation showing the indentured laborer and *holmskioldia* derogatorily named "coolie plant," Breakwater, 2021. Breakwater. CC4r.

Plate 43 *Fermented Flower*, part view of the installation showing the plantation master and his indentured laborers, with embroidered dandelions, Breakwater, 2021. Breakwater. CC4r.