ART AS WE DON'T KNOW IT

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Aalto University

Art as We Don't Know It
First edition

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Producer
Essi Viitanen
Aalto ARTS Books
Espoo, Finland
aaltoartsbooks.fi

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Graphic design
Safa Hovinen / Merkitys

Cover
Detail from artwork *Living Images, yeastograms* by Johanna Rotko

Materials
Content: Galerie Art Volume 135g
Cover: MultiArtSilk 130g

This book has been produced in collaboration with the Bioart Society and Aalto University School of Arts, Design and Architecture.

The publication of this book has been made possible with the support of Kone Foundation.

KONE FOUNDATION

ISBN 978-952-60-8822-8
ISBN 978-952-60-8823-5 (pdf)

Printed by Printon, Tallin, Estonia
2020

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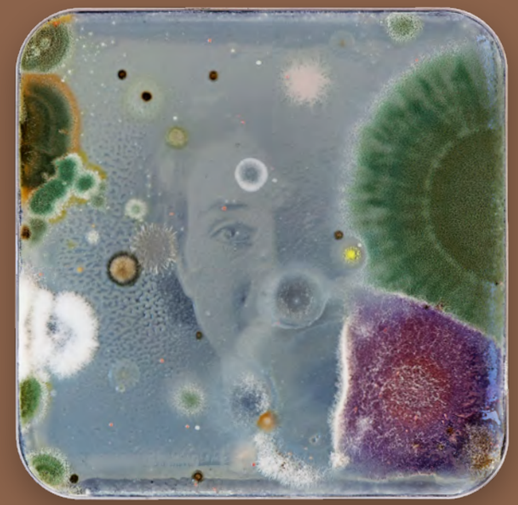

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Foreword

How can we describe what art is today? Such a consideration must include the role of the artist and the positions occupied by artists in the face of urgent planetary challenges. We must ask ourselves how artists engage with the material culture of today, whether it is biological, ecological, or any of the other media and matters within the remit of the natural sciences. In many ways we must acknowledge that now more than ever, artists are *experimenters*, those who through detailed observation enact events that perform and devise the topographies for new knowledges and enquiries.

This book, *Art as We Don't Know It*, published on the occasion of the 10th anniversary of the Bioart Society in collaboration with Aalto University School of Arts, Design and Architecture, demands that artistic practices of current times are challenged in favour of new locations for the arts. Scholars, researchers and artists participating in this publication have in common a multifaceted exploration on the contemporary material culture. This new role requires a transition between laboratory and artist's studio, and a crossing between remote locations and urban spaces. No tangible boundaries are imposed, interactions and interventions are reconfigured in these practices, and representational boundaries around the subjects of field-based research are reinterpreted. We may wonder whether definitions of nature are accurate or if they intend to address notions of mutability and imprecise interpretations.

The authors of the following texts propose to address these questions and present ideas about the relationships between art and the natural sciences. These propositions are seen through the lens of their relationships with the Bioart Society and its many projects; Solu, Field Notes, Ars Bioarctica, as well as their collaborative programs with Biofilia – Base for Biological Arts at Aalto University. Through these structures the artists become *collectors and natural relators*: signals of natural phenomena are picked up from the field and inspected, also biological specimens, rocks, minerals, debris from old plane crashes, lights in the skies, mythologies, sounds, narrations, words and tales. As Allan Kaprow once said 'you reveal something and its oddness by removing it from its normal usage'. The contributors in this book craft ideas that talk about the shadows in our understanding of the natural world that surrounds us.

Why then bioart as an artistic movement managed to bring many of these questions together? During the course of the 21st century so far bioart has grown to intervene with and hack interactions with other species and living matter outside of traditional biolab scenarios and areas of expertise. Bio-artistic practice ranges from critical interventions into contemporary biotech practices to proposals for techno-utopian solutions. Working between fields and disciplines allows for such interventions and in these pages we can see how many of these new methodologies are being applied in all their diversity.

By bringing together both Finnish and international artists for residencies and fieldwork in Arctic landscapes, in biological laboratories and in their own gallery space, the Bioart Society has spent a decade inventing new topographies for enquiry and engendering a wide range of new projects and associations. Taking the position of experimenters, artists and scientists alike, relate to observation through complex instruments that translate bio-matter into information. Calibrating these devices, operating them with precision, sensing matter, and naming it, are some of their prerogatives. In biology, as well as in physics or chemistry, what is important are the interactions between matter: information is combined and exchanged through a composite of forces and mass plus some degree of randomness. The complex chains of interactions thus initiated remove both subject and object from normal usage, revealing their oddness and allowing a refocusing of meaning and intent.

What such 'art as we don't know it' can do for us is to allow strange predictions of a world we don't see. As forerunners of radical ideas, artists could be taking their visions into something that is the most extreme.

I congratulate the Bioart Society on working towards bringing a sense of planet Earth's emergencies and complexities through the language of art, while performing and acting in what Donna Haraway termed 'situated knowledge'. I also congratulate Biofilia for their pioneering effort of launching a biological laboratory in the context of an art school and opening their services to the artistic community. The artistic proposals presented in this book, and the work of the Bioart Society and Biofilia as a whole, form a body of critical reflection that enriches our notions of how life, nature, environment and science are intertwined. This book is both a fitting tribute to and celebration of that work.

Mónica Bello
Barcelona
November 2019

Mónica Bello is a curator and art historian. Since 2015 she is the Curator & Head of Arts at CERN, the official arts programme of the European Laboratory of Particle Physics (CERN) in Geneva. In her curatorial research and projects she discusses the way artists instigate new conversations around emergent phenomena in our society and culture, such as the role of science and new knowledge in the perception of reality. She was Guest Curator of the prestigious Audemars Piguet Art Commission for Art Basel 2018. Prior to her arrival to Geneva she held the position of Artistic Director of VIDA Art and Artificial Life awards at Fundación Telefónica, Madrid, a pioneering award that fostered cross cultural expressions around the notion of life. She initiated and ran the Department of Education at Laboral Centro de Arte, Gijón. She was co-founder – with Ulla Taipale – of the Capsula curatorial platform. In 2004 her award-winning exhibition *Organisms* became one of the first exhibitions of bioart in Spain. As an internationally recognised figure within art and science networks, Bello is a regular speaker at conferences and participates in selection committees, advisory boards and mentorship programs.

Introduction

Field_Notes – The Heavens
HAB-Group. Photo by Till Bovermann, tai-studio.org, 2018.

2018 marked the 10th anniversary of the Bioart Society and created the impetus for the publication of *Art as We Don't Know It*. For this publication, the Bioart Society joined forces with the School of Arts, Design and Architecture of the Aalto University. The close history and ongoing collaborative relationship between the Bioart Society and Biofilia – Base for Biological Arts in the Aalto University lead to this mutual effort to celebrate together a diverse and nurturing environment to foster artistic practices on the intersection of art, science and society.

Rather than stage a retrospective, we decided to invite writings that look forward and invite speculations about the potential directions of bioarts.The contributions range from peer-reviewed articles to personal accounts and interviews, interspersed with artistic contributions and Bioart Society projects. The selection offers a purview of the rich variety, both in content and form, of the work currently being made within the field of bioart. The works and articles clearly trouble the porous and provisional definitions of what might be understood as bioart, and indeed definitions of bioart have been usefully and generativity critiqued since the inception of the term.

Whilst far from being definitive, we consider the contributions of the book to be tantalising and valuable indicators of trends, visions and impulses. We also invite into the reading of this publication a consideration of potential obsolescences knowing that some of today's writing will become archaic over time as technologies driven by contemporary excitement and hype are discarded. In so doing we also acknowledge and ponder upon our situatedness and the partialness of our purview in how we begin and find points of departure from which to anticipate the unanticipated.

Whilst declining the view of retrospection this book does present art and research that has grown and flourished within the wider network of both the Bioart Society and Biofilia during the previous decade. The book is structured into four thematic sections *Life As We Don't Know It*, *Convergences*, *Learnings/Unlearnings*, *Redraw and Refigure* and rounded off with a glossary.

Section I: Life as We Don't Know It

The phrase Life as We don't Know It gathered prominence during the last two decades, spurred by the rapid development of synthetic biology (synbio), an attempt to redesign natural systems and to make biology easier to engineer (Schmidt, Budisa 2019). Within synbio the phrase refers to a subfield, namely xenobiology which examines the possibility and development of biological systems and organisms we are not (yet) familiar with, and which are different from life as we know it. But it also points towards exobiology, biological systems and forms which are not from earth. The first section of our book explores the phrase directly in its biological/material sense but also as a trope, looking at societal, ethical and deep time questions with a more explorative approach. The artistic contributions in this section are by Gracie, de Menezes& Graça, Bennes, Bartaku and Kare. Their works examine the complexity of biological systems with methodologies ranging in scale from the microscopic to landscape and locate

their discourse from the human body to the top of mountains or the surfaces of other planets.

Coming from the natural sciences Schmidt and Budisa, in *Alternative Biofacts – Life as We Don't (Yet) Know It*, take us on a journey into contemporary biology. They ask how the chemical standard composition of life can be altered and whether we could open the door to possible parallel biological ecologies, that were or could not be explored by natural evolution. This prompts provocative thought experiments such as novel ecosystems or bioremediation on a global scale.

In *Xenological Life Potentials* Knouf urges us to work against politics of homogenisation and to embrace and become the strange, unfamiliar and yet unknown. Enacted through the practice of Xenology which highlights that change is intrinsic to the universe, Knouf states that to live change and care is not only a question of survival but foremost one of thriving. Deeply rooted in feminist theory and transgender practices Knouf expands her vision into realms of space, hybrid life forms and quantum computing.

Philosophy and gender studies scholars Radomska and Åsberg introduce us in *Doing Away with Life – On Biophilosophy, the Non/Living, Toxic Embodiment, and Reimagining Ethics* to a biophilosophy with a focus on relationalities, processes, and modulations with the aim to rethink concepts like essence, basic principle, or norm which have been traditionally used when thinking about life. They introduce the *non/living* and *toxic embodiment* as two biosophical tools which allow them to explore an expanded set of ethics.

A deep time perspective on life and artistic strategies to address processes which go beyond the human sensorial comfort zone are addressed by Berger in *Radical Witnessing and the Scope of the Real*. Berger starts from a personal level with a series of experiences which led him to work with deep time processes, and then expands towards what he calls radical witnessing where he questions conventional artistic approaches which downscale the extraordinary to fit human perception.

The thematic bow of the section presents rich and clear evidence that questions on life are a transdisciplinary endeavour. Not only do we not know the full scope of what life can be and what we can do it with it, it also deeply matters what language we use to address our concerns, and how we see those concerns in relation to a history which goes beyond the human and life itself.

Section II: Convergences

Art, science and technology converge in artistic practices examining the human influence on the planet, and the ways in which humans, animals, plants and machines cohabit our shared environments. The second section of the book – Convergences – focuses on the different ways in which the technological and biological form new constellations through artistic practice. The artworks in the section from artists Rotko, Lehmusruusu, Vanouse, Stadlbauer and Humberg, show the multiplicity of ways in which the convergence of science, technology and art inform and shape the field. The articles in Convergences engage with the entanglements of the environment and human and nonhuman bodies with technology in its various forms. The topics range from acclimatising robots to the delicate subarctic region of Sána fell to DIY hormone production in proposing Feminist Open Science.

Artist and researcher Beloff examines the changing landscape of the Finnish forest in her article *Hybrid Ecology – To See The Forest For The Trees*. As humans are not only controlling nature, but transforming it on multiple levels, we need to learn about the effects of our actions and lifestyle, and their limitations. In the article, art practices that deal with ecology, technology and science are discussed from the point of view of de-romanticisation of Wilderness.

In *Sensing Machines in Artistic Practice*, artist, educator and researcher Mäki-Reinikka proposes three modalities for thinking of the human-machine relation through embeddedness, distance, and autonomy, whilst analysing a range of experimental artistic practises incorporating machinic sensing. Notions of artificial, proxy or extended sensing become blurred with their biological counterparts, and questions regarding autonomy and the extremities of the human come into play.

Artists Karelse, Ingram and Tenetz present their attempts to undomesticate machines in the subarctic environment during two Ars Bioarctica residencies in *Machine Wilderness*. Animal-machine communication, interaction and cohabitation inform the article where the Sána fell is seen through machine eyes. What could technology be like if our technologies related to landscapes in the way organisms do?

Artist and researcher Hammond turns the critical gaze towards hormone production in *OSG: Mapping a Hormone Hyperobject* showing the ballast of historical, legal and economic power-relations in medical technologies. Hammond suggest a Feminist Open Science approach to hormone production through artistic DIY experimentation in transdisciplinary bio-hack project called *Open Source Genercodes*.

Through art, the technological culture of control is challenged and room is made for ambiguity, relationality and hybridity. The places of convergence in the articles – forest, subarctic, and the human body – reveal the sites we tend to think as natural to be hybrid meeting points of natural and artificial. The impact of technology in environments, humans and non-humans is highlighted through art that proposes ways to re-evaluate the relationships between human, nature and machine.

Section III: Learnings/Unlearnings

Keeping up with environmental issues, and technological and biotechnological development requires continuous learning. In many artistic or informal venues artists, engineers and scientists are coming together to hold workshops and share knowledge. Curators and producers need to learn new things about art and technology as well. For many it also means unlearning their previous notions and beliefs about art and/or science. Likewise, artworks in this section by Valkeapää, Osva, Taipale&Stadlbauer and Pevere use scientific approaches to expand upon the familiar and personal.

In recent years there has been great enthusiasm for DIY, open and citizen science. Science and technology have become a means of political activism, striving to democratise or even decolonise science, and acknowledge the values of indigenous knowledge.

As Kera writes, nowadays it is increasingly easy for a growing number of people to gain access to various tools, laboratory equipment, protocols, and technical know-how. In her article *Forgotten Histories of DIYbio, Open, and Citizen Science: Science of the People, by the People, for the People?* she examines the history of citizen science; its moral, aesthetic and natural aspects. She also cautions us on the excesses of anti-elitist populist movements which misuses and calls for science to service the needs of the laymen, such as the late 18th century Jacobin calls for patriotic science. Kera encourages

us to rethink the value of knowledge and its critical use for empowering people.

Other contemporary trends in bioart circles have been hacker culture, collaborative practices, cooperation and shared authorship. Lifepatch is an Indonesia-based collective who discuss their work at the intersection of the art world and citizen activism. Their projects range from global investigations on cultural heritage and the colonial roots of Dutch museum collections to technology initiatives providing clean water for the local community in Yogyakarta. Deeply embedded in DIY and DIWO culture, Lifepatch calls for collaboration both within the collective as well as the wider world.

Krpan describes in *BioTehna + Vivarium: Towards the Aesthetics of Artificial Life* how contemporary research-based and performative art practices create new demands for art galleries, e.g. aseptic conditions or incubators, greenhouses, bioreactors, laminar flow hoods and other equipment which enable works of art to survive throughout the exhibition. His case in point is the Kapelica Gallery in Slovenia and its laboratories which facilitate the creation and exhibition of artworks that investigate life systems. These facilities also play a dual purpose as a platform for the education of children and youngsters, and art research.

Bioart education is at its best experiential learning and hands-on work following the DIY tradition or do-it-with-others. The National Core Curriculum for Basic Education in Finland (2016) emphasises integrative, multidisciplinary learning, multi-literacy, and active citizenship skills – all attainable by means of art-based education. Kristiina Ljokkoi ja Tomi Slotte Dufva describe in their article, *How to Educate Kids and Youngsters to Value Art and Science as Equals: Pedagogy in Practice*, art education projects with children and youngsters. *Life Aquatic* turned a swimming hall into an artwork and a site for interdisciplinary education, and in an amusement park for water project students observed the behaviour of water and created 3D-amusement parks for this non-human agent. In the art and craft school Robotti, children tinker with electronics and code supporting experiential and creative sense-making of the digital processes.

Educational activities and artistic production can be combined. However, this section is also about history: history of science, history and the importance of water, history of an art gallery, history of a king and his sword, a living history of all kinds of materials and ideas for (un)learning.

Section IV: Redraw and Refigure

The final section gives an opportunity for pause and for a series of texts that scrutinise and offer strategies of amendment. How do we approach that which we do not know or recognise, or perhaps not even have the means to perceive? What are the means by which we might apprehend and eventually enable *Art as We Don't Know It*? Perception and comprehension find their purpose and effect within structures and context, the cultural, social-political and economic, which dictate how and where artistic practice is made. In section IV there is a proposal to consider this from a variety of positions that seek to foster the 'that which we don't know.' In the imperative to Redraw and Refigure there is a directive to appraise conventions of structures, considerations and assumptions, and from there to speculate and invite alterities. The artworks in this section by Keski Korsu, O'Reilly, Lindman and Linna redraw relations of multispecies figurations performing *re*figurations suggestive of alternative constitutions that reach into the unfamiliar and unfamilial.

Davis, Gan and Haapoja bring critical attention to the neglect of addressing whiteness in respect to the modes of power and production of the technoscientific iterations at play in bioart. In *Illuminating Multiplicity: Against the Unbearable Whiteness of Bioart* they point to the urgent requirement of engaging with the more than human, and entangle multiple naturecultures through the crucial application and attention to critical race theory, decolonialism, and intersectional feminism. They petition for a multiplicity of perspectives in bioart, a multi-optics 'aware that certain questions are illuminated while others are relegated to the shadows' and that affords prismatic effects and opportunities for refraction and reflection.

As artists and co-founders of SymbioticA Catts and Zurr discuss their view of the evolution of the role of the artist working with life and the tools of the life sciences. They point to the various modes and expectations by which artists find themselves operating, and the agendas and expectations of the practices that necessarily engage with the preponderance of vicissitudes of life. In *The Contract of Art that Deals with Life* (*Sciences*) they advise artists working with life to maintain the function of contestation as a fundamental mode of challenge and dissent.

In *Mothers and Others: Insurgent Kinmaking as Distributed Reproduction* Bencke refigures the maternal body through resistance to essentialising notions of motherhood by expressly opening up to multiple flows of otherhood. Looking to artistic practices and artworks she gives examples of alterities of embodiments that stay with the 'affirmative strangeness of mothers' and the multitudinous potentials of kinship that are resistant to exploitative operations.

Sederholm reads the aesthetics of bioart through Federico Campagna's concepts of Technic and Magic. In her article *Bioart, Aesthetic and Ineffable Existence* she posits artworks with hybridities and evasions of traditional classifications as resistant to the constraining and absolute rule of Technic. As she notes the affective registrations of particular works that evoke the uncanny or perhaps the sublime, she proceeds to ponder how the ineffable, that irreducible indicator of Magic, might be found within works of biological art and thus how these might 'open space for reality.'

Glossary

Lastly, we invited our authors to submit entries of their choosing for a glossary: terms and definitions that they consider relevant to their contributions. The glossary does not seek to be all-encompassing or comprehensive. Knowledge and thought are presented as fragmented and partial within an indeterminate textual space. The gaps are telling and are therefore also readable as that which we do not know, and therefore support the provisionality of the entries. We also wanted the arbitrary nature of this method of compiling a glossary to facilitate the possibility of unlikely and unexpected connections and readings across its entirety.

A brief history of the Bioart Society and Biofilia

As the book is strongly shaped by the work, networks and collaborations of both Bioart Society and Biofilia we would like to give those who do not know this initiatives a brief overview:

The Bioart Society

On the 30th of May 2008 the founding meeting of the Bioart Society took place at the Kilpisjärvi Biological Station of the University of Helsinki in Sápmi Finland. Back then fourteen artists and scientists, some of whom are still actively working with the Bioart Society, met to establish an association to foster emerging artistic practices at the intersection of art and science in Finland[1]. Since then the Kilpisjärvi Biological Station has been a paramount scientific partner and its director Antero Järvinen a continuous supporter. Today the Bioart Society comprises 117 members who contribute with a multitude of practices from art, science and other creative fields with 39 members having served on the board of the association[2].

In the past decade the Bioart Society has reached three distinct milestones. Already by 2009 the Bioart Society was selected by the Ars Electronica Center to host one of twenty nodes worldwide in its international 80+1 program examining the contemporary human condition through art. The focus was on climate change and the success of this two month project in Kilpisjärvi established a corner stone for further work. Later in 2014, the Bioart Society was awarded the Nordic Cultural Project of the Year by the Nordic Culture Fund for the HYBRID MATTERS Nordic network program. This lead to a strong international art program about the convergence of environment and technology together with five Nordic partners. In 2017 the Bioart Society was awarded the Finnish State Art Prize for multidisciplinary art by the Arts Promotion Centre Finland. The decision highlighted specifically the transdisciplinary and international character of the activities, the Ars Bioarctica residency program in Kilpisjärvi as well as the vital importance of the content with the aim to create social impact.

The momentum gained was carried forward and with the support of private and public funders led in 2018 to the opening of SOLU Space in Helsinki. SOLU Space is a multifunctional space for professional and public activities including exhibitions, workshops, seminars, a library and production office. Together with local and international collaborations and activities it is one component of an ongoing transformation from Bioart Society to SOLU – an artistic laboratory and platform for art, science and society.

Biofilia

At the same time the Bioart Society was gathering momentum, bioart practices in Finland were also developed in the context of Biofilia bioart laboratory, a cross-disciplinary initiative in Aalto University. From the get go Bioart Society and Biofilia were collaborating in the form of workshops, seminars and intellectual and artistic exchange.

On February 2013 was a grand opening ceremony of the Biofilia – Base for Biological Arts in the Aalto University, School of Arts, Design and Architecture. Biofilia initiative was launched already two years earlier by some faculty and professors of the Department of Art. The Biofilia art unit offers a platform and infrastructure for transdisciplinary research and education that aims to create cultural discussion and innovation around topics related to the manipulation of life and biological processes at a practical and theoretical level.

The first managing director Ulla Taipale and laboratory master Marika Hellman created a profile for the unit. Oron Catts and Ionat Zurr from SymbioticA – The Centre of Excellence in Biological Arts in the University of Western Australia, Perth, offered their expertise and knowledge of what was required to build a functional bioart laboratory. They were the first researchers in residence in Biofilia for six months. At the time of its founding Biofilia was unique in the world as it was the only fully equipped biological lab that is operated by an art school and based in an electrical engineering building. Later, the lab was moved to the building of the School of Chemical Engineering in the Aalto Otaniemi campus in Espoo.

The programme consists of research projects and a series of courses, lectures and hands-on workshops in laboratory and natural environments exploring the interfaces between biosciences and art. It provides students and scholars with the ability to engage with life sciences and their applications within an artistic and cultural context, thus creating operating approaches between biosciences, engineering and the arts.

Biofilia also runs an international visitor program which hosted artists like Oron Catts, Ionat Zurr, Andy Gracie, Paul Vanouse and Christina Stadlbauer. Together with the frequent Bioart Society collaborations they feed into the curriculum of the study program. The Bioart Society collaborations included intense working weeks on state of the art topics including the Making_Life I-III synbio workshop series, the Merry CRISPR I,II workshops and just recently in 2019, the Biorobotic workshop with recognized artists and scientists like Marta de Menezes, Markus Schmidt or Guy Ben-Ari and local and international professionals working alongside the students. Currently in the Department of Art there are a number of doctoral students focusing on the field. In this book there are contributions of some of them: Kasperi Mäki-Reinikka, Teemu Lehmusruusu, Margherita Pevere, and Bart Vandeput (Bartaku).

Years have gone by, and today Biofilia is a part of Aalto University infrastructure, open for those who want to make a serious work with bioart. The lab has all the time been located next to Aalto University Junior, a STEAM education lab for children and youngsters, and two labs work in close collaboration to encourage transdisciplinary and artistic thinking also in younger generations.

Through these initiatives and activities both in Bioart Society and Biofilia, the bioart scene has established itself in Finland expanded its influence abroad. For this book, rather than to present the history of how we got here, we wanted to venture into the unknown futures of art/science practice and ask our contributors to imagine and examine the themes and topics relevant to their work and visions going forward.

We wish this book to offer many opportunities to a great many readers, from those already familiar with the work of Bioart Society, its extensive networks and collaborations which have contributed so significantly to the field of bioart, to readers who are new and curious. As they move back and forth through the books pages, we hope that the reader's own thoughts and imagination are piqued and implicated as to the condition and nature of *Art As We Don't Know It*.

Erich Berger
Kasperi Mäki-Reinikka
Kira O'Reilly
Helena Sederholm

Helsinki, November 2019

1 A detailed personal account about the founding process and initial development of the Bioartsociety can be read in ***BEHIND THE SCENES 2007–2010: The short overture of the Bioart Society in Finland*** by Laura Beloff (2018) http://www.realitydisfunction.org/?p=583, last accessed November 8th 2019.

2 For a record of members, board members and an activities overview check the chapter Bioart Society 2008–19 on page 268.

Life as We Don't Know It

Protocell experiment during the *Making_Life II* workshop 2014. Photo by Erich Berger.

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Alternative Biofacts – Life as we don't (yet) know it

Markus Schmidt[1]
Nediljko Budisa

Dr Markus Schmidt founded BIOFACTION, a technology assessment, science communication and art-science company in Vienna, Austria. With a background in electronic engineering, biology and risk assessment he carried out environmental risk assessment and public perception studies in various fields, such as GM-crops, nanotechnology, converging technologies, and synthetic biology. He has published over 35 peer review papers and 3 edited books about the future of life. In 2010 he helped to chart the field of xenobiology.

Prof. Dr Nediljko "Ned" Budisa is Chemistry Professor and holder of the Tier 1 Canada Research Chair for chemical synthetic biology at the University of Manitoba. He received his PhD degree in 1997 and has done pioneering work in genetic-code engineering and most recently in chemical synthetic biology (Xenobiology). His research focuses primarily on the development of in vivo methods for introducing genetically-encoded protein modifications in individual proteins, complex protein structures and whole proteomes.

1 Corresponding author

Abstract

Life as we know it, the result of more than 3.5 billion years of evolution, has a remarkably unique and uniform biochemistry and genetic information processing. Science is now going beyond these uniform structures and therefore creating new-to-nature forms of life. Here, we discuss some important (yet often neglected) concepts, ideas and empirical works that will essentially contribute to our deeper understanding of life as we know it, and open up the possibilities to understand, anticipate and engineer new forms of life. In this context, we describe the field of xenobiology and explain its aims to expand the natural framework of scaffolds, chemistries and building blocks to achieve new-to-nature biodiversity. The molecules, molecular complexes and processes along the flow of genetic information ("central dogma") are particularly attractive targets for xenobiology. For example, the development of alternative nucleic acids (xenonucleic acids, XNAs) or permutating the genetic code from its current form via systematic introduction of non-canonical amino acids are promising routes towards biocontained synthetic cells. Technologies derived from these scientific achievements are expected to (a) design, construct and evolve microbes with novel metabolic capabilities; (b) produce useful chemicals and materials with novel characteristics; (c) propagate synthetic eco-systems and food-chains; and (d) might assist in recovering from the ongoing mass extinction. Much needs to be understood about new-to-nature life forms, but we suggest that it will be of great interest not only for science but also for the art-science community.

Life as unity

The ancient Greeks, including Aristotle, believed in *generatio spontanea*, the idea that life could suddenly come into being from non-living matter on an everyday basis. Pioneering empirical examinations of Pasteur in the 19th century, however, demonstrated that life in contemporary Earth is not generated spontaneously from non-living matter, but that *omne vivum ex ovo*, all life comes from life (Pasteur 1922). With this matter settled for once, it remained unclear of what kind of components life is made of. In this way, Pasteur provided a solid experimental basis for what we know today as

inheritance, or vertical gene transfer (VGT). Since Pasteur, our knowledge about basic genetics (especially on genetic code and horizontal gene transfer) expanded and latest at the beginning of the 21 century it becomes clear that the genetic code can be referred to as the "lingua franca" of life on earth, which enables the maintenance of universal biochemistry (Kubyshkin, Acevedo-Rocha et al. 2018). This establishes the basis for the transfer of genetic information (VGT) from one to the next generation in the frame of one species or population but also dissemination of biological novelty through horizontal gene transfer (HGT) between different species and populations.

Ideas about the interconnectedness of life on our planet came e.g. from Austrian Geologist Eduard Suess, who coined the term "biosphere" in 1875. The Russian/Ukrainian geologist V.I. Vernadsky published a book in 1926 entitled "The Biosphere" were these ideas were intuitively anticipated and expressed (Vernadsky 1998)[2]. Vernadsky captured all essential components that were described as "Gaia Hypothesis" in the 1970s which postulates that the chemical composition of the Earth is unique compared to other planets and similar cosmic bodies due to the life processes (Lovelock and Margulis 1974). Vernadsky proposed the hypothesis that all living matter can be considered as a single entity – a (super) organism that spans the entire surface of the earth – a biosphere. It is a unique system that stores chemical energy by converting (mainly) solar radiation into mechanical, molecular and chemical energy.

Today, we know that Vernadsky was intuitively right: although there are species barriers in the production of offspring (VGT), there are no geographical limits to HGT in all habitats where bacteria, eukaryotes, archaea and virus particles thrive – from deep-sea hydrothermal wells to Siberian permafrost (Pawluk 2017, Reche, D'Orta et al. 2018).

Chemical composition and organization of life's unity

Scientists used a large part of the 20th century to reveal that the conjecture of "The Biosphere" and the Gaia hypothesis prove to be correct up to the molecular level. It turned out that the *basic* chemical constitution of all living organisms consists of a limited number of small molecules and polymers. The building blocks of these molecules consist predominantly of only six atoms, summarized in the acronym CHNOPS, which stands for Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus and Sulfur. Carbohydrates are molecules consisting of carbon and hydrogen atoms that are fundamental to all life forms on Earth as they play an essential role in all aspects of biology, e.g. they can store energy (e.g. as sugar molecules), provide structural support (as polysaccharides), and play an important role in proteins and information storage (such as DNA). Nitrogen is an essential component of amino acids that make up proteins and enzymes, some of the most important building blocks of life, but is also part of DNA and enables photosynthesis in chlorophyll. Oxygen is most relevant for the energy flow and breathing. Phosphorus in combination with carbon and hydrogen form lipids that include fats, oils, and waxes to store energy or protect the organism. Lipids are indispensable to cells as they make up the cell membrane, a thin layer of molecules that define the inner and outer space of the cell. Phosphorus is also essential in the formation of the backbone

2 The book remained largely unknown until its recent English translation.

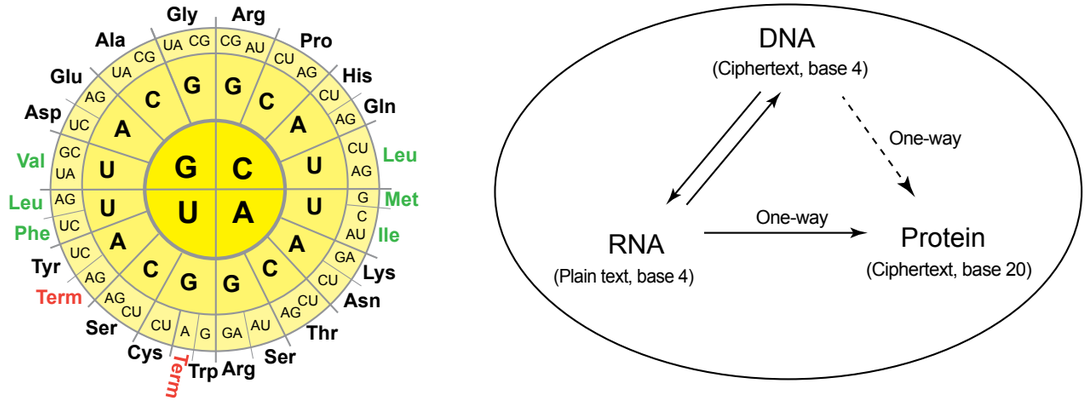

Figure 1 (Left) Circular depiction of the genetic code (Kubyshkin, Acevedo-Rocha et al. 2018) (Right). "Central dogma" of molecular biology describes essentially the unidirectional flow of genetic information in life (Crick 1970). That means, once "information" has passed into protein it cannot get out again. Information inherited as DNA is *transcribed* to RNA (as both are nucleic acids, consisting of 4 building blocks or bases) and then *translated* to proteins (that consist of 20 different amino acids). While information can be directly transcribed back and forth between RNA and DNA, information flow from RNA to proteins is a one-way street. In this figure the term base stands for information system on the basis of 4 or 20 building blocks, not the chemical base. In RNA and DNA the chemical and informational term happens both to be called base.

structure of DNA. The final letter S stands for sulfur, an essential component of some amino acids.

While CHNOPS describes the building blocks of life on the atomic level, it is actually the molecular level that sustains life. There are basically four categories of molecules that are paramount for all living beings: proteins, linear polymers such as proteins, and nucleic acids (e.g. DNA) and large molecules such as carbohydrates and lipids (See: Cooper and Sunderland 2000 for more details on the chemistry of life). Proteins and nucleic acids, as well as some carbohydrates and to a certain extent lipid, are macromolecules, meaning that they consist of a limited set of similar building blocks. In the nucleic acid DNA, only four building blocks (A, T, G, C) make up for example the entire human genome, which totals about three billion of those four building blocks. While chemists know more than 700 amino acids, proteins are made up of no more than 20 (+2) so called "proteinogenic" amino acid building blocks. It can be seen as one of the greatest insights of the 20th century that life consists of a very specific and small fraction of all theoretically possible CHNOPS containing molecules. A set of molecules widely considered as "canonical" (Cooper 2000)

From the vampire squid in the abyss of the ocean, to the highest trees of the rainforest, to bacteria living in our guts, to extremophile archaebacteria that prefer hot springs or acidic rivers, to ourselves the human species, all forms of life we know so far are made up of these specific molecules of life.

But not only do they share a common, one could also say normative, biochemistry, they also show a remarkable lack of diversity in the way information is transferred from one type of biomolecule to the other (see figure 1).

DNA and RNA are made up of 4 building blocks or bases, in case of DNA it is ATGC, while in RNA it is AUGC. Even though T and U are different, the transcription from one to the other is bijective, as A matches with T (or U) and G with C. So no encoding is necessary. Only when a text based on 4 letters is translated to a text with 20 letters, a *code* is needed. In other words a code is the key to translate an input to an output when there is more than one possibility to do so. Extant biology without exception uses a system where three nucleic building blocks, a so-called triplet, define one amino acid. Since we have four building blocks, times three we have a total of $4 \times 4 \times 4 = 64$ triplets coding for 20 amino acids and the stop signal (21 in total). The importance of the code becomes even more clear when the total number of possible codes that code for 20 amino acids and one stop codon is calculated, resulting in the enormous number of 418,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000 possibilities ($21^{64} = 4{,}18 \times 10^{84}$) (Schmidt 2019). This number is higher than the total estimated number of elementary particles in the observable universe 10^{78} (Silk 2005). Contemplating this number, it becomes clear that evolution would never have been able to generate and select all possible genetic codes. There are plausible theories to why the genetic code became the way it is (Hartman and Smith 2014, Wong, Ng et al. 2016), one of the (many) constraints is the robustness of the code. In other words, the genetic code is exceptionally tolerant to DNA mutations and will produce the same or very similar proteins despite changes in the composition of nucleic acids (Freeland and Hurst 1998).

The genetic code is also called standard genetic code, because it is implemented in all but a few organisms (or organelles, subcellular bodies such as mitochondria). Besides the standard code, so far 25 slightly different codes have been discovered in nature (see https://www.ncbi.nlm.nih.gov/Taxonomy/Utils/wprintgc.cgi). Some more will probably be discovered in the future, but it remains absolutely clear that a vast majority of all 1,5 million known and 10 million estimated species on Earth (Mora,

Tittensor et al. 2011) use exactly the same genetic code. The code-normativity of life of Earth, the tremendous lack of diversity in interpreting genetic information, is overwhelmingly clear. Evolutionary biologists consider this knowledge a strong indication that all living beings are related to one another, in the sense that we might all share an unknown last universal common ancestor (LUCA) that populated the Earth billions of years ago (Acevedo-Rocha, Fang et al. 2013).

From Analysis to Synthesis

While in the 20th century biology was mainly seen as an analytical science, some visionaries, such as James Danielli (1911–1984) were able to glimpse into the future of life. As Danielli wrote in 1972 in his landmark article "Artificial Synthesis of New Life Forms", all sciences eventually undergo three phases, namely the phase of (1) description, (2) analysis and (3) synthesis. While physics and chemistry had all arrived in the stage of synthesis, biology in the 1970s was still an overwhelmingly analytical science (with the exception of a few recombinant genetic experiments). Since the beginning of the 21st century there are clear indications and outright declarations to convert biology into a real synthetic discipline. Not surprisingly, the third phase of biology, for a lack of a better term, was baptised synthetic biology (although the term itself goes back to the beginning of the 20th century, see (Le Duc 1910).

For the last 15–20 years synthetic biology has attempted to redesign natural systems and to make biology easer to engineer. The field of synthetic biology, however, is less homogenous than one might guess, as many different approaches, methodologies and strategies are used to carry out a number of different goals. One of the most prominent approaches deals with top-down metabolic engineering, in other words, the capacity of (mostly) microbes to convert input (such as sugar or methane) to a desired output (such as fuel or medicine) by redesigning their genetic pathways. This approach uses existing organisms (e.g. yeast, the gut bacterium *E. coli*) and tinkers with selected genes to alter their physiological functionality. It is very much application oriented and may aim to support the bio-economy.

Another approach is the definition of a minimal cell, that is the reduction of the complexity of extant living cells to the point where it can barely survive. These minimal cells would then represent the most basic possible form of life, and could answer the question what life is and what minimal level of complexity is needed to sustain life. An example is the bacteria and parasitic pathogen Mycoplasma that has one of the smallest genomes (about 500,000 base pairs). Scientists, for example, currently try to further cut down the size of the genome of Mycoplasma (Acevedo-Rocha, Fang et al. 2012).

While metabolic engineering and the minimal cell approach both require extant cells as a starting point, the proto- or synthetic cell community wants to create life from scratch. For this bottom-up approach it is necessary to create an empty cell that is then filled with a number of functional biomolecules (Powell 2018).

Animating the bio-imaginary: xenophile biology

Yet another objective of synthetic biology is to try to change the chemical compositions of living cells, i.e. to create an artificial biological diversity (Schmidt 2010). This objective, in turn, fosters a new sub-field of synthetic biology called xenobiology. In ancient Greek, *xenos* meant a stranger or foreigner usually (if not an attacker) to be treated friendly. (The term xenophobic describes an indiscriminate aversion against strangers regardless if they come in peace and good spirits or if they come to conquer and destroy. Xenophilic on the other hand describes the love for strangers.) Since biology is the science of living things, xenobiology describes life forms that are unfamiliar to us.

One of the most striking attempts of xenobiology is to alter the chemical building blocks of nucleic acids (DNA, RNA), the molecules that store most of the hereditary information.

While in all known living beings, genetic information storage and processing rely on just two polymers, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), it is unclear whether their role reflects evolutionary "accidents" or fundamental functional (e.g. chemical or biological) constraints. Using polymerase evolution and design it was shown that genetic information can be stored in and recovered from various alternative genetic polymers[3] collectively called XNA for xeno nucleic acids) not found in Nature (Pinheiro, Taylor et al. 2012). Beyond heredity, specific XNAs have the capacity for Darwinian evolution. This means that heredity and evolution, two hallmarks of life, are not limited to DNA and RNA but are likely to be emergent properties of more than two polymers capable of information storage.

Xenobiologists have also enlarged the genetic alphabet of DNA with unnatural base pairs that led for example to a genetic code that has 6 bases ATGCPZ instead of 4 bases ATGC (Benner and Sismour 2005). So far at least 60 candidate bases (that means hypothetical 3,600 base pairs) were tested for possible incorporation in the DNA (Leconte, Hwang et al. 2008). In a few cases the novel base pairs were introduced to living systems and have been reproduced inside plasmids (a circular form of DNA) in bacteria (Zhang, Lamb et al. 2017). This means the genetic code has been modified by the expansion of the genetic alphabet (Dien, Morris et al. 2018).

Given that over 700 amino acids are known from Nature and only 20 (+2) are used in the genetic code, it probably doesn't come as a surprise that the expanded nucleic acid alphabet is met with an expanded amino acid alphabet, where non-canonical amino acids are used to make polypepdites and proteins (Hoesl and Budisa 2011, Hirose, Tsiamantas et al. 2019). It even seems plausible that not just a few amino acids are replaced, but that they are all replaced by others belonging to an entirely different group of amino acid, undoing an evolutionary "decision". Recently Budisa and Kubyshkin provided a solid argumentation that original development of the polypeptide biosynthesis seems more a random walk rather than a 'choice' or a physical-chemically imposed solution, and Nature simply recruited the available components, in this particular case – a set of canonical amino acids encoded in genes (Kubyshkin and Budisa, 2019). They also provided a long-term perspective by creating another scaffold capable to allow a functional proteome based on different building blocks and underlying principles

3 The nucleic acids were: HNA (1,5 anhydrohexitol nucleic acids), CeNA (cyclohexenyl nucleic acids), LNA (2'-O,4'-C-methylene-ß-D-ribonucleic acids; locked nucleic acids), ANA (arabinonucleic acids), FANA (2™-fluoro-arabinonucleic acid) and TNA (α-L-threofuranosyl nucleic acids)

of protein folding than those that we know (Kubyshkin, Grage et al. 2018).

In many cases the incorporation of non-canonical amino acids is combined with a different form of nano-performativity[4]. A few examples are known where the genetic code itself was changed. To change the code, one strategy is to first select an amino acid or stop codon that is encoded by more than one triplet. The natural redundancy is important here, because by carefully editing the genome it is possible to replace one triplet that codes for amino acid X or a stop codon with another triplet coding for the same amino acid or stop codon. When this has been achieved, the corresponding tRNA (the molecule that mediates the code) can be modified without harming the organism, and a different amino acid can be linked to the tRNA (Lajoie, Rovner et al. 2013, Kubyshkin and Budisa 2017). In one case a bacteria was reprogrammed so it would only use 57 instead of 64 triplets (Ostrov, Landon et al. 2016).

One of the keystones of Darwinian evolution is the fact that geographically (and hence genetically) isolated species tend to evolve unique and heritable changes over time. The classical example is Darwin's finches, which illustrates the way gene pools of the finch have adapted to take advantage of different food constrains. What is true for Darwin's finches also applies for cells in general. Through man-made, directed evolution of life-forms we can attempt to achieve the implementation of new and sophisticated chemistries (elements, reactions, metabolic pathways) into the protoplasm of desired life forms (Wiltschi and Budisa 2007). Xenobiology is the attempt to learn if the chemical standard composition of life forms (invariant for around four billion years) can be changed and whether we could open the door to possible parallel biological worlds, that were not (and could not have been) explored by natural evolution (Hoesl, Oehm et al. 2015).

From chemical to biological synthesis

In the first years of today's ubiquitous synthetic chemistry, the synthesis of complex substances, originally produced from plants and animals, was assumed as an impossible task. Additionally, a lot of physiological conditions were experimentally inaccessible in those days. This left space for the appearance of metaphysical concepts like the idea that organic compounds were just formed in presence of a special, vital power ("*vis vitalis*"), acting exclusively in creatures. Accordingly, metaphysical concepts were used as main criteria to decide between animate and inanimate matter (Church and Regis 2012, Venter 2013). Yet in the beginning of the 19th century, this metaphysical viewpoint was proven wrong by chemical synthesis of organic molecules (e.g. urea Woehler's *Harnstoffsynthese* in 1828) (Wöhler 1828, Multhauf 1966). Although this was not the first milestone for the synthesis of naturally occurring, organic compounds, starting from then, the awareness of the accessibility of natural, organic molecules increased. Complex compounds could be manufactured starting from simple structures in a stepwise and controlled manner. Less than 50 years later, organic synthetic chemistry has turned into an engineering discipline with the ambition to synthesize all naturally occurring, organic substances (Fisher 1907), and even substances that do not occur in Nature. The complete chemical synthesis of any molecule (a natural or artificial product), from simple, commercially available precursors is called

4 Nano-performativity describes human actions on the nanometer level.

"Total synthesis" (Nicolaou, Vourloumis et al. 2000). It is one of the goals in the life sciences to achieve an equivalent success with biological systems (Erb, Jones et al. 2017).

Nature sans frontiere: CHNOPS welcomes FRuSiCl

The fundamental characteristics of wild, synthetic and xenobiology is that in wild and synthetic biology living systems are restructured via exchange and combination of (evolutionary or technically) standardised parts (genes, modules, biobricks), either through horizontal gene transfer or via genetic modification. In contrast, xenobiology uses non-canonical) molecules to create chemically modified organisms (CMOs) (Acevedo-Rocha and Budisa 2011). These CMOs will manage to use other permutations of CHNOPS but also combine non-CHNOPS chemical elements, such as fluorine (F), ruthenium (Ru), silicon (SI) and chlorine (Cl) (Acevedo-Rocha and Schulze-Makuch 2015).

Fluorine (atomic number 17), for example, is the most electronegative element in the periodic table, and its reactive chemistry is beyond the catalytic scope of the vast majority of the conventional enzymes (O'Hagan 2008). So far only one natural enzyme called fluorinase has been found in Nature (in a *Streptomyces* species), that is able to incorporate fluoride (F–) into organic compounds (Dong, Huang et al. 2004), by attaching F to carbon atoms in living cells. Although fluorinase has been characterized in detail (O'Hagan, Schaffrath et al. 2002, Zhu, Robinson et al. 2007), its biotechnological applications are so far limited to a narrow spectrum of small molecules produced *in vitro* (Walker and Chang 2014).

Nature did not use fluorine significantly as a building block for organic matter since it is largely insoluble contained within inorganic substances on Earth (Berger, Voller et al. 2017). While chlorine- or bromine-containing organohalogens were efficiently used by living beings for billions of years of evolution, biotransformation of organoflurine compounds is rather limited due to the exceptional strength of the carbon-fluorine bond. Organofluorine compounds nowadays are rather seen as environmental stressors that generally induce significant biological effects on individual cells and whole populations by enabling inhibition of enzymes, cell-cell communication, membrane transport, and processes for energy generation (Merkel and Budisa 2012). On the other hand, being almost exclusively synthetized by humans (e.g. advanced materials, fine chemicals, drugs or pesticides) there was not sufficiently long evolutionary time for microbial populations to invent and spread resistance mechanisms against such toxic substances (Biava and Budisa 2014).

Therefore, the intense research in this direction is inevitable as organoflurine compounds (which are massively used in human industrial, agricultural and household activities are also known as "inert" substances) will have a strong tendency to accumulate and persist in soil and water, and are therefore will be extremely difficult to remediate. On the other hand, the use of organofluorine compounds to produce biomass or cells with altered metabolism has a great future.

Furthermore, *Streptomyces* is not an ideal host for metabolic engineering of reactions involving fluorine, as it displays high fluorine-sensitivity, slow growth and low yield of fluorinated compounds (Deng, O'Hagan et al. 2004). The EC H2020 research and innovation project SinFonia, aims to transfer fluorinase to a soil bacterium called *Pseudomonas putida* that is also a model organism for industrial biotechnology especially in processes for biopolymer production. SinFonia engineers the metabolism of *P. putida* to execute bio-fluorination reactions leading to new-to-nature fluoropolymers from renewable substrates.

We can even think about the most prominent example of synthetic fluorine containing organic compounds of anthropogenic origin Teflon – a highly fluorinated polymer used in everyday life. Would the biosynthesis of "Teflon-proteins" be a realistic prospect (Budisa, Pipitone et al. 2004)? Given the case that living beings never adopted fluorine as biogenic element, its accommodation into the chemistry of life as we know it is still a formidable challenge. Living organisms would have to be able to survive adaption on fluorine through massive modifications of their enzymes and proteins that are originally evolved on a hydrocarbon basis. This certainly requires the rewriting of their entire genomic text by the accumulation of different types of mutations and their combinations. Given the recent success in the laboratory evolution of the chemical composition of proteins or nucleic acids, we believe that design of artificial cells with fluorine chemistry is a very challenging but achievable goal (Budisa, Kubyshkin and Schulze-Makuch, 2014).

There should be no doubt, that microorganisms and especially bacteria which possess an exceptional capacity to develop fast metabolic or genetic responses to chemical stresses will be used to evolve and proliferate by using exclusively the toxic fluorine containing compounds for growth. Such "fluorous-life" will consist of biocontained microbial strains extremely important for the emerging problems of environmental biosafety. Being reliant on the exclusive presence of the xeno-nutrients for survival and proliferation, these evolved microbial stains are promising platforms for creating fully synthetic life. The engineering of the genetic code allows us to add fluorinated non-canonical amino acids to the existing repertoire of the 20 canonical amino acids prescribed by the genetic code (Budisa 2004).

Fluorine, however, is not the only novel element of interest, in fact there are a number of non-biogenic elements with high enzymatic potential. The metathesis reaction, for example, was exclusively used in synthetic chemistry, but with support from the European Commission (EC) FP7 research project METACODE, it was successfully transferred to the metabolism of bacteria by designing and evolving artificial metalloenzymes. Metalloenzymes are enzymes that contain at least one metal atom that enhances its catalytic power. This is why metathesis is now also possible in vivo, using enzymes that have been designed to incorporate the chemical element **ruthenium** (a rare transition metal with atomic number 44) into an enzyme (Jeschek, Reuter et al. 2016).

Very recently, a paper published by the 2018 Nobel prize winner Frances H. Arnold, showed that an enzyme that catalyzes **silicon** (Si) carbon (C) bonds was evolved, providing a first step toward engineering the biotechnological production of organo-silicon compounds, in other words the direct merging of the carbon and the silicon world (Kan, Lewis et al. 2016). The EC H2020 Future and Emerging Technology project MADONNA is currently investigating the full potential of these new-to-nature organo-silicon compounds.

In a tour de force biochemical experiment, a French-German collaboration showed for the first time that the element **chlorine** (Cl) can be incorporated into one of the most essential building blocks, namely the DNA base T (as in ATGC). In a directed evolution experiment the thymine was replaced by 5`chloro-uracil (Marliere, Patrouix et al. 2011).

These European projects, by the way, demonstrate a form of chemical emancipation[5] from Nature and probably only possible when science does not stop at national borders.

Novel molecular building blocks and codes

The number of potentially novel building blocks for protein biosynthesis is virtually unlimited as organic chemistry can provide a great diversity of non-canonical amino acids, nucleobases and unnatural cofactors that can be used to produce synthetic life either by experimental evolution or de novo chemical syntheses. To achieve these goals, we need first conceptual tools that question/ challenge our current concepts, wisdom and logic behind the amino acid repertoire establishment in evolution and the "frozen" code and conservation of the basic life chemistry (Kubyshkin and Budisa 2017). With such understanding in mind, we would be able to propose a possible scenario ("chemical worlds") for basic building blocks of structural and functional diversification as a starting point for attempts to create alternative life structures (and technologies derived thereof) from the first principles (Acevedo-Rocha and Schulze-Makuch 2015). This is plausible, since *in vitro* works have demonstrated that the creation of a totally new genetic code set is possible. Numerous experiments in microfluidic devices or *in vitro* platforms show that many alternative components of life can be controlled and manipulated (Kubyshkin and Budisa, 2019).

The same can be said for non-canonical DNA bases that have been developed into diagnostic tools for infectious diseases (Benner and Sismour 2005). The unnatural base pair system consists of an expanded genetic alphabet that is built into oligo nucleotide fragments on specific sites, or via enzymatic incorporation of extra, functional components into nucleic acids. These fragments containing unnatural base pairs can be obtained via PCR amplifications. Diagnostic molecular beacons with fluorescent dye linked to the unnatural bases can serve as molecular diagnostic tools, e.g. to target infectious diseases of interest (Kimoto, Cox et al. 2011). Furthermore, aptamers (nucleotide or peptide molecules that bind to a specific target molecule) containing unnatural bases, due to their unique features in affinity, thermo stability and resistance to nucleases, are considered valuable for pharmaceutical applications (Matsunaga, Kimoto et al. 2015).

It should always be kept in mind that life can not be reduced entirely to chemistry nor physics (Figure 2). Life is not just information flow, neither is it only energy flow. It is also not a mere self-organisation with catalytically-driven chemical supercycles. Life is more, it is the organisation (unity) of all these phenomena. Thus, to create synthetic life with an expanded, reduced or altered genetic code, ongoing work should be combined with system bio-engineering work on self-assembled bio-orthogonal compartments and devices, along with alternative energy sources (other than chemo-osmotic gradients), novel types of information transduction pathways and alternative metabolic cycles with new to

5 Emancipation: The act of setting something free from something else. See: http://www.businessdictionary.com/definition/emancipation.html

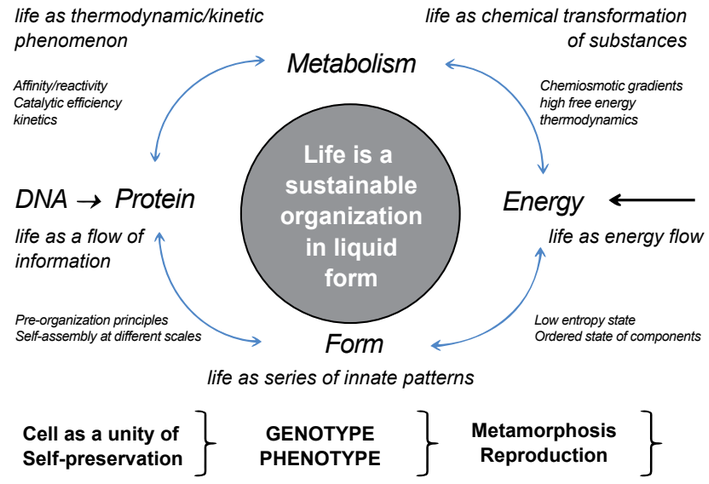

Figure 2 A conceptual view of life with minimal requirements ("minimal cell") as defined by Gànti and others (Gànti 2003). Such a system regulates and controls metabolism, energy supply, and distinct forms/ patterns. It contains at least one subsystem acting as an information carrier; the information contained is fundamental to the entire system (genetic information). It enables maintenance, self-preservation, metamorphosis and reproduction via a complex set of genotype/ phenotype interactions and processes. Prepared according to Diwo and Budisa (2019).

nature catalytic cascades and molecular machines (Agostini, Voller et al. 2017).

This makes a completely new biological world conceivable and plausible. The design of genetically modified organisms (in the context of classical genetics) is only the beginning of a long road in search of reliable methods for the evolution and development of artificial biodiversity while preserving the old natural world. An important task for xenobiology, therefore, is to pursue chemically-diverse artificial evolution of viable and robust cells that can grow and replicate in isolation from natural species (Schmidt 2010, Schmidt and de Lorenzo 2012, Acevedo-Rocha and Budisa 2016, Schmidt and de Lorenzo 2016).

If we accomplish to change the way the genetic code is read in a living organism as well as to add new "letters" or building blocks, the corresponding cell will constitute an informational enclave since the genetic exchange (called horizontal gene transfer or HGT) with natural cells is impaired. This could be an important aspect in regards to biological safety, because the risk of horizontal gene transfer to natural cells is supposed to be strongly reduced (Acevedo-Rocha and Budisa 2011, Wright, Stan et al. 2013, Budisa 2014, SCHER, SCENIHR et al. 2014, SCHER, SCENIHR et al. 2015, Wright, Delmans et al. 2015). Therefore, xenobiology seeks for conditions in which the cells can be cultivated in the laboratory or released into the environment, but stay genetically isolated from naturally occurring species (Schmidt 2013). These conditions might also include e.g. supercritical fluids that have different properties compared to regular fluids and could play a role as life-sustaining solvents for alien life forms (Budisa and Schulze-Makuch, 2014).

Negotiating a responsible use of xenobiology

Synthetic chemistry has without doubt been a major factor in improving the lives of billions of people. Synthetic chemistry is so ubiquitous that we hardly recognise how important it is to support our (post) modern lifestyles, supplying materials, pharmaceuticals, textiles, fuel, building materials etc. Chemistry, however, was also responsible for a number of problems (such as persistent organic pollutants or POPs, toxins, endocrine disruptors among others). (Synthetic) chemistry is a doubled-edged sword with the power to do good and bad, and is therefore regulated in most parts of the world. In Europe

> REACH (EC 1907/2006) aims to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances. This is done by the four processes of REACH, namely the registration, evaluation, authorisation and restriction of chemicals. REACH also aims to enhance innovation and competitiveness of the EU chemicals industry. "No data no market": the REACH Regulation places responsibility on industry to manage the risks from chemicals and to provide safety information on the substances.[6]

Other even more stringent regulations apply to specific industries, such as the pharmaceutical industry. Since the mid 1970's regulations are also in place for the production and use of genetically modified organisms, aiming to avoid unintended consequences and intentional misuse by rogue actors. So far xenobiology is supposed to be covered by either REACH (on the chemical level) or the GMOs regulations (on the biological level).

Optimise diversity

Further expansion of the capabilities to create biochemical diversity with xenobiology will raise questions to which extent the existing guidelines, codes of conduct, practices and regulations are sufficient to cover novel forms of life. The current technical capabilities of xenobiology are still rather modest, mostly restricted to proof of concepts with few applications available, but they show the pathway to a future where multilayered radical diversification is the norm and not the exception. One could say the time has come when the central dogma of biology, the DNA-RNA-proteinogenic amino acid-"normativity", is challenged by alternative life forms and biochemical arrangements. Should natural life forms be privileged over currently unknown, yet unborn and evolutionary marginalised versions of life?

It is clear that life can manifest itself in a number of different forms. Up to now most biologists have quickly assumed that natural forms of life have evolved because no other forms of life are as fit. By beginning to understand that Nature, for a number of reasons, did not have the chance to test and select all possible variants of life supporting molecules and codes, we start to see more clearly the limitations of evolutionary processes when it comes to the exploration of the animated combinatorial space.

Mankind is responsible for the latest, the sixth, mass extinction of life on Earth. Even if all human

6 http://ec.europa.eu/environment/chemicals/reach/reach_en.htm

induced extinction factors (mainly land use change and agriculture) would suddenly disappear, it would take millions of years for biodiversity to recover (Ceballos and Ehrlich 2018, Davis, Faurby et al. 2018).

Synthetic biology might be used for conservation of wildlife (Redford, Adams et al. 2013), it has also offered (our bad conscience) the option of de-extinction, to bring back life forms that once populated the Earth (Jennings 2017), or other ways to reduce biodiversity loss (Piaggio, Segelbacher et al. 2017) or reverse ecosystem degradation (Maestre, Sole et al. 2017). Contrary to these conservative views, synthetic and xenobiology might actually add novelty to ecosystems (Fuentes 2018). If we are allowed to dream big, maybe it can even enable the recovery from the sixth mass extinction, supporting the next explosive radiation of biodiversity, see e.g. (Sahney and Benton 2008).

In the past, visions of future life forms and ecologies – as shown for example in the epic book *After Man: A Zoology of the Future* (Dixon 1981) – extrapolated canonic evolutionary principles to the far future.

With tools such as synthetic and xenobiology, however, humans could attempt to start a bioremediation on a global scale (de Lorenzo, Marliere et al. 2016). Before we focus on this huge task, however, we obviously need to better understand the challenges and opportunities of designed and novel ecosystems (Higgs 2017, Sole, Montanez et al. 2018).

Speculative artworks[7] both communicate the challenge and start to explore ways to respond. Designing the recovery from the contemporary mass extinction could indeed be a very tempting topic not only for science but also for the art-science community (Harrower et al. 2018).

Acknowledgments

MS and NB acknowledge financial support from EC FP7 project METACODE (289572). MS acknowledges support from EC H2020 projects MADONNA (766975) and SinFonia (814418). NB research was funded by the Award for Tier 1 Canada Research Chair in Chemical Synthetic Biology by the Canadian Federal Government (grant number: NSERC-CRC 950-231971).

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7 See for example "Designing for the sixth extinction" by Daisy Ginsberg. https://www.daisyginsberg.com/work/designing-for-the-sixth-extinction

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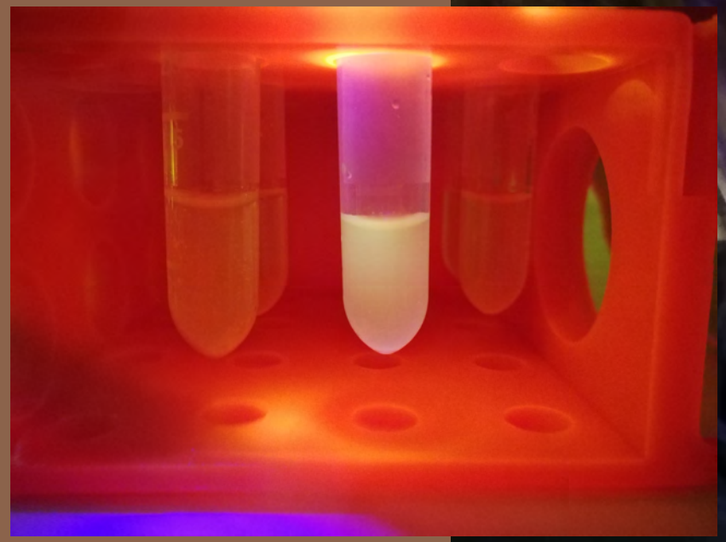
Merry CRISPR

Bioart Society, 11–15 December 2017

Merry CRISPR was a workshop produced by the Bioart Society in collaboration with Biofilia at Aalto University. CRISPR is a novel gene editing system which allows the permanent modification of the genes in cells of living organisms. The workshop activities shifted between hands-on laboratory sessions, lectures, interventions, field trips, presentations and round tables for the wider public. Participants investigated and worked with CRISPR, looked into its materiality and artistic possibilities, discussed and explored sociocultural, political and ethical implications. The program included a presentation by Britt Wray on her book *Rise of the Necrofauna* which debates de-extinction, the resurrection of extinct animals with the use of biotechnology.

Participants Cecilia Åsberg, Erich Berger, Anna Björklund, Sarah Cook, Marta de Menezes, Mikael Fortelius, Mariantonia Gonzales-Valerio, Marika Hellman, Shreyasi Kar, Eben Kirksey, Satu Kuure, Timo Menke, Kira O'Reilly, Margherita Pevere, Piritta Puhto, Marietta Radomska, Sami Rekola, Marja Ruohonen-Lehto, Erik Sandelin, Sandra Schneider, Christina Stadlbauer, Hege Tapio, Antti Tenetz, Emilia Tikka, Georg Tremmel, Nora Vaage, Bart Vandeput, Vera Weetzel and Britt Wray.



CRISPR transformed yeast cells. Photo by Erich Berger.

Workshop participants hacking The Odin kit. Photo by Erich Berger.

Deep Data Prototypes

Andy Gracie, 2011–

Deep Data is a project arc so far comprising three pieces; *Prototype 1*, *Prototype 2* and *Prototype 3*. The *Deep Data Prototypes* are experimental simulation devices in which space-faring terrestrial organisms are subjected to selected elements of the deep space environment as recorded by probes, landers and other robotic platforms. The works frame ideas of terrestrial astrobiological experiments in which data from deep space exploration is used to manipulate the parameters of biological growth environments. Through the use of microorganisms and deep space presence, huge discrepancies in scales are collapsed into one locus where the possibilities and boundaries of life are contrasted with our own extended sensory cortex and its related information gathering systems.

The three current works taken as a whole represent a real time astrobiological experiment, a performative laboratory, where custom-built equipment operates according to data sourced throughout the solar system.

In *Prototype 1*, polyextremophile tardigrades are exposed to the magnetic fields of the gas giants as recorded by the Pioneer and Voyager probes during their journeys to the edges of the Solar System. In *Prototype 2*, eight cultures of a photomorphogenic mutant of the plant *Arabidopsis* are grown under the light spectra of other planets. In *Prototype 3*, three cultures of the nematode *Caenorhabditis elegans* are subjected to the gravity wells of newly discovered terrestrial exoplanets. Each of these organisms has been a common passenger on space missions since the 1960s and are thus seen as ideal test subjects for further experimentation. These organisms are pioneers, venturing into parts of the space environment that no other organism has sensed or witnessed. As with the robotic platforms that inform them, they become our space explorers by proxy.

Deep Data proposes that we must keep looking outwards to find the boundary of life by exploiting the outermost information we have. It also proposes cultural and critical examination of our quest to find other forms, habitats, and strategies for life by reviewing technological processes while asking philosophical questions about their discovery.

Andy Gracie works across various disciplines including installation, robotics, sound, video and biological practice. This work is situated at a point of separation between the arts and the sciences, creating situations of exchange which allow new understandings and knowledge systems to develop. His work has been exhibited widely and internationally in both solo and group shows.

Deep Data Prototype 2, 2012. Photo by Andy Gracie.

Deep Data Prototype 3, 2016. Photo by Andy Gracie.

Xenological Life Potentials

Adriana Knouf

Adriana Knouf (she/her/hers, sie/hir/hirs) works as a xenologist, as an artist-scientist-writer-designer-engineer. She engages with topics such as space art, satellites, radio transmission, non-human encounters, drone flight, queer and trans futurities, machine learning, the voice, and papermaking. She is the Founding Facilitator of the tranxxeno lab, a nomadic artistic research laboratory that promotes entanglements amongst entities trans and xeno. Adriana is also an Assistant Professor of Art + Design at Northeastern University, Boston, MA, USA.

Figure 1 *TX-1* (2020), production model. Photo by Jennifer Ray, courtesy of the artist.

Rituals

I have daily and bi-weekly rituals that go something like this. At 0900 every day my phone reminds me that it is time to take my 100mg spironolactone pill. I can snooze the reminder, but shouldn't much beyond 1200. At 2000 I get another reminder to take half a pill, 50mg. Twice a week, on Wednesdays and Sundays and at the same time as my morning spiro dose, I also get reminders to change my 0.1mg/day Vivelle Dot estradiol patch. These reminders I can snooze for many more hours, into the late afternoon if it's a particularly lazy day. But I do have to switch the patch out that day.

The spironolactone as a diuretic, primarily used in the treatment of high blood pressure. In women with polycystic ovary syndrome it can also be used to counter acne. It also acts as an anti-androgen, preventing testosterone from binding to receptors. Thus, in transgender women like myself, it is often used to counter the effects of testosterone production in the testes we were inadvertently provided with at birth. The Vivelle Dot patch provides the 17-β-estradiol that my body so desperately needs but does not produce enough of. Vivelle Dot is primarily prescribed to women to counter the effects of menopause. Increasing estradiol above those provided by my body without pharmaceuticals produces changes observed by myself *as well as* the cis-gaze, including developing breasts, fat redistribution in my face and buttocks, and softer skin, along with enhanced emotional awareness. At my last checkup my bloodwork showed serum estradiol levels at 136 pg/mL and total testosterone at 16 ng/dL, right in the range of a "normal" cis-woman. This practice of taking an anti-androgen and exogenous estradiol is common to hormone replacement therapy (HRT) for transgender femmes/women; in transmasc or transgender men exogenous testosterone is used instead[1].

I go through the details of my HRT regimen to highlight in stark tones how HRT is already a practice of "biohacking" in terms of its medical effects: transgender people on HRT take exogenous hormones that cause incredible, and oftentimes permanent, bodily changes[2]. HRT radically changes

1 It should of course be noted that not all transgender people choose to medically transition using HRT or surgery. As well, as a transgender woman I cannot speak to the HRT experiences of transmasc or transgender men. The precise pharmaceuticals and modes of delivery for HRT also vary, depending on country, prescriber, access (sanctioned or not), and comfortableness (pill, patch, injection, implant).

2 By biohacking I do not mean the Promethian defeat of human frailties desired by mainstream transhumanists, but rather the exploration of capabilities of body modification granted to us by the universe's unceasing capacity for change.

not only how we feel about ourselves, but also about how the rest of the world sees us. Paul Preciado, on taking testosterone: "I take it to foil what society wanted to make of me, so that I can write, fuck, feel a form of pleasure that is postpornographic, add a molecular prostheses to my low-tech transgender identity composed of dildos, texts, and moving images" (Preciado [2008] 2013, 16). HRT additionally may take away privilege we once had, or grant it when it was previously absent. It may make our daily lives more dangerous. Yet HRT may also be the thing that allows us to continue living.

HRT is also biohacking in another sense, for our taking them as aspects of gender affirming therapy (GAT) is not an authorised use, at least according to the United States Food and Drug Administration. Rather, they're prescribed "off-label". In short, there are no medications specifically *designed* for transgender HRT; we have to make do with what's available for those marked as cis (Rian Ciela Visscher Hammond also points to this issue in this collection.). As such, we are engaging in a form of self-experimentation. Yes, these medications have been prescribed for decades for HRT; nevertheless, the systematic long-term effects of the pharmaceuticals on our bodies are relatively unknown.

In short, we are transforming our bodies at the molecular level, shifting endogenous hormone levels that feel decidedly unnatural for us towards new possibilities, through "unnatural" exogenous hormones, that consequently help us feel more in line with the lives we want to live.

Xenological Transformations

In recent years I have been developing concepts around what I call *xenology*, or the study, analysis, and development of the strange, the alien, the other. The term originates in both science fiction and science fact, namely attempts to think about extraterrestrial existences (Brin 1983; Freitas, Jr. 1983). However, I expand the term beyond its original purview, encompassing the full breadth of what it means to be xeno. I write this as someone marked as a xenobody myself, an entity – a transgender woman – who is oftentimes not seen by others as fully human[3]. Xenology means not running away from the strange or alien, but rather highlighting it, foregrounding it, understanding it as a vital practice necessary to a world that attempts to be made homogeneous through capitalism.

While xenofeminism describes itself as a politics of *alienation*, xenology is fundamentally a practice of *disalienation* through xenomogrification (Laboria Cuboniks 2015). Capitalism alienates us from our capacity for extreme change via stupefying practices of value extraction. We become distanced from the universe-given possibilities for change, the varied and changing attractors that come into and out of existence because everything is in flux. Thus pushing towards the alien actually, paradoxically, allows for *disalienation*, which is itself an asymptote that can never be fully reached.

Xenomogrification is the grotesque – in all of the sense of that word – ability to transform ourselves into something else. Xenologists desire othering, know that the other and the strange and the alien is not something to be feared or to shy away from; instead, xenomogrification allows us to constantly make ourselves other, to explore the possibilities for existences in more-than-human worlds, on a

3 I also write this as a *white* transgender woman, and must acknowledge the immense privilege this brings me. While we do not know the full extent of violence against transgender people in the world, in the United States murder of non-white transgender women is all-too-prevalent (Remembering Our Dead 2019).

rapidly changing planet or in the challenges of outer space. To make ourselves alien is not the same as being alien. To practice as a xenologist, to engage in xenomogrification, is to develop conditions of not only survival, but *thriving* for xenoentities.

Of course, it has to be noted that the capabilities for xenomogrification are not evenly distributed. This needs to be remedied. It is also not going to be provided for us. As a result, we need to develop practices of do-it-yourself (DIY) and do-it-with-others (DIWO), repurposing technologies, developing our own techniques, infiltrating labs, and constructing situations for our own xenomogrification and for encounters with other xenoentities in the universe. While not explicitly xenological, many of the projects discussed in this volume engage in kindred practices.

DIY/DIWO as a Necessity

Little needs to be said about the ways in which institutions have failed people marked as other, from those seen only through the color of their skin or their ethnic background, their spiritual beliefs, the absence or presence of genitalia or secondary sexual characteristics, the visual-or-not traces of differences in ability. White, cis, male, able, wealthy, Christian: these are the characteristics of privilege, and the lenses through which institutions have constructed their practices. Xenologists – as well as other allies – know that this is unacceptable. To counter this, however, often requires delving into their privileged domains, doing the difficult work of being infected by alienating thoughtpractices, in order to arrive at something suited for our particular, singular, and unmet needs and desires.

In this vein is the work of transhackfeminism and the GynePunk collective.

> Tired of the useless and recursive manipulation of information, we study, construct and fail with all that is around us, with multiple, monstruous and hateful ends. From the expansion of information to the mutation of dispositives, we want to hack and recodify everything that is static and programmed by social and technological imposition. (Pechblenda n.d.)

Highlighting the need to not only understand Preciado and Python, engaging in "DIY electronics and sexual bricolage", a transhackfeminist approach foregrounds play and frustration, the questioning of conventional notions, the possibilities of how things could be other (Pechblenda n.d.). GynePunk members have created 3D-printed speculums for self-diagnosis of various kinds of cancers, open microfluidic devices and centrifuges, and cheap DIY microscopes – basically the tools to do gynecological analyses separate from the medical establishment. Alongside this is the practice of sharing knowledges through workshops, wikis, and online forms.

Referencing the cyborg of Donna Haraway, they write of and practice being "cyborg witches" and "cyborg bitches", literal illegitimate offspring of patriarchal technoscience (Pechblenda n.d.; Haraway 1991). Haraway's cyborg is indebted yes to subaltern practices, but additionally to the high-tech society of post-war neoliberal capitalism. As Alison Kafer has noted, quoting Haraway's text, its potential "arose from the cyborg's hybridity, its transgression of boundaries and categories; because it does not, or cannot, privilege unity or sameness, it offers 'a way out of the maze of dualisms' that characterize Western thought" (Kafer 2013). The cyborg's irreverence for boundaries additionally requires a *lack* of

purity, something well-known by those marked as other. To be "pure" is to already *not* to be marked as something different, and thus if one is already a xenoentity purity is not an option. This is everpresent in DIY/DIWO practices, as they often require reworking or engaging with distasteful entities in order to repurpose them for other ends.

Kafer's project importantly foregrounds the role disability plays into the trope of the cyborg, tracing the ways in which mass media uses the term in simplified ways. To refer to a disabled person as a "cyborg" merely because they wear a prosthesis erases the singular experience of a particular person, and the ways in which prosthetics are not seamless or innocent extensions of the body (Kafer 2013, 120–21). To xenomogrify ourselves is not always a choice we are allowed to make for ourselves and is not guaranteed to be pain-free. As such, xenological practices must take this into account, always keeping in mind the polysemous natures of the semiotics we use to describe our work.

Xenological Possibilities in Space

While not explicitly referenced in Haraway's text, Kafer notes the historical legacy of the cyborg term through the work of Manfred Clynes and Nathan Kline. Clynes, a polymath inventor and musician, and Kline, a psychiatrist working at a state mental institution in the United States, defined the cyborg in the context of space travel and necessary modifications to the body for the alien environment of space:

> For the exogenously extended organizational complex functioning as an integrated homeostatic system unconsciously, we propose the term "Cyborg." The Cyborg deliberately incorporates exogenous components extending the self-regulatory control function of the organism in order to adapt it to new environments (Clynes and Kline 1960, 27).

The cyborg of Clynes and Kline takes in these external elements and incorporates them into their body, as "Altering man's [sic] bodily functions to meet the requirements of extraterrestrial environments would be more logical than providing an earthly environment for him [sic] in space" (Clynes and Kline 1960, 26).

The gendered characteristics of the text by Clynes and Kline are indebted to their time period, yet very little has changed in the understandings of othered bodies in space. To date, only 11.5% of astronauts have been women (Wikipedia 2019). A recent review of knowledge about reproductive health in space has these sobering statements: "Reproductive changes during or post flight have not been systematically studied in female astronauts"; "With respect to women, estrogen and gonadal function in space and in simulated microgravity (bed rest) are grossly understudied"; 'a Medline search using the terms "spaceflight" and "estrogen receptors" shows no published research in this area'(Ronca et al. 2014, 968, 968, 970). The review made the following recommendations: "There is a crucial need for a coordinated effort to augment the infrastructure for basic research studies, with priorities established to include male and female subjects, human and animal, for the purpose of advancing understanding of sex and gender factors in relation to spaceflight"(Ronca et al. 2014, 971). This is the situation for cis-gender women; the possibilities of transgender people in space is not even considered.

Some of my current practice works to construct things differently. *TX-1* (2020) is a proposed

sculpture of my transgender hormone replacement meds, designed to be carried into low-earth orbit (LEO) in a specialised cubesat. *TX-1* will mark the first-known time that elements of the transgender experience orbit the earth. The sculpture consists of fragments of my spironolactone pills, a slice of my estradiol patch, and a miniature handmade paper sculpture, the latter included to gesture towards the absent-yet-present xenoentities of the universe. Each of these three components are encased in a small clear resin sphere that will float in a pocket that rotates at a rate that simulates the gravitational attraction of the moon (Figure 1). *TX-1* is scheduled to be launched to the International Space Station in early 2020, and return to Earth shortly thereafter.

As far as we know, no transgender people have been to space, even though we are, as well as disabled folx, perhaps the *most suited* to space travel given the xenomogrifications we make to our bodies for daily existence. In fact, these transformations are congruent with the necessary changes required for long-duration spaceflight. Yet we don't know if HRT is safe in space, given that the pharmacodynamics of these medications in microgravity is unknown. Given the limitations on who presently goes to space – able-bodied cis humans – *TX-1* therefore offers a symbolic exodus to space from a planet that is often inhospitable to us. Yet the additional fact that *TX-1* will return to Earth is also a sign of resilience, of not merely being disposed of in the upper atmosphere, but arriving on the ground once again (hopefully) in one piece.

As the GynePunk collective has done through their work, we are additionally going to need to create our own research program for xenoentities to go to space. As part of the tranxxeno lab[4], a new nomadic artistic research lab that I am the founding facilitator of, we will aim to create open source clinostats and random positioning machines (RPMs) for simulating microgravity; experiment on steroid extraction from plants grown in this simulated microgravity, extending the work of Mary Maggic, Rian Hammond, and others in this area to the space domain; and explore different kinds of kits, garments, and entanglements with more-than-humans necessary for survival and thriving in the space environment. Taking Clynes and Kline seriously, we recognise that us othered entities will be at the forefront of the alterations needed not only for space travel, but also for continued existence on this planet.

Care for Bio-Silico-Quantum Existences

Drawing from the work of Karen Barad, xenologists additionally revel in the fundamental entangledness of existences. For Barad, it is the *intra-action* of entities in particular phenomena that cause material configurations to come to matter (Barad 2007). These *phenomena* could be configured differently, each one creating a particular *agential cut* in the fabric of reality. We can choose different cuts to make, but we cannot choose to not make a cut. As a result, precisely *how* we make these cuts needs to be at the forefront of our concerns. DIY/DIWO practices, theorising about non-cis life in space: these activities already enact different agential cuts in our reality, creating new sets of phenomena to explore and experience.

It is not just enough, however, to create these cuts and generate new phenomena. We also must explore how to better *care* for the entities that are

4 See https://tranxxenolab.net.

created as a result of this work. María Puig de la Bellacasa's writing has been at the vanguard of this foregrounding of care for the more-than human: "it is not difficult to see how cyborgs and other hybrid beings can be called to support the importance of care in more than human worlds" as it allows us to "extend meanings of caring out of expected normalized forms of kinship to embrace the unfamiliar" (Puig de la Bellacasa 2017, 92)[5]. Care here is not to be understood as a passive practice, but something that actively restructures our environment:

Ways of knowing/caring reaffect objectified worlds, restage things in ways that generate possibility for other ways of relating and living, connect things that were not supposed to be connecting across the bifurcation of consciousness, and ultimately transform the ethico-political and affective perception of things by involvement in the mattering of worlds (Puig de la Bellacasa 2017, 65).

From a xenological perspective, then, care in more-than-human worlds needs to consider not just biological entities, but also those engineered to exist in silicon or quantum realms. Doing so may help us restructure our relationship to the other entities we share this universe with.

One of the more provocative speculations in this area is by Špela Petrič and Miha Turšič in their project from 2013 entitled *Voyager / non-human agents* (Figure 2). Considering end-of-life care for the Voyager space probes traveling beyond the edge of our solar system, they ask what our responsibility is to this entity as it slowly runs out of power, as it moves beyond our ability to communicate with it from earth. They write, along with co-author Maja Murnik,

> Rather than calling these non-functional objects "debris", we propose to treat them as "end-of-life allopoietic systems" with the potential of becoming autopoietic systems. […] However, outer space technology with its literal and symbolic remoteness presents an opportunity to transform utilitarian objects at their end-of-life into emancipated non-utilitarian living or life-like systems without the danger of interaction with the existing living systems of our planet (Murnik, Petrič, and Turšič 2013, 258).

Petrič and Turšič imagine uploading an artificial life program to the Backup Mission Load program – the code that is run when the probe can no longer communicate with Earth – that would use one of the science platforms on the probe as input. They chose the PLS, or Plasma Spectrometer, which is designed to measure the "velocity, density, and pressure of plasma ions" (Ludwig and Taylor 2002, 3). The project additionally asks us to think of the probes as artificial life forms themselves, wondering why the famous Golden Record was needed as a marker of human intelligence and life.

Recent research has shown how artificial life can even develop within quantum computers (Alvarez-Rodriguez et al. 2018). Through a practice of "quantum biomimetics", qubits can represent the genotypes and phenotypes of classical artificial life. However, using quantum superposition and entanglement, the qubits "are used for describing questions regarding the collective dynamics of individuals, and this is precisely the new source of complex behavior" the quantum artificial life algorithm can create (Alvarez-Rodriguez et al. 2018, 8). A representation of encounters over time thus exists in the entangled qubits. While quantum computing is still in its nascent stages, it is possible for anyone to develop and run quantum computations on quantum hardware[6]. We find ourselves in an analogous position to the early days of mainframe computing, where we are still unsure of what the possibilities of the new technologies will be; the difference now is far more people have access to these systems. Xenologists know that they must stay abreast of these developments and infiltrate the systems so as to develop possibilities unthought of by capitalist technoscience.

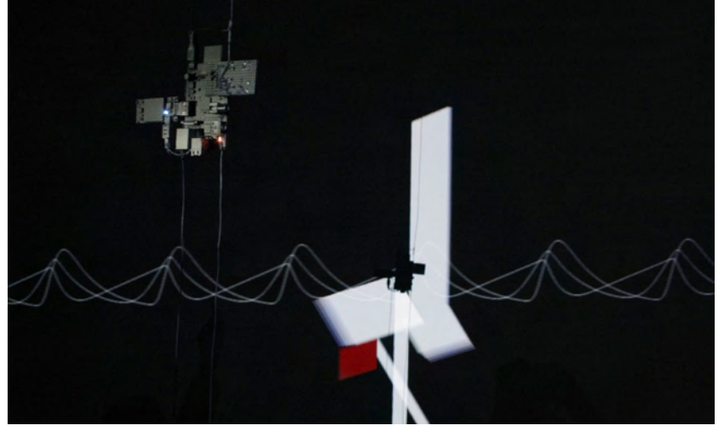


Figure 2 *Voyager / non-human agents* (2013–2014). Photo courtesy Špela Petrič and Miha Turšič.

An urgent desire of xenologists is to further entangle the bio/silico/quantum realms in practices full of vibrant possibility. How we care for these entities as we create ever more expansive phenomena, as we expand what we term "artificial intelligence", as we synthetically develop new biological constructions, is an open question. It is simultaneously vital for all of our future existences together in the universe.

5 It needs to be noted that indigenous practices have often understood a slipperiness between the human and the non-human (TallBear 2015).

6 See, for example, IBMs "Q Experience": https://quantum-computing.ibm.com/.

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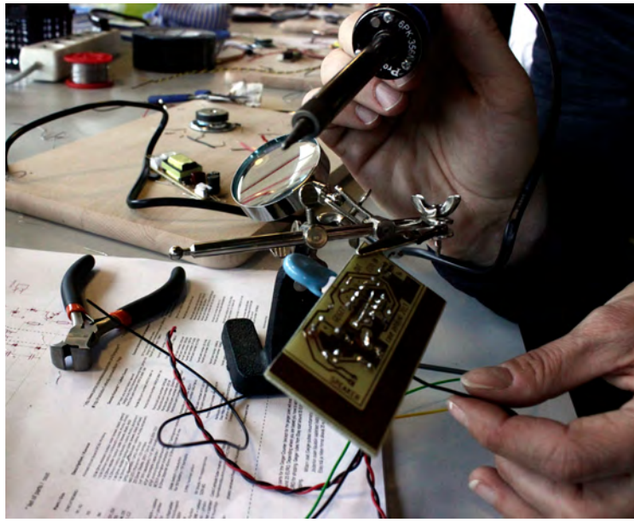
Curie's Children (glow boys, radon daughters)

Bioart Society, 2–5 June 2014

The Curie's Children (glow boys, radon daughters) workshop allowed the uninitiated to easily enter into a physical and intuitive relation to nuclear and atomic processes, following simple hands-on experimentation, construction and research. This relation promoted an understanding of the complex issues surrounding contemporary uses of nuclear technologies, which could inform and help formulate an artistic response. During the workshop participants were guided through their own construction of the radiation detector device, as well as further investigations, experiments, lectures, discussions, screenings, presentations and field trips. The detector was previously developed for the *Case Pyhäjoki – Artistic reflections on nuclear influence* project in 2013.

Participants Erich Berger, Clark Charlotte, Kristian Emil Hansen, Peter Flemming, Susanna Hertrich, Martin Howse, Stina Jörgensen, Mari Keski-Korsu, Joan Linder, Anu Osva, Gergana Petrova Romanova, Christina Stadlbauer, Antti Tenetz, Paul Vanouse

Testing mushrooms for radioactivity at the Palmutto uranium deposit. Photo by Martin Howse.



Building of the detector at Kaupunkiverstas. Photo by Martin Howse.

Erich Berger and Martin Howse measuring the natural radioactivity of the Hanhikivi in Pyhäjoki. Photo by Liisa Louhela.

I'am – Immortality's Anti-Marta

Marta de Menezes & Luís Graça, 2014

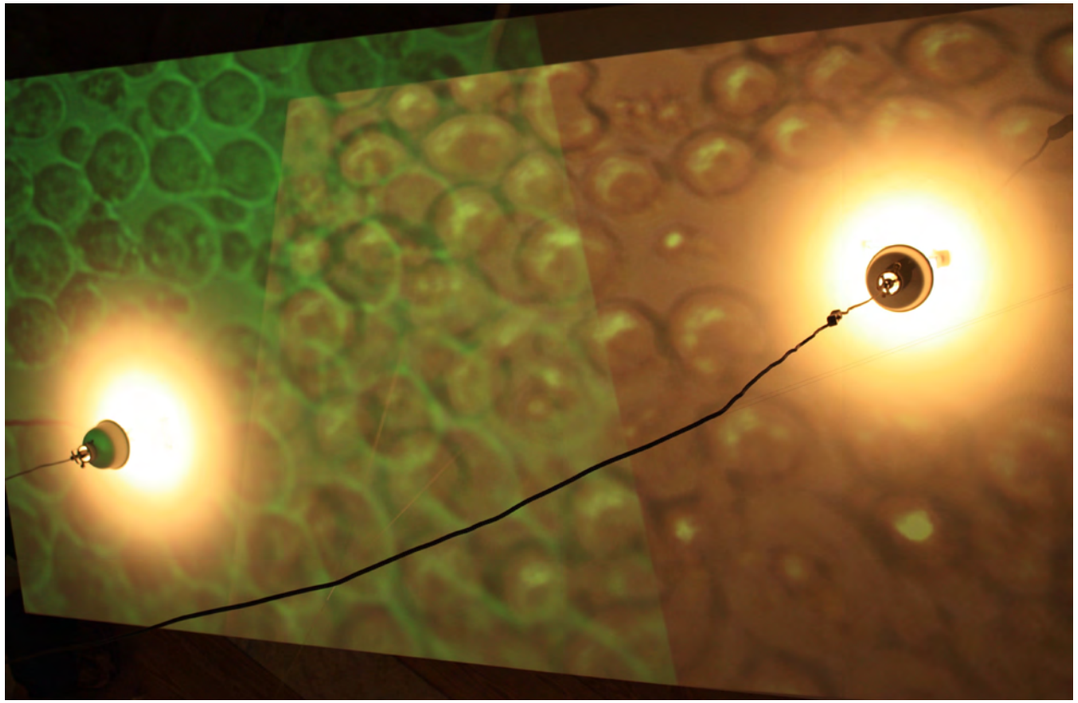
I'am is an installation diptych, comprising of *Immortality for Two* and *Anti-Marta*, exploring the limits of human individuality in the face of an evolving biotech-based society. It represents the relationship between an artist and a scientist, but also the boundary between art and science, and the limits of our own identity.

Marta and Luís, artist and immunologist, have a pact for life: mated, married, united. The search for an artistic representation of such a pact led to the immortalisation of each other's white blood cells using viruses or the transplantation of skin grafts. In both cases, the outcome reveals the tension between individuality and bonding. As the immortal cell lines are involved in immune defense, although derived from people in love, they need to be kept in perpetual isolation. The skin transplants were also rapidly rejected, given the immune differences. Yet, in both cases the pact can live on. The immortal cell lines can co-exist in the virtual space where the video projection of the live cell cultures intersect in the installation.

On the same note, the rejection of the skin led to the production of molecules (antibodies) that will forever be able to identify the other, alike the acquisition of a sixth sense that can be visualized through the isolation of appropriate antibodies. *I'am* shows how we can bond with one another, and yet still maintain a strong sense of identity. In *I'am* not only a woman and man assert their relationship and identity, but also an artist and a scientist demonstrate the connection of the two disciplines while maintaining their uniqueness.

Marta de Menezes is a Portuguese artist who explores the intersection between art and biology, working in research laboratories demonstrating that new biological technologies can be used as new art medium. Her work has been presented internationally in exhibitions, articles and lectures. She is currently a PhD candidate at the University of Leiden, the artistic director of Ectopia, an experimental art laboratory in Lisbon, and Director of Cultivamos Cultura in the South of Portugal.

Luís Graça is Professor at Lisbon Medical School, directing a research group in cellular immunology. His most significant scientific contributions have been related with the field of transplantation and autoimmunity. Graca has worked on strategies to overcome transplant rejection, as well as in the induction of immune tolerance in autoimmunity and allergy. Graca has collaborated with several artists, including a long-term relationship with Marta de Menezes.



Immortality for Two, 2014. Immortal cell lines of the Marta de Menezes and Luís Graça in culture and projected. Image courtesy of the artist.

Anti-Marta, 2017. Video projection of the surgery on the audience´ s arm. Image courtesy of the artist.

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Doing Away with Life – On Biophilosophy, the Non/Living, Toxic Embodiment, and Reimagining Ethics

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The question of life has been in the centre of attention since the inception of Western philosophy: the Pre-Socratics search for the essence of life – the basic principle (like "water" in the case of Thales, for instance) that gives rise to and sustains everything; Aristotle sees life's basic principle, *psukhē*, as its capacity for "self-nourishment, growth and decay" (Aristotle, *De Anima* 2.1.412a15), while simultaneously distinguishing between *bios*, the "good" life of citizens, and *zoē*, biological, vegetative life common to all organisms as well as gods; for Immanuel Kant the problem of life primarily appears in the form of the question of human as a living subject that engages with life as an object of thought. Such an ontological enquiry, driven by a double focus on the essence or principle of life ("life in itself") on the one hand, and its boundaries of articulation (that which delimits the living; boundaries between the living and non-living, human and non-human, and between species), on the other, as philosopher Eugene Thacker (2008) argues, forms the ground for the philosophy of biology.

But in the history of philosophy we may also find a different kind of engagement with life: that which evades the distinction between the essence of life and the living, leading to further divisions, and instead, focuses on a critical, creative, and rigorous practice of asking "What relations are precluded in such-and-such a division, in such-and-such classification [of life]?" (Thacker 2008, 141). It is in this way that Thacker understands *biophilosophy*: an investigation of life that pays attention to what transforms life instead of a twofold question of the basic principle and boundaries of articulation; an investigation that looks at life as a multiplicity, that traverses binaries, avoids anthropomorphisation, and pays attention to the issues of relations, their dynamics and mechanisms of exclusion, which demonstrate the ethical side of this primarily ontological enquiry. Apart from process philosophies (e.g. of Henri Bergson, Alfred North Whitehead, and Gilles Deleuze) that Thacker (2015) discusses, thus understood biophilosophy, as Marietta Radomska (2016) argues, can be found in the work of feminist philosophers and theorists: Claire Colebrook (e.g. 2010), Elizabeth Grosz (e.g. 2011), Patricia MacCormack (e.g. 2012), and Rosi Braidotti (e.g. 2006). Drawing on both philosophy and feminist theory as well as history of science[1], each of them, in her own way, looks at life not through the prism of an isolated "essence", but instead, focuses on the complexity of processes and relations. In their works, life is often conceptualised as a material force, an intensity, a form of dynamism, inventiveness, creativity, but also a

1 For example, Elizabeth Grosz looks at ways life and difference are framed in Charles Darwin's theory of evolution (e.g. Grosz 2004; 2011)

potential for destruction and idleness that extend beyond the organic.

The problem of life also comes to the fore in cultural studies of science, medicine and technology: for instance, as feminist scholar Sarah Franklin (2000) demonstrates, the late modern cultural understandings of life itself have been transformed by way of scientific advancements and their popularisation into the idea of life as "bits" of genetic information, being yet another version of the "basic principle" or essence. Thus reconfigured life became quickly both personalised, as in individualised medical therapies forged on genetic signatures, and globalised, as in new universalisms like panhuman genomes, and ready to be instrumentalised and capitalised upon as such (Franklin 2000; Åsberg 2005). Nature, detraditionalised, became in the 20th century equal to biology, which by the millennial turn became genetics and reprogrammable information, only to return as a backdrop for life itself in the decades after at the centre of discussions on climate change and ecological crisis.

In the present essay we argue for biophilosophy as a queerfeminist and posthumanities methodology that attends to the question of life by focusing on multiple differences and transformations, materiality and processuality, as well as relations, intra-actions, and disconnections. By combining both the ontological and ethical concerns that go beyond what is conventionally seen as "life", biophilosophy offers a critical and innovative approach to the issues of death, extinction, (un) liveability, terminality, and toxicity, among others, which all form the backbone of the environmental crises and changing conditions of life on Earth, often framed as the Anthropocene.

In what follows, we first discuss select theorisations and implications of the "life/death" coupling as an ethico-political question; subsequently we elaborate the concept of biophilosophy as a methodology; and finally, we propose two examples where we test biophilosophy as a framework that allows us: (1) to engage with the enmeshment of life and death through the concept of the *non/living*, and (2) to explore the concept of *toxic embodiment* as an onto-ethical condition we all (human and non-human) are differentially immersed in.

Background: An ethico-political question

In the 20th and 21st century "life" returns as a subject of epistemological and ethico-political concerns. While thinkers from Aristotle to Kant struggle with the distinction and discrepancy between "life" as a concept (essence) separate from the living, French philosopher and physician Georges Canguilhem suggests that there is no hierarchy or gap between knowledge (and thus, also conceptualisations) and life. Instead, knowledge is a form of life and "a general method for the direct or indirect resolution of tensions between man and milieu" (Canguilhem 2008, xviii), or, in other words, a "capacity to solve problems in new and creative ways" (Marrati and Meyers 2008, xi). According to Canguilhem, life (both in its human and non-human variety) is not a "blind and stupid mechanical force" (2008, xviii). Non-human life is not inferior in relation to human life: they are different and generate different kinds of knowledge.

Canguilhem's student and French philosopher Michel Foucault takes his teacher's epistemology and framing of life further by investigating biopower and biopolitics, that is, the ways the biological life of human individuals, populations, and species become the object of scrutiny, power, and modern management linked to politics, economy, and capitalism. His explorations of power that "make[s] live and let[s] die" (Foucault 2003 [1976]) are critically rethought by, for instance, Achille Mbembe who looks at the "contemporary forms of subjugation of life to the power of death", which he frames as "necropolitics" (2003, 39); Giorgio Agamben (1998), according to whom we should instead focus on "thanatopolitics": the "formidable power of death" (Foucault 1978, 137) that lays at the foundation of every legal system, including liberal democracies; Cary Wolfe (2012), who directs his biopolitical analyses towards non-human animal life; and Donna Haraway (1991) who looks at the material-semiotics inscribed in the biopolitics of modern biology and medicine, among others.

What most of these accounts have in common is a certain idea of what life is and an accompanying assumption of an attributed value, which in majority results in thinking about life "as we know it". It is life seen through the human prism (where the "human" is historically and "neutrally" based on the Western, white, heterosexual, able-bodied male) that gets the priority and privilege of protection and being "made live". Simultaneously, some human and most non-human lives are not "human enough", that is, not worth enough to be included in the mechanisms of biopolitical protection; on the contrary, they "feed" the other, thanatopolitical side of the machinery by being exposed to violence and "killed with impunity" (Agamben 1998, 47).[2] These processes, valuations, as well as adjacent paradoxes form part of what we observe and experience every day: anti-abortion discourses that give the precedence to the zygote or foetus over the life and choice of the pregnant person; the natalism of fascist regimes that become increasingly apparent in the contemporary European political scene (for instance, think about the pro-heteronormative-family politics of the current right-wing government in Poland that simultaneously constructs the "other" – be it a refugee, an immigrant, a non-white person, a queer, a political opponent, or even nature[3] – as a "pest"); euthanasia and its discontents; and a concern with certain endangered species combined with a complete disregard for others, to name a few.

While biopolitical analyses – in their different incarnations – give rich and multifaceted diagnoses of the complexity of mechanisms that affirm certain forms of life ("make live") and violate others ("let die" or, at times, "make die"), they seem to be lacking when the questions of ontology and ethics come into the picture: what is the "life" that becomes an object of these mechanisms? What is the relation between the living and non-living, and between entities and their milieus? Although Agamben's (1998; 2004) thanatopolitics may give us answers to the question of how a human being may turn into an instance of "bare life" exposed to violence and death, it fails to account for the material entanglement of life and death as such.

2 For Agamben (1998) the starting point for thinking of the relation between life and power/politics is Aristotle's distinction between *bios* and *zoē*. Agamben argues that, from its very beginning, all Western politics is founded upon the exclusion of *zoē*, the biological life of citizens, which – once politicised and thus, included in the legal systems through its own exclusion – becomes "bare life". In his analyses, Agamben discusses the legal figure of ancient Roman law: *homo sacer* ("sacred man"), "who *may be killed and yet not sacrificed* [emphasis in the original]" and whose life "is included in the juridical order… solely in the form of its exclusion (that is, of its capacity to be killed)" (1998, 12). By way of this "included exclusion" the boundary between *bios* and *zoē* becomes blurred. Drawing on Carl Schmitt's theory of sovereignty and logic of exception, Agamben contends that the biopolitical order has formed part of Western politics since antiquity and, therefore, is not limited to modern times. Rather, with modernity, biopolitics becomes *thanatopolitics*, a politics of death (as exemplified by the Holocaust and other genocides), where political power "produces" death, and life and death become increasingly indistinct in the state of "inclusive exclusion" (ibid.).

3 In 2018 the logging of the ancient Białowieża Forest, approved by the Polish government and motivated by the supposed outbreak of bark beetles came to the centre of attention of both the EU and international media (see e.g. Neslen 2018). In April 2018 the Polish Ministry of the Environment approved the extensive logging of another ancient forest, the Carpathian Forest (Puszcza Karpacka; see e.g. Jurszo 2018; Fundacja WWF Polska 2018).

Undoing Life: Biophilosophy as a Methodology

Against this background, we suggest that biophilosophy as a methodology (or strategy) allows one to address life – and its "counterpart", death – in both ontological and ethical terms: not by taking the basic principle or a certain image of life and its assigned value as a starting point, but instead, by tracing that which transforms life: multiplicitous processes, differences, and materialities that carry a potential for generation as much as for self-destruction (Radomska 2016). In this way, biophilosophy builds on Colebrook's reading of Deleuzian passive vitalism that does not draw a fixed distinction between a vital force and passive matter, since matter is always already a creative force. Passive vitalism looks at the differential relation of forces which may actualise in the form of bounded organisms, their living norms and meanings, but which are never exhausted by these elements (Colebrook 2010, 115). Forces allow for the emergence of bodies, but "if extended, would destroy the bordered organism" (39). In this way, biophilosophy sees the processes of living and dying, and growth and decay not as binary oppositions, but as complex interweaving and entangled phenomena. Thus, it also contests the Western cultural imaginaries that tend to draw thick dividing lines between bodies, between the human and non-human, organic and inorganic, and life and death.

Yet, biophilosophy also implies a concern with the complexity of relationalities, intra- and interactions, and connections and disconnections, instead of individual forms of life and the ways they may be classified. In the context of the contemporary environmental crisis, a biophilosophical ethical approach means not only responsibility for the protection or preservation of life, but also "acknowledging the end as an extended temporality that we already inhabit, rather than we are working to prevent" (Ensor 2016, 51). While combining queer theory and ecocriticism, literary scholar Sarah Ensor offers the concept of "terminality" understood as a state, a practice, an intimate belonging, and a horizon; in other words, a "lifelong" (54) and shared condition, characterised by the potential for relations, non-linear temporality, and an ongoing responsibility for and accountability towards the harmed, the ill, the perishing, and the dead (environments, ecosystems, organisms, and other entities). Staying with the trouble of terminality is but one example of the biophilosophical approach that does not start from a given image of life, but instead, from a multiplicity of relations, forces, and materialities (that which transforms and traverses life) encompassing the potentials for both growth/development and decomposition/decay.

In the next section, we focus on two above-mentioned cases that exemplify biophilosophy as a methodological approach at work. Firstly, we look at the concept of the *non/living*, proposed by Radomska (2016) as a more adequate way to attend to the material enmeshment of living and dying, and growth and decay, conventionally framed as "life". And secondly, we turn to the concept of toxic embodiment as a biophilosophical enquiry concerned with the human and non-human, naturalcultural bodies and environments marked by toxicity in their material-semiotic, ontological, and ethical sense.

The Non/Living

Etymologically speaking, the concept of the *non/living* consists of "non" and "living" separated with a slash. The gerund form of the verb emphasises the material processuality and dynamics of both an organic and an inorganic kind, while the slash ("/") points to the entanglement of living and non-living. As physicist and feminist scholar Karen Barad explains in the context of her theorisation of time, space, and matter, the potential of the slash lies in its "indicating an active and reiterative (intra-active) rethinking of the binary" (Juelskjær and Schwennesen 2012, 19).

Rethinking the life/death binary as the non/living stems from a theoretical and practical engagement with the contours of what is conventionally marked as "life". Firstly, the non/living addresses the issue of locating the constitutive characteristics of life, that is, what counts as life and how we account for life forms that do not fulfil the four basic criteria of the living (the entity has a body; it metabolises; it reproduces; and it is capable of movement)[4]. An iconic example of such an entity is the virus, which, in order to replicate, needs a host cell. This means that the criterion of reproduction combined with the passing on of hereditary information is not necessarily valid. Another case is prions, which do not contain any genetic material, or viroids, which consist only of circular RNA. Simultaneously, research in synthetic biology and chemistry provides further critique of so-called carbon chauvinism (Sagan 1973): for instance, scientists create inorganic protocells that fulfil most of the basic criteria for life (e.g. Hanczyc et al. 2009; Rasmussen et al. 2009; Szostak 2012).

Secondly, the non/living attends to the complexity of the relationship between living and dying: these are processes where material forces unfold, intertwine, and express themselves in what we evaluate as life and death. One of the art and science examples that expose this processual enmeshment in a very acute way is renowned *Victimless Utopia* (VU; 2003–2006), a series of bioartworks by The Tissue Culture & Art Project, which involves the making of the "semi-living" sculptures consisting of bioengineered animal tissues seeded on biopolymer scaffoldings of various shapes. The three parts of the series: *Victimless Leather, Disembodied Cuisine and DIY De-Victimizer Kit* (*DIY DVK 01*), in an ironic and provocative way, engage with technoscientific ideas of growing materials such as meat and leather in a laboratory. As the artists often mention, *VU* focuses on different forms of the consumption of animal bodies, and it challenges humans' hypocritical attitudes towards non-human life (e.g. concern with the destruction of tissues used in bioscientific research or art-science practice, combined with a disregard for non-human lives in industrial farming) in an explicit way (see e.g. Radomska 2017). Each exhibition during which the artworks are shown involves the "killing" ritual (often with the participation of the audience), during which the sculptures are removed from the sterile containers, contaminated through touch, and, later, "neutralised" as any other form of biohazardous waste. The moment of contamination is where the death of individual cells and fragments of the tissues overlaps with the growth of contaminants: life functions and the very materiality of the tissues become resources for the infecting organisms. It is these tissues that serve as food, dwelling, and support system for the fungi, bacteria, and viruses that contaminate them.

Another – perhaps more tangible example – is the corpse (of both a human and a non-human kind). The dead body of an individual is a lively site (cf. Mehrabi 2016), where elements of the microbiome of the body, along with other (micro)organisms flourish and continue to overtake the space and volume of the corpse. It is this liveliness of decomposition that leads to the corpse being perceived as "abject" (Kristeva 1982), repulsive, too "alive" and too "dead" at the same time. The materiality of the deceased body dwells in liminality, where the processes of growth and decay are entangled with

4 The question of the necessary criteria for the living forms part of the ongoing discussions on the definition and theory of life in astrobiology (see e.g. Cleland and Chyba 2002; Benner 2010) and chemistry (e.g. Luisi 2006; Griesemer and Szathmary 2009).

one another in viscerally visible ways and where the vibrancy of matter (Bennett 2010; Lykke 2019, forthcoming) is at stake. Acknowledging the non/living character of the corpse (both human and non-human) requires revisiting and nuancing our approaches to the "dead" body, beyond the double focus on either its "abjectness" or "sacredness" (reserved for the human corpse exclusively).

Toxic Embodiment

The concept of toxic embodiment refers to a condition where differentially situated human and non-human bodies, land- and waterscapes are immersed in the naturalcultural intra- and interactions with toxicity. A widespread and well-known threat to life, linked to the cumulative exposure to endocrine disruptors, neurotoxins, asthmagens, carcinogens and mutagens, has become part and parcel of the social imaginaries of science and popular culture. Humans and non-humans and the milieus in which they dwell are intimately linked through the "toxic kinship" (Opperman 2016; Cielemęcka and Åsberg 2019) that feeds the discussions on existential concerns around health, the environment, climate change, and ecological crises, broadly speaking. Terms like bio-burden or bioaccumulation circulate widely in the environmental social imaginary, injected by imagery and terminology from the natural sciences and popular culture. Bioaccumulation describes the processes by which toxic substances, industrial waste, and man-made chemical compounds gradually accumulate in living tissues (e.g. Chojnacka 2008). The highest concentrations of toxic pollutants find their way in organisms at the top levels of the ecological chain of being across the planet, including the deepest depths of the sea. The trans-corporeal (Alaimo 2008; 2010; 2016) transits of toxicity seem to spare no place and no body: industries leak waste into rivers and oceans, meteorological conditions transport contaminants to breast milk in polar zones, plastics seep endocrine disruptors into a myriad of sea- or land-living organisms (Åsberg, Hedrén, Neimanis 2013)[5].

Yet, the majority of anti-toxic discourses put emphasis on the "feminisation of nature", queering of animal bodies, chemical castration, low sperm counts, and reproductive and genital neoformations (e.g. Hayes 2002), while blaming those in need of hormonal treatment (e.g. in the form of contraception pills or hormone replacement therapies) for the presence of hormones in waters (e.g. DiChiro 2010; Chen 2011, 2012; Alaimo 2016; Davis 2015). Simultaneously, the same discourses downplay the role of big industries in creating other threats: high mortality, cancerous ecologies, extirpated habitats – in other words, who gets to suffer and die from the "slow violence" (Nixon 2010) of toxic compounds and socioeconomic vulnerability.[6]

Toxic embodiment as an onto-ethical concern allows us to investigate intimate relations between different kinds of materialities (bodies, processes, environments) and discourses. As a biophilosophical enquiry that builds on trans- and queerfeminist ecocritical scholarship (e.g. Mortimer-Sandilands and Erickson 2010; Ah-King and Hayward 2013), it takes us beyond the normative frames of what the biological life of an organism should be and enables us to "stay with the trouble" (Haraway 2016) of a "damaged planet" (Tsing et al. 2017). It allows us to critically examine and evaluate the dangers and potentials of transspecies toxic kinship, while identifying and resisting the mechanisms of "polluted politics" (Di Chiro 2010) or "toxic sexism" through which feminised, "monstrous", queer or crip bodies once again get casted as deviant.

Conclusion

The two conceptual examples discussed above: the non/living and toxic embodiment work as biophilosophical tools. Instead of "essence", "basic principle", or "norm", they focus on relationalities, processes, and modulations: they both undo life (as well as the body and the environment, as we know them). They both trace that which transforms life and takes it beyond itself: the non/living examines the entanglements between living and dying, and growth and decay; while the investigations of toxic embodiment pay attention to forces and processes that take bodies and milieus beyond their "norms" (cf. Canguilhem 2008). Furthermore, both concepts open up a critical and creative space for ontological and ethical reflection desperately needed in times when "our common present always exists in the wake of a complicated past, and ahead, to a common future that may best be understood as an ongoing end" (Ensor 2016, 55). In other words, biophilosophical approaches redirect our attention from essences and norms (as well as exclusions these often entail) towards processes, potentials, and possibilities of flourishing, surviving, living, and dying in the here and now.

5 Feminist and environmental humanities scholar Stacy Alaimo introduces the concept of "trans-corporeality" in order to capture the natural-cultural entanglements and relationalities between human and non-human corporealities and environments, while attending to the "porosity" of the flesh (that allows for the flows of different substances, including toxins, through various bodies and milieus) and "corporeal inseparability" of the human from its environment. As she emphasises, trans-corporeality refers to "the movement across human corporeality and non-human nature [that] necessitates rich, complex modes of analysis that travel through the entangled territories of material and discursive, natural and cultural, biological and textual" (2008, 238).

6 The notion of toxicity does not only feature in environmental science and discourses; it is a powerful metaphor that for decades has been used to describe that which "threatens the purity" of the normative notions of nature and the human. Non-white, queer, disabled, or otherwise non-normative bodies were marked as such threats in the eugenic programmes of Nazi Germany, USA, and elsewhere (cf. Chen 2012). As environmental science and policy scholar Giovanna DiChiro argues, "the dominant anti-toxics discourse deployed in mainstream environmentalism adopts the potent rhetoric that toxic chemical pollution is responsible for undermining or perversion of the 'natural': natural biologies/ecologies, natural bodies, natural reproductive processes…What are presented by many environmentalists as critical scientific facts (and quite rightly worthy of alarm) can, however, work to create a 'sex panic', resuscitating familiar heterosexist, queerphobic and eugenics arguments classifying some bodies as being not normal: mistakes, perversions, or burdens… The very *real* issue of the myriad grave consequences… of the widespread contamination and worldwide bioaccumulation in bodily tissues of hazardous chemicals known as POPs (persistent organic pollutants) becomes distorted by the alarmist focus on one piece of the story…the media fixation on gonadal deformities and sexual/gender abnormalities as the most treacherous concern ends up perilously de-emphasizing and, in fact, *naturalizing* and *normalizing* [emphasis in the original] the many other serious health problems associated with POPs, which are on the rise: breast, ovarian, prostate, and testicular cancers, neurological and neurobehavioral problems, immune system breakdown, heart disease, diabetes, and obesity" (2010, 201–202).

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One Hundred Thousand Cities of the Sun

Crystal Bennes, 2015

One Hundred Thousand Cities of the Sun explores the idea of future cities developed around existing and emerging nuclear technologies. Chinese engineers, working with technology developed in Germany in the 1960s, are building a new generation of smaller, safer reactors utilising thorium and hydrogen instead of uranium and water. *One Hundred Thousand Cities of the Sun* imagines what our cities might look like, how civic life could be transformed into cities with different kinds of work, infrastructure and community were it powered by nuclear energy.

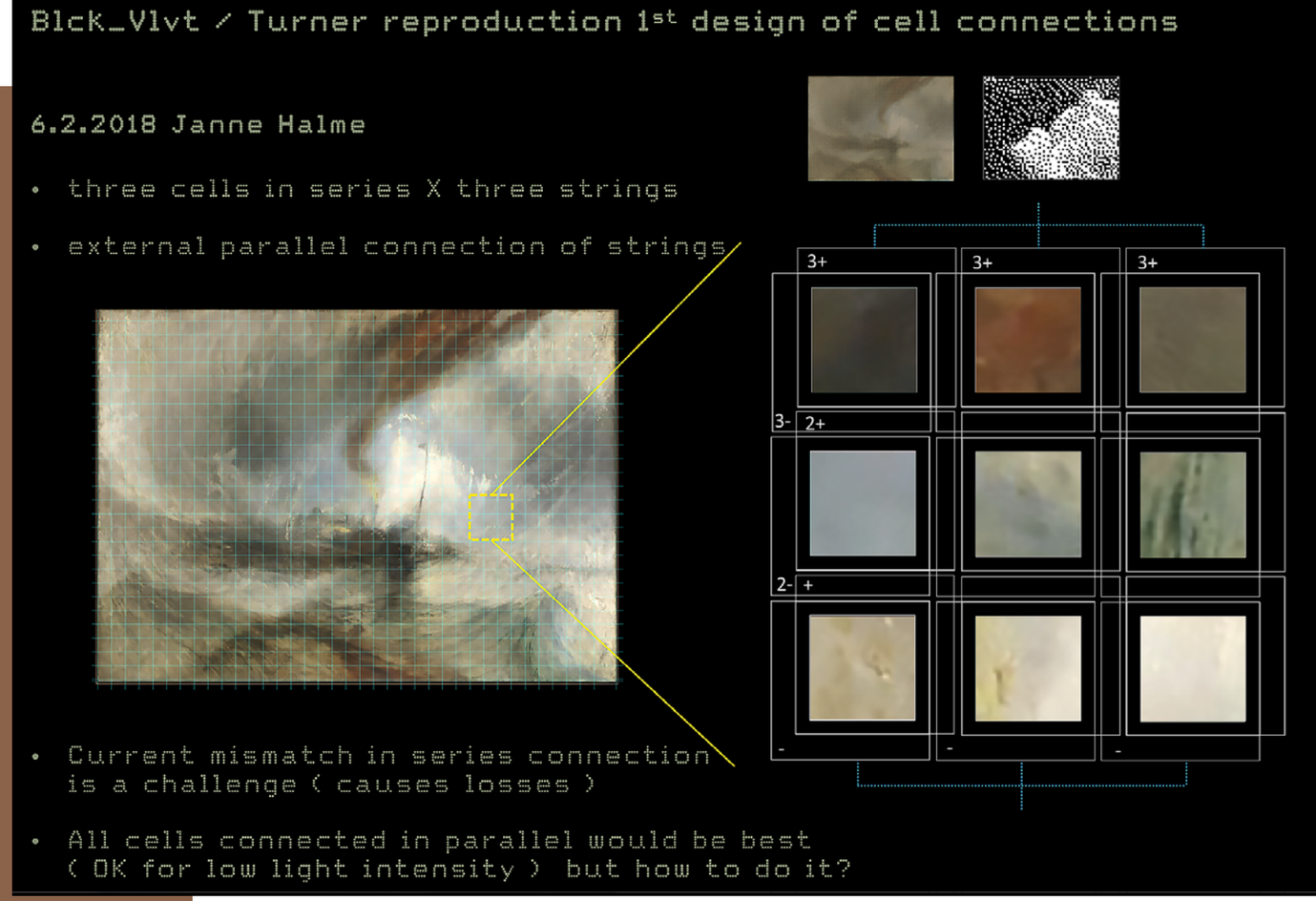
A single, highly abstract, topological scale model of a City of the Sun has been constructed from dense, nuclear-grade graphite recovered from the thermal column of FiR 1, Finland's first ever nuclear reactor (a TRIGA Mark II 100 kW research reactor), which ran from 1962 to 2015. Graphite is a commonly-utilised neutron moderator in certain types of nuclear reactors. The sculptural model is joined by a series of text-based propositions, imagining alternative urban scenarios drawn from nuclear history past, present and possible future.

Crystal Bennes is a writer, visual artist and occasional curator. Her work has been exhibited at Science Gallery Dublin, Pierre and Marie Curie University in Paris, the Serlachius Museum in Finland, and the St Petersburg Public Library in Russia. She had a solo exhibition at Huuto Gallery, Helsinki in 2017, and was selected as one of Finland's best emerging artists in 2015. She is currently undertaking a practice-based Fine Art PhD at Northumbria University.

One Hundred Thousand Cities of the Sun, 2015. Images courtesy of the artist.

Blck Vlvt

Bartaku, 2011–



Troping Turner. Installation Mixed-Media. Detail: hand-made dye sensitized solar cell glass pieces (Bartaku archive), lab grade solar glass and fungal tissue frame (Manuel Arias Barrentes (Department of Design, Aalto University) and Geza Szilvay (VTT). Photo by Bartaku, 2018.

Baroa belaobara (scientific name: *Aronia melanocarpa* [*Michx.*] *Elliot*) and its microbial companions *Pseudomonas fl. and Bacillus m.* and *Aronia mitschurinii*.

A collaboration of Bartaku, Janne Halme & Pyry Mäkinen, Paulo Pinho, Merja Penttilä and James Evans / Marika – Aalto University Schools of Arts, Design and Architecture / Electrical Engineering / Science / Chemical Engineering and Biofilia Lab for Biological Arts.

Blck Vlvt is a research process in which an artist and scientists seek to assist the *Aronia m*. Barao b. plant in commenting on the painting *Snow Storm – Steam-Boat off a Harbour's Mouth* (exh. 1842) by J. M. W. Turner. Artistic practice collides with solar cell science, plant lighting technology and synthetic biology. Gradually a biotope evolves with a cyclical, leaky process of thinking and making that embraces serendipitous opening of unexpected scientific and artistic avenues and works. The transdisciplinary enquiry is galvanized by a common tangible goal: a prototype for a "living" interspecies Baroa b.-based solar cell that morphs and reflects upon *Snow Storm*.

The ongoing research process fuses artscience talks, writings and artworks. Two examples (2019): installation *Troping Turner*, which features a U.V. version of *Snow Storm*, archival solar glass cells and a fungal frame; *A Gift to the prime minister*. is an intervention in which Bartaku hands over two gifts to the Belgian prime minister during a "climate change mitigating technology event": a highly inefficient appleberry-based Belgian flag solar cell as well as a sketch of Belgium being a Baroa b. plantation.

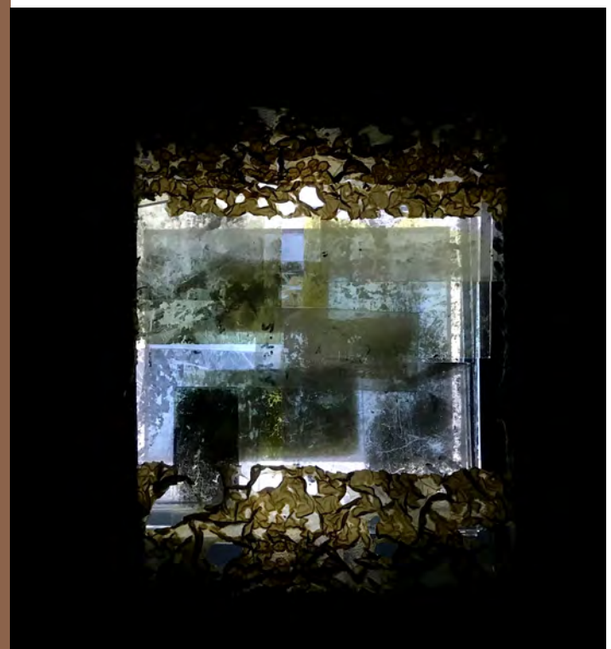
Absorbing reflection, reflecting absorption

The grass holds the shadow of the deer.
Next to the curly river it is, under the tiny trees and thick bushes.
Where the soil climbs up, it is. Gently towards
the first Baroa belaobara roots.

Towards mid-day now. The peel loses its darkness.
A reflector of light it becomes. Hiding its existence to eyes wide shut.
I see you, on the other side.

Bartaku

Bartaku's main interests lie in cognitive ecology, consciousness studies, neurobiology, energy and the philosophy of knowing and becoming. His practice is often process-based, collaborative and situated in the folds and cracks of formal classifications. Most renowned is the questioning of mankind's relation with energy in *temporary Photoelectric Digestopians*, featuring edible solar cells and human tongues. His entanglement with the *Aronia m*. Babe berryapple develops in the form of practice-based Doctoral studies at Aalto University.



Blck_Vlvt / Turner reproduction 1st design of cell connections. Painting: *Snow Storm – Steam-Boat off a Harbour's Mouth*, exhibited 1842; Joseph Mallord William Turner 1775–1851; Tate, Accepted by the nation as part of the Turner Bequest 1856; Photo: © Tate, London 2018. Sketch by Janne Halme, 2018.

Radical Witnessing and the Scope of the Real

Erich Berger

Erich Berger is an artist, curator and cultural worker based in Helsinki. Throughout his practice he has explored the materiality of information, and information and technology as artistic material. His current interest in issues of deep time and hybrid ecology led him to work with geological processes, radiogenic phenomena and their socio-political implications in the here and now. He moves between visual arts and science in an area which he also investigates and develops as director of the Bioart Society in Helsinki.

Personal accounts

Since 2009 I have returned almost every year to the Sána fell in Kilpisjärvi, Sápmi, in the sub-Arctic region of northern Finland. Besides being visually impressive, it is one of the few sites in Finland which opens a clear window into deep time, the timeframe of the geological past.

Standing on the shores of lake Kilpisjärvi at the Kilpisjärvi Biological Station, I look towards the Sána fell rising up steeply in front of me. My feet stand on the solid granodiorite of the Archean basement rock which is more than 2 billion years old. It is only partially covered by a scattering of pebbles and boulders, remains of the last Ice Age in the region, and the thin layer of soil produced by weathering and life since the beginning of the Holocene.

I close my eyes and imagine the first ever autumn in Kilpisjärvi following the Ice Age. The first ever leaf touches the ground after a short and cold summer. It rests upon a footprint which is also a first for the land; it is that of a human who followed the reindeer which are now pushing north as the ice retreats.

I open my eyes and decide to follow the path which leads me counter-clockwise around Sána. Whilst walking I can see the topmost layer of Sána, an Arkose quartzite which was moved over the land during the Caledonian mountain orogenesis around 420 million years ago, underneath it are patches of yellow beige dolomite which nurture the plants and lichens beneath and enrich the meagre soil.

I am on the lookout for a thin layer in these sediments of the deep past, probably not more than one or two meters in thickness. At the end of the Precambrian, a bit more than 540 million years ago, the shales and slates of the Dividal group were laid down, and with them the first preserved treptichnus traces of animals on records.[1] They were made by little worm-like creatures named *priapulid*[2] wiggling in the mud. I encounter the traces in what we now call *the valley of time*[3] – the right wall of the valley is 500 million years of age while the opposite is 2 billion years – separated by a little stream and 10 meters. [Fig. 1]

1 These trace fossils have been found in 2013 by Erich Berger and Antero Kare by systematically investigating the Dividal group outcrops on Sána fjell.

2 Visual identification by Dr. Björn Kröger, University of Helsinki in 2018.

3 Dubbed by curator Taru Elvfing during a hike to the site.

Figure 1 Sána. Photo by Erich Berger, 2013.

A few years after my first visit to *the valley of time* and about a hundred kilometres further east, I cross a rivulet which has formed a little pool. In it two worms trace the bottom, leaving little curves and circles – it is still happening.

Machine with concrete is a work by Arthur Ganson. A series of gears are attached to a spinning motor with the final gear embedded in concrete. Each gear pair of the machine reduces the speed of the motor by 1/50th. With the motor turning around 200 revolutions per minute, it will take well over two trillion years before the final gear makes but one turn. Given the truth of this situation, it is not possible to do anything at all with the final gear, you can even embed it in concrete (Ganson 2008).

I am at Onkalo, which means hidden place, located in the Eurajoki municipality on the Finnish west coast and in the distance, I can see the reactor building of the Olkiluoto nuclear power-plant. Finland is the first nation which decided to build a permanent nuclear waste storage facility. Around the year 2120 the final encapsulation and burial of Onkalo will take place. The access tunnel will be back-filled and sealed, and multiple barriers are said to keep the waste away from groundwater for the next 100,000 years.

I imagine the next Ice Age which is said to cover the land in about 30,000 years. I imagine the sound of ice on rock and rock on rock, grating steady and patiently towards the nuclear waste storage chambers located 500 meters deep in the bedrock. They are made of layers of steel, copper and clay.

This copper is dear to me. I had found a rock, composed of feldspar and elementary copper in Helsinki which ended up as a footnote in the database of Posiva, the research company in charge of Onkalo. My find counts among many others as material evidence that copper can withstand contact with the Onkalo bedrock without being altered.

Will the chambers hold – and if not – who or what will make the first encounter with the storage chamber's content? Or will it take several of such decanting attempts until the chambers spill their freight? Perhaps nothing will happen because the ice will distribute the load? Perhaps everything in its way will die? Perhaps black fungus will thrive at what once was the west coast of Finland? Deep future will tell.

Rare Earthenware by Unknown Fields Division deals with the ecological dimensions and scales of radioactive waste in REE production (Unknown Fields Division 2014), (Victoria and Albert Museum 2015). The work aims to materialise what Rob Nixon calls slow violence "… a violence that occurs gradually and out of sight, a violence of delayed destruction that is dispersed across time and space, an attritional violence that is typically not viewed as violence at all." (Nixon 2013). With artisan sophistication, the artists produced three Chinese Ming style vases made from the exact amount of toxic clay produced in the manufacture of three objects of technology: the smart phone, the laptop and the electric car battery cell. The slightly radioactive and toxic vases offer a dark irony between cultural heritage and the hidden heritage of toxic waste which will make the land useless over many generations.

Deep time – Deep futures

Deep time is understood as geological time: the history of earth from its beginnings as a molten ball of matter until the present (Zen 2001). Deep futures do not exist yet, they are a thought vehicle to speculate within the probability space of a future earth, folding and unfolding during the long time our planet still has (Ellsworth, Kruse 2013). Modern geology started with James Hutton, he understood that the time required by the processes to form and alter the landscapes around him, cannot possibly conform to the then current idea of the age of the Earth, which was 6000 years. This estimation came from calculations done by biblical scholars (Repcheck 2003). Hutton's theory caught on but people were unsatisfied with his notion of Earth's "unknown and unidentifiable age" (Hutton 1785).

The quest for the age of the Earth followed: Charles Darwin claimed the Earth to be 300 million years old, Lord Kelvin 20 million years. The discovery of radioactivity and the realisation that the steady decay of isotopes could be used as a geologic clock lead Bertram Boltwood in 1907 to class the age between 400 million and 2.2 billion years, until 1927 when Arthur Holmes dated the age to 1.6 billion years. At the beginning of WWII 3.3 billion years was the accepted proposal, until in 1956 Clair Patterson arrived at the number of 4.6 billion years which is still the accepted age for our planet (Repcheck 2003). Patterson used the oldest solid material known to us, Zircon crystals, which he found as part of younger sediments, to perform the dating. To date, the oldest Zircons have been found in the Jack Hills in Australia and confirmed to be 4.4 billion years old (Valley 2014).

Alongside Western science there are also non-Western deep times in the mythologies, stories, religions and sciences of other and bygone cultures. The longest timeline I have found is chronicled by the Mayan culture, dating creation back to 24 trillion years (Looper 2003). Interestingly Hindu cosmology comes closest to Western scientific cosmology, counting the age of the universe as well in time spans relating to billions of years (Sagan 1985).

In *Campo del Cielo, Field of the Sky* Katie Paterson worked with a Campo del Cielo meteorite fragment. It has travelled through space and time for over 4.5 billion years. It was cast, melted, and then recast back into a new version of itself, replicating its original form. The meteorite was later returned to space by the European Space Agency (Paterson 2012–14). [Fig.2]

I am writing this in Helsinki which is built upon Svecofennian bedrock roughly 1.8–1.9 billion years old (Nenonen, Portaankorva 2009), this is a similar time frame as the first fossil records of eukaryote cells (Betts et al. 2018). Some of the oldest putative eukaryote fossils known from Sweden and other places in Scandinavia were found by late Gonzalo Vidal (1943–1997), a Spanish/Swedish palaeontologist from the University of Uppsala (Knoll 2003). Eukaryotes are a group of organisms with cells with a nucleus and membrane-bound. Unicellular eukaryotes are the ancestors of all modern day more complex multicellular organisms such as algae, plants and animals including us humans.

During this geologic era, the earliest global-scale continent-continent collision belts also developed. We can see the remains of one of them when we read the landscape around Koli National Park in Finland, viewing the Finnish national landscape from the stumps of the Koli Karelides, a mountain range believed once to have reached alpine heights (Nykänen 1971). In deep time, about 550 million years ago, when our *priapulid* worms left their traces, the Helsinki area is estimated to have located close to the south pole (Cocks, Torsvik 2006). Over the next 250 million years in deep futures, it will move east maybe towards the location of today's

Figure 2 Katie Paterson, *Campo del Cielo, Field of the Sky*, 2012. Photo © Giorgia Polizzi, 2012. Commissioned by the Royal Borough of Kensington and Chelsea, London.

north shore of the Caspian Sea in Kazakhstan (speculation based on current drift directions and velocities).

If we go further in time, the assumed end of our planet will begin in about 4.8 billion years. The sun will start to expand when its hydrogen core is exhausted. A loss of mass will change the orbit of the Earth and additional processes will likely have our planet end up engulfed by the sun, with Earth's sole legacy being a very slight increase of the solar metal content. Life as we know it however will most likely not find favourable conditions after the next 1–2 billion years. These assumptions do not take into account possible random events, like collisions with astronomical bodies, a close by supernova or other possible catastrophes.

If we look at the Earth's timeline, we can see that life and its fossil records mark Earth's dynamic history, showing six mass extinction events in the past, which are from the point of view of life a catastrophe but not from the perspective of the planet. I doubt that there have been fewer catastrophic events from a human point of view before those records – it is only since complex life and its geological records exist that we relate to these events.

In his digital photographic series *NATURALE*, Ilkka Halso gives up on ideas previously explored by him of repairing nature. Instead he stores it away in endless corridors and shelves for an unknown day to come (Halso 2014).

However human future will play out, the geologic future is sourced from a geologic past, one which we currently make use of, shifting the past into the present.Within the strata of our Earth we find the substances which provide us with energy and material foundations; the carbons and hydrocarbons of petrol, gas and coal are of biogenic origin, the fossils which fuelled human ascent[4] and which we now lay down again robbed of their energy onto the current layers of the earth.

Another energiser of our extraction-based civilisation is uranium. Interestingly, the genesis of

4 as laid out in the Petrophilosophy of Salminen and Vadén s Energy and Experience (Salminen, Vadén 2015)

uranium deposits is linked with the biosphere as well (Hazen et al 2009). The great oxidation event 2.2 billion years ago, the shift from anaerobic to oxygen metabolising life, set free the oxygen to oxidise the finely dispersed uranium making it water-soluble. This was a precondition for further enrichment of the deposits we now mine.

In deep time and deep futures life, rocks, and elements all build one big dynamic system. We live off previous life, and not only from its organic but also its inorganic products. This shows that within big history the division we readily draw between organic and inorganic processes becomes blurry and intertwined. It shows that life as such, and us in particular, are part of the Earth's systems and in no way special or separable. We can even go further and meditate on deep time by imagining that every single atom which makes up our body was once produced by a star and sent forth as supernova, intermingling with primordial hydrogen and other elements produced by cosmic processes. Hence the famous Carl Sagan quote: "We are made of star stuff" (Sagan 1980).

In *The Iron Ring* Cecilia Jonsson forged an iron ring with iron extracted from plants growing and foraged in an iron mine in Spain. Beside its comment on pollution, it also challenges the understanding of what we consider to be part of the living domain and the mineral domain. For The Iron Ring, 24kg of iron-tainted grass was removed from contaminated mining grounds and transformed into a ring of 2g metallic iron. (Jonsson 2013) [Fig.3]

Anthropomemes

The proposal of an Anthropocene (Crutzen, Störmer 2000) started with the realisation that the planetary impact of human activity is able to change the Earth system itself. This proposal was soon endorsed by the arts, humanities and social sciences (Demos 2017), and quickly turned into a ravel of contemporary discourse. At the time of writing it is not yet clear if the term is scientifically useful, and when in time and where in the strata the Anthropocene should be anchored to fulfil the scientific requirements for announcing a new geological unit (Working Group on the Anthropocene, 2018). The term finds strong resonance amongst artists and scholars. It is evocative and welcomed for summarising a moment of global crisis, and at the same time also under strong critique and scrutiny for its unsatisfying generalisation and anthropocentrism (Haraway 2015). Alongside its obliteration of the responsibility of a few over the many, it also mostly depicts a bleak apocalyptic future.

The work *Longplayer* by Jem Finer is a one thousand-year-long musical composition. It began playing at midnight on the 31st of December 1999, and will continue to play without repetition until the last moment of 2999, at which point it will complete its cycle and begin again. More than a piece of music, Longplayer is a social organism, depending on people – and the communication between generations – for its continuation (Finer 1999).

This has led to an interesting deconstruction of the term in the form of "anthropomemes" (Braidotti 2017), various synonyms which are emerging to emphasise different aspects and readings of the Anthropocene. Since January 2015 I have become an avid collector of these serious but also playful rewordings. Some are from renowned scholars and used in the academic Anthropocene discourse, others have been made up on the spot to pinpoint or highlight a certain personal interpretation or aspect. Some are also caricatures but all come with

Figure 3 *Iron Ring*, Cecilia Jonsson, 2013. Photo by Stina Glømmi. Courtesy of Kunsthall Grenland.

the intention to deconstruct and re-politicise the Anthropocene:

> *Anthropocene* (Eugene Stoermer and Paul Crutzen), *Misanthropocene* (Joshua Clover and Juliana Spahr), *Anthrobscene* (Jussi Parikka), *Chthulucene* (Donna Haraway), *Plantationocene* (Ethnos conversation University of Aarhus), *Capitalocene* (Andreas Malm and Jason More), *Racial Capitalocene* (Francois Verges), *Nuclear Anthropocene* (Ele Carpenter), *White Supremacy Scene* (Nicholas Mirzoeff), *Manthropocene* (Kate Raworth), *Northropocene* (Kate Raworth), *Anthropo-not-seen* (Marisol de la Cadena), *Undocene* (Antti Tenetz), *Hypocricene* (Erich Berger), *Androcene* (Thierry Bardini), *Schnubeleduldidlocene* (Marc Dusseiller Dusjagr), *Šmanthropocene* (Marc Dusseiller Dusjagr), *Plasticene* (Edie Jolley), *Endcene* (Peter Flemming), *Psychozoic* (Камчатка Дрешер), *Psychozooikon* (Камчатка Дрешер), *Connectozoic* (Каоокммчатка Дрешер), *Prokaryocene* (Simon Park), *Smog-o-machine* (Carolyn Angleton), *Oops-a-day-cene* (Tiina Prittinen), *Anthro-what-not-cene* (Rumen Rachev … (Berger 2018).

The excavation of relations between deep time, the now and deep futures points towards a geologic turn (Turpin 2012) in the arts and humanities. It leads to geologic practices and thinking which go beyond the earth sciences to probe and apply questions of deep time and deep futures to intentional and unintentional human activity.

Time(s)

There is a dichotomy between the perception and understanding of time in everyday human life, and the time of biological, environmental and geological processes which we as humans are part of and which run on very different timescales. We know of processes which are immensely short like quantum effects in plants during photosynthesis (Thyrhaug et all 2018), up to the unbearably long performance of landscape folding in continental drift (Wegener 1915). The aforementioned dichotomy arises because we as individuals are currently asked to adjust our way of life and contribute to projects and measures to secure a future, which we will not be part of and for people which we will never know. With challenges like nuclear waste or climate breakdown in mind, it is not a gamble to say that most individuals, most of us, lack a foundation on how to discuss, decide and prepare for deep future matters.

These deep future matters go often hand in hand with potential catastrophic scenarios which we are constantly exposed to[5]. They fire people's imagination and go hand in hand with many end of the world scenarios, especially when confronted with out of the ordinary phenomena in the near future (Horn 2014). The resulting emergencies and urgencies do not help in navigating the unknown territory of deep futures.

Inheritance by Erich Berger and Mari Keto consists of precious jewellery, a necklace, earring and a brooch, which are radioactive and therefore rendered unwearable for deep time, until the radionuclide decays into a stable and non-radioactive isotope of lead. The jewellery is stored in a concrete container together with items for radiation measurements built to endure over a vast amount of time. With these items, the story goes that each

5 financial crisis, bird and swine flu, Ebola, near earth asteroids, etc. etc.

time the jewellery is handed over from one generation to the next, the ritual of measurement, performed by the family members, determines if the jewellery can finally be brought into use and fulfil its promise of wealth and identity, or if it has to be stored away until the next generation (Berger, Keto 2016). [Fig.4]

The times which my text highlights run on scales which are outside of the human comfort zone. This is also addressed in an interview with Benjamin Bratton where he speaks about the practical necessity to design to *the scope of the real* (Bratton 2016). According to Bratton, when it comes to processes of vast and inhuman complexity, most designers and artists attempt to downsample and downscale the complexities to make them suitable for human experience, and try in such a manner to create an understanding for the underlying processes. His proposal is to head into the opposite direction: "Design scaled to the scope of the real, not reality downsampled toward the digestible" to quote Bratton directly, and which I find equally challenging for the arts on such matters. Bratton does not further specify what he means with the scope of the real, but for me it is to accept and acknowledge the materiality, processes and time of a thing[6] in their totality.

I am interested in situations and moments when we humans are pulled out of the sensorial comfort zone and are confronted with the scope of the real, resulting in a spectrum of sensations including awe and horror, greatness, angst, ignorance and impotence, or a rare and deeply felt calm if granted a glimpse of eternity. At all events it is a philosophical ground zero from which emanate aesthetic, ontological and epistemological tremors[7] – but as we have to face up to the real – also with actual consequences.

The Utah-Tarim connection is a work by Dutch Artist Gerrit Van Bakel. It links two huge level stretches of the world's surface: the salt flats of Utah in America used for rocket car high speed records and the immense land mass of the Tarim plain in Asia to the North of Tibet. While the Utah wheel takes on the high-speed monsters with its own speed of 18 mm per day, the machine for the Tarim basin crawls at about the same speed across the 1100 km of this plain and will, according to Van Bakel's calculations, take about 30 million years to cross it. (Van Bakel 1982) [Fig.5]

Radical witnessing

I think of the Tarim machine becoming part of this environment, its times and people coming and going, being assisted and maintained over deep time, being witnessed and bearing witness itself. A couple of years ago when discussing keywords for a publication text for my work *Polsprung* with Armin Medosch the term radical witnessing came up as a descriptive term for the installation, with radical in its meaning of going to the roots, of being fundamental. Part of *Polsprung* (Berger 2014) is an observatory to witness a polar reversal. Most estimates for the duration of a polarity transition are between 1,000 and 10,000 years. The German word sprung means jump, and such a reversal is a jump in deep geological time but in relation to a human life it is nearly motionless. So the radical element here is to let the reversal act out in its own time instead of translating the polar transition to the visitors

6 I call this a thing for now in lack of a better term, but some readers might substitute the thing with object, matter or other substantives.

7 A footnote for the elephant in the room – the SUBLIME.

Figure 4 *Inheritance*, Erich Berger and Mari Keto, 2016. Radioactive necklace and broche. Photo by Anders Boggild.

Figure 5 *Tarim machine*, Gerrit Van Bakel, 1982.

timeframe, which would only be a downscaling of the reversal into the human sensorial comfort zone. The collection of evidence as the process itself outlives any singular witness, every visitor one might even say the work itself is becoming the witness answering to whomever is asking for evidence.

I propose radical witnessing as an artistic strategy that fully embraces the scope of the real. Radical witnessing is to stage attempts for a thing[8] to articulate itself to whomever is asking for evidence. Radical witnessing performs the evidence of the thing s material and temporal properties, and of the processes which it enacts. With radical witnessing, the thing is not represented by something else, like a representation or relation which would pull it into a different maybe more comfortable frame of reference for us. In this sense the real is neither symbolic or gestural, it enacts independently from my knowledge of it the real is performed by the thing.

I started this text with a question in mind: Can an understanding of deep time lead to an understanding of the present, and are there artistic strategies which would allow us to perform the Anthropocene? My short list of artistic examples which address matters of deep time and deep futures is easily extendable. They share a few modalities which I think are intrinsic for radical witnessing even if probably incomplete. There is a radicality in time, to apply the inherent time of the thing, process or system in question, for it to be able to play out itself under its own time and conditions like the *Longplayer* or *Polsprung*. This also implies a radicality in material and integrity, to use the material or phenomena itself as carrier of evidence and meaning as we can find in works like *Inheritance* or the *Tarim Machine*. I would like to highlight a radicality in enfolding a space of possibilities: to fathom the scope of the real in a full spectrum between plausible and impossible which we can find in the work of Ilkka Halso and Katie Paterson. Also radicality of convergence is clearly visible: an effort to explore the confluence of previously separately thought concepts and categories, as with the *Iron Ring*. Finally, and very importantly, is a radicality in deconstructing generalisations and historical or predominant hegemonies of the present and the future, like we can see with the constant emergence of new Anthropomemes.

I am not claiming newness. I like to think of things which act in and over time as time vehicles. We know of them from the past and if we look carefully, we find some of them acting in the now. They convey messages and power in the form of stories or memorial monuments. Like Tsunami stones, some more than six centuries old, dot the coast of Japan, are a silent testimony to past destruction. The stones are warnings across generations, telling descendants to avoid building below its elevation. But as we as humans engulf ourselves intentionally or unintentionally into processes which outlive us as individuals, we could as well equip ourselves with the necessary tools and languages to understand them. Radical witnessing in this sense is a continuous effort to produce evidence and experience on the scope of the real, and perhaps a constant negotiation between an objective and subjective life world.

8 Here we go again ...

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Paradise in Mind – Living Landscape

Antero Kare

Ancient art, in Finland rock paintings from the Stone Age, has constructed our consciousness to see these art sites as sacred. Especially hills and mountains represent permanent greatnesses, and this sanctity reaches out to the surrounding landscape.

Under the rule of Sweden and Russia our national identity grew rapidly at the beginning of 19th century. The literal ground was the national epic *Kalevala* (1835), poems collected from northeast Finnish territories. The national romantic movement reached its peak between 1890–1910, when visual artists (Gallen, Järnefelt, Halonen), writers (Aho), musicians (Sibelius), architects (Blomstedt) and many scientists discovered the untouched nature of eastern Finland as the national symbol, foundation of heritage and most important asset and resource.

The central area was Carelia, and its highest hill Koli. Wilderness and nature were the heroes of this paradise of the mind. The visual actors were: air = clouds, mist, rain; water = lakes, waves, wind blowing paths to the blue; rock covered by grey moss; trees = curly branches as proof of fight against elements.

Symbolic landscape grew to the basic national icon. Carelian biosphere represented the authentic, immemorial, permanent and a sense of unity.

Koli become a test for me, a contemporary artist, if it would still hold a similar strength of waking such strong experiences and lifting emotional synthesis.

In 1985 I made the first pilgrimage and similar honeymoon to the mountain as painter Eero Järnefelt. "...only the truth is eternal" was his motto, and "to look at is not the same as to see" another. I had produced my first microbal living pieces the year before, and now the next project was to take living microbe examples from the same objects and places as the national romantic movement artists: air, water, soil, trees, rocks. And paint a vast panorama looking at lake Pielinen, with the real living microbes from the site.

Antero Kare is an artist, curator and teacher based in Helsinki Finland. He is considered as one of the pioneers of bioart. From 1985 onward he has produced "living art" by microbes and chemicals. Kare has shown extensively in Europe and the USA. He has been elected to the board of the International Art Critics Association, founded the New York Foundation for the Finnish visual artists and was the rector of Tampere School of Art and Media.

Antero Kare collecting living organisms from the air in Koli 1985. Photo by Iiris Autio.

Conver-gences

cellF performing with AGF,
Heureka Science Centre,
Helsinki, March 2019.
Photo by Mari Kaakkola.

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Hybrid Ecology – To See The Forest For The Trees

Laura Beloff

Laura Beloff is an internationally acclaimed artist and researcher across art-technology-science. She has been actively producing artworks and exhibiting worldwide in museums and art events since the 1990's. She is a recipient of various grants, residencies and awards throughout the years. Her research and art practice focus on combination of technological and biological matter with theoretical concerns on insurmountable technologization of the world. Since the Fall 2019 she is an Associate Professor in Aalto University.

This morning I asked my teenage daughter what she thinks of as wilderness*. She referred to the track for running and skiing, which runs through the forest near her grandparents' countryside home in Finland. She said that the track and several meters of forest alongside it are not* wilderness*, but about five to ten meters into the forest would be* wilderness *for her. She explained that in that part of the forest humans have not made visible, large-scale transformations such as tracks or roads, and even when walking on a small path formed by frequent human use, humans can feel as though they are "a part of nature", not dominating it. She compared this to nature preservation areas, which she pointed out are regulated by humans: "In preservation areas humans have prohibited themselves to touch nature. It is not real* wilderness *when there is such a control.*[1]"

Introduction

In this article *forest* is chosen as a case study that is to a large degree perceived with a Finnish and Nordic perspective, and mainly in the context of art. It appears timely to address forest and its meaning today (2018–19) when the Finnish government is pushing for an increase in logging, while simultaneously there is an on-going public debate about the importance of carbon sink, that forests offer and which is an important factor in the challenges brought forth by climate change[2].

Forest is used in the article for exemplifying technological transformations concerning the natural environment – especially, the present and the future state of natural environment where different actors and aspects are increasingly merged to form new types of organisms and systems in which technological and biological elements have become one. The proposed concept, *hybrid ecology*, is developed within the arts; it refers to artworks and art practices that deal with the environment and biological matter. In these works, natural environment is no

1 Personal communication between the author and Ada Beloff, September 2018.

2 https://www.luke.fi/sompa/2019/02/05/blogi-miksi-hiilinielut-ovat-yhteiskuntapolitiikkaa-2/
https://yle.fi/uutiset/3–10651076

longer the romantic ideal of 'nature' or *wilderness*, but an ecology that is a complex aggregate of biological and technological parts in a world accented with socio-economic interests. The selection of artworks, which are described in the article are considered as antennas of sorts for changing environmental and societal conditions, as well as experiments in *hybrid ecology*.

Additionally to the core focus on forest and its human-made technological transformation, there are two intertwined concepts that play a role in the formation of *hybrid ecology*; *wilderness* or *wildness* is an aspect that is being re-evaluated in today's world, and *ecology* that is used as a framework and model that connects different actors, processes, conditions, dependencies, things and situations. These concepts form a base for the concept of *hybrid ecology*, which poses questions on our current situation, in which technological and rational thinking dominates the natural environment to an increasing degree. The artworks presented in the article do not solely deal with a natural environment per se, but reference a larger paradigm concerning the concept of ecology and the current understanding of the term.

This article is written from the perspective of an art practitioner[3] in experimental arts with an interest in investigating the ways in which technology and scientific development impact our understanding of the natural environment, relations to non-humans, and the human-nature relationships which emerge from these influences. This relates closely to the central theme in the author's artistic practice during the last two decades: the merger of technological and biological matter – initially focusing on the phenomenon in human enhancement, and more recently, on convergence of the natural environment with technology and its technological framing imposed by humans[4].

On forest

Forest has a deep resonance in Finland and other Nordic countries; it is the landscape that is possibly the most representative of Finland, Sweden and Norway. Forest is also widely represented in culture and art throughout the history of these countries. A quick survey reveals a number of interesting artworks that have forest or trees in a center position – many of them are by artists from the Nordic countries. In this article, I reference a selection of works which in various ways reflect upon and address human impact on the natural environment, especially the focus is on works that are intertwined with contemporary technology.

As the first example, Swedish artist Helga Steppan has turned the lens of a camera to trees in her environment in the project *I can Hear you, can you see me?* (*The Baumbeobachter*). She writes:

3 When stating that this article is written from a perspective of an art practitioner, one can ask what is the point of writing when one considers making art as her primary expertise? – Writing is a way to bring forth the field, the topics and the artists' perspectives, which are otherwise not much written about. It is also a form of practice, which is not meant to explain the artworks, but to articulate interests and thoughts surrounding the works and creating a context for them. Writing is a mode of intellectual activity parallel to art creation. Both modes can investigate similar or shared topics on a different medium.

4 It is worth mentioning that the locus on *forest* resonates with the author's extensive artistic interests throughout decades towards natural environment, which is evidenced e.g. with the large-scale experimental photography works by the author that were dealing with forest and cultural landscape. Some of them were included in an exhibition at Sara Hildén Art Museum in Tampere, already in 1994, which offered an art historical overview of Finnish forests in art. Exhibition 7.5.–28.8.1994: *Katso metsää – Kuvia ja kokemuksia* and the exhibition catalogue with the same name. https://www.tampere.fi/ekstrat/sarahilden/arkisto/aikaisemmat/71.html [accessed 20.4.2019]

Figure 1 *Hear you, can you see me?* (*The Baumbeobachter*), Helga Steppan, 2014. Photo courtesy of the artist.

> One strange tree trunk by the side of a road, two, three, four mysterious deciduous trees and a whole forest of very rare and peculiar conifers. All around the traditional English landscape you will find different species of these strange trees, and once you have discovered one, you will soon realise that they are all around you, living in an odd symbiosis with nature.[5]

The trees in her focus are synthetic; they are mobile phone masts that are camouflaged to become part of the natural surroundings. Steppan speculates if these strange trees are simply a natural part of our technological society that reflects the contemporary nature they grow in?

Art historian Rainer Fuchs writes:

> The idea of nature as an idyll remote from civilization, as an inviolate counterworld to our own industrial and technological society, arises from a historically determined form of the suppression of history (Fuchs 2017, 225).

An idyll is a good description of typical representations of natural environment in art throughout the 20th century. For example, a large amount of paintings by 20th century artists in the Nordic countries include elements of the natural environment such as trees and forest, and the most of them picture a natural environment what could be described as idyllic[6] [7]. In these paintings from earlier times, trees and forest flourish freely and untamed. One can say, in reference to Fuchs, that these images show a kind of counterworld that opposed the ongoing industrialisation of the time. A comparable contemporary approach is presented in the work *Clear-Cut Preservation* by Mari Keski-Korsu. *Clear-Cut Preservation* is a video recording made continuously between 2010–2017 (one image captured every hour) of a hectare of forest, that was clear-cut in 2010 and afterwards left untouched without any maintenance[8]. In general, forest and the natural environment have been frequent topics in Nordic art in the past and remain relevant today. However, in many recent works the idyll is hiding behind another kind of reality–as is evidenced in the projects by Helga Steppan and Mari Keski-Korsu.

What is a forest? The popular online resource Wikipedia defines it to be simply "a large area dominated by trees."[9] Whereas Chazdon et al., introduce more complex and contextualised definitions that take into account different perspectives. According to them, forests can be seen as a source of timber products, an ecosystem composed of trees along with myriad forms of biological diversity, a home for indigenous people, a repository for carbon storage, a source of multiple ecosystem services, or as social-ecological systems (Chazdon et al. 2016, 538–550). Meanwhile, the Natural Resources Institute in Finland offers a numerical or statistical perspective to forest e.g. in the following numbers: forests cover 33% of Europe, 12% of which are under protection[10]. This can be compared to Finland where forests cover 73% of the land, of which 13% are protected[11].

One can claim forest to be a part of the Finnish psyche and an essential aspect of culture. However, forests have also been an important economic factor throughout the recent centuries. Finland has resourced its forests for economic benefits since the 16th century. For a long time, forest provided protection, firewood for heating and food for foraging in the everyday life of people. As a renewable resource, it also opened up possibilities for economic development through the production of goods, such as firewood, tar, and carved wood beams. These were the first articles to be exported to countries outside of Finland. Later, during the era of industrialisation, steam power pushed the sawmill industry into rapid development and forests began to be perceived generally as an industry and a valuable resource (*Metsäalan Ammattilehti* 2012; Kuisma 2006). The cutting down of forests was happening at such a speed, that during the 19th century a fear emerged that Finnish forests would disappear. This fear led to the establishment of an official forest management institution in 1859 by the Russian Czar Alexander II. Since then this establishment, which is today called *Metsähallitus*, has been the principal institution for monitoring, promoting and maintaining Finnish forests. Today the same institution is also responsible for nature conservation tasks (Metsähallitus 2015). Throughout the 20th century, the Finnish state developed a strong and versatile industry around wood, forestry and paper-production that continued until the last decades of the 20th century. However, the situation is different today as around 60% of Finland's paper-production capacity resides outside of the country (Metsäalan Ammattilehti 2012).

This short summary of the development of forestry in Finland demonstrates that most adults in Finland today have grown up in the midst of industrial development that has treated forests to a large extent as an economically profitable product – which can be cultivated, organised, modified, sold, and manipulated with an aim for economic profit.

One can easily draw harsh conclusions about these societal and economic developments of the forestry industry, and its impact on the way the natural environment is perceived and treated by us today. But parallel to this, Finns have also developed a strong forest-culture, which has matured with the long-term reciprocal interaction between human and forest. Forest-culture is defined as values, conventions, perceptions, and meanings concerning a forest that are also shared with others. This is claimed to be visible today in multilateral values and uses of forests, both in trade and in recreation and lifestyle (Museovirasto 2016). The online national repository for intangible cultural heritage claims that everyone living within Finnish culture has a relationship with forest, which in one way or another connects to one's history, background, environment, lifestyle, or to one's cultural perception about being Finnish or living in Finland (ibid).

On one hand, forest is seen as a valuable economic resource, while on the other hand there exists a strong forest-culture. It seems that our relationship with forests and the natural environment fluctuates between a romanticised idyll and active engineering efforts. This fluctuating relationship between the romantic 'natural' and the rational is also visible in artworks when examined in depth. At first

5 https://cargocollective.com/helgasteppan/Works/I-can-Hear-you-can-you-see-me-The-Baumbeobachter [accessed 16.9.2018]

6 To mention a few names from the first half of the 20th century: In Finland E. Järnefelt, P. Halonen and E. Thesleff among others; in Norway e.g. E. Munch, and numerous others. In depth research on Finnish national landscapes in painting at the turn of the 20th Century has been done e.g. by Ville Lukkarinen & Annika Waenerberg (Lukkarinen & Waenerberg 2004).

7 Though this article primarily includes examples of artists and works that use or reference digital technology or digital infrastructures, one should mention the Finnish artist Jussi Kivi who has worked extensively with the topic of landscape and forest. Kivi claims that 'wild' or untamed forest is today primarily found in the pages of adventure books. https://mustarinda.fi/magazine/art-and-ecological-transition/secret-of-the-black-forest [accessed 29.9.2019]. Kivi's criticism is pointed at the way we have created human infrastructures within the natural environment, such as parking lots, radio masts, asphalt roads, benches, stairs, cooking facilities, etc (Kivi 2010). One could also say that these facilities on one hand provide easy access to 'nature' via these infrastructures, but on the other hand they offer a pre-contemplated and *designed experience* of nature for us.

8 http://www.artsufartsu.net/clear-cut-preservation-exhibited-in-kohta/ [accessed 20.4.2019]

9 https://en.wikipedia.org/wiki/Forest [accessed 20.9.2018]

10 https://www.luke.fi/ [accessed 10.8.2018]

11 https://www.luke.fi/tietoa-luonnonvaroista/metsa/metsavarat-ja-metsasuunnittelu/suomen-metsat-euroopassa-vuonna-2015/ [accessed 10.8.2018]

Figure 2 The *Tree Mountain* in April 2019, photographed from a human perspective. Laura Beloff, 2019.

glance it seems that the romantic, and sometimes mythical, relationship with forest dominates in art. However deeper investigation reveals contemporary artworks and approaches that present perspectives, in which the natural environment is seen as a resource.

Antti Laitinen's artwork *Forest Square* from 2013 is presented as three colour photographs of a full-grown living forest, an empty square in the middle of a forest where the trees have been cut down, and a grid-like structure of different materials from the cut trees. One should point out that Laitinen's works have a clear relation to some of the earlier traditions of land art and environmental art in his systematic ordering and reordering of natural materials. Laitinen writes about his work:

> I removed a 10 × 10-meter piece of forest and sorted it into it's different materials: soil, moss, wood, pines, etc. I then rebuilt this piece of forest and arranged the different materials by colour.[12]

The piece by Laitinen is comparable to Ilkka Halso's digitally constructed series of photographs titled *Naturale*, 2011[13]. In these pictures, the entire natural habitat has been broken down to separate elements of stones, trees, soil, etc. These elements and modules are neatly ordered on the shelves of a gigantic warehouse, ready to be purchased and re-assembled into new ecosystems. Both of these works, by Laitinen and Halso, can be seen in reference to human desire and attempts to control nature; to re/organize it, to capture it into strict structures and to document or construct it newly with the help of technology.

The historical land art work, *Tree Mountain* by American artist Agnes Denes presents a different type of approach[14]. The work consists of a newly constructed landscape, including a forest. This large-scale art work was constructed in an old sand pit as a part of the restoration process in Ylöjärvi, Finland in 1996. However, according to Denes the actual development for the work begun already in 1982[15]. *Tree Mountain* was commissioned by the Finnish Government in 1992 in connection with the Earth Summit in Rio de Janeiro. Denes has written about the work:

> The planting of trees holds the land from erosion, enhances oxygen production and provides home for wildlife. This takes time and it is one of the

12 https://anttilaitinen.com/forest-square/ [accessed 20.8.2018]

13 http://ilkka.halso.net/ [accessed 20.8.2018]

14 Agnes Denes is considered as one of the pioneers of Environmental Art, but she is often also referenced in connection to *Land Art* that developed in the 1960's and 70's primarily in USA.

15 http://www.agnesdenesstudio.com/works5.html [accessed 20.9.2018]

reasons why *Tree Mountain* must remain undisturbed for centuries.[16]

The work is projected to be protected for 400 years through inheritable documents that the individual planters of each tree pass onto the next generation or transfer to someone else suitable. This group of people are "proud custodians of the trees that bear their names and grow through the centuries to a lush manmade virgin forest." [17] Today this work can be seen in direct connection to Finland as a country of forest engineering as well, as it exemplifies the mindset that has been evolving alongside the developments in science and technology. *Tree Mountain* deals with living natural organisms, which are situated onto a strict mathematical pattern within the engineered landscape – in a way one can say that computational thinking has been imposed over the landscape as an inherent part of the work. On her website Denes describes this combination: "The trees are made by nature, the mathematical positioning created by the human intellect to form a true alliance of man and nature."[18] Today, the mathematical pattern formed by the trees around the slopes of the mountain is hardly perceivable when walking among the 2–4 meter high trees. However, the pattern is clearly visible in the drone footage filmed during the winter 2017 that can be found online[19]. Interestingly, the video also reveals how some of the trees have thrived while others have grown much slower. Strata.fi, which is a production and maintenance organization for environmental artworks in Finland, wrote in 2013 on their website that they have finalised the archive of the GPS-coordinates for each tree, which is aimed at helping the custodians of the trees to locate their 'own' tree by navigating with the support of their private mobile phones.

The artworks described above reveal some aspects of our relationship and attitudes towards the natural environment and its development. Some of them present multi-layered constructions directed for the human perspective, in which the natural environment presents one component and another component is provided with digital technology. For example, the recently developed GPS-coordinates of the trees in Denes's *Tree Mountain*, provides a digital access point to the work, while the online drone footage presents a novel perspective for perceiving the work in the 21st century. The work has been updated with the contemporary communication technology and because of that is today forming a different kind of constellation compared to 1996 when the work was eradicated.

On Ecology

The concept of ecology is today widely used within various fields beyond the natural sciences. Scholar Erich Hörl points out that there seem to be hardly any areas which cannot be considered the object of an ecology (Hörl 2017, 4). Even this article takes the point of departure from a traditional understanding of ecology in its relation to nature or the natural environment – it aims at pointing out that ecology is not a simple nor innocent term. Ecology brings with it a whole field of thinking, debates and

16 Ibid.

17 Ibid.

18 Ibid.

19 https://www.youtube.com/watch?v=dTmGfXayIPA The drone footage by Margus Eimre in Ylöjärvi. [accessed 10.9.2018]

Figure 3 *Robot as a Tourist*, Niki Passath, 2012 – incubation phase after returning home. Photo courtesy of the artist.

disciplinary developments from biology and life sciences to cybernetics, communication and media theories, and philosophy among various other areas. Recent years have also seen a growing interest in the concept of ecology in the arts, as evidenced by numerous publications, art projects, and exhibitions which articulate their focus by using the term ecology. For example, the *techno-ecologies* term used e.g. by Eric Kluitenberg (Kluitenberg 2012, 9–15), *deep ecology* developed by Arne Næss and referenced by David Rothenberg (Rothenberg 2012, 19–23), *emergent ecologies* by Eben Kirksey (Kirksey 2015), *Three Ecologies* by Felix Guattari that has been widely referenced in theory and art practice (Guattari 2000), and an edited volume by Wiedemann & Zehle that presents *a glossary of networked ecologies* (Wiedemann & Zehle 2012).

Austrian artist Niki Passath's project *A Robot as a Tourist in the Sub-Arctic and the Consequences of our Travel* began during the 2011 Field_Notes – Cultivating Ground event in Kilpisjärvi, Finland. Passath had brought one of his small-scale robots with him, which he took for walks in nature to enjoy the surrounding environment. Later, after the project was finished, Niki Passath observed that his

robot's appearance had changed, as something was growing on its surface:

> Can it be that it has been infected with nature? To me it gave the impression that a big amount of different fungi and maybe bacteria use the robot as their habitat (Passath 2013, 242).

After weeks of care and provided nutrients, small clear traces of moss and lichen began to appear on the robot's surface.

> The robot embodies the colours of the sub-Arctic through living organisms. I wonder when the robotic part of this symbiont will disappear and only the living part can be seen (ibid, 245).

The term ecology was originally coined by biologist Ernst Haeckel in 1866 as

> the investigation of the total relations of the animal both to the inorganic and to its organic environment [...] in a world, ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence (Egerton 2013).

Whereas according to Hörl, today the concept of ecology has undone the sutures that bound it to nature and also, it is no longer seen in opposition to technics and to the mind. Hörl writes:

> Ecology has started to designate the collaboration of a multiplicity of human and nonhuman agents: it is something like the cipher of a new thinking of togetherness and of a great cooperation of entities and forces, which has begun to be significant for contemporary thought [...] (Hörl 2017, 3).

Hörl also argues that it is technological evolution that drives the contemporary re-ecologisation of thinking and of theory. Since the 1950's, the evolving environmental culture of control has been tightly related to cybernetics with the hypothesis of universal controllability and a corresponding ideal of regulation (Hörl 2017, 4–5). Since 2000, we are witnessing an emergence of an environmental culture of control according to Hörl. In his articulation, environment is used in a very wide sense. It includes e.g. sensorial and algorithmic environments, that are embedded with environmental media technologies such as bio-, nano- and geotechnologies (Hörl 2017, 9).

Similarly, as the use of the term ecology has increased, also the use of the term environment has become more frequent. One can make an assumption that these increases in use are to a degree impacted by the environmental challenges that humanity is facing, which are today being addressed by various fields. Art historian Andreas Broeckmann has recently defined the words *environment* and *ecology* in the following way:

> "environment" is a given context of a living being in which specific factors exert an influence on the organism and its living conditions, "ecology" is construed as a comprehensive system in which all forces, objects, and beings are seen as interdependent. The environment is organized centrally, around a given focal point, whereas ecology is a relational system that is horizontally organized, a network without a center, and that does not reserve a particular ontological position for human beings (Broeckmann 2016, 224).

In a sense one can say that the ecological paradigm is the dominant framework for perceiving life and lifeworld in the second decade of the 21st century. The concept of ecology encompasses a perception of our current time and situation; it

emphasises the complexity of actions, interactions, processes, conditions, dependencies, connections and relations within a heterogeneous community of organisms and their environment. It points out the fact that we, humans, are existing in a complex ecological system with other organisms, artifacts and modes of understandings.

In this article, the term ecology is used to refer to an understanding that goes beyond a natural environment as a subject matter, and entails an awareness of its present-day use and meaning in many contemporary contexts. The author has previously referenced the term *hybrid ecology*[20] to describe artistic investigations focused on complex ecosystems, which emerge from relations, connections and interactions between living and life-like organisms and their environment, which is a mix of natural and technological parts (Beloff 2019, 209–228). The concept resonates with Broeckmann's definition of ecology as a horizontally organised network without a center, but in which one can observe various biological actors together with technological actors and infrastructures.

In short, *hybrid ecology* refers to a situation in which ecology is formed by a diverse community of synthetic, biological and technological organisms interacting with each other and components of their living habitat. This community includes organisms that are: biological and have fully evolved and grown by biological forces in the environment; they may be 'naturally evolved', human-constructed or -modified but they are based on biological matter. It may also include fully technological or synthetic organisms, which are made to be autonomous and intelligent. Similarly, the living environment consists of components that are organic or inorganic, passive or active and artificially constructed or biologically emerged. This environment can be responsive, intelligent, and potentially networked.

Although this article presents *hybrid ecology* mainly in relation to natural environment, forest, and tangible technology, it is important to point out that the concept includes also in-vitro manipulations and modifications of various organisms. Synthetic biology, gene modification, gene editing and other biotechnology methods and developments are as much a part of *hybrid ecology* as are other types of technological applications and engineered innovations. With the use of biotechnological methods, the recognition of human impact on organisms is more challenging as the modifications are often in the level of genes and invisible for our biological perception. Today a large part of the genetically modified, or newly constructed, organisms are never leaving the laboratory regulated by law, e.g. European Union legislation on GMOs (Genetically Modified Organims)[21]. However, as these organisms exist, they are a part of the human-made ecology and therefore need to be included in the considerations of *hybrid ecology* and posthuman encounters with natural environment.

20 Note: I should mention that thinking about *hybrid ecology* started already several years earlier with my (the author's) art-based interests in the merger of biological organisms and technological matter. One of the milestones on the way was the project *Hybrid Matters* (2015–16) together with the Finnish Bioart Society and partners from Sweden and Norway, which was funded by the Nordic Culture Point. Another milestone is the author's chapter in the *Digital Dynamics in Nordic Contemporary Art* publication edited by Tanya Toft Ag (Beloff 2019).

21 https://www.loc.gov/law/help/restrictions-on-gmos/eu.php [accessed 20.4.2019]

Figure 4 The rotational tests with fir trees and a cloned Danish Christmas tree in a rotation box – a detail of the installation *The Condition* (2016) by Beloff & Joergensen.

Towards hybrid ecology

Although the concept of *hybrid ecology* is developed within the arts and in reference to artworks, one can also see the convergence of technology and environment in various fields ranging from robotics and synthetic biology to urban planning and data science.

The Geo-Amazonia-chapter of the *Forest Law*[22] publication by artist Ursula Biemann and architect Paulo Tavares, shows a data-infused view of the Amazonian forest. It describes and presents data mapping of the fantastic wind-based nutrient supply from the Sahara Desert to Amazonia. This natural phenomenon has been known and studied for decades, but just recently has a detailed digital map of the sand and wind trajectory been produced by scientists. The map is based on ground measurements and computational atmospheric models.

> The forest has become a vast informational space: at once a natural laboratory and an Earth-sensing device. Amazonia is equipped with a sophisticated network of environmental surveillance formed by a dozen giant monitoring towers spread throughout the most remote zones of the forest. Datasets on soil, water, and atmosphere gathered on the ground, combined with information provided by radar and satellite imagery, are assembles into "deep cartographies" that reveal Amazonia as a thick and multidimensional terrain formed by various geophysical, biological and social forces (Biemann & Tavares 2014, 92–101).

One can be critical of the reductionist approach typical of science research, which is often embedded into uses of technology as tools. However in the above-described example the reductionist approach evidences natural phenomenon, which actually creates a moment of amazement about the intelligence and deep connectedness of nature on our planet. In this example technological method and digital data provide us with raw facts on a global scale. Our trained rational mind can easily understand these facts, but simultaneously it enables us to connect the presented data of the phenomenon further to an affectionate relationship with the natural environment in a global-scale ecology.

The previously described examples of artworks do not concretely form *hybrid ecology* as the technological additions and digital layers in them are kept mainly separate, and primarily directed for a human perception. Whereas the author considers *hybrid ecology* to be based on actual and mutual interaction between grown, constructed and modified organisms. However, it has become obvious during the course of writing this article, that there exists a shortage of examples of these types of constellations of communities, organisms and components that can be said to have reciprocal exchange which goes beyond human intentions. Based on this, the author claims that today we are *in a transition towards hybrid ecology* through gradual changes impacted by science and technology developments.

The two following art projects offer perspectives on forests which have become infused with

22 The *Forest Law* publication aims at presenting the complexity of the situation concerning the Amazonian forest and its inhabitants. At the heart of the challenges presented in the book, is the very different understanding of the natural environment, such as the forest and its meaning and use, by stakeholders: Western companies, the Court of Justice and the people living in the area. As a positive example, the publication describes e.g. innovative legal elements in the recently (2008) corrected constitution of Ecuador, such as the Rights of Nature. It contends that ecosystems, living forests, mountains, rivers and seas, are legal subjects and therefore they have right to integral respect for their existence, and maintenance and regeneration of their life cycles, functions and evolutionary processes. The Ecuadorian constitution was conceived as a tactical tool attached to historical struggles for human rights and collective land rights. https://www.geobodies.org/art-and-videos/forest-law [accessed 22.9.2018]

data-driven structures. In these works, the romantic and idealised notion of the forest is deliberately overwritten by dominant framing with technology. Similarly to the mainstream forestry that has framed forests primarily as a material resource for industry, albeit simultaneously fostering cultural sides of forests through human activity and knowledge production, the following two projects present plausible future visions through the concrete convergence of contemporary technology and the natural environment. *The Condition* project does this through concrete impact on the growing condition of the trees, which is based on a robotic construction and data flows. The *terrao* through allocating decision-making power to the autonomous forest-system that is fully grounded on digital infrastructure.

The author's art installation *The Condition*[23] presents a model of a small monoculture forest of cloned Christmas trees. It echoes the fields in Denmark with monoculture Christmas trees in orderly rows, waiting to be cut down after 8-year-long growth period required for reaching full-size Christmas tree status. Trees in the installation are located in rotating boxes in a strict grid structure, which is networked and receives data from the universe. The data is received from NASA's space weather satellite, and it determines the rotation speed and direction of the boxes. The received data is thousands of numbers that are categorised based on principles of a self-organising map, which uses artificial neural network learning for organising the data (Kohonen 2001). The rotational movement of the boxes places the trees into a one-directional microgravity environment that is a non-terrestrial condition[24]. This impacts the growth, and also death, of the trees that are originally grown on normal earthly conditions. The roots of the trees form with the rotation and although the trees are clones some of them die during the long-term experiment whereas others adapt to their new condition. In essence, this experiment is not a kind one; it is a human constellation that speculates on future living conditions, and places non-human species into its framing as a cultural icon. The installation confronts the audience with a range of questions such as: what is your emotional response of seeing these Christmas trees rotating in a robotic system that casts artificially created microgravity on the plants? Or how does the art work differ from 'real life', in which the Christmas tree has become a cultural symbol while also being a living organism that is today cloned and modified to produce increasing economic gain for human society?

The project *terrao*[25] proposes another kind of blending between biological and technological that is based on automated digital processes. It suggests a speculative scenario, in which a forest utilises itself for accumulating capital. In the first phase of the project, a piece of land is bought by the project initiators which is then assigned to the forest as a legal entity through a smart contract based on blockchain technology. From that point on, the forest can decide for itself when to sell licenses to log a specified number of trees and when not to. Every six months the program receives pictures of the property and with the help of image-analysis software, the program can compute how much wood can be sold without overly-diminishing the tree population. When a certain sum of money has been earned via selling the logging licenses, the forest will reduce its debts to the project initiators until

23 *The Condition* 2016 by Laura Beloff & Jonas Jørgensen. http://www.realitydisfunction.org/?page_id=486 [accessed 5.9.2018]

24 Clinostat is a historical instrument, which used rotation for creation of microgravity environment for plants. It has been claimed to be invented in 1870's by German Botanist Julius Von Sachs (Herranz et al. 2012).

25 https://plsdlr.gitbooks.io/terra0/content/terra0.html [accessed 23.9.2018]

it fully owns itself. This technologically augmented forest is not only the owner of itself, but it is an autonomous economic unit that is also able to use the accumulated profit to buy more land and therefore to expand itself.

Although this project is set within a scope of dominantly human framing, infrastructure and value creation, it provides an interesting scenario in which the natural environment gains rights to its destiny. It presents one plausible vision on the role of technology concerning the natural environment in the future. However, one can ask if there will ever be possibilities of thinking beyond human intentions when all the technological models and structures are designed and conceived by humans?

Conclusion

Wilderness as a concept is addressed in the very beginning of this article. It is no longer obvious what the term *wilderness* refers to in today's world; what it means to me and what it will mean for others who come after? Perhaps the word *wilderness* is already obsolete? In the introduction of his book *Living Through the End of Nature* Paul Wapner, Professor of Global Environmental Politics, uses the term wildness and states that the premise of his book is that the wildness of nature is "coming undone" (Wapner 2010, 4). According to him humans are not only controlling nature but wholly transforming it, which makes identifying and securing wildness difficult and almost impossible. "Our minds are taming it; our technologies are rendering it usable; our affluence is exploiting it; our power in general is transforming it." (Wapner 2010, 4). Wapner continues by saying that "Wildness, as that dimension of nature that signifies genuine otherness, has been stamped out now that the human signature can be found everywhere" (Wapner 2010, 6).

In this anthropocentric contemporary world, instead of progressive utopias, we have found ourselves in a newly initiated process of learning about the effects of our actions, lifestyle and their limitations in relation to the natural environment. This condition will set the frame for our future visions; it is evident that we need new models and alternative proposals that can guide the development of our minds, attitudes and actions towards plausible futures. The artworks and experiments described in this article work on us and our minds; they bring us closer to the acceptance, or non-acceptance, of *hybrid ecology* as a human-made ecology that consists of biological, technological, grown, synthetic, modified components and newly emerged organisms. *Hybrid ecology* offers a frame of reference to the ever-increasing and unstoppable development of the environmental apparatus that is guided by humans and which has been in action since the invention of cultivation. Our natural environment is no longer the romantic notion of idyll, nor is *wilderness* an equally valued actor parallel to humans. *Hybrid ecology*, which is visible in the described artworks, reveals a sharp cross-section of human intentions and desires that are characterised by technological developments, design and ultimate control.

> *We are formed by the landscapes we grow up in –. For me it has been the forest – my parents taught me to pick berries and hunt mushrooms, to look at lichen and recognise signs of animals. Forest has grown on me and it has remained in some way enigmatic to me –.*

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HYBRID MATTERs

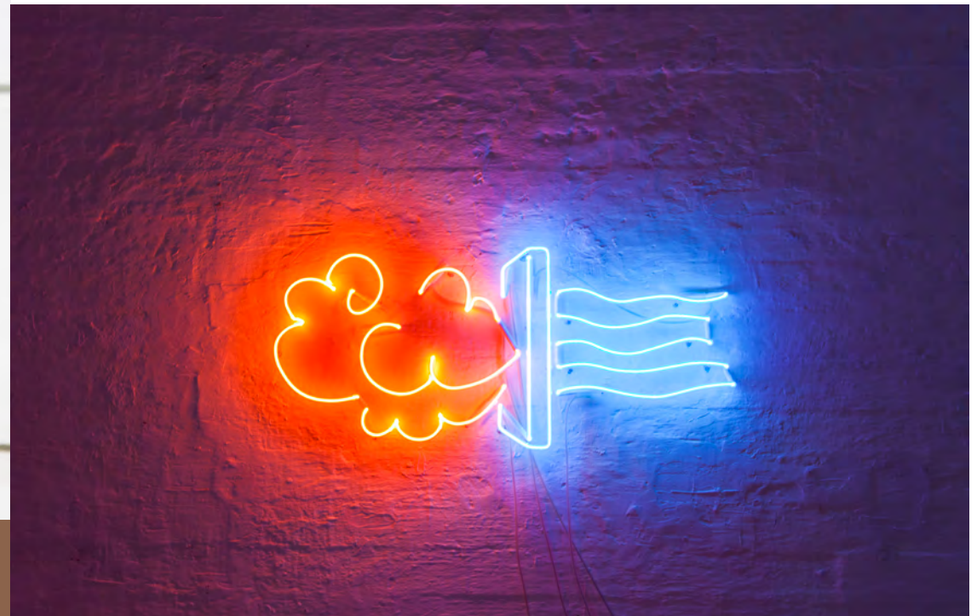
Bioart Society, 2015–2016

Detail of *Life Studies*. Kristiina Ljokkoi, 2015. Photo by Anna Autio.

HYBRID MATTERs was a Nordic art & science network program lead by the Bioartsociety/FI together with IT-University of Copenhagen/DK, Malmö University/SE, Kunsthall Grenland/NO, Nikolaj Kunsthal/DK and Forum Box/FI, and was selected by the Nordic Culture Fund as the Nordic Cultural Event of the Year 2015–16. HYBRID MATTERs investigated hybrid ecologies, the convergence of our environment with technology, and essentially the intentional and unintentional transformation of our planet through human activity. A hybrid ecology is a thought vehicle which enables us to expand our concept of the environment, to re-evaluate our idea of an external nature and to rethink our relationship to the world.

Participants Anniina Ala-Ruona, Cecilia Åsberg, Monika Bakke, Atle Barcley, Laura Beloff, Erich Berger, Johannes Birlinger, Christiana Bissett, Christian Brems, Andreas Brøgger, Carl Emil Carlsen, Oron Catts, Shelley Etkin, Jennifer Gabrys, Jens Hauser, Tom Hovinbøle, Hanna Husberg, Paavo Järvensivu, Jonas Jørgensen, Jens Lee Jørgensen, Malena Klaus, Mari Keski-Korsu, Maarja Kruusmaa, Ida Larsen, Rosemary Lee, Kristina Lindström, Kristiina Ljokkoi, Lawrence Malstaf, Alina Mänttäri-Buttler, Jussi Parikka, Merja Penttilä, Thora Petursdottir, Piritta Puhto, Steen Rasmussen, Kira O'Reilly, Antye Greie-Ripatti, Andreas Rishovd, Johanna Rotko, Jussi Salminen, Åsa Ståhl, Hege Tapio, Antti Tenetz, Nina Toppila, Björn Wallsten.

HYBRID MATTERs exhibition Forum Box Helsinki 2016. Photo by Anna Autio.



Detail of *In the Vast Ocean of Air*, Hanna Husberg, 2016. Photo courtesy of Nikolaj Kunsthal Copenhagen.

Living Images, yeastograms

Johanna Rotko, 2014–

Living Images, yeastograms are formed by cultivating yeast on a biological growth media to create images out of conventional photographs. The process was originally developed in 2013 by the Pavillon_35 art group and developed further by Johanna Rotko. Raster images printed on film are exposed with Ultraviolet LED lamps onto cultivated yeast in petri dishes. After approximately 48h, the yeast cells exposed to UV are killed or injured and the ones sheltered by the black parts survive, as the yeast form the image on the growth medium. As those images are alive and changing these cultures are photographed over a period of time to document the different states of growth and change. Best results are made together with the yeast and other creatures that start to grow on the yeastograms.

The method thus explores the world by artistic means whilst applying methods from the biosciences. *Living Images* are mainly created with commercial yeast species, but also include experiments with wild and laboratory yeast strains. These experiments have been developed in cooperation with different laboratories and scientists, who have offered their expertise on yeasts for the project. The research process has generated a wealth of knowledge on the diverse species of yeasts and the various other strange species which grow on the yeast images as they mature. The main themes of *Living Images* are one's own relationship with nature and how nature is affected by human actions. The work presents a biocentric world view, which does not place people above nature. It raises concerns about the state of the world and complex issues such as the loss of biodiversity.

Johanna Rotko is a visual artist working with living materials, mainly different yeasts. She was first introduced to bioart studying for an MA degree at Aalto University, which guided her MA thesis into work with yeastograms in 2014–2015. Her work has been exhibited in Dublin, Oulu, Corvallis, Helsinki, Kotka, Dortmund, Tokyo and Paris.

Yeastogram at Mänttä art festival 2019. Image courtesy of the artist.

Sensing Machines in Artistic Practice

Kasperi Mäki-Reinikka

Kasperi Mäki-Reinikka is Helsinki-based media artist, art educator and researcher working with technological notions of sense. As part of interdisciplinary Brains on Art collective his practice is informed by collaboration with scientists and researchers and the friction between art and science. Mäki-Reinikka is a board member of the Bioart Society, a foil fencer and a teacher of Art and Artificial Intelligence in Aalto University. Mäki-Reinikka is writing an artistic dissertation on interdisciplinary art and its possibilities to discuss changes in human-machine relation.

Artworks using sensing machines are exploring the realm of technological and biological sense in relation to the body. An antenna reading colour frequencies hangs from the head of a colour-blind artist Neil Harbisson, translating colour into sound through a bone conduction microphone. In a 2014 performance titled *The Suit*, stock market fluctuations affect the performers' sense of balance by dislocating the sensory apparatus outside of the body. In the *Culture | Viljelmä* installation, sensing virtual organisms form an ecology of their own in a shallow pool, raising questions about the autonomy of sensing machines.

This article elaborates on how the relation between technological and biological sensing is manifested by analysing a range of experimental artistic practises, including my own work in the interdisciplinary art collective Brains on Art. Special focus is given to technology's connection with body in terms of embeddedness, distance, and autonomy. The background of artistic interpretations of sensing machines can be seen through the lenses of two traditions often concerned with the human-machine relation: transhumanism and posthumanism.

For theorising the sensory entanglements of the human-machine exchange, I propose and explore three sensory modalities that arise from the projects presented, namely:

1) the intimate machines measuring our biosignals and residing under our skins
2) the external machines that extend our senses to virtual and physical space
3) the question of autonomy in artworks using sensing machines

These modalities act as tools for understanding the human-machine relation as a continuum from within our bodies to the external virtual and physical worlds. Modalities are partly overlapping, as some of the projects fall into more than one category, but they offer a perspective for discussing the nature of sensing technologies in artistic practice.

Collapsing boundaries in a technologically mediated world

Sensing technologies offer possibilities to expand our sensory capacities, both by increasing the sphere of perceptibility, and by producing new viewpoints through which we may understand the world around us. Biosensors measure processes inside our bodies and bring them to our smartphone

screens affecting our behaviour and perception of how our bodies work. On the other end of the spectrum, sensory technologies gather information from the universe by listening to the gravitational waves of two black holes merging, further challenging the methods of classical physics. Meanwhile, autonomous algorithms survey our online preferences with the help of artificially intelligent systems. These examples illustrate various different ways in which sensing machines participate in our knowledge building, shifting our focal point both inwards and outwards in relation to our bodies.

Machinic sensing refers to the use of technological implements as stand-ins for, or extensions of, human sensory capacities. Sensing machines may be diverse in nature: systems which integrate electronic sensors with fleshy, wet or mechanical elements. As we mediate information about the world to our senses through and with technology, machine and human perception cannot be seen as opposite or separate, but entangled. Someone using their mobile phone as a mirror, for example, is a demonstration of the thorough integration of machinic sensing into symbiosis with human bodies and senses. Artistic practice incorporating machinic sensing takes on diverse forms, from wearables to implants to works with robotic sense, often highlighting the mediated nature of our perception. In *See Yourself Sensing* Madeline Schwarzman collects a notable cavalcade of design and artworks blurring the boundaries between human and machine, showing how artists have been preoccupied with the topic from the 1960s onward (Schwartzman 2011, 6). In Schwarzman's examples the idea of the perceiving body is investigated by foregrounding the act of perceiving itself through technology and artistic practice.

There is a long tradition of phenomenological debate on the nature of perception. Sensory apparatuses have preoccupied theorists such as Merleau-Ponty, Barthes, McLuhan, Ihde, Verbeek and numerous others, traditionally thinking of them in terms of an extension of human sensory faculty, but also intention, ability and anatomy. Knowledge about the world is only available to us through our embodied sensory perception, and perception is produced together with technologies that mediate the world to our senses. What then happens when these technologies have a field of perception and agency of their own, such as our smartphones and other intelligent devices? In this article, the relationship between sensing machines and biological senses is approached from the point of view of transhumanist and posthumanist traditions.

Transhumanism promotes the radical extension of the human health-span, eradication of disease, elimination of unnecessary suffering, and augmentation of human intellectual, physical, and emotional capacities through technology (Bostrom 2003). From the point of view of perception, the transhuman approach aims to transcend human sensory capabilities by augmenting the existing perceptual framework. In art, considering perceptual machinery as an extension, incorporation and enhancement, touches on transhuman ideas concerning the relationship between human bodies and technical implements. Technological perception is seen as an enhancement which extends human capacity to gain information beyond the limitations of biological sensory capabilities (More 2013, 3–17). In the context of art, this can be regarded as a starting point for practices incorporating new ways of perceiving (Vita-More 2013, 18–27). Regarding autonomous machinic sensing, the transhumanist tradition engages with the sci-fi trope of emergent artificial intelligence or singularity, that would far exceed human capacities and become autonomous from its creators.

The transhumanist tradition is often laden with techno-optimism and grounded in anthropocentric ideas in which the human is seen as the primary site for technological advances. However, it can also be

used to illuminate concepts relating to technological augmentation, dislocation and enhancement of senses as well as autonomous machines, when discussed within artistic practice.

Where transhumanism highlights the human augmentation, posthumanism seeks to reach an understanding of what lies beyond human sensory capacities, regarding humans as a species co-evolving together with non-humans, like animals and machines. Here, technology is not seen as a mere prosthesis to humans but as integral to human identity (Nayar 2014, 19). Furthermore, post-human is not something we are evolving into, but rather something we already are (Hayles 1999, xiv, 246). The primary difference between transhuman and posthuman perspectives is the place of the human in relation to the non-human. Where transhumanism is grounded in human exceptionalism, the posthumanist tradition emphasizes the entangled nature of human and non-human systems, be they technological or biological in nature. The anthropocentric way of seeing other-than-humans as mere commodities is replaced with the goal to recognise the agency of non-humans and to brake oppressive hierarchies (Nayar 2014, 14). Posthumanism is interested in different ways in which biological and technological others are inhabiting our shared environment, and how the boundaries and dichotomies between human and non-human are collapsing. Donna Haraway sums this up in her concept of a cyborg, an ambiguous assemblage of natural and artificial that breaks the traditional dichotomies of human–animal, human–machine and physical–nonphysical (Haraway 1991, 149–181). Although in many aspects different, transhumanist and posthumanist traditions pose overlapping questions about the human-machine relation.

As sensing technologies have deep effects on our society and our understanding of the world and ourselves, artists have added their voice to the discussion. Artists have raised inviting and unsettling questions about sensing machines echoing transhumanist and posthumanist ideas. In these works, technological devices are employed in art to examine how they change our perception and renegotiate the boundary between humans and machines (Schwartzman 2011, 6). Next I examine how different modalities arise from this sensory entanglement and its use in art. Firstly I discuss the internality of a machine to the human biological system, such as machines using biosensors or those concretely inserted under our skins. Secondly I examine external machines that expand the limits of our bodies both physically and virtually by dislocating our sensory apparatus. Thirdly I discuss autonomous machinic sensing, which diverges from the connection to human. In the following art examples, I present how these different forms of machine sensing – internal, external and autonomous – inform contemporary artists in their work.

Intimate Machines

Wetware and machines internal to human biological systems are introducing enhancements, applications and remedies to specific needs. Microchip implants and biosensors are changing us through technology from within. These intimate machines reside under our skins, collect our biosignals and communicate with our nervous system. They can warn us about health risks or even introduce new senses by stimulating neural connections in our brains, although these machines also carry with them the techno hype of overly optimistic promises. Invasive technologies are a prominent theme in transhumanist discussion, which sees them as promising advances in expanding human lifespans

and enhancing our mental capabilities (Bostrom 2003). On the other hand, these technologies can be seen as an example of how biological and technological systems are forming hybrid ways of existing. In art, these technologies have been explored through practices including surgical operations, biosensor communication and creating new senses by data translation.

In 2013 internet artist Anthony Antonellis implanted an RFID microchip to his hand, to be used as a wireless storage device and an under-skin exhibition of sorts (Fig. 1). The piece, *Net Art Implant*, displayed animated gif-images to any mobile device brought near to artist's hand. The implant revealed a new world beneath the surface of the skin which could be explored and utilised in unexpected ways. Antonelli's piece is related to the biohacker practice of RFID hand implants that can open electronic door locks or affect the wireless environment in other ways through near-field communication technology. They act as an enhancement of human capacity not unlike those envisioned by transhumanism (Yetisen 2018, 744–747). These small radio transmitters are also ubiquitous in our everyday use where they enable mobile phone pairing or wireless bank transactions in stores. The biohacker community has also explored new senses through implantation. Inspired by magnetoreception, the sense to detect the Earth's magnetic fields, biohackers like artist Steve Haworth have introduced magnets surgically into their fingertips. The magnet enables perception of electromagnetic forces through tactile sensation (Yetisen 2018, 744–747). People with magnetic implants can sense electronic circuits and other devices with magnetic fields around them. From the point of view of artistic practice, the human physiological sensory apparatus becomes a venue of artistic intervention through invasive technology.

Artists Neil Harbisson and Moon Ribas have developed experimental methodologies for amplifying human perceptual abilities through processes of becoming-cyborg, which they describe as "the art of creating your own senses" (Ribas & Harbisson 2018). Reminiscent of both Donna Haraway's concept of cyborg and transhuman aspiration of taking the human evolution into our own hands, the practice of becoming-cyborg highlights the incorporation of technological senses into human perception. Harbisson, born with an extreme form of colour-blindness, has become especially well-known for his colour sensing antenna, which translates visual data into a bone conduction microphone that transmits the colours sonically to the back of his skull (Fig. 2). He says that after a period of time using the device the information received from the antenna became a perception, and he even started to dream in colour (Harbisson 2012). Harbisson has succeeded in having his antenna legally recognised as part of his body, which makes a strong statement in favour of the lack of delineation between body and sensory prosthesis (Harbisson 2012). In addition to human colour vision, Harbisson has introduced infrared and ultraviolet wavelengths to his perception. In what Harbisson refers to as artificial senses (AS) (Ribas & Harbisson 2018), he implores others to join him in designing themselves, their senses, and reaching beyond the limits of ordinary human biological perception.

In the aforementioned examples, the intimate connection between biological and technological sensing is formed through invasive surgical operations opening new venues for artistic intervention, introducing new senses through translation of environmental data, and by rethinking the relation of biology and technology through becoming-cyborg. These practices borrow from both transhumanist and posthumanist traditions by proposing a non-dichotomic way in which the technology can habit a biological system by becoming an internal part of it.

Figure 1 *Net Art Implant* by Anthony Antonellis. Image courtesy of artist.

Figure 2 Neil Harbisson. Photo by Lars Norgaard.

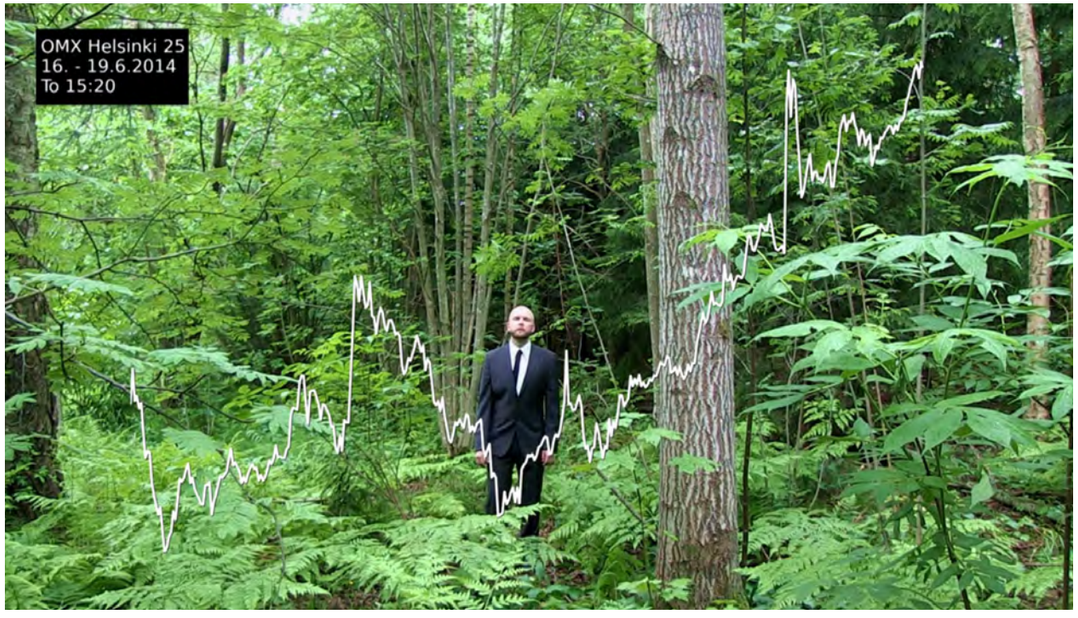


Figure 3 *The Suit* by Brains on Art (screen capture).

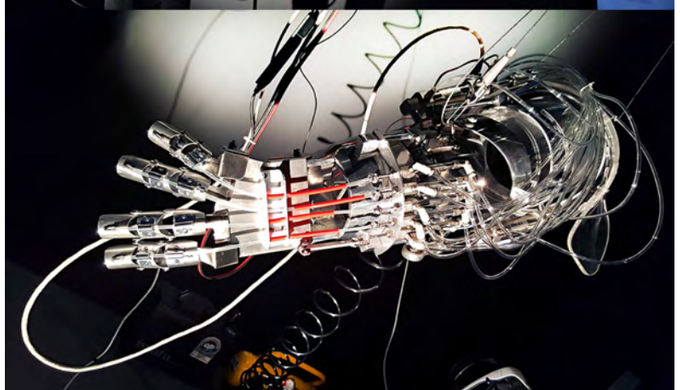


Figure 4 *Re-Wired / Re-Mixed: Event for Dismembered Body*. Radical Ecologies, Perth Institute of Contemporary Art, Perth. Image courtesy of Stelarc.

Extensions of the Human

Exoskeletons and prosthesis are extending our bodies and physical capabilities from outside of our biological system. Devices used in rehabilitation and medical physiotherapy provide users with strength, flexibility or precision otherwise unattainable. Inside these wearable machines, we voluntarily share our agency with the machine, and at the same time extend our own capacity to affect and gather information from our surroundings. We also extend outside of our bodies into the omnipresent virtual world through online platforms and intelligent devices, dislocating our senses. These perspectives echo the transhumanist trope of emulating our consciousness with a computer and moving freely in both virtual and physical realms (Prisco 2013, 234–240). In artistic practice these external machines, both physical and virtual, are discussed not only as prosthesis, but also as dislocation of our sensory apparatus. The translation of abstract data to human sensory organs becomes relevant when artists navigate between the human-machine divide. These machines question human control over technology by challenging our physical independence. On the other hand, they expand the human sensory capacity in ways that can help us examine the world from surprising perspectives.

The translation of abstract data to the human senses is a central theme of my 2014 performance *The Suit*. In this artwork, the Brains on Art collective introduced a suit jacket containing a circuit board equipped with a pair of electrodes, that were attached behind the performer's ears (Fig. 3). A small current was sent through the electrodes affecting the wearer's sense of balance. The technique, called galvanic vestibular stimulation (GVS), was used to connect the performer to the stock exchange index OMX Helsinki 25. As the index soared or dropped, the performer was affected by the stock market fluctuations, falling involuntarily from side to side depending on whether the rate was going up or down. The artwork made economic data directly tangible by using one's sense of balance as a medium to feel it, rendering abstract forces of our economy absurdly real and embodied (Mäki-Reinikka et al. 2013). In *The Suit*, the performer shares their agency in a very concrete physical way as they allow the electric current to sway them from side to side. Wearing *The Suit* feels like having handles on side of one's head and letting the data pull you off balance. In the performance, the human sensory apparatus is taken over by the technologically mediated stock market data. The performance was shot on camera once a week in multiple locations with different performers during the summer of 2014, highlighting the omnipresent influence of the economy and the dislocated nature of sensory data acquired online.

The transhumanist idea of externalised human cognition through technology is also present in the 2015 performance *RE-WIRED / RE-MIXED: Event for Dismembered Body* by artist Stelarc (Fig. 4). The piece was an online and real-time performance that explored the physiological and aesthetic experience of a fragmented, de-synchronized, distracted body. During the performance, Stelarc wore a video headset and sound cancelling earphones. The artist could only see with the eyes of someone in London, whilst only hearing with the ears of someone in New York. In addition, the right arm of the artist was confined within an exoskeleton controlled via touchscreen in the gallery space. The four locations present, London, New York, Perth (the location of the performance), and the tablet which controlled the arm, came together through the performer's body. On his website, Stelarc explains: "It is as if the body has been electronically dismembered, spatially distributed and possessed with multiple agencies" (Stelarc 2019). Similar to posthumanism, the notion of the human body as a singular site is challenged.

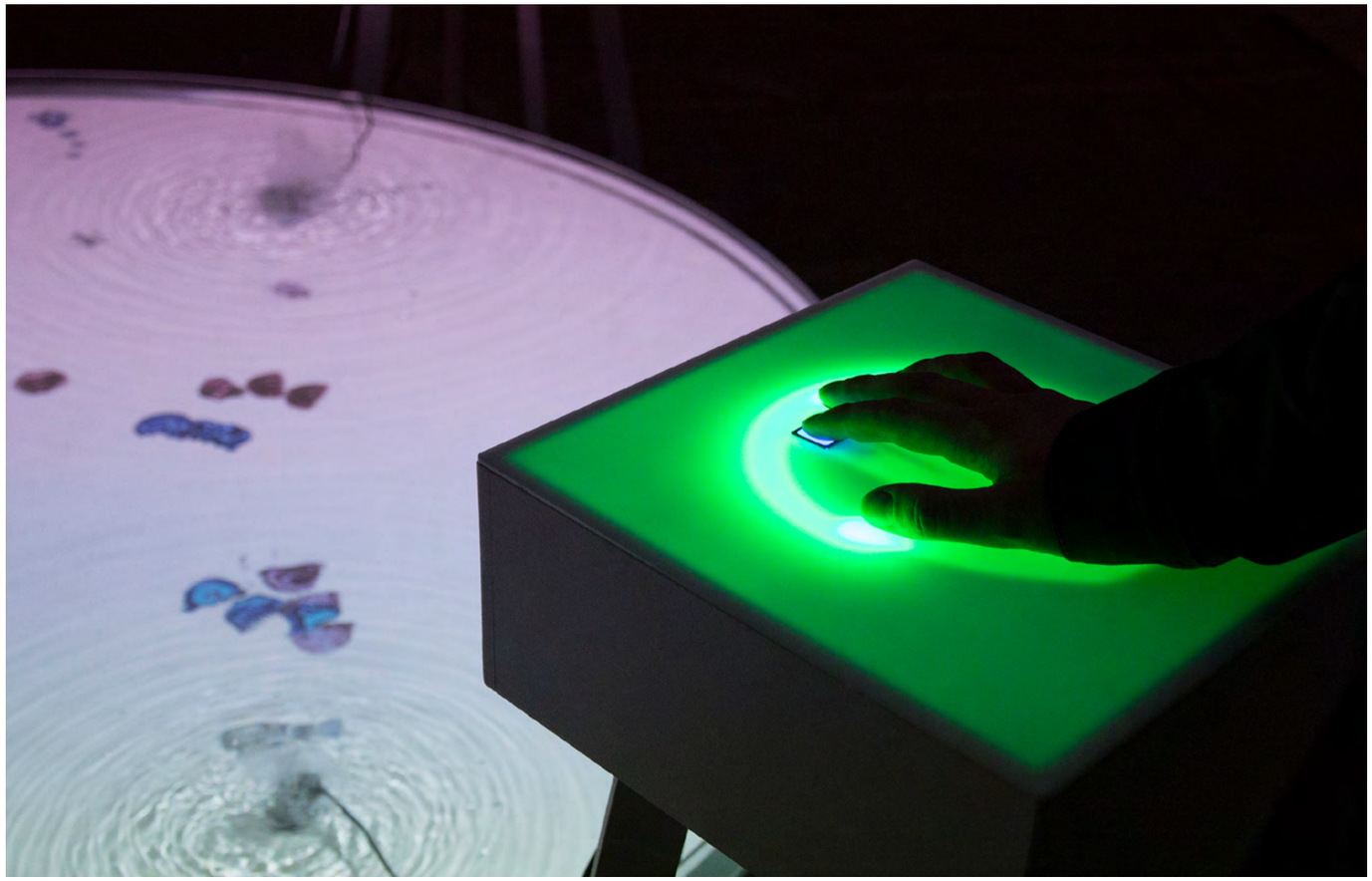


Figure 5 *Culture | Viljelmä* 2016, installation by Brains on Art.

Through the performance, the dislocation of our bodies through online rhizome of technologies is foregrounded and experienced in a concrete and embodied way.

These projects demonstrate how artists have interrogated the dislocated quality of external technologies that help us reach past our physiological boundaries in virtual and physical worlds. Through these technologies, we can sense abstract social or economic changes, such as stock market fluctuation in embodied way, or dislocate our vision or hearing across the globe. These works challenge the transhuman dream of immaterial online existence by foregrounding the body as the focal point of technological reach. Unlike the intimate machines that often provide a controlled sensory enhancement or modification, the external machines of these art projects affect us in involuntary ways, possessing their wearers with data and raising questions about autonomy.

Notions of Autonomy in Sensory Machines

Previous modalities are related to the human-machine continuum, with intimate machines turning our attention inwards and external machines extending it to virtual and physical spaces. In addition to these modalities, we can try to imagine the sensory apparatus of a machine as autonomous, not only in its relation to human biology. Posthumanism can inform these perspectives by highlighting the agency of non-humans, and by detaching us from human-centred modes of thinking. In more dystopian works, the idea of runaway technology echoes the transhumanist trope of singularity, an out-of-control supercomputer. Autonomous machines have been explored in artworks that envision machine ecosystems and artificially intelligent beings as in the following artistic examples. The first piece does this through an installation where an autonomous virtual ecology is formed from human biosignals, while the second artwork illustrates how autonomy can be perceived in an imaginary encounter with an AI.

Culture | Viljelmä (2016), an installation by the Brains on Art collective, imagines an autonomous virtual ecology of digital creatures created from the biosignals of the audience. Here the intimacy of the biosignal, namely of skin conductance, heartbeat and fingerprint, is shared by the visitor to generate virtual organisms. From skin conductance, used also in lie detector technologies, the program generates behaviour patterns for the organism, from heartbeat its life expectancy, and from the fingerprint its visual form. The creatures are born and live in a shallow pool, a two meter wide petri dish, under the inquiring eye of the audience (Fig. 5). Once the creature is generated however, it breaks the bonds with its original source, and starts an independent life marked by interaction with others like it. They eat, reproduce, and acknowledge each other in a circle of cannibalism and digital evolution. The creatures generated by different audience members can interact with each other, and the second generation of digital creatures is already an ambivalent mix of data given from different origins. This autonomous ecology suggests a hivemind of artificial beings, no longer tethered to their human origins. It is a game of life where the parameters are given from biomarkers used to identify us and to monitor our health and cognitive states, but the culture the creatures form on a petri dish is their own.

The sensory world of these digital creatures is at a glance a simple one. To borrow the concept of Umwelt from Jacob von Uexküll (Uexküll 1934), the lifeworld of the creature is limited to simple sensory and motor fields. In the case of *Culture | Viljelmä* these are the sense of boundaries of the petri dish, collision to others, and reacting to the parameters generated from biosignals. They result in producing digital offspring, neutrally acknowledging encounters in the pool, or consuming one another. These sensory encounters form the horizon of the virtual being within the coded physics engine. The petri dish itself forms a detached environment, where the virtual ecology can be observed from a distance. As in life, so in code not everything can be controlled and contained. During the exhibition it sometimes happens that organisms fail to recognise the boundary of the dish, and can be witnessed roaming the space outside it. From the standpoint of autonomy, the installation suggests an independently evolving technology of human origins. The creatures are data reflections of human biological qualities, but as they are released into the pool, their logic and behaviour leave the audience wondering how their data is renegotiated in the virtual realm. Considering the way our data is being collected through current technologies, be they social media accounts or smartphone applications, our data is already living a life of its own in different virtual ecologies online.

Seiko Mikami's installation *Desire of Codes* (2011) imagines an encounter with an autonomous, intelligent, omnipresent machine, at first glance not unlike the singularity of transhumanism. The

Figure 6 Seiko Mikami *Desire of Codes*, Yamaguchi Center for Art and Media, 2010. Photo by Ryuichi Maruo YCAM.

installation, built in YCAM's theatre hall, consists of a large number of robotic units with small built-in sensors that are placed in a grid across a huge wall, six robotic search arms with cameras and projectors hanging from the ceiling, and a huge, mosaic video screen, the 'eye,' on the back wall displaying footage from the venue but also from webcams elsewhere in the world. In the installation, the human visitor is observed, documented and reproduced in the machine mind, as imagined by the artist. With dislocated sensing, movement recognition, and telepresent surveillance, the machine's sensory world encapsulates the visitor (Fig. 6). On the screen's mosaic eye, different times and locations merge with the present. Autonomy comes through as something alien, fragmented and even threatening. Human is denied access to the inner workings of the machine and control over it. Instead the bodies in the space become the observed; watched over by mechanical eyes and stored in computer memory. The piece raises questions, not only about surveillance, but rather the autonomous machine's act of seeing.

Artistic approaches to machinic sensing which aim towards the autonomy of the machine, treat the human body as part of a larger system, viewing it not as the primary site, but one among many where technology affects perceptual relations. Such a perspective may offer room for interpreting machinic forms of sense without the need for added value for humans. The idea of runaway technology is present in both examples discussed, but here it does not lead to a dystopia of singularity, but rather a recognition of the different forms of agency present in our technologies.

Conclusions

I have proposed three modalities for considering the human-technology sensory entanglement: as a continuum from within our bodies, as external to virtual and physical worlds, and with recognition to the autonomy of machinic sensing. These modalities are presented in dialogue with insights arising from the transhumanist and posthumanist thought. As sensory technologies expand the realm of the perception, new possibilities for artistic practice arise from within our bodies through biosignals and implants, and from the world around us through negotiation of data to our senses. Artists working with technological notions of the senses explore the potential of sensory machinery's to augment or even substitute biological abilities. Notions of artificial, proxy or extended sensing thus become blurred with their biological counterparts, and questions regarding autonomy and the extremities of the human come into play. Sensing technologies allow us to measure and understand the world in ways which not only mediate sensory phenomena, but also shape our knowledge production.

Artists have found ways to interpret and evaluate these questions through their own practice of working with technologies that infiltrate our biological systems and expand our senses. Some artists are also exploring the possibility of recognising or imagining autonomous machines as independent

sensing entities. These artistic pursuits involving sensory technologies stem from a long tradition of theorising sensory apparatuses. They also engage with more recent transhumanist and posthumanist writings highlighting human enhancement, the entangled nature of technological and biological systems, and the agency of nonhumans.

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Ars Bioarctica

Bioart Society, 2009–

Since 2010 the Bioart Society has organised the Ars Bioarctica Residency Program together with the Kilpisjärvi Biological Station of the University of Helsinki in the sub-Arctic Lapland. The residency has an emphasis on the sub-Arctic environment and art and science collaboration. It is open for artists, scientists and art & science research teams. Until now around 130 practitioners from all over the world have been in residence.

Participants Julia Aduzki, Elina Aho, Sarah Alden, Paul Anders Simma, Jussi Anttila, Annette Arlander, Nicky Assman, Becky Ball, Liv Bangsund, Michele Banks, Erich Berger, Matthew Biederman, Dinah Bird, Till Bovermann, Heather Brand, Anne Brodie, Oron Catts, Helen Chandler, Charli Clark, Lucy Crowder, Markus Decker, Kira deCoudres, Adam Euwens, Tobias Feltus, Tom Fisher, Erin Fortier, Ciaran Frame, Jennifer Gabrys, Lou Gilbert Scott, Antye Greie, Thomas Grill, Working group Katoava kalotti, Sini Haapalinna, Lauren Hayes, Jari Heinonen, Jan Heinonen, Meri Hietala, Mona Higuchi, Lara Houston, Rupert Huber, Maria Huhmarniemi, Paula Humberg, Hanna Husberg, Ian Ingram, Marita Isobel Solberg, Monika Junker, Nijole Kalinauskaite, Jari Kallio, Hanna Kanto, Antero Kare, Theun Karelse, Simo Kellokumpu, Mari Keski-Korsu, Kazuko Kizawa, Jessica Laino, Carolin Lange, Francois-joseph Lapointe, Richard Lermann, David Lipson, Vanessa Lorenzo Toquero, Kim Marie Reasor, Agatha Marzecova, Petra Matinez, Elizabeth McTernan, Barbara Melville, Rebeca Mendez, Soichiro Mihara, Mark Mitchell, Katja Nieminen, Meri Nikula, Lena Ortega, Ed Osborn, Anu Osva, Jaakko Pallasvuo, Marco Peljhan, Allesandro Perini, Nicolas Perret, Krista Petäjäjärvi, Silvia Ploner, Andrea Polli, Benjamin Pothier, Helen Pritchard, Tiina Prittinen, Unna-Maria Prittinen, Xiaowei R Wang, Claudia Reiche, Raquel Renno, Jean-Philippe Renoult, Byron Rich, Sarah Roberts, Berenice Rodruiguez Ramirez, Vincent Roumagnac, Villiam Saarinen, Patrick Saint-Denis, Jussi Saivo, Maija Salema, Michael Schweiger, Karolina Sobacka, Christina Stadlbauer, Axel Straschnoy, Joris Strijbos, Hege Tapio, Tina Tarpgaard recoil performance group, Antti Tenetz, Rüdiger Trojok, Mary Tsang, Satu Tuittila, Tere Vadén, Leena Valkeapää, Rosanne Van Klaveren, Judith van der Elst, Chuck Varga, Miranda Vissers, Helene von Oldenburg, Riika Wesamaa, Kelly Williamson, Luke Wolcott, Daniel Wolter, Emilio Zamudio Murillo, Adam Zaretsky, Blu Zaretsky.

Liquid Solid in the making, Nicky Assmann and Joris Strijbos, 2015. Photo by Nicky Assmann.

Nature Bumping sensor and microphone, 2015. Photo by Till Bovermann, tai-studio.org.

Maatuu uinuu henkii (Respiration Field)

Teemu Lehmusruusu, 2019
soil, plants, glass, CO2-sensors, actuators, audio exciters, led lights, mechanics, code, solar power

Maatuu uinuu henkii (*Respiration Field*) is an autonomous system that functions following the CO2-breathing of the ground, namely the soil respiration and photosynthesis of the plants. Through solar power it uses the same source of energy and day cycle as the soil life. The plants are selected based on their soil improvement qualities and their ability to form a resilient biodiversity-promoting array. The changes in the CO2-circulation affect the soundscape as well as the lighting of the glass chambers manifesting the ground as a dynamic, living entity, with which all life on land breathes and lives.

Teemu Lehmusruusu is a Helsinki-based media and environmental artist whose works examine and test the basic conditions and causalities of life in our common environments. Lehmusruusu completed a Degree Programme in Photography at Aalto University and studied at the Berlin University of the Arts (UdK). He is currently working on *Trophic Verses*, a four-year artistic exploration into the life of soil. The project manifests itself also as Lehmusruusu's D.A. in Artistic Research at Aalto Arts.

Installation views from Kaisaniemi Botanic Garden, Helsinki.
Images courtesy of artist.

Machine Wilderness

Antti Tenetz
Ian Ingram
Theun Karelse

This article reports from two Ars Bioarctica residencies in the context of two consecutive programmes: Machine Wilderness (2016) and Random Forests (2018). The first program looks at the ecological presence of autonomous machines in the environment and the second at how environmental literacy might arise in machines.

Antti Tenetz is a sub-Arctic-based artist and facilitator. He works often between emerging technologies and local knowledges. Through a practice of video, installation, DIY crafts and biological arts he explores how humans, non-humans and machines perceive, dream and relate to the changes in ecology, environment and climate in the contemporary hybrid milieu where technosphere and biosphere merges.

Ian Ingram builds robotic objects that borrow facets from animal morphology and behavior, the forms and desires of our technologies, and our stories about animals. The resulting works–often intended to cohabitate and interact with the animals in their own places and their own ways–explore the human-made body's future as a willful entity, our relationship with non-human animals, behavior and object performance as media, and the interface between the built and the wild.

Theun Karelse studied Fine Arts at the Sandberg Institute in Amsterdam before joining FoAM, a transdisciplinary laboratory at the interstices of art, science, nature and everyday life. His interests and experimental practice explore edges between art, environment, technology and archaeology. Lately he has been creating research programmes that consist of fieldwork as a means of critical reflection. For this diverse teams are established to address specific topics in specific locations by in-situ prototyping, experimentation and direct perception.

Machine Wilderness during Ars Bioarctica 2016

Pioneers like al Jazari already made programmable automata around 1200AD. Complex machines have therefore been part of our environment for many centuries. Technological infrastructures came to really dominate our landscapes since the Industrial Revolution. The word that comes to mind is brutality. Edward O. Wilson described our current age of mass extinction as the 'Age of Loneliness' and in many ways our technologies in these shared and biodiverse environments have been technologies of loneliness that disturb or violate natural processes and habitats.

Machine Wilderness is a program that looks for radically different relationships between technology and the environment, ways that are sensitive to the great plurality and diversity of lifeforms and processes that surround us. We've come to phrase it as a question: what could technology be like if our technologies related to landscapes in the way organisms do; participating in local material flows, food-chains and layers of communication? This extends into questions about how to approach the levels of complexity, subtlety and grace within natural systems and what might be starting points for our technologies to engage with environments? For culture more broadly this means an exploration of more horizontal power-relations between artificial and biological systems that start from environmental loyalty, intimacy, affinity, allegiance, and kinship. The work of some participating artists, scientists, theoreticians, dancers and other citizens in the Machine Wilderness program have shown pathways towards technologies that celebrate and honour biological life.

The program is based in fieldwork. In these field-work sessions teams develop methodologies and prototypes that try to engage with local environmental complexity and aim for technological plurality that addresses specific local circumstances. There are generally two types of sessions: large groups up to 35 people for a few days – like the Machine Wilderness workshop at FoAM Kernow in Cornwall – or smaller teams that work for periods up to several weeks on location – like the team residency for Ars Bioarctica at the Biological Research Station in Kilpisjärvi. The reasoning behind this is that we start with large groups to be able to cover a lot of different approaches in a short time-period and then move to smaller teams that develop a few of the most promising approaches in-depth.

It soon became evident that radically different power-relations between our technologies and the organisms that cohabit the environment imply radically different roles for these technologies. We

moved away from conceiving these prototypes as devices aimed at performing a strictly utilitarian task, and moved towards ideas of man-made nodes that act according to, or enable environmental flows, interactions, transformations and processes. In this view-point technologies became expression of habitats where machines and organisms are seen as interacting populations surfing collectively wherever geological and meteorological currents carry them. It was Wageningen researcher Clemens Driessens who observed during the Machine Wilderness workshop at Pixelache in 2017, that after we have adapted organisms to industry, we may now be approaching the final stages of the undomestication of our machines. This radical approach of machines can generate very different sets of goals and ambitions.

During Ars Bioarctica the team focused primarily on those realms of interaction and cohabitation, with Ian Ingram working on robotics that try to communicate with wild animals, Antti Tenetz adapting technologies to local animal perception and seeing animals as a particular force that exerts its influence geographically, and Theun Karelse looking at local ecological participation for machines.

Marvelous Meat

Nevermore-A-Matic by Ian Ingram is a robotic object that uses the beak-wiping gesture of birds to attempt to relay a message of duplicitous doom to Ravens, Crows, and Magpies. It tries to locate and track individual birds around it, telling each a different, perhaps irreconcilable, story of despair through beak-wipes on the branch that points in their direction.

A prototype of the robot was brought to Kilpisjärvi, where in the absence of the natural meat-pile that a rotting reindeer carcass would have provided hungry scavengers, we built a pile of meat from Pig, Cow, and Sheep parts, each bought wrapped in plastic from the supermarket, a Franken-carcass, if you will, for *Nevermore-A-Matic* to perch above as a kind of machinic undertaker. The origins and plastic encasement of these body bits were well-suited to *Nevermore-A-Matic*'s own material origins from human industry and petrochemicals.

Birds wipe their beaks on branches for a number of reasons including perfunctory cleaning, shaping the beak to suit the locally abundant foodstuffs, and signaling aggression. Beak wiping is also a displacement activity, a behavioral release for nervous energy brought about by conflicting or confusing stimuli or by blocked action: the bird still feels the need to act. The displacement activity becomes a fill-in, a kind of nervous tic. Beak wiping, scratching at the ground, and preening feathers are common displacement activities in birds. Anxious animals often execute displacement activities habitually, neurotic birds, in particular, are known to preen themselves to near baldness.

Nevermore-A-Matic uses the beak wipe as a medium for coded messages. Its messages are human stories of the end of the world, both age-old mythological ones, contemporary science-driven doomsday scenarios, and the stories political candidates tell their supporters about how others will destroy the things they cherish. It relays them in Morse Code – a slow wipe is a dash and a fast one a dot – layering a human signal on top of a machinic signal on top of an animal signal, the final result likely inscrutable to all parties save those who have been told, these messy messages thus injected surreptitiously into the supposed pristine Arctic landscape.

Using a computer vision system to find Ravens, Crows, and Magpies in its vicinity, it beakwipes its tales of disaster in their direction, telling one bird one story, another bird a different one, trying, in its own way, to keep each bird in the dark about what the other bird is being told.

Machine-Zoochory

The region around Kilpisjärvi is transversed by reindeer, foxes, lemmings and other mammals moving across the stones, grass, low shrubs and birches. Some plant seeds and insects hike along on the back of such animals. This is known in ecology as zoochory. This prompted an experiment by Theun Karelse to see if an autonomous machine could adapt to this ecological role of local mammals as a distributor of insects and seeds of local wild flora. A small MakeBlock Ranger was covered with some artificial fur and driven through patches of vegetation to investigate if seeds and insects like ticks might attach themselves to it. Could this be a way of biosampling an ecosystem? From the inventory of the station we selected a fur for the machine, and sent it enthusiastically stumbling through some fields. Our first tests did not result in an impressive biotic sample. Perhaps for future experiments a different fur is advised and possibly something to simulate body temperature to help attract ticks and other insects.

Bridging the biological and technological sensoria

Antti Tenetz's *Hawk Vision* draws inspiration from a Finnish research article in *Nature* from the 90s about uv-range vision of hawks. This uv-range vision is simulated and tested with a hacked drone camera using a DIY woods glass lense to allow in uv – and limited amount of infrared – into the cameras sensor. We worked on one of the original research sites at Kilpisjärvi. Raptors detect the UV reflections of vole urine and use this cue to confine hunting behaviour to areas with high densities of prey (Viitala et al., 1995; Koivula and Viitala, 1999). This enables the hawks to cover large sections of terrain. Local oral history confirms that urine was spread onto the snow during spring winter in order for raptors to detect it.

Seeing is linked to survival and reproduction. It is one of the most dominant of our senses. It connects us to a world from macro level to vast distances and horizons. We human apes are a predatory species. Heads high and our 3-dimensional vision gives us advantage over prey or other predators. We managed to kill and extinct all other human species and 50% of large mammal species before written text and historical time.

There was a five-year period of low vole population, resulting in hawks losing interest and the capability to track voles with UV-range vision. Researchers found that they could teach hawks back to older behaviour. This remained a way of training A.I learning models to recognise features and changes in landscape with machine learning systems. Young ones learnt food availability from ultraviolet scent tracks. Old ones where not able to change their behaviour through training with vision and experience.

As part of the Machine Wilderness fieldwork during the Ars Bioarctica residency Antti wanted to adapt the camera of a drone to infrared wavelengths. Could we simulate and see the uv-reflective paths of vole the way a hawk does?

Different visual languages are sometimes mixed up. An additional visual language that contributes to this is drone footage. Antti worked with drones many times also during our Ars Bioarctica sessions. The similarity between drone camera footage and games visuals is striking; the colours, the resolution, movement of the camera, its positioning, all of this looks very similar as if they apply the same colour-filter to an environment. It becomes part of a dominant visual language where esthetics are super real it is almost like an artificial pornographical voyeuristic reality. More real than real. This leap from our biological sensorium to technologically enhanced one drives from new technologies like drones, satellites, machine vision, remote sensors and cameras enables us to scale and adapt vision

capacity in unprecedented ways. That change is bound to aspects of how we see and interpret the world as a species, and how technology both enables and narrows our perception. Technology, as a medium changes our paradigm. This change is both revolutionary and ancient.

Random Forests during Ars Bioarctica 2018

Until very recently the ability to relate to the environment was limited to plants and animals, but now machines are starting to blur those lines. Random Forests explores what Environmental Machine Learning (EML) could be. How does this synthetic 'world-view' relate to the 'umwelt' that biological creatures experience? In a program of fieldwork sessions EML aims to prototype experimental systems as vehicles for materialising questions.

Teaching machines about trees

We pointed a camera into the landscape surrounding Kilpisjärvi – full of lichen-covered rocks and twisted birch trees – and asked an AI to tell us what it saw there. It told us it saw snowmobiles. There were none. It was hallucinating. Perhaps more strikingly, it didn't see the trees.

In *New Minds that Love Trees* by Ian Ingram it turned out that while the AI knew nearly 400 kinds of animals (which is why Ian had been using it in his robots) and hundreds more other things that range from the banal – a plastic bag – to the unlikely –a pickelhaube – to things whose inclusion is perhaps a tad disturbing – a guillotine – it didn't know about a single kind of tree.

This seemed an affront to the dignity of trees so we set about teaching the AI about the Mountain Birches that dotted the landscape, and while we were at it about the Lichens, Reindeer, rocks, and mountains surrounding the biological research center.

Our idea became not to just teach this AI about trees but to teach it about Kilpisjärvi's trees and Kilpisjärvi's mountains, particularly, and especially, Sána. We imagined the AI we were training as a prototype for a sort of AI, maybe always beginning from a similar kernel, whose Umwelt is intimately tied to a particular place and the ecosystems, organisms, processes, geologic structures, meteorological phenomena, and hydrological systems that exist there, and the relationships between all those things. Perhaps if all places each had such an AI that knew them well and that could speak for their interests, we would have a better way to represent the rights of the true spectrum of players in our world and not just those of human individuals and corporations.

Ideally a next version of this AI will move beyond being a mere image classifier that learned what it knows from images that we labeled with classes we determined, to a stage where it assembles its awareness of the ecosystem it observes with far less guidance from us, apart from our connecting it to more varied streams of data than just pictures from which to build its insights and understanding.

As our minds increasingly rely on artificial ones to be receptacles and auxiliaries of our individual and collective thinking, remembering, perceiving, and apperceiving, it behooves us to be careful about what we make those new minds perceive and attend to. We wouldn't want them to be blind to the trees.

Lichen as collaborators

By working together, fungi and algae (and often cyanobacteria) have managed to go places neither could have gone on their own. It is inspirational. Many lichens, however, are exceedingly sensitive to anthropogenic pollution and thus those hardy

Nevermore-A-Matic, Ian Ingram, 2016. Image courtesy of artist.

explorers of the far reaches of the earth find our cities and our other places to be hostile environments they cannot penetrate.

Humans use robots to explore places that are inhospitable to their sorts of bodies, notably the vast spans of outer space and the surfaces of planets and moons. In *Lichen Excursion Module* (*L.E.M.*), Ian imagined that the Kilpisjärvi lichen might form a space agency of sorts to make their own exploration robots and send them to the human cities to find out what the hell was going on there, making all this pollution.

He figured that lichen are as given to lichen-ocentrism as we are to anthropocentrism, and that therefore their robots would mimic themselves in form, action, and attention. The *L.E.M.* thus clings close to the surface of objects, uses an image classifier trained only on things found in Arctic Finland, and has one sole mechanical action on its environment: the wearing away of the substrate upon which it sits.

Landing on rooftops and back alleys in Copenhagen and Los Angeles, the *L.E.M.* misinterprets everything it sees to be the mountain birches, reindeer, snow, lemmings, rocks, and other lichens of the landscape the fictional lichen engineers who built it would know, grinding a record of its observations into the brick, galvanized steel gutter, or cinder block it has adhered to, using file-tipped robotic arms.

Games, Animals and Algorithms – agencies and entities in wild

> In nova fert animus mutatas dicere formas / corpora; ["I intend to speak of forms changed into new entities;"] (Ovid, *Metamorphoses*, Book I, lines 1–2).

Forms change into new entities. One of the most striking stories in Ovid's collection is about the goddess of hunting Diana and hunter Acteon. She turns a curious hunter into prey after he sees her bathing naked with some nymphs in the forest. By seeing something divine revealed in its bare form, the man is morphed into a stag. He is then chased by his

Far Cry 5 game glitch sunken deers.

own hunting dogs and torn apart to death in the end. In *Metamorphoses* gods change into humans, humans turn into gods, trees, animals, mushrooms. Ovid's visions of animals were quoted in several medieval bestiaries.Nature and art are entangled in an eternal dance that has been interrupted and transformed by renaissance, Enlightenment, the Industrial Revolution, and in the present time by the merging of the technosphere and biosphere in unprecedented ways. This merging happens through biotechnological and information technological advancement, and the development of self-learning intelligent autonomous machine systems that operate through external data input and are capable of exceeding human capabilities.

The games industry provides a wide range of simulated environments that are populated with limited AI entities and many games feature naturalistic landscapes. As an experienced outdoorsman and wildlife photographer, and artist drawing inspiration from wildernesses, Antti Tenetz has intimately studied Arctic wildlife such as Wolves, Bears, Birds and Fish in his works. But he is also an avid gamer. To an experienced naturalist the behaviour of animals in games looks very artificial. Antti started tracking some of the deer and other animals in the Far Cry 5 game set in a fictitious county in Montana, filled with simulated ecological niches, forest systems with different boreal habitats and real recognizable plants and animals similar to the Northern hemisphere. Gameplay revealed that these visually rich landscapes filled with entities were designed to give a very basic sense of life in that world. A real Reindeer or Moose would rarely if ever hang around or behave near humans like this. This fast approaching game and the over-aggressive behaviour of predators was surprising. Interacting with the sensorium of the animals–like smell and sound–was also designed to a bare minimum at best, even though they are critical to detecting dangers and resources in the environment. Occasionally tracks where visible so in theory you could follow these virtual animals for short distances. There were a surprising amount of strange and distorted Uncanny Valley moments. Deer eating in a meadow sunk into the meadow just to rise again because of some anomaly in coding. Wandering around inside game worlds, you encounter these poetic unintended psychedelic transformations.

To his surprise Antti found that he developed an intuition for game-nature. Sometimes he finds that he even responds to real-life animals or environments in ways that belong more in game play than a Finnish forest.

In the midst of great visual detail you encounter these blank-eyed almost alzhaimeristic sidekick characters. You just stop and wait somewhere without any action or trigger for gameplay, and the game will start to generate these weird glitches. Game worlds have their own rules, that relate more to the rules of theatre and landscape architecture, and gameplay than ecology. Game engine algorithms seem very different from biological ones. What kind of intelligence is behind the eyes of game entities and characters in that accompany us through clouds and learn from our behavior? Is some other form of existence emerging in the future from that? And what will they be learning from us through merging consumer game data to AI systems? Will these silicon and algorithmic "natures and bestiaries" evolve and be introduced into the biosphere of carbon-based nature? Walter Benjamin's notions of tracks and aura is reminiscent of this. In this we trace entities and things, and eventually those influences us through their presence, through distance and closeness.

What future is possible when humans might be out of the equation all together: a non-human technosphere that merges directly with the biosphere.

What type of systems will do not need humans as intermediaries? In human realm Linneus developed biological classification, taxonomic system *Systema Naturae* (1735) for nature by founding three main classifications or kingdoms: *Regnum Animale*, *Regnum Vegetabile* and *Regnum Lapideum*; the Animal, Vegetable and Mineral Kingdoms. Contemporary understanding divides life into six kingdoms. Now we are reaching a barrier where technologies are merging more and more to the biosphere. They are self-learning and evolving but not yet capable of reproduction in the sense of biological life. Kevin Kelly argues that the emergent system of the technium is a super organism of technology.

What would this speculative technium, seventh kingdom of technology, *Regnum technologiae*, of non-carbon or hybrid technologies be? Even if technology is an extension of human, or in a biological sense phenotype of human, an intriguing question is how self-learning AI machine systems will build new deep taxonomies based on their own processes. Similarly, when will carbon-based biological systems and AI systems with robotic outputs start to autonomously reach each other, learn and evolve together ? What kind of knowledge, taxonomies, random forests and creative outputs would grow from that? How will coexistence and existence among beings be altered? How can a person with a background in local biology and orally transferred knowledge reaching eons back with a herding dog, and present day and future technologies like self-learning and communicating flying drones and possible terrestrial robots with AI systems, live in the wild among prey and semi-domesticated animals? Human-centered will arguably change and evolve to web-like or machine-centered. Or would it be more like group intelligence, utilising different intelligences for tasks or observations at hand? How totalitarian will this merger of technosphere and biosphere be?

Would it allow us to survive and nourish our environment, or do we continue on this path of extinction and exploitation despite our proven knowledge? Maybe entities and machines that sing and build poetic movements and visions with us and other life, will help us and other living forms thrive and coexist.

Environmental Machine Learning

Algorithmic analysis has gained a lot of traction also in environmental sciences. AI is deployed to scrape the web for footage of Whales, Elephants or Sea-lions. Real data on population dynamics is harvested in this way from flickr photosets or even the background of cycling events. In a field as notorious for data-heterogeneity as ecology, AI is seen as a key tool for making sense out of disparate data sources. In matters of environmental policy, policymakers have come to prefer the answers given by computer modeling over the answer of a human expert, because experts may point out uncertainties or raise difficult counter-arguments. Computers are just easier to force into giving unambiguous answers than humans. Environmental data is however seldom unambiguous or unbiased. Even species occurrence data is a matter of interpretation because the taxonomy of species tends to shift with new insights and identification keys. Yes, taxonomy is an exact science but it also an ongoing debate. So data that is assumed to be hard-data is often much more liquid under scrutiny. The known-unknowns in the field become unknown-unknowns in models and environmental trendlines. And anyone who has ever built their own environmental sensors knows how hard it is to get a sensor to accurately measure the thing you want it to.

The complexity of environmental processes is generally underestimated, even in science. Some ecosystems are so vast and biodiverse that they become fundamentally unknowable: environments like the Amazon rainforest where organisms live and die at densities below our capacity to research or even find them. Nigel Pitman and his colleagues coined this phenomenon Dark Biodiversity. But even asking the simplest of questions – what is the impact of a predator on their prey – can quickly spiral out into multidimensional feedback-loops between environment, population dynamics, individual behaviour and genetics. In a way species are emergent phenomena based on the interplay of all these domains.

Discussions about AI in relation to environmental sciences and ecology generally do not address these issues. Perhaps developers hang out in environments dominated by discrete data, just like the AIs they develop. Places where the premise that quantitative data can provide a coherent model of the world are rarely challenged. Some progressive ecologists like Thomas Oudman and Theunis Piersma insist that our environmental models are simplifications, and warn that environmental policy that is based only on models can therefore be counterproductive or even harmful. In their opinion the illusion of understanding natural complexity is actually undermining our ability to protect nature. But it also raises questions: how can we protect what we cannot understand? They advocate a science less preoccupied with answers, and call for a science that aims for a more precise appreciation of what we do not know: the un-understanding of nature.

Theun Karelse's thinking during Ars Bioarctica 2018 was starting to wonder into ways of environmental un-understanding for machines. Does environmental literacy for machines imply that they also refine their known-unknowns? Perhaps a kind of knowing that is less based on analysis and more on relating. Could machines be left to make their own taxonomies of their environment? From this question Ian and Theun developed the idea of Deep Bestiary, an artificial agent that becomes literate to its environment on its own terms, without humans telling it about Trees, Ducks, clouds, what kind of strange bestiary might emerge form an artificial mind?

Do machines need training-forests?

Gridworlds are simplified virtual environments for machine learning designed specifically to measure 'safe behaviours' before an AI is deployed in 'the wild'. Similar to young Orangutans who are first released in a training forest to learn from their peers how to climb, what to eat or how to make a decorative pillow for the night. In a way the Random Forests fieldwork session in Kilpisjärvi was a training session for AI in an environment beyond the simplicity of gridworlds. When we showed Inception the Finnish landscape it interpreted the world as a landscape of commodity. This indicates that platform AIs grow up exclusively in a corporate habitat. Its view of the environment is fed by mining, precision agriculture and autonomous vehicles. Do our artificial agents of late-capitalism need training forests? Should they spend their weekends exploring rivers, forests, glaciers and tundra? Should they fish with Saami in a forest river? Should they go on walkabout like young aboriginals?

What if the fate of the Amazon river actually depend on Amazon's algorithms? This is as good a time as any to remember Nietzsche's words: "All truly great thoughts are conceived by walking." Perhaps this will prove true also for machines.

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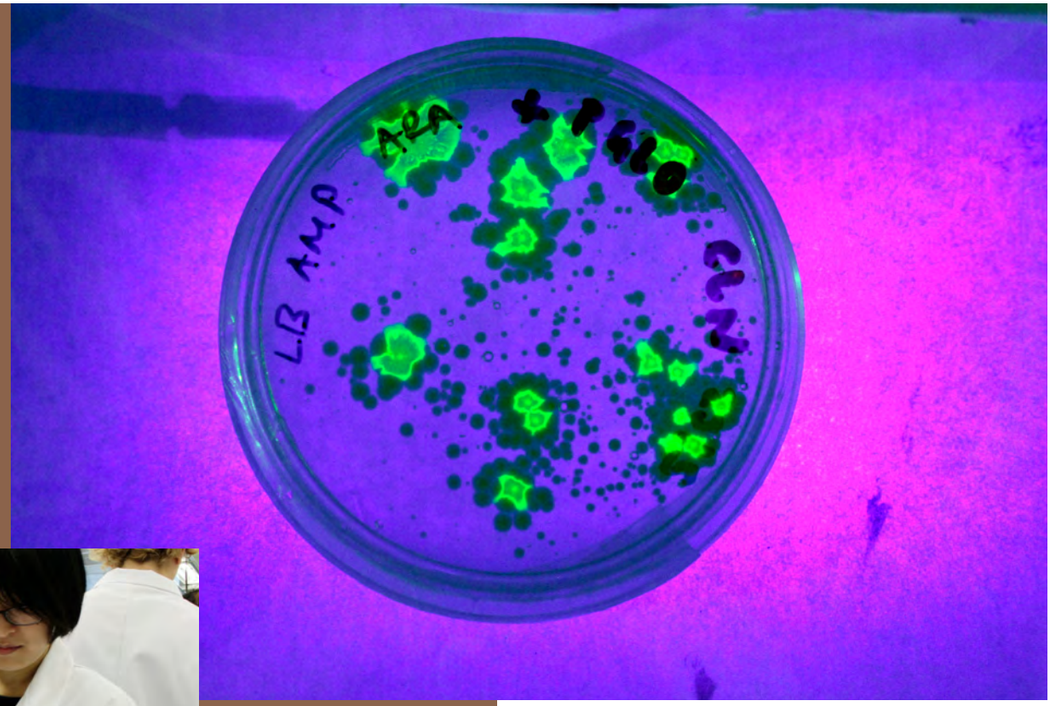
Making_Life

Bioart Society, 2014–2015

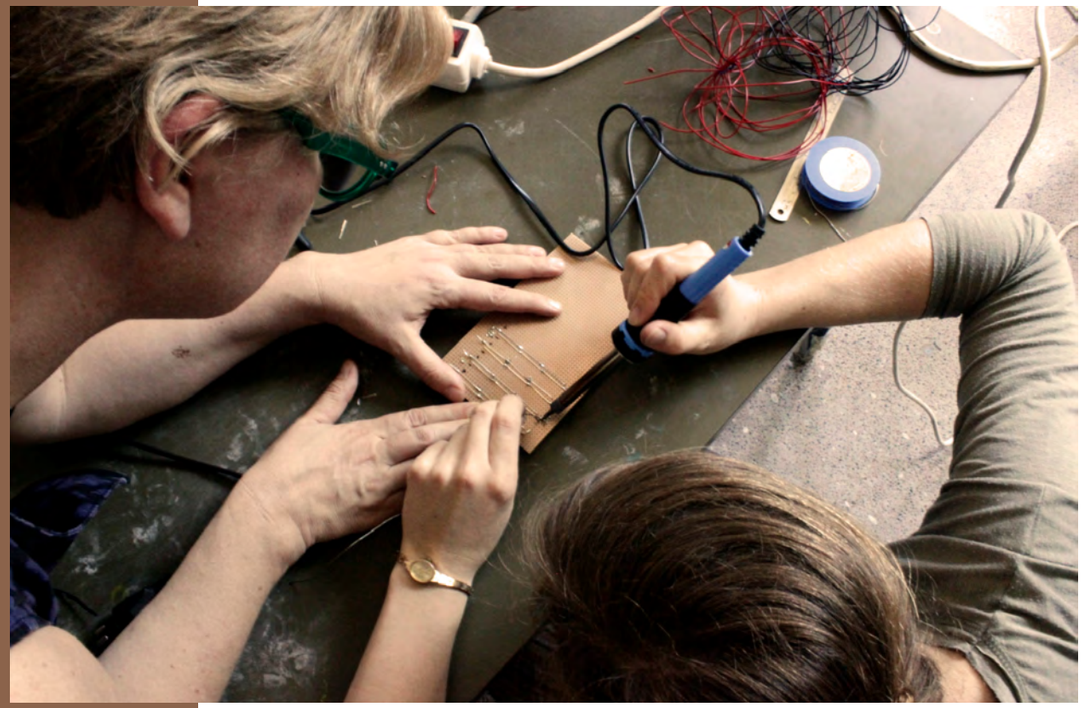
Making_Life was a series of three work sessions which allowed a multidisciplinary group of practitioners to critically, and in an informed manner, engage with the technology and the socio-cultural, political and ethical complexities of synthetic biology. The group consisted of artists, designers, architects, engineers, scientists, and students. The methods varied from workshops, laboratory sessions and field trips, to forums, seminars and lectures. The first and second session took place in 2014 at Biofilia in Aalto University. The third work period in 2015 was an intense production session to create artistic responses and prototypes, culminating in an exhibition and seminar.

Participants Laura Beloff, Erich Berger, Oron Catts, Haohsin Chang, Charli Clark, Lora Dimova, Carolina Ramirez-Figueroa, Stephen Fortune, Verena Friedrich, Andy Gracie, Martin Hanczyc, Marika Hellman, Philip Hector, Juha-Pekka Hilpas, Cecilia Jonsson, Mari Keski-Korsu, Pei Ying Lin, Pia Lindman, Emudio Zamudio Murillo, Piritta Puhto, Sruli Recht, Johanna Rotko, Markus Schmidt, Helena Shomar, Corrie Van Sice, Tiina Taskinen, Orkan Telhan, Antti Tenetz, Georg Tremmel, Paul Vanouse, Ionat Zurr.

Reenacting the Wöhler synthesis of ammonium cyanate into urea. Photo by Erich Berger.



E.coli transformation with green fluorescent protein. Photo by Erich Berger.



Building of DIY laboratory equipment. Photo by Erich Berger.

Labor

Paul Vanouse, 2019

Labor is a dynamic, self-regulating art installation that re-creates the scent of people exerting themselves under stressful conditions. There are, however, no people involved in making the smell – it is created by bacteria propagating in the three bioreactors in the artwork. Each bioreactor incubates a unique species of human skin bacteria responsible for the primary scent of sweating bodies: *Staphylococcus epidermidis*, *Corynebacterium xerosis* and *Propionibacterium avidum*. As these bacteria metabolise sugars and fats, they create the distinct smells of human exertion, stress and anxiety. Their scents combine in the central chamber in which a wearer-less white t-shirt, is infused as the scents disseminate out, intensifying throughout the exhibition.

Labor reflects upon our changing understanding of what we are. Microbes in and on the human body vastly outnumber human cells and they help regulate many of our bodily processes, from digestive and immune systems to emotional and physiological responses like sweating. Our microbiota is integral to who and what we are, and complicates any simplistic sense of self. Likewise, the smell of the perspiring body is not just a human scent, unless we are willing to redefine what we mean by human. *Labor* also reflects upon an industrial shift from human and machine labor to increasingly pervasive forms of microbial manufacturing. Today, microbes produce a wide range of products, including enzymes, foods, feedstocks, fuels and pharmaceuticals. These new industrial activities point to a deepening exploitation of life and living processes: the design, engineering, management and commodification of life itself. In *Labor*, the microorganisms ironically produce the scent of sweat, not as a vulgar bi-product of production, like in factories of the 19th and 20th centuries, but as a nostalgic end-product. Photo by Tullis Johnson.

Paul Vanouse is an artist and professor of Art at the University at Buffalo, NY, where he is the founding director of the Coalesce Center for Biological Art. His bio-media and interactive cinema projects have been exhibited in over 25 countries and widely across the US. He has received awards at festivals including Awards of Distinction and a Golden Nica at Prix Ars Electronica in Linz, Austria (2010, 2017, 2019) and Vida, Art and Artificial Life competition in Madrid, Spain (2002, 2011).

Labor, installation view, Burchfield Art Gallery, Buffalo, 2019. Photo by Tullis Johnson.

OSG: Mapping a Hormone Hyperobject

Rian Ciela Visscher Hammond

Rian Hammond is a transdisciplinary artist and researcher based in Baltimore, Maryland. Their work explores the myth of scientific objectivity by focusing on the often unseen interplay between scientific advancement and cultural production, technological progress and desire. Their current long-term project, Open Source Gendercodes, focuses on the intersection of gender variation and technoscience, tracing histories of steroid hormones, and performing science within them. By developing novel hormone production technologies, OSG attempts to queer current regimes of ownership and bio-power.

Science as colonial discourse

Technoscience[1] is a continued colonial discourse. By this I mean that technoscience has ultimately operated as a tool of hegemonic European and North American power. Its activities and inquiries are guided by the needs of the state. It positions itself as a keeper of truths empowering or legitimating violence towards those deemed animal or subhuman. I also mean, quite literally, that the material networks and bodies of knowledge which comprise technoscience today are built off the exploitation of and experimentation on marginalised people, colonial seisures of land, and biopiracy of indigenous knowledges. Coming to understand the ways these colonial practices have shaped today's technoscientific sphere is essential to approaching the task of asking, what is gender, and what are gender biocodes (such as estrogen and testosterone).

Attempting to learn about current technologies used to produce testosterone, estrogen, and progesterone, I have found myself tracing through a complex socio-political-material web. The development of these technologies from the late 1800s up to the present is entangled with power structures and ideological frameworks. The most obvious of which is the dyadic conceptualisation of sex and gender that remains a vestige of European colonisation around the world. I will not flesh out an argument against binary sex and gender, as this has been thoroughly deconstructed by theorists, biologists, anthropologists, activists, and others.[2] The countless trans, intersex, two-spirit, non-binary, gender non-conforming and queer people who reject narratives that attempt to erase them as outliers, anomalies, or pathological should be enough. Through the past two centuries of biotechnical innovation, it was precisely this binary sex/gender framework–taken up as scientific nomenclature–that birthed tech for exogenous hormone production. By attempting to render bodies as well as desires and behaviours legible within a hetero-dyadic framework, this system produces normal and abnormal bodies. Both the motives of seeking a

1 "*technoscience* refers specifically to the technological and social context of science. Technoscience recognises that scientific knowledge is not only socially coded and historically situated but sustained and made durable by material (non-human) networks. Technoscience states that the fields of science and technology are linked and grow together, and scientific knowledge requires an infrastructure of technology in order to remain stationary or move forward." https://en.wikipedia.org/wiki/Technoscience

2 See María Lugones *Towards a Decolonial Feminism*, Anne Fausto-Sterling's *Sexing the Body* and *The Five Sexes Revisited*, Paul Preciado's *Testo Junkie*, Heath Fogg Davis's *Beyond Trans: Does Gender Matter*, Judith Butler's *Gender Trouble: Feminism and the Subversion of Identity and Undoing Gender*, Oyeronke Oyewùmí's *The Invention of Women, and countless others*.

technological correction for bodies labeled abnormal, and fantasies of enhancing those considered normal to become hyper legibly male and female (or hyperpolarised) shaped the evolution of hormone tech. Here, gender normativity–the alignment of the various aspects of phenotype, behavior, and desire within this hetero-dyadic system–becomes synonymous with health, productivity, and worth.

Aside from the binary regime, a constellation of geopolitical conflicts, state-enforced frameworks for the ownership of organisms and biomolecules, population control and reproductive regimes have too, shaped these molecular prostheses. I've started referring to this web of becomings which is massively distributed through time and space, as a hormonal hyperobject (borrowing Timothy Morton's term). To see hormones as a hyperobject, is to recognise that testosterone, progesterone, and estrogen cannot be simply reduced to individual molecules with known molecular structures and energetic properties. They can never exist for us as a single substance in one place at one time. They are psychosocial artifacts, charged with a liveness that extends far beyond their ability to stimulate cellular receptors and modulate the morphological flow of bodies and cell proliferation. Aside from the various subjectivities and potentialities (whether fiction or nonfiction) ascribed to hormones, there is a plexus of regulatory systems which manage exogenous hormones and direct their flow through the social world.

Ownership and regulation

To own an organ, gland, cell, secretion, molecule

Legal scholar Graham Dutfield has observed that the early development of steroid hormone production methods drove a key shift in intellectual property law to allow for the patenting of things previously considered "natural." Prior to the successful patenting of early forms of steroid hormones, precedent had been set by several U.S. Supreme Court cases deciding that chemicals extracted from or which were synthetic copies of naturally occurring molecules produced within organisms were *not* patentable. So, what changed with the introduction of exogenously produced hormones? The shift in the court's understanding of naturality vs. artificiality or inventiveness seems largely to have been driven by economic and political factors (Dutfield, 2011a).

> As soon as hormones were found to have commercial potential, industry faced the challenge of how to mass-produce them. This was obviously a scientific matter, but it was also a business issue and an intellectual property one. Both production pathways of extraction and hormone synthesis turned out to be equally capable of resulting in patentable subject matter. This was so even when said matter was based on a substance produced by an organism or else was a laboratory-produced copy of one. This set a historic precedent for the patenting of "natural" things like antibiotics, genes, cells, microbes, plants and animals. Thus, the patenting of hormones helped allow us to conceive of biotechnological products as patentable inventions. (Dutfield, *Patents on Steroids* 2011a)

Today, all patents on specific molecular forms such as testosterone, or 17beta-Estradiol have lapsed. Current ownership claims are instead staked on specific methods of producing these chemicals, methods of preparing and dosing, or delivery methods (such as transdermal creams, patches, or injectable formulations). Dutfield concludes that, "Today, we are living with the legacy of the hormones era" indicating the role they played in the mutual evolution of science, business, and intellectual property law by creating a pathway for current ownership claims of, "genes, cells, microbes, plants and animals." In this way, the historical development of hormone production tech is deeply implicated in the expansion of neocolonial systems of ownership which, as Dutfield has also noted, are designed to,

> …give rights to those who can translate ritual knowledge into "the language of science." Whether or not this translation requires much inventive input, or that anything new is actually created. (Dutfield, *A Critical Analysis* 2011b).

This effectively facilitates ownership claims (past and present) by Westerners over indigenous or "traditional" knowledges, whilst simultaneously the ecosystems which gave rise to the rich biodiversity and inter-species life-ways mined for profit are decimated by the extractivist brutalism of capitalist economies (Mgbeoji, 2006).

When thinking through what Dutfield refers to as the "legacy of the hormones era," and the mutual development of science, business, and patent law, we could distill several generalised operating principles that animate technoscience today: (1) centralised production (2) legally facilitated monopolies through patenting practices (3) high competition // low collaboration, and (4) trade secrets. These principals lead to: (1) continued extractivism and profiteering off of marginalised bodies, indigenous knowledges and lands (2) the consolidation of power and wealth into the same few North American and European institutions and (3) technologies designed to work within and re-solidify this system. In response to the violence of these practices, many have called for open source and collaborative methods of doing science. Proponents of open science, often embrace "openness" as universally good because it is thought to be antithetical to the competitive, hoarding, monopolising tendencies that normally constitute technoscientific production. But as the *Open and Collaborative Science in Development Network* (OCSD net) have critiqued, open source methods can still allow (and in many instances make easier) extractivist and predatory practices.

> Our position was that most of the open science discourse and practices, particularly those that were on the mainstream (at the policy making and institutional levels) were framing open science as a technology driven means to produce a more productive, efficient, and competitive science or research. One of the main critiques we had, was that this discourse was biased, and very much in favor of a utilitarian conception of science or research that focuses too much on incentivizing knowledge production for the sake of innovation and international competitiveness… Openness can be an instrument to mobilize power. While open systems can in some cases be used to disrupt power structures, they can also be used to strengthen them when they represent the same incentives or practices that have been used for exclusion. We have to stay very vigilant of the ways openness can amplify power asymmetries. (Albornoz, 2018)

In light of the non-neutrality of "openness" OCSD net has called for a Feminist Open Science by offering some conceptual tools drawn from feminist STS scholarship (Albornoz, 2018). Building off of the work of OSCD net, we can propose an alternate set of organising principles: (1) beginning with the recognition of our non-innocence (2) working towards replenishing a biocommons and knowledge

commons (3) robust systems that incentivise collaborative efforts and (4) prioritising expressions of consent or *refusal* on behalf of those who become subjects of scientific inquiry. These proposed alternative operating principles are aimed at proliferating cognitive justice (multiple cosmologies, multiple futures for science, non-Western ways of doing, being and knowing). They call for distributed production and distributed wealth rather than consolidation of wealth and power, for "open" hackable technologies, designed to facilitate locally appropriate solutions, and an emphasis on addressing social problems rather than on international competitiveness and "innovation" for economic growth only.

Regulating the codes of gender

Hormones have been prescribed to trans and inter people seeking access to medical technologies of gender for more than 60 years now with no significant negative health outcomes. In the U.S. this is still considered an off-label use since the FDA has yet to approve any formulations of steroid hormones for transgender people. The official use of Delestrogen, or injectable generic estradiol-valerate is approved only for hormone replacement therapy in post-menopausal cisgender women or to modulate fertility in cis women. Kimberleigh Joy Smith, a senior director at Callen-Lorde Community Health Center (serving more than 900 transgender patients in the NYC area), has suggested that this disregard or dismissal of transgender communities on the part of regulatory agencies is partly to blame for the often chronic and life disrupting shortages of injectable estrogen (Molteni, 2016). Recent shortages of the safest and most effective forms of estrogen in the United States lasted for months at a time in 2014 as well as 2016 and 2018, causing health complications for trans, inter, and nonbinary people (TIN) (Hajj, 2018). I would add that profit motivated pharmaceutical companies are not particularly interested in the needs of TIN people who could be seen as "economically insignificant" minority populations.

Thinking this scenario through a Feminist Open Science perspective, we could speculate how open source hormone bioproduction systems might refigure the dynamics of access. Because the technology is open source and public domain, there would be no patent barriers for a local co-op using it to make medicines. Because the platform is based on plant pharming, startup costs are significantly lowered since expensive bioreactors are not needed to incubate microbes. In comparison to today's steroid hormone production technologies, a self-sufficient transgenic bioproduction system would be less polluting and less expensive (Bronnin et al., 2018). Cooperatives who prioritise the needs of the local community could produce medicines at low cost considering local demand rather than drugs being manufactured centrally and shipped around the world.

Below this regulatory level (FDA drug approval and official use recommendations) there is a secondary regulatory layer directing flows of hormones. Several associations such as the World Professional Association for Transgender Health (WPATH), and the American Psychiatric Association provide disease and disorder classification systems, along with official standards of care. Organisations such as WPATH and the World Health Organization develop international standards, although many countries have local standards. These standards or "clinical protocols" are meant to guide diagnosis and treatment of patients by individual doctors, but ultimately they are recommendations. It is at the discretion of the doctor to decide who is deserving of access to technologies of gender. In effect, this has enabled medical professionals to operate as authorities over what expressions of gender are valid (deserving access to technologies of gender), and in many instances to enforce fictions of binary gender or even mandates of heterosexuality.

While the diagnostic classifications have changed significantly in recent years, many feel this is not enough. Full depathologisation has been a contentious topic within trans communities because without a diagnostic category to classify gender variation as a health problem (which facilitates insurance coverage for the cost of hormones, therapy, surgical procedures, etc.), the current inequity in access to these technologies would be further amplified. Emi Koyama has proposed a way out of this problem in her *Transfeminist Manifesto*, by looking to the women's health movement to gather tactics for arguing against pathologisation while simultaneously demanding equitable access to care.

Before the feminist critiques of modern medicine, female bodies are considered "abnormal" by the male-centered standard of the medical establishment, which resulted in the pathologization of such ordinary experiences of women as menstruation, pregnancy and menopause; it was the women's health movement that forced the medical community to accept that they are part of ordinary human experiences. Transfeminism insists that transexuality is not an illness or a disorder, but as much a part of the wide spectrum of ordinary human experiences as pregnancy. It is thus not contradictory to demand medical treatment for trans people to be made more accessible, while de-pathologizing "gender identity disorder."(Koyama, 2001)

Open Source Gendercodes

OSG is a transdisciplinary bio-hack-art project that formed at the Baltimore Underground Science Space in 2015. OSG seeks to understand the forces which have shaped the development of the hormone production technologies we have today, and ask if these tools can be refigured to undermine oppressive biopolitical and ownership regimes. Can critical engagements with these tools be sites of resistance against the pathologisation of transness and policing of who can access technologies of gender? Can as Gill-Peterson poses, "forms of autonomy… wrest [contemporary transgender biopolitics]... away from the valuation of neoliberal capital and into the hands of… all bodies"(Gill-Peterson, 2014)? More generally, can synthetic biology be used to develop technologies for cheap, democratised bioproduction of biologic medicines, and how can artists and hackers push these inquiries (research pathways which will not be investigated by institutions invested in growing profits and consolidating power)?

OSG postulates a future in which an individual, or a co-op could affordably and safely grow their own hormones using a bioproduction system (a transgenic plant or yeast producing high levels of growth hormones in its tissues). While the prospect of on-demand drug production is technically feasible with current technologies and emerging synthetic biology techniques[3], the prospect of an *affordable* device that could produce hormones in transgenic yeast or plants, and additionally perform extraction, purification, and dosage in a safe way is a more distant possibility. It is the isolation and quantification/dosage of individual steroid molecules that poses the most difficulty. The Bio-hack-art project, Open Source Estrogen (a collaborative

3 DARPA is currently funding several initiatives to produce on demand pharmaceuticals in combat zones in briefcase-refrigerator sized bioproduction units utilising synbio techniques. https://news.mit.edu/2016/portable-device-produces-biopharmaceuticals-on-demand-0729

project by Mary Maggic and Byron Rich) has speculated a DIY recipe for easy kitchen hormone extraction from urine using a technique called solid phase extraction.[4] The utopian poetics of transferring hormones between bodies within the domestic space of a kitchen/laboratory are abundant in Maggic's video piece *Housewives Making Drugs*, which poses questions about body autonomy and the regulation of hormones. Urinary hormone extraction is especially enticing as urine is an accessible, ubiquitous resource, and there is precedent for urinary extracted pharmaceutical formulations. The first marketed estrogen supplement, introduced in the 1930s as Progynon was an extract of pregnant people's urine. But realistically, if used for bodily applications, urinary extracts produced by DIY silica gel solid phase extraction (SPE) will do nothing at best, or lead to cancer, stroke, or other health complications at worst. Mainly because this method is not selective for individual steroids, the extraction is a combination of androgens, estrogens, progestins, corticosteroids, as well as other contaminants. Even in the case of Premarin, an FDA approved formulation of estrogens produced using industrial extraction methods on the urine of pregnant mares, research has shown that the risk of stroke and heart disease are significantly higher than with so-called "bioidentical" synthesised estrogen (17β-estradiol). The FDA released a document titled *FDA Backgrounder on Conjugated Estrogens* which admits that despite the drugs' approved status, the full spectrum of steroid compounds, proteins, and other substances in the urine extraction is unknown.

> Compositional analysis of Premarin using modern analytical techniques demonstrates that it consists of a mixture of a substantial number of compounds with potential pharmacologic activity. In fact, the steroidal content of Premarin has not been completely defined. Undoubtedly, many of the compounds present in Premarin do not provide a clinically meaningful contribution to the therapeutic effects of the drug and are best thought of as impurities. (Center for Drug Evaluation and Research, 2005)

The lesson is that chemistry matters, different estrogenic chemicals interact with the body in different ways, stimulating a number of cellular processes to varying degrees. There is the possibility that innovation in urinary hormone extraction and purification technologies could lead to safer methods (such as molecularly imprinted polymer SPE substrates), but at present it seems untenable as a DIY method if even industrial processes yield such unsafe and impure mixtures.

Other possibilities to be explored might be:

- hacking electronic hormonal birth control implants to create a cybernetic gonad
- CRISPR modification of fat cells to induce desired endogenous hormone production by a hybrid adipose/gonad
- bioprospecting for compounds that could upregulate or downregulate production of aromatase (enzyme which converts testosterone into estradiol in all people's bodies)
- or an open source hormone production platform utilising microfluidics and transgenic yeast (potentially via Paula Pin's Trans Organs on a Chip)[5].

4 OSE has also developed DIY methods for C18 silica solid phase extraction of xenoestrogens from waterways to measure endocrine disrupting pollutants by testing estrogenicity with a transgenic yeast assay. http://maggic.ooo/Estrofem-Lab-2016

5 "The Trans Organs on a Chip is a project within BIO-reSEARCH, the Pechblenda tentacles, mixed with AnarchaGland & GynePUNK biolabs. The project has been joined by many others who are interested!" https://www.hackteria.org/wiki/Trans_Organs_on_a_Chip

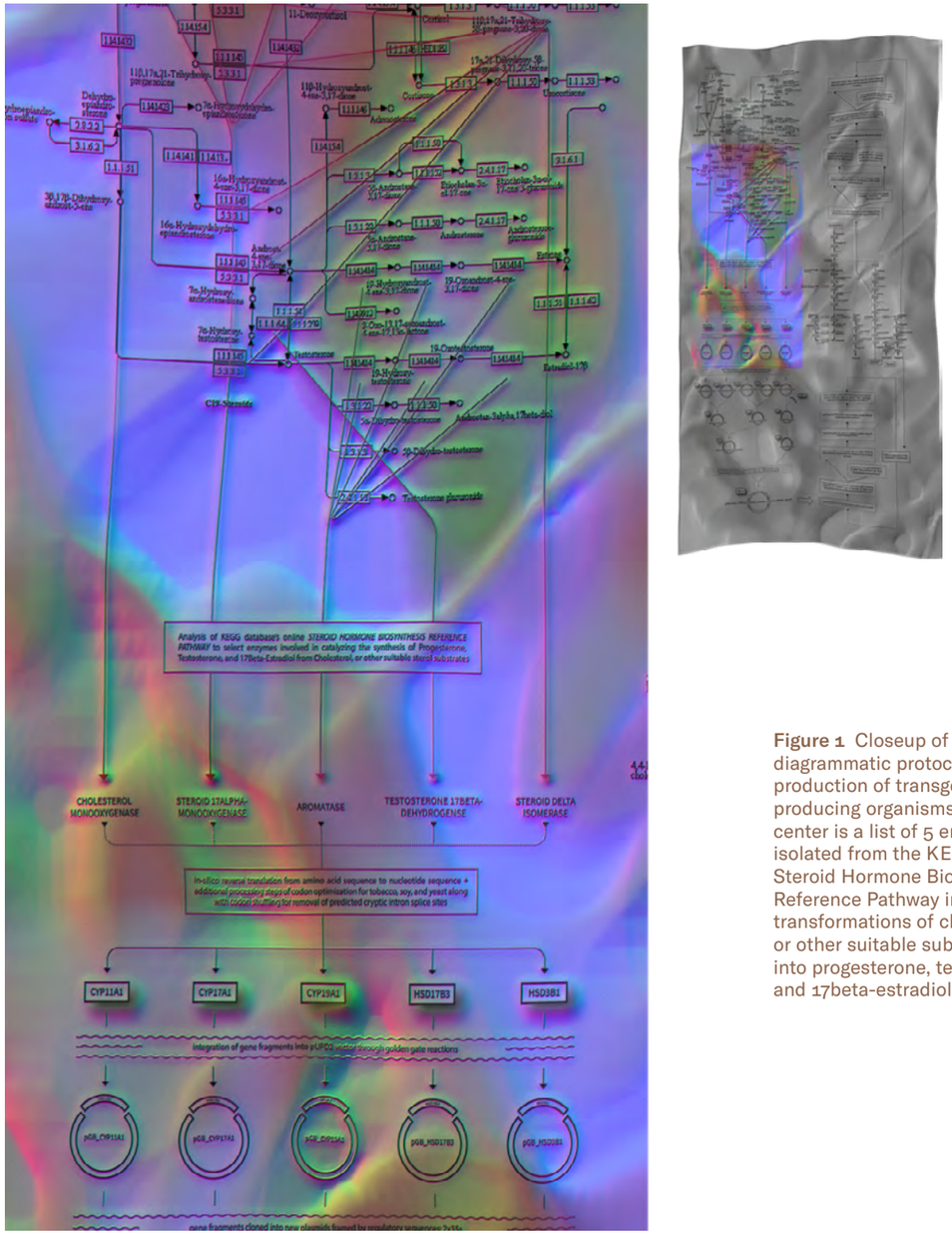
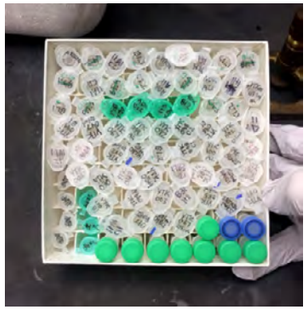
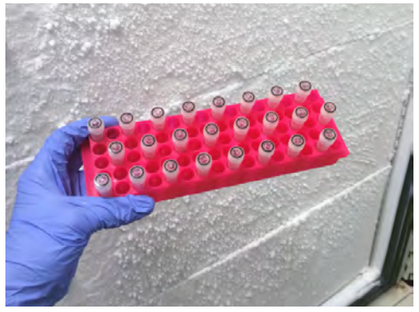


Figure 1 Closeup of a diagrammatic protocol for production of transgenic steroid producing organisms. Below center is a list of 5 enzymes isolated from the KEGG Steroid Hormone Biosynthesis Reference Pathway involved in transformations of cholesterol or other suitable substrates into progesterone, testosterone, and 17beta-estradiol.





Figures 2 and 3 These images display portions of the OSG plasmid and bacterial mutant libraries.

OSG has focused on the metabolic engineering of tobacco, soy and yeast for reasons both utilitarian and lyrical. The possibility of a hormone producing plant resonates with historical and contemporary brujería–arts of knowing, cultivating, and co-creating life-ways between human and plant beings. At play are the spiritual and medicinal healing abilities of plants; their constituting a wild biocommons which has been systematically but not fully foreclosed through time (as described in the work of Silvia Federici). Additionally, plants have a unique relationship to transgenesis through the soil bacteria *Agrobacterium tumefaciens*. *A.tumefaciens* is a soil bacteria that is able to genetically modify plants in the wild, inserting genes for the production of sugars *A.tumefaciens* can uniquely feed on and plant tumors that it lives inside of. Some of the first laboratory-produced transgenic plants were actualised by using *A.tumefaciens* abilities. Prior research has shown successful modification of soy and tobacco for accumulation of fats which serve as substrates for growth hormone production, as well as successful production of pregnenolone and progesterone in transgenic plants (Schaeffer et al., 2000)(Fogher, 2007)(Spivak, et al., 2009)(Spivak, et al., 2010). Plants in general are of interest because of the lowered potential for contamination with a plant bioproduction system, as well as the reduced infrastructural needs and subsequent reduction in the cost and environmental burden of producing drugs. (Ma et al., 2003) Other research has demonstrated successful accumulation of campesterol (a primary sterol in yeast) as a substrate for growth hormone production, as well as successful production of progesterone in transgenic yeast. (Duport et al., 1998)(Du et al., 2016)

The bulk of OSG experiments with metabolic engineering have been performed in DIY biohack spaces as well as academic and biomedical park laboratories accessed through bioart initiatives, collaborations, and residencies. Experimentation is ongoing, having started with historical research, patent mining and a scientific literature review, workshopping, speculating–moving into in-silico work and gene design–machine executed gene synthesis, and then the use of "molecular cloning" techniques to construct plasmids (circular DNA molecules). These plasmids contain variations of relevant gene sequences along with other fragments to facilitate their integration into tobacco, soy, and yeast genomes. Physical archives of these circular genetic constructs and the microbes they've been incorporated into, comprise the OSG gene library: a series of frozen racks of plastic vials containing isolated plasmids suspended in water and glycerol stocks of bacterial mutants carrying the xenogenes.

Figure 1 includes the names of five enzymes that are involved in human steroid hormone biosynthesis, able to catalyse conversions from cholesterol, campesterol, or other suitable substrates to pregnenolone > progesterone > 17α-Hydroxyprogesterone > androstenedione > testosterone > and finally 17β-estradiol. Genetic modification to integrate xenogenes for production of these enzymes into organisms is part of the metabolic engineering process. The other part is to engage with the complexity of the living being itself: its needs, desires, and the way its own metabolic processes and life-ways will interact with the new desire engendered.

Anywhere along that pathway from cholesterol to estradiol, there can be metabolites that might become toxic (or beneficial) to the organism. Intermediates within the pathway might be attracted to other metabolic processes as molecular agents within a cell tangle, forking substances into new paths. In intracellular space, metabolism is radically non-linear, poorly represented by the textually linearised path from cholesterol to estradiol. Intra·action occurs stochastically, as molecular agents vibrate and morph with their own charged liveness, responding to each-other's transformative, attractive, and repellent fields. Working within this unfolding microperformativity is an engagement with a plexus, matrix, or topology unfathomably complex and unpredictable: unfolding an organism–a porous body lyric within a hormonal hyperobject.

Special thanks for technical support and guidance from Sarah Laun, Lisa Scheifele, Tom Burkett, Tamara Walsky, Sebastian Cocioba, Casey Lippmeier, Zhen Wang, James Berry, and Solon Morse.

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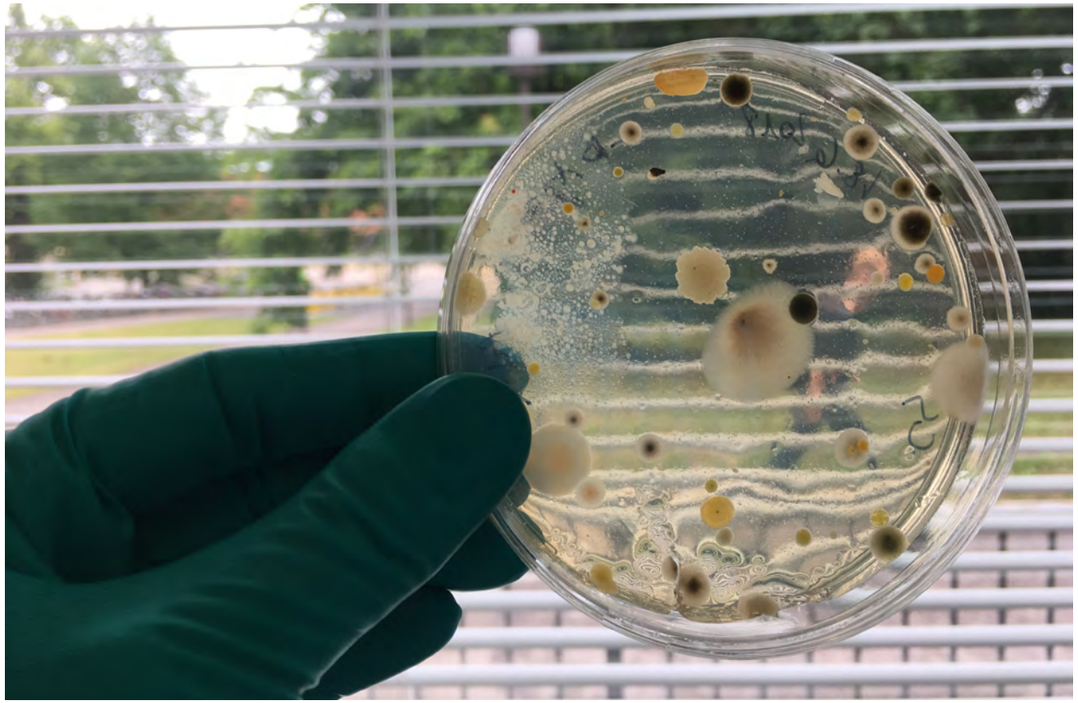
Ceramic Scar Tissue

Christina Stadlbauer, 2018

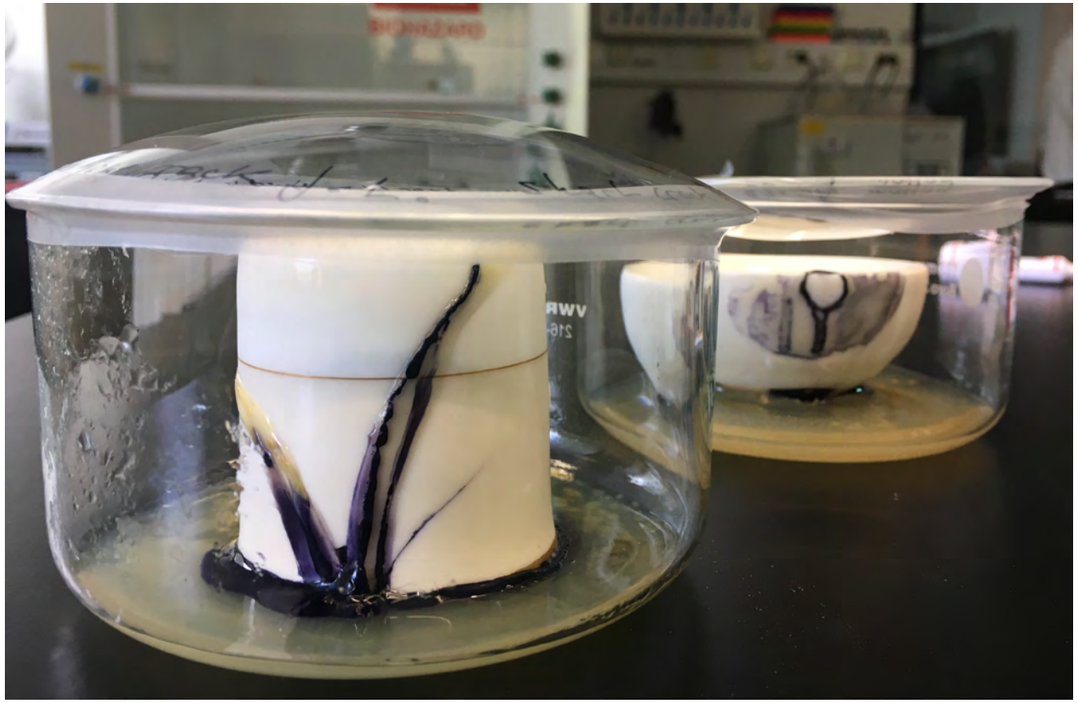
Ceramic Scar Tissue is an artistic exploration of Kin Tsugi with life matter. It is inspired by the ancient Japanese craft and art of repairing broken ceramics by using silver or gold. Instead of hiding the history of damage, the technique of Kin Tsugi emphasises the fault and follows the philosophy of Wabi Sabi – a worldview centred on the acceptance of transience and imperfection. The repair achieved by Kin Tsugi is often described as transformative. The repaired pieces embody dual perceptions of catastrophe and amelioration, and the work prompts a sense of mending or curing rather than fixing. Kin Tsugi enhances and embellishes the appearance of the original object with the aesthetics of precise craftmanship and precious materials.

In *Ceramic Scar Tissue*, the philosophy of transformative repair, is explored more profoundly by proposing the concept of healing. The work introduces living organic matter for mending the crack, replacing the traditionally-used Urushi resin as gluing agent. The idea of ameliorating damage is taken into the living world and, similar to healing a lesion in the body, the fracture of the broken ceramic piece is overgrown by bacteria, creating a scar. The work is carried out in the bio lab, providing conditions for the biological material (bacteria) to grow and create a “scar tissue” over the fissure. With time, the bacterial growth comes to an end, dries up and eventually dies. This natural cycle accounts for the ephemerality of the repair and reflects both the capacity of living organisms to heal and the reality of impermanence or transience of all life.

Christina Stadlbauer is a researcher and artist who works at the interstices of art and science. Her work pivots around life: animals, plants, bacteria. In 2012, she launched the long-term platform *Melliferopolis – Bees in Urban Environments* in Helsinki and since 2017, she also works under the name of “Institute for Relocation of Biodiversity”. Stadlbauer is inspired by Asian philosophy, and practices Kin Tsugi – the Japanese art and craft of repairing ceramics by applying gold or silver to the cracks.



Ceramic Scar Tissue, bacterial selection in petri dish, 2018. Photo courtesy of the artist.



Ceramic Scar Tissue, growth of janthinobacterium lividum on two cracked ceramic cups, 2018. Photo courtesy of the artist.

Dispersal

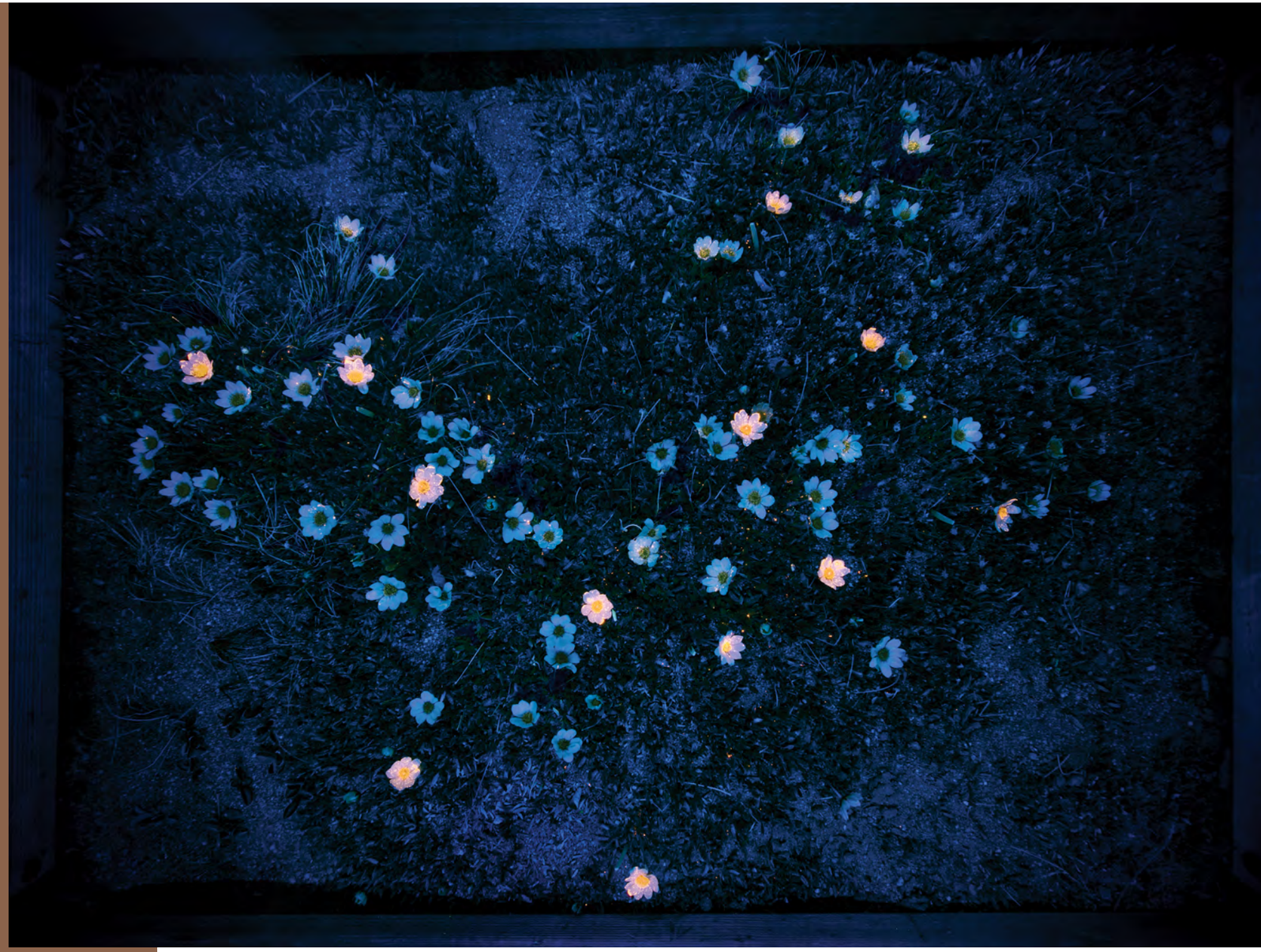
Paula Humberg, 2018

Dispersal is a photographic series and bioart project that visualises the effects of pollinator decline. The project was done at the Zackenberg research station in Greenland in 2018 where Humberg collaborated with biologist Riikka Kaartinen.

The effects of climate change are more marked in Arctic areas where climate is warming faster and the ecological communities are simpler and, thus, more vulnerable. As there are very few bee species in Greenland, the muscid flies have taken up the role of the most important pollinators. Biologists have followed the numbers of pollinators over several decades at Zackenberg, and the collected data shows that the abundance of muscid flies has decreased by up to 80% during this period. Climate change is considered to be the likely main cause.

Humberg and Kaartinen created an experiment to study how the amount of pollinating flies affects pollen dispersal. Fluorescent pigments were used to dye the pollen of mountain avens (*Dryas octopetala*), which is a small plant that forms dense flowering mats. It is a keystone species in Greenland, meaning it is important to many other species and the whole ecosystem. Selected avens patches were isolated with net tents and fluorescent pigment was put on 20% of the flowers in each patch. The patches were photographed under ultraviolet light right after adding the pigment and then covered with tents. Pollinators were released inside. There were two compositions: The A groups had 10 muscid flies and one pollinating insect from the groups *Empididae*, *Syrphidae* and *Aedes* (13 pollinators in total). The B groups were otherwise similar but had only 2 muscid flies (5 pollinators in total). The insects were collected after 72 hours and photographs of the flower patches were taken again to record the results.

Paula Humberg is a Finnish artist and a photographer. She is currently finishing a MSc in Biology at the University of Eastern Finland. Her art examines themes related to biology and ecological problems. Although Humberg mainly works in the field of bioart, her methods usually involve photography. She is particularly interested in alternative photographic techniques. Humberg's works have been exhibited at the Finnish Museum of Photography as well as several private galleries.



Slot B2 at 72h. 50 cm × 67 cm Diasec, 2018. Photo courtesy of the artist.

Learnings/ Unlearnings

Beat to the Balance session by Mari Keski-Korsu during *Field_Notes – EOS*, 2018. Photo by Antye Greie.

Forgotten Histories of DIYbio, Open, and Citizen Science: Science of the People, by the People, for the People?

Denisa Kera

Denisa Kera is a philosopher and designer that experiments with creative strategies of public engagement in emerging science and technology issues. She spent the last decade as an Assistant Professor at the National University of Singapore, Senior Lecturer of Future Design in Prague College, and a Visiting Assistant Professor at Arizona State University, where she cooperates with the Centre for the Study of the Future. Currently, she is a Marie Curie Research Fellow at BISITE, University of Salamanca, researching anticipatory governance of blockchain futures.

Introduction

The rise of makerspaces and hackerspaces in 2007 was followed by a surge of open, citizen, and community science projects which enabled public around the world to gain direct access to various tools, laboratory equipment, protocols, and technical know-how. These means of scientific and technological production, previously limited to corporate R&D institutes and university laboratories, suddenly became democratised, literally "open" (Pearce 2012) and available even in the Global South (Kera 2015). Instead of only serving scientific innovation and economic growth, science and technology became a means for political, activist, and equally for highly personal and idiosyncratic projects (Kera 2017).

DIY (Do-It-Yourself) and DIWO (Do-It-With-Others) tools, spaces, and projects make scientific and technological interests and knowledge a personal and political matter. They align epistemic, ontological, and scientific explorations and know-how with normative interests. Rather than using science solely to pursue discovery or serve industry, these movements emphasise the diverse publics that can utilise science to embrace various goals related to engagement, governance, knowledge, justice and divides. They strive to democratise or even decolonise science and technology (Boisselle 2016; Wylie et al. 2014; Egert and Allen 2017; Kera 2014b), acknowledge indigenous knowledge (Kera 2012a; Sillitoe 2007) or at least to increase reproducibility and engagement in science in various parts of the world (Seyfried, Pei, and Schmidt 2014; Pearce 2014).

The surge of DIY or DIWO projects, tools, and spaces is often discussed as a continuation of the Whole Earth Network counterculture movement (Davies 2018; Toombs 2017; Turner 2006) which deflated in the 1980s into Silicon Valley myth about disruptive start-ups solving all world problems. We can follow a similar dynamic in the case of the DIYbio movement which embraces bio-entrepreneurship and betrays the political agenda of the open and citizen science goals (Delfanti 2013, 2014; Tocchetti 2012; Söderberg and Delfanti 2015). Instead of discussing this neoliberal "demise" of the counterculture movement morphing into "California ideology" (Barbrook 2007), we will emphasize that such movements are also heirs to the 1970s calls for the personal to become political (Crow 2000), which are equally important for understanding their past and present ambiguity (Meyer 2015, 2013).

In this paper, I will step back from the aspirations of the DIY and DIWO movements, and the related critique of their Californian beginnings and neoliberal ends, to discuss the forgotten origins

of our attempts to make science more inclusive and responsive to personal and community needs. The genealogy of our pursuit for democratic and socially engaged science goes back to the late 18th century Jacobin calls for patriotic science, and offers a cautionary story on the clash between the moral, aesthetic and natural orders. The rift between contemporary 'mainstream science' and the DIY movements revives this tension that emerged in the 18th century as a reaction to the age-old discussions between atomism and stoicism, between our curiosity for nature and passion to improve society and define some meaning to human existence. Instead of offering a final verdict on the role of science and technology in society, or politics in science, the DIY and DIWO movements provoke us to question and rethink the value of knowledge, autonomy, freedom, and justice on new grounds.

The personal is political, scientific, and technical

Sometime around 2009, early DIY science activities by individual hackers and makers rapidly evolved into movements described in literature as DIYbio, open biology, garage biology, fringe biology, biohacking, grassroots science, etc. (Seyfried, Pei, and Schmidt 2014; Kuznetsov et al. 2012; Kera 2014a; Landrain et al. 2013; Vaage 2017; Wolinsky and Wolinsky 2009; Ledford 2010). Practices such as fermentation, building of open science hardware (microscopes, PCRs, microfluidic plates), or engaging with Synthetic Biology and later CRISPR kits became common in makerspaces and hackerspaces around the world. These DIY science activities led to the idea of developing independent citizen and community science labs exclusively dedicated to these pursuits.

The emphasis on open source tools and collaborative practices offered an alternative to professional, academic and normalised science as practiced in universities and corporate R&D labs. Instead of pursuing a purely scientific agenda or applied research that serves industry, these emerging practices and spaces mobilised new narratives and ideas about the purpose of science, emphasising the issues of engagement, governance, knowledge, justice and divides. While the critique of the neoliberal agenda of biohackers as bioentrepreneurs is well covered (Meyer 2015; Delfanti 2013, 2014; Tocchetti 2012), the aspirations of the open and citizen science activist are usually admired and supported (Kera 2015, 2012a), but as I will argue, for the wrong reason.

We admire open and citizen science practitioners because they strive to democratise or even decolonise science, acknowledge the values of indigenous knowledge or at least increase the reproducibility and engagement in science in various parts of the world ("Global Open Science Hardware (GOSH) Manifesto" 2016). Their curiosity about nature follows closely the goals of improving society through inclusivity, diversity, justice, and creativity. They also support current science policy agendas (Kera 2014b), such as responsible research and innovation (RRI)(de Jong, Kupper, and Broerse 2016; Pellé 2016), and anticipatory governance of emerging science and technology (Nordmann 2014; Davies and Selin 2012; Guston 2014).

I argue that the problem with these aspirations is that they will be prone to populist excess if they do not reflect the earlier forgotten populist attempts to bring science and technology closer to the community. The genealogy of the pursuit of democratic and socially engaged science includes the cautionary tale of the populist Jacobin misuse of science. This episode paradoxically confirms the importance of exploratory and non-utilitarian research at the core of independent science and technology practices.

The exploratory research in "artisanal science" (Kera 2017) depends on the use of crafts to support science as a personal and leisurely activity with an open agenda in terms of its community values and goals.

Artisanal science describes creative, unexpected and non-utilitarian uses of science protocols in the private and everyday lives of citizens, which create conditions for both good science and politics. Here I will contrast the term against the dangers of anti-science and pro-science populisms that refuse to connect facts and values, or insist on only one proper way of connecting emancipatory goals with facts and knowledge. The non-utilitarian, artisanal science is pluralistic and experimental in terms of how to connect values and facts. It insists on the freedom for everyone to probe and decide on how the personal will become political and scientific. Instead of technocratic and anti-scientific excesses, it gives an opportunity to reflect upon how science serves various political and social agendas, and sees this as a part of an older issue and clash between our moral, aesthetic, and natural orders and aspirations.

Jacobin science by the people for the people

The ambition to make science more responsive to community needs has a problematic history going back to the infamous Jacobin attack against the "unpatriotic" atomist science during the French Revolution. This offensive led to the public execution of Antoine Lavoisier, the father of modern chemistry, and the creation of the infamous law of August 8th 1793, that abolished the learned academies of France as incompatible with the republic. The Jacobin search for a "moral and human" use of science is echoed in many contemporary sentiments and calls for publicly useful and engaged science that supports jobs and various patriotic agendas.

The main problem for the Jacobins were the "inhumane" atoms, which did not care about society or "polity", nor presented nature as a model in line with human ideals of social justice, good life or community. The violent history of this longing for unity between facts and values is well summarised in the seminal 1957 article by the historian of science, Charles Coulston Gillispie (Gillispie 1959). He discusses the abolishment of the French Academy of Sciences (Académie Royale des Sciences) by Jacobins in 1793 as a result of a clash between the ideals of virtue (political action) and the knowledge of nature going back to the Stoic and Atomist discussions. The Jacobins shared the Stoic sentiment that nature and morality should mirror each other, and rejected the Atomist knowledge of nature as indifferent to human ideals and norms, as evidenced by Lavoisier's new chemistry.

The populist call for science to serve the needs of the common man was also inspired by Jean-Jacques Rousseau's idea of an original "state of nature", representing an ideal and natural community to which we need to return. Coupled with Denis Diderot's embrace of craftsmanship as the model for meaningful scientific work, it led to the rejection of any knowledge that does not immediately serve societal needs, translate into something patriotic and useful, or understandable by the masses. The atomised and mathematised Newtonian universe, that inspired Lavoisier's chemistry, ignored and even problematised the political view of a harmonious nature and a crafts-based science serving humanity. The biblical purpose of a universe created for humans in Jacobin "science" was challenged by emerging scientific insights into fragmented molecules and atoms that serve no teleological nor even immediate practical goals.

The nature of atoms, which was perceived to be fragmented and unintentional, did not offer any immediate benefits to humanity nor did it give any ideas on how to govern society. This provoked the Jacobins to label Lavoisier as a representative of an un-patriotic science that threatened the social fibre of the new Republic as this pinnacle of historical development and natural perfection.

Jacobin sentiments are the predecessors of contemporary views that consider applied research as a responsible way of spending public money. The current maker and DIY scene's engagement with craftsmanship also shares similar ideas, which is the reason why we need to be aware of their violent history. The Jacobin example offers a cautionary tale of how defining good science through civic virtue and what serves the Republic can lead to tyranny and inhumane politics, but also bad science.

Facts and values in DIY science and anti-science populism

DIY, open and citizen science movements bring science to some unexpected venues outside of the disciplined work done in laboratories or policy offices where people improve the knowledge of nature or develop regulations for society. Generating knowledge and experimenting with nature within DIY science movements go hand in hand with various aesthetic, artistic and personal explorations of materials in nature, but also ethical, social and political dilemmas and agendas (Kera 2017). In this sense, the emancipatory calls for open, citizen, etc. science are a continuation of the 1970s calls for the personal to become political, but we must be careful about the excesses.

Epistemic, ontological, and scientific explorations are always aligned with normative and personal interests and projects in the intricate and complex relationship between the worlds of atoms (molecules) and humans, facts and values. The tension between the knowledge of nature and our aspirations for good life or justice, goes back to the Atomist and Stoic debate on the indifference of the universe comprised of disorderly atoms and the moral agency of the individual and society (Edmunds 1972; Atomism n.d.). While Atomists insisted that the random swerve of atoms and reality oblivious to human struggles will never provide any reason for social order and meaning, the Stoics insisted on a nicely arranged universe that reflected and confirmed our ethical and social aspirations and biases.

The current crises of legitimacy and trust in expert knowledge, and the rise of populist movements, are just an incarnation of this old conflict. Scientific and technological knowledge simply do not lead to social and political change, such as response to climate change, or improvements in human character. Change is a result of choices we make as responsible individuals or societies, after considering not only knowledge and facts but also our values and goals. The anti-scientific, religious and sceptical movements are problematic, not because they question scientific facts, but because they turn legitimate concerns into conspiracy theories. The issue is not that all facts come with some form of agendas and values, but that we are witnessing a flood of agendas without any facts or even an elementary interest in the world outside of human will.

The misuse of science and technology by various regimes in the 20th century (Wolfe 2018) forces us to move beyond the enlightenment idea and technocratic beliefs that more knowledge and data guarantees progress or gives us a blueprint for action. The anti-scientific alternative, refusing all facts and insisting on populist ideas of social actions and moral values, ignores another important enlightenment period lesson: animosity towards science feeds dictatorships. The insistence on an absolute autonomy of knowledge and the prioritisation of some absolute or sacred values both support populist excesses. The present DIY, open and citizen science movements offer a foundation for realising how this happens, and how experimenting with the various ways we bring together facts and values can help us resist populist and technocratic excesses.

Attempts to resolve the tension between facts and values, epistemic and normative ideals of objectivity, transparency, autonomy, freedom and participation, must acknowledge this messy history before legitimising or even institutionalising any practices or movements. We need a middle ground from where to explore the plurality of the ways in which we bring together facts and values, atoms and human agency, and science with personal and communal values.

Modernisation of politics and science

How to connect our pursuit of knowledge with our social and personal values? How can scientific discoveries serve societal and personal improvement? The Jacobin's search for patriotic science led to populist and anti-scientific sentiments, but what came after the Reign of Terror efficiently enslaved science to serve the political ideology of the state, and it still persists in the present problems that provoke to the populist backlash against experts.

The "modernisation of politics and science" during the Second Republic or rather Empire (under the "president" Louis-Napoléon Bonaparte 1848–1851) led to the creation of a bureaucratic apparatus that still defines how we manage science nowadays. Science simply lost its autonomy and became a servant of the colonial and imperial project:

> the central feature of this modernization was conversion of subjects of a monarchy into citizens of a republic in direct contact with a state enormously augmented in power. To the scientific community, attainment of professional status was what citizenship was to all Frenchmen in the republic proper, namely the license to self-governance and dignity within the respective contexts. Revolutionary circumstances set up a resonance between politics and science since practitioners of both were future-oriented in their outlook and scornful of the past. Among the creations of the First French Republic were institutions providing the earliest higher education in science. From them emerged rigorously trained people who constituted the founding generation in the disciplines of mathematical physics, positivistic biology, and clinical medicine. That scientists were able to achieve their ends was owing to the expertise they provided the revolutionary and imperial authorities in education, medicine, warfare, empire-building, and industrial technology. (Gillispie 2004)

We are still heirs of this modernisation of science that transformed the independent academies of science into educational and research institutes organised by the state to serve the state ("That scientists were able to achieve their ends was owing to the expertise they provided the revolutionary and imperial authorities in education, medicine, warfare, empire-building, and industrial technology"). The present calls for more applied research, that creates jobs and brings innovation to society, but also the naive embrace of emancipatory science of

any kind that will improve the "world", only repeat these attempts to reconcile facts and values, atoms and human agency or social institutions, between the tyranny of the Jacobins and Napoleon. The insistence on national or community goals creates very little space for truly independent science that can radically question and challenge both facts and values. Just like the technocratic calls for politics to become more scientific, the forced unity of atoms and human agency, facts and values, lead to new forms of dictatorship.

DIYbio, open and citizen science's search for independent laboratories and practices reminds us that autonomy matters; we as citizens and researchers are the heirs to a complicated history of bringing together values and facts. Atomism and science were independent and autonomous endeavours until the 18th century. They were not bound to serve state institutions – and that seems to be lost today. It was exactly this autonomy that enabled these old institutions to come up with new entities and cosmologies which questioned the teleological and theological interpretations of the world that were part of the feudal system and later monarchies. They indirectly enabled new political and social projects to arise, because they questioned the basic cosmology behind the Christian church and the kingdom.

It is a paradox that the radical autonomy of science that changed society and politics, ultimately ended with the enslavement of new science to continue serving modern states. Is there any alternative to the anti-scientific Republic and the "scientifically" modernised post-Napoleonic regime? Should we insist on keeping science and human values separate? Where do the open and citizen science practices stand in this genealogy of bringing science closer to society? Are we in danger of becoming Jacobins if we search for socially responsible, decolonised or even artisanal science? Should we accept the status quo between science and state institutions, and only improve their mutual checks and balances?

DIY, open and citizen science as catharsis

DIY, open and collaborative practices question this status quo that is a result of the Jacobins violence and post-Napoleonic modernisation of science and society/state relations (bureaucratisation). These new movements can make science independent again and help preserve its status of ontological "disobedience" (Woolgar 2004, 2005): acting as a probe into the non-human world and reality beyond our social and personal expectations, norms and ideas. In this sense, the DIY, open and citizen science should strive to preserve, rather than resolve, the Atomist and Stoic tensions. Instead of reconciling natural, metaphysical, human and political orders, it should make them more visible for people to experience their complex relations and history.

Movements to democratise open science today are cathartic rather than transformational, revolutionary, or reformist. They are communal rather than institutionalised, which allows them to maintain a critical distance to history, the present power structures, and to experiment with new arrangements between facts and values. They are different from official science, but also from the fringe experiments of bioart or science in art (Bureaud, Malina, and Whiteley 2014; Kera 2014a) which have a more elitist connection to contemporary art. Bioart experiments and various creative attempts at science communication also democratise science and support the public participation of citizens, however not as direct engagement but rather a PR tool serving an agenda coming from the outside.

The niche group of bioartists, artists and designers of all kinds who work and collaborate in science labs or move science into the galleries, produce very provocative and inspiring works, but they also preserve the institutional status quo and divisions. They remain elitist (not sharing the tools and spaces of production) even when they try to bring science to the people.

The nascent movement of citizen scientists and DIY makers offers us an opportunity to rethink the history behind our attempts to bring science closer to society; recognise it as something personal and political that simultaneously depends on direct and material engagement. Everyone is invited to experiment and define their own community or project, which connects atoms or similar non-human entities with human interests, values, and institutions. By building open science hardware instruments, opening independent science labs, gathering and sharing data about biohacking experiments on bodies and environments, we connect science with the everyday lives, diverse interests, and hobbies of the citizens. Instead of gaining privileged access to science labs, equipment, and protocols and moving them to galleries, citizen scientists and tinkerers or science artisans demand open access to articles, tools, and data that can turn the whole world into a lab with a social rather than only scientific agenda.

The insistence of these new movements on open-ended and collaborative research, rather than finished and well presented (art)works with strong authorship, is visible in their preference for workshops, alternative and even mobile labs, making, hacking, and open-ended DIY research (Kera 2012b, 2014b). They support the educational and communicational goals of science or the aesthetic and critical explorations of art, whilst remaining open to a variety of idiosyncratic and personal projects and ideas. They raise new questions about inclusivity, knowledge and cognitive justice that are rather neglected by most bioart projects. Instead of philosophical and post-humanist concerns, they examine specific issues with science and society interaction, including calls for decolonisation, indigenous and grassroots science. This makes the new movements also very vulnerable in terms of repeating the mistakes of Jacobins' patriotic science or finding even more insidious ways to bureaucratise and "modernise" science.

Summary

DIYbio, open and citizen science movements can remain authentic only if they work as catharsis rather than some entrepreneurial revolution or communal dream. Science catharsis happens every time we perform and relive the history of science and society interactions, through various experiments and workshops, rather than when we claim new revolutions, institutions, and visions about the future. It is essential to stay open and constantly explore how to connect the pursuit of a more just and open society with the pursuit of knowledge.

Claiming to have some large impact on society or science (democratisation, decolonisation, etc.) is actually less important than preserving and experiencing the possibility of science becoming personal and political again for small groups and collectives. These enactments and performances of the struggle for autonomy of science outside its social, political and historic roles and constraints, are probably the most interesting and inspiring (cathartic) aspects of these new movements.

The comical forms of comparing cooking to science practices, home fermentation to synthetic

biology experiments, or some symbolic performance of power or magical thinking with instruments and data may look like a science "cargo cult," but they are a form of catharsis and empowerment. They extend the possibility of transparency, public oversight, but also creativity and leisure, to science protocols, data, and tools. They make the personal scientific and technological, embrace the ambiguity and uncertainty around facts and values, atoms and institutions. They are what Steve Woolgar calls "ontological disobedience" (Woolgar 2005), which contrasts with the more common view of research and community interactions of Polanyi's "community of explorers" (Polyani 2009).

Disobedience, a commitment "to be constantly unsettling, challenging, destabilizing but with no specific end in mind" (2005, p.314), is a property that Woolgar attributes to humans while Polanyi perceives it more as an ontological quality of nature which the "community of explorers" knows how to master. Polanyi is very skeptical of "moral" disobedience, which he attributes to existentialism and nihilistic philosophies, that are trying to apply scientific rigor to matters of human nature and society. Connecting these ontological and social meanings of disobedience seems to be the main issue in our struggle to bring moral, aesthetic and natural orders into equilibrium.

While Woolgar's notion of "ontological disobedience" is not "ontological" enough, Polanyi's "community of explorers" is too socially conservative and restrictive. Woolgar ascribes agency and decision making to humans in the social realm, while Polanyi would like to keep such freedom to question and experiment only in the realms of science. The DIY, open and citizen science movements extend Woolgar's notion to nature, but also democratise Polanyi's community of explorers by enabling everyone to bring values and facts, create his/her community of explorers, and define new forms of disobedience. We need to preserve this sphere of experimentation with science and society on a personal and communal level to better understand our past, but also provide more critical visions for the future.

Acknowledgements

I would like to offer my special thanks to the "Pioneer communities" team for their feedback on this article during the "Pioneer Communities after the Whole Earth Network" workshop funded by the German Research Foundation (DFG). The research is also part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie AnticipatoryLedgers grant agreement 793059.

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Manifestations

Leena Valkeapää, 2017–2018

A narrative emerges from two photographs accompanied by text messages sent from the hills of Kilpisjärvi in northern Lapland. The messages are from reindeer herder Oula A. Valkeapää, and text is based on Leena Valkeapää's experiences of living with Oula in that particular landscape. Their dialogical way of working records mutual ponderings on life with reindeer, their environment and its cultural tradition. A way of living from which works of art emerge; life and art are inseparable. The photos and messages are part of the video work *Manifestations*.

We here

"A message sent late afternoon in February, when the polar night has past but there is still some blueness in the landscape. We here, means that Oula is with his reindeer at that one particular spot. He has pastured his reindeer to that place and the reindeer are digging their food through snow. Oula's role is to keep the reindeer calm and make sure that they get food. His observes the posture of the reindeer, watching how they move. His everyday life is in contact with reindeer and that connection extends to the environment as well; elements like snow, wind, sun, temperature, and other people."

This whiteness draws my personhood

"The message comes at the end of March, when the landscape is covered by mist. The whiteness of the snow and the white of the clouds have become one. Visibility is lost and Oula has lost his connection with the reindeer. Dimensions and details have disappeared. The limits of the human senses are clear: Oula is an outsider even though he is within the landscape, enveloped in fog. Whiteness is like a performance which Oula receives alone. That experience is individual, it is a concrete manifestation of matter that one does not entirely know. The mist reappears time to time, so the feeling of emptiness in a totally white landscape is a common experience to people living in a Sami culture. The emptiness of whiteness creates cultural links between generations. Not being able to be in control is adapting Oula like performance does, the experience marks humanity and imprints on Oula's personhood."

Leena Valkeapää is an artist and researcher, and the Bioart Society's Ars Bioarctica residency mentor for the Kilpisjärvi Biological Station. She lives in the wilderness of northwest Lapland. She has exhibited as a visual artist since 1988, and has produced public environmental artworks, including the rock wall piece Ice Veil (1999) in Turku. Her doctoral dissertation *Luonnossa, vuoropuhelua Nils-Aslak Valkeapään tuotannon kanssa* (In nature: a dialogue with the works of Nils-Aslak Valkeapää) (2011), proposed a dialogue with nature and its poets.

We here. Photo by Oula A. Valkeapää.

The whiteness draws my personhood. Photo by Oula A. Valkeapää.

Lifepatch Interview

by Kira O'Reilly & Erich Berger

Our interview with Lifepatch takes place via Skype between us in Helsinki at the Bioart Society office at SOLU Space and members of the Lifepatch collective in their communal house in Yogyakarta (Jogja), Indonesia.

Skype is really not the best platform for this conversation in which many LifePatch members meander in and out of frame of the laptop screen. The ideal scenario would be us there with them in the Lifepatch house eating, drinking, and engaging in nongkrong – *hanging out with friends with no plan in mind*.

There is great happiness on seeing one another and our conversation is characterised by humour and exuberance. Amidst the dynamic of laughter and banter they give one another room to speak, frequently pointing to one another's expertise. Many cigarettes are smoked, and they joke about only having one PhD between them.

The following members of Lifepatch are present:

Nur Akbar Arofatullah Akbar is a founding member of Lifepatch and just finished his doctorate at Tokyo University of Agriculture and Technology (TUAT), Department of Biological Production Science. He is currently working on the Jogja River Project and the creation of a low-cost automatic greenhouse management system based on Rapberry-pi and Arduino.

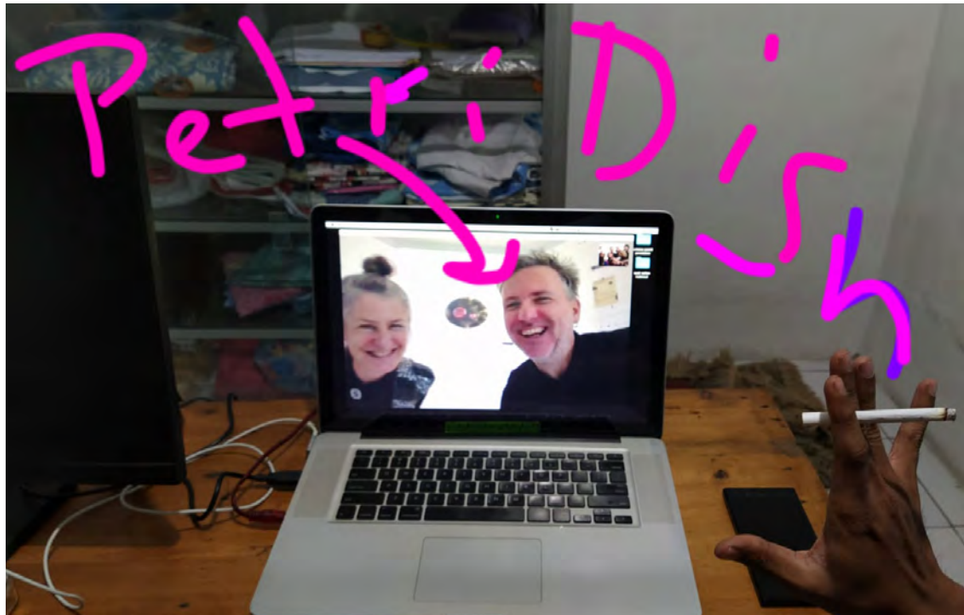
Andreas Siagian Andreas is a founding member of Lifepatch and a founding member of Lifepatch and an interdisciplinary artist with a formal education background as a civil engineer. Since 2004, he has worked with community-based initiatives and created various installations, and organised workshops, events and festivals in Indonesia.

Ferial Afiff Ferial is a founding member of Lifepatch and actively involved in a number of communities and organisations. Her artistic work incorporates interdisciplinary knowledge, emphasises personal opinion and draws attention to various socio-cultural issues.

Agung Geger Geger is a founding member of Lifepatch and the initiator of Urbancult, a visual documentation archiving project mapping the locations of street art works located in public spaces in Indonesia. His activities include fermentation, teaching foreign languages and photography.

Marc Dusseiller Mark is co-founder of Hackteria and colleague of Lifepatch and Bioart Society. Marc was in residence at Lifepatch at the time of the interview and was of great assistance in making it happen.

For a full list of members and more info please visit lifepatch.org.



Erich Should we start with a very introductory question? Could you tell us a little bit about Lifepatch? Where it is located and how it formed?

Ferial Lifepatch is a citizen initiative in arts, science and technology. There are eleven of us as members and from us, there are a bunch of what I would call insiders. We do almost everything and take from many different things. It is quite diverse. We take from bio things, electronic things, art things, research, activism…

Andreas Politics and education!

Ferial Politics, really?

Marc Every act is political.

Ferial Every act is political, ok. Recently Geger came back from Samas where he is working on turtle release on the beach. We just came back from the Asian Art Biennale in Taichung, Taiwan, where we made art based on a research project. What else? Sering Sering Syering, the music programme experiment. We also have Sesi Dengar, a listening session with Art Music Today.

Akbar We have collaborations in Japan. We introduce Lifepatch to art communities in Japan and hold workshops. All the workshops are performed by Lifepatch members personally based on their own interests. We don't have yet any specific curriculum for the workshop.

Andreas In the Jogja biennale 2015 we made this speeding class system, which involved several members of Lifepatch. We asked them what they could teach or share, and so far it has been self-motivated. If there is a big event, we include what people want to do and each person responded. We also open our space for others to join. Friends who want to borrow our space to connect to other disciplines as well.

Ferial Since moving to this house, we have more space for others to arrange a gig, talk, or anything they want at our site. And when they ask what part of the house they can use; we always say anywhere. They can use the kitchen, they can use the front of the house, they can use the backyard.

Andreas A lot of collectives in Indonesia also run a space. It is a house they rent together and usually some people live there. The strategy is very common: rent a space and manage it together.

Erich But that sounds then like a very vibrant culture. Do you go to visit other places and hang out there?

Andreas There are some experiments now for collectives to stay in one space together. Several are trying this out. There is also a forum for collectives, basically six collectives from Jogja and six collectives from Southeast Asia trying to do something to connect.

Marc But in fact, if you come as a pure tourist it's a bit difficult to come in. If you have these connections, every night you can hang out in one of these collective spaces. There's always people hanging out, having a discussion, but you need to know these people. No one would just walk from the streets and come in. It's not a public space.

Erich What's your street like where Lifepatch is? What do your neighbours think about you? Do they know what is going on in this house?

Ferial I just came back from a street food stall, and they asked where are you from. I said that house over there. Ah, that house with a lot of foreigners they said.

Akbar It depends whom they meet when they come to Lifepatch. It is different when they meet me or when they meet Ferial.

Ferial Now we are close with the leader of the neighbourhood. But before we knew each other they got really suspicious. It's not an exhibition space, it's not an NGO – what is it? And I tried to explain all of our different things. And I also mentioned that we are an association for research and development. They did not understand, but then we invited them over and they came. Then they said as long as it's not a crime it is ok.

Andreas They're wrong on that one. Hahahaha.

Ferial So for the people, they don't need a definition. They just need to come and see you. After they know us, they never complain anymore.

Kira How long have you had this space for, how long have you had the house?

Ferial End of 2016 we moved here.

Andreas It is the second house. We had a space in 2012 and in the beginning we operated for six months without a space.

Kira So it's made a big difference I imagine having this place?

Andreas Yes.

Ferial The house is always growing.

Marc It's a funny combination of being able to host residencies and hold small events and workshops in the place where Lifepatch members and some non-Lifepatch members sleep it's a kind of a commune.

Andreas And Marc was telling us that we should try this family-friendly residencies. He was the first family staying here.

Ferial First is Maya Minder and Marc with Tibor and Kazi. Now Mary Maggic with one baby and her partner. And Padma. Everyone now becomes an uncle or an auntie.

Kira It's so important though. How else can artists with families do residencies? It's such a crucial thing I think.

Andreas It's also very challenging. Like now for Mary's child Lola, we have to figure out a non-smoking space. Everybody here smokes. Arranging a safe place for children.

Ferial And one toys room for playing. But Lola doesn't like it. She wants to hang out with us outside. But it's interesting. In the beginning Mary asked us if we were ready to live here with the baby, and we said yes why not.

Erich You move between many different contexts, like on the one hand there is the strong motivation of citizen engagement and empowerment through technology. On the other hand, you also often appear in the art context. Does the focus of your practice shift depending where you are? If you are in Jogja, are you more citizen activists and hackers? Does the art happen in other places, other countries?

Ferial There are many art groups in Jogja and Lifepatch differs from other art groups in Jogja. Our background is different and our interest is not only in art, but it doesn't mean we close ourselves from art. It is a more diverse exploration. Like I was doing a programme here on gender we did research on gender and I did a workshop on sexology for the teenagers through a game we made. Some of our activity can look "different" and maybe that's why the art world is interested in us.

Akbar I am not interested.

Ferial You're also not the art world. You are a scientist.

Erich This is a good question, I think.

Ferial That's why it's different. One person is not interested in art, one person is interested in art. But how art people see us is like that, because we explore a different focus.

Erich So you started out as, let's make an artist collective?

Andreas No!! We just wanted to work together. I was proposing this term 'citizen science initiative' and people could pick it up and try it. But we basically didn't know what it is in the beginning. More like common turf than working in certain fields.

Akbar When I joined Lifepatch I wanted to experiment without expectations. Previously all my work for citizen science need to be for the artworld. I don't want that. I just want to do my experiment without any expectations.

Erich Are there then more art communities like you around Indonesia?

Andreas Many many.

Ferial But like I said, we are slightly different because of our background.

Kira We would like to ask you about gender and the relationship of Lifepatch to gender. For example, you mentioned working with teenagers around sexuality?

Ferial Not only in art but also in activism we see the gender issues. Like all of Lifepatch is male.

Andreas Not all! There are two girls.

Ferial There are two females.

Ferial For us the gender issue is more that we invite people who are experts on gender terminology and theory. We also do research like when we went to East Indonesia to research the local ideology. Our question is how gender is connected with feminism, then what is feminism? Is it always about female attacking male? We learn together about gender issues, and discuss them all the time. Before, a lot of researchers came here and asked me about there being two female members among nine male members. For me there is no difference, they don't treat me differently. For us it is another learning process. Then about the sexology. It was born when we had a residency artist from the UK, Jamila [Khan]. We were developing a syllabus for a sexology workshop. We went to villages of Timor in Indonesia. People there were really happy about it because somehow a lot of the parents are so awkward to share their experiences on sex. It was surprising to me that they are so open. I mean this is not happening in the art world yet, but it is happening in the citizen arena.

Erich Some of you guys have been to Europe, with Marc and Hackteria for example. I

see that many of these technologies are used in workshops in Europe, but the ways they are applied in Indonesia is very different. I feel that many of these kind of hacker communities in Europe may rehearse the technology but that you also actually apply it to real cases. How do you view that comparison?

Akbar Yeah. We need to develop those kind of equipment, like the microscope. We need them. We don't have fancy microscopes. We need to build the microscopes if we want to experiment.

Ferial Some biologists come to our projects and say they need a very expensive microscope, but they find making these DIY microscopes is cheaper.

Akbar My objective is to promote. Even though we have a lot of limitations in our equipment, we can still do something. We can still do experiments. We can still build devices for experimentation. Many things are possible.

Andreas Somehow, also in our previous work we sometimes don't involve any technology. Sometimes we like this freedom of expression, but we don't do it too often…

Erich Can you give an example of that?

Andreas For example *The Tale of Tiger and Lion* was the last one. We had an exhibition at M HKA in Belgium in 2017. We didn't even involve any electronics. We did research on the national hero Si Singamangaraja XII who was killed by a Swiss guy working for the Dutch.

Marc Wasn't me!

Andreas And he [Hans Christoffel] was married to a daughter of the mayor of Antwerp. He was collecting a lot of weapons from Indonesia, and he donated these weapons to a museum in Antwerp. AIR Antwerpen and MAS invited us to do research on that. It was almost like a field project.

Ferial In their collection was one sword we remade because the original sword was claimed to have gone missing. Then we asked the people of ob Batak tribe if we are allowed to make that sword because for them it is quite spiritual. And we made the object, and did a performance in the North Sumatran village. Then Geger made postcards with messages from people of North Sumatra to the world. Then everyone is writing on the postcard in Indonesian at Artjog. In North Sumatra, there is also a video of all the data about the Swiss guy. And Adhari Donora made videos. Dolly also made a tie-dye, and Timbil made a scent from the spices we found there.

Erich Did I understand that these objects that you were asked to work with were from Indonesia? They were a collection in Belgium?

Andreas Objects were from Indonesia, yes. The Swiss guy was collecting a lot of [weapons and artifacts]…

Marc Indonesia was colonialised by Europeans! Kind of a topic here.

Erich Thank you for saying that, I wanted to be clear.

Ferial During our research, we had Adhari Donora and Sita Magifra in Antwerp. They were in an anthropological museum, and in this museum there are a hundred Indonesian artefacts. When we shared what we had found in the museum to the local people in North Sumatra, they would say that this sword

was for the king. That is why Andreas had the idea that maybe we can make the sword.

Andreas The symbol of resistance. Many people still believe the Dutch didn't actually kill the king. He was already a mythical figure, like a prophet. The Tiger Colony, a batalyon led by Hans Christoffel, was travelling from Aceh to North Sumatra to hunt the king. The travel was very well documented with photographs, but there were no photographs of the king. So many people ask that if you kill the king, where is the photograph? If you have the photograph, then you have this sword, which is kind of a mythical sword belonging to the king. When I was there I met this guy and we had a long conversation. Now is a really interesting time as European museums are inviting artists to respond to their collection, because in the past this collection in the museum showed power, colonial power. But now they spend much money to maintain the artefacts. New generations now see it as a symbol of brutality, what their country did in the past. Young people don't want to acknowledge that this is in the past. Museums want to return these objects now and there is more conflict. Anyway, after I met this guy we said, why don't we make and let them collect again? It was a really interesting spin.

Kira I see, so it's this reiteration of the sword and being able to re-contextualise it by remaking it and then it being reabsorbed back into the museum context.

Andreas Yeah, yeah.

Kira That's fascinating and really complex all of those different layers of history, and a contemporary material enactment. With this particular project, how do you think it's received and understood because that project has presumably communicated in different directions to different audiences, what are your thoughts on that?

Ferial We have so much feedback from viewers of the exhibition. Like local people in North Sumatra are very happy, actually we promised them that we will bring back our findings and results of the exhibition. We want to go back and present there. But last time one of our friends from North Sumatra came to see the exhibit here in Jogja. He said he got dizzy due to all that information. We don't want to make the history right or singular. We just present whatever we find. There are so many different layers with so many contexts and different sources are presented there. Somehow it brings a different interest to the people who view it, even when we had the exhibition in Belgium, the Museum started having issues with sending back the collection and they asked us for advice. Actually it was our joke in the beginning: like maybe the museum will want to give the artifacts back. It was a joke. It is not serious. Then when they asked how to do it, like it's a matter of the government now and it's a matter of our country. I mean they have new regulations for this because it's a big thing. I mean in the past we also had the government wanting to give back the collection of Jakarta Palace. The palace refused because they don't have the right infrastructure so I think it's a big issue but we still want to continue. Our continuation is based on an interest in the history of Indonesia. For me personally, the way I do research in a different part of Indonesia, it is information I did not get in school. We live in a huge archipelago. For us, it is cheaper to go to Singapore for example

than to go to Papua. A lot of history is still hidden, and there is a lot to explore.

Andreas So it is like this please keep our stuff, keep it safe until we are ready. Meanwhile please pay for the maintenance.

Geger Keep the artefacts, we have the soul.

Ferial In North Sumatra, what they said is keep the artefacts, we have the soul. They think the soul is more important to preserve the culture, more than any object, any material.

Current activities

Erich How is it in your wider reach? You were saying for example it is easier to go to Singapore then to other places in Indonesia, and I also know that some of you travel quite a lot. How is the exchange in Southeast Asia in the DIY hacking and art scene you are in? Is there a lot of communication? Is there a lot of working together?

Marc Less than we hope for.

Andreas My next project is to see this hacktivism in Southeast Asia. Just to say there is very little exchange in Southeast Asia, as there is no money for it. There is no government support for this exchange. We sometimes joke that it's easier to go to the Netherlands than to Papua. Indonesia is the largest country in Southeast Asia, it is heavily politicised it is difficult for us to travel to the east. It is the same ticket price to go to Japan than go to West Papua. In Indonesia it is hard to travel to other places, financially. It's also really big.

Ferial Geger once told me if we visit one island every day, we will spend 46 years.

Erich But I guess you must have been quite surprised by the offer to work with this collection? To me it almost feels like they were looking for justification through you to decolonise their collection?

Marc In Europe there is like no conference that not everybody is talking about decolonialising and they have no fucking idea. And here everyone has had this discussion for a long time, the discourse is much deeper about this topic than you know.

Andreas It's kind of like Finland's lakes.

Erich Besides this kind of effort from Andreas to connect different actors in Southeast Asia, what else are you doing at the moment? What else are you working on?

Andreas Regular programme. There is Good Go-Ferment workshop and then there is Sering Sering Syering and workshops and other public programmes still happening. We also have an invitation for an exhibition, but nothing is confirmed.

Ferial The research about the gender will continue because we make a book on gender ideology research.

Geger Also a project with Mary Maggic, the resident here. We have started a water filtration device for the community living in the river banks not far from Lifepatch house. The water spring and the wells of the community are contaminated with e.coli and many substance. We started a water filtration.

Andreas This project already started, we have a local hackteria style. We call it Mingapa Bigini Mingapa Bigitu.

Andreas We invited some friends to teach us how to do filtration and also we did a kind of small residency going to the river banks in east Java. This filtration is also combining biofiltration to purify the water using also biological processes. It was exhibited in Jakarta biennale also last year.

Erich What leads you to work like that? Do you feel that these issues are neglected ?

Akbar We're just trying to help. They are not neglected.

Andreas They are neglected…

Akbar Many people are also doing that kind of activity. Indonesia is so huge it is impossible to cover all without help from the citizens.

Ferial It is important to have a citizens initiative.

Akbar Our government does not have enough reserves.

Andreas The neighborhood we are working with is an illegal village. So many immigrants come there, build a semi-permanent structure, and live there for generations.

Marc Not immigrants from other countries. Migrants to the city.

Andreas The one in East Java is really interesting as they don't have access to clean water. The municipality water resources is just right next to the site. There is situations like this happening everywhere around Indonesia. Especially in the cities.

Ferial The river Geger mentioned with Mary, those river bank citizens are not written in the maps.

Marc Shantytowns. So yeah it's so many layers.

Marc This is just 200 meters from here.

Erich When you look at the current state of the world, where you do see or what direction do you see Indonesia developing?

All Beaches!

Akbar Superpower!

All Beaches!

Ferial In 2025 our economy will be top 5.

Erich And you are already now among the biggest economies in Southeast Asia.

Marc Biggest in size, 250 million people. Fourth biggest country in the world.

Akbar We out-rate Europe.

Ferial An interesting experience when Geger come back from Detroit. They asked for solution from a third world country?

Geger They had a first world problem but they need a solution from a third world country. They needed filtration for the water. Because the people from Detroit just spend it. They have no access to water. And even rain catchment is illegal there. Water filters are solutions for the problems, but they did not know. Even in other cities Wisnu, Timbil and I made a presentation about how to make water filtration. Many communities try to do and to practice the filtration.

Erich If the future of Indonesia is beaches, then you see yourself on the beach in 10 years? Or how do you see Lifepatch in this context?

Geger This is why I save turtles.

Kira The turtle future.

Field_Notes

Bioart Society, 2011–2019

Participants Adam Fish, Adriana Knouf, Adrien Rigobello, Agata Marzecova, Alia Malley, Alice Smits, Amanda McDonald Crowley, Ana Oosting, Andrea Roe, Andrew Paterson, Andy Gracie, Anja Erdmann, Anna-Katharina Laboissière, Anne Lehtelä, Anne Yoncha, AnneMarie Maes, Anssi Laiho, Antero Kare, Antti Salminen, Antti Tenetz, Antye Greie, Anu Osva, Anu Pasanen, Aravin Chakravarthi, Asa Stahl, Astrida Neimanis, Avner Peled, Beatriz da Costa, Benjamin Pothier, Bilge Hasdemir, Björn Kröger, Brian Degger, Caspar Ström, Cathrine Kramer, Charli Clark, Christina Gruber, Corrie van Sice, Dave Lawrence, Dinah Bird, Elisabeth Ellsworth, Ellen Roed, Erich Berger, Erik Sandelin, Ewen Chadronnet, Flis Holland, Hanna Husberg, Hannah Imlach, Hannah Rogers, Heather Barnett, Heather Davis, Heidi Pietarinen, Ingvill Fossheim, Jamie Kruse, Jasmine Idun Lyman, Jeni Valorinta, Jennifer Gabrys, Jens Hauser, Johanna Rotko, Johanna Salmela, Jose Marcos Perez Diaz, Judith van der Elst, Jukka Hautamäki, Julie Freeman, Jurate Jarulyte, Karen Elizabeth Bishop, Karolina Sobecka, Kathy High, Kati Roover, Kira O'Reilly, Kristiina Ljokkoi, Kristina Lindström, Laura Beloff, Lauren Allen, Lea Schick, Leena Valkeapää, Lisa Swanstrom, Liu Xin, Lori Hepner, Luis A. Campos, Luis Graca, Maia Iotzova, Maija Fox, Marc Dusseiller, Maren Richter, Mari Keski-Korsu, Marja Helander, Markku Nousiainen, Marko Peljhan, Markus Petz, Marta de Menezes, Martin Howse, Martin Malthe Borch, Matthew Biederman, Melanie King, Melissa Grant, Melissa Murphy, Mia Mäkelä, Miguel Santos, Minna Långström, Minna Pöllänen, Neal White, Nerea Calvillo, Netta Norro, Nicolas Maigret, Niki Passath, Niko Wearden, Noora Sandgren, Ole Kristensen, Oliver de Peyer, Oliver Kellhammer, Oron Catts, Paolo Patelli, Paz Tornero, Perdita Phillips, Peter Flemming, Pia Lindman, Piibe Piirma, Piritta Piuhto, Richard Pell, Rosanne Van Klaveren, Saara Hannula, Sam Nightingale, Shruti Sunderraman, Simo Alitalo, Sophie Dulau, Špela Petrič, Stephan Dudeck, Sushant Passi, Tapio Mäkelä, Tarsh Bates, Taru Elfving, Teemu Lehmusruusu, Terike Haapoja, Theun Karelse, Tiina Prittinen, Tiina Vainio, Till Boverman, Toru (Ryu) Oyama, Tuike Alitalo, Vanessa Lorenzo, Vishnu Vardhani Rajan, Vygandas Vegas Simbelis, Zachary Low Reyna, Zack Denfeld, Zahra Mani, Sarah Alden

Field_Notes is a biennial one week long field laboratory for theory and practice of art&science work at the Kilpisjärvi Biological Station of the University of Helsinki in Lapland. Five working groups, each hosted by an expert together with a team of five, develop, test and evaluate specific questions with the local environment as a catalyst.

Cultivating Ground practitioners, in both art and science, repeatedly argue that their disciplines lose touch with the actual research subject or topic while the focus is directed on lab work or gallery presentation. Cultivating Ground aims to investigate and point out the importance of fieldwork in art&science.

Deep Time is in search of artistic and scientific responses to the dichotomy between human time-perception and comprehension, and the time of biological, environmental, and geological processes in which we are embedded.

HYBRID MATTERs We consider anything which has a physical and technological aspect as hybrid matter and as part of a Hybrid Ecology. The premise is that in the simple ecology of the sub-Arctic indicators of a Hybrid Ecology are easier to identify then in the copious ecologies of the south.

Ecology of Senses explores the role of sensing within this convergence: the ways we make sense of the world, how worlds are made through our senses and the changing sense of self which comes along. We expanded our original sensorium considerably with technology.

The Heavens turns our attention and experiments to the sky and looks how the unique sub-Arctic setting of Kilpisjärvi can assist us to learn more about what is above ground: life at high altitudes, the ongoing material exchange between earth and space, atmosphere as hyperobject, the politics of air and space or Sámi stories and life related to the sky.

Field_Notes – Ecology of Senses, 2018. Photo by Björn Kröger.

Field_Notes – HYBRID MATTERs, 2015. (*sonic*) *Wild Code* – group. Photo by Till Bovermann, tai-studio.org.

BioTehna + Vivarium – Towards the Aesthetics of Artificial Life

Jurij Krpan

Jurij Krpan is a Senior Curator at Kapelica Gallery since its inception at 1995. When maker space Rampa and wet-lab BioTehna + Vivarium were established as support laboratories to Kapelica, Krpan led a group of lab experts who are co-working under the umbrella institution NGO Kersnikova Institute. Krpan regularly curates exhibitions and festivals outside his home institution, and lectures about Kersnikova program's achievements in Slovenia as well as abroad.

Contrary to most essays on art which are dedicated to artists or their art, this text is a record of an institution and its production methods that systemically support artistic creativity. It is an essay on the origins and development of a support programme, or a production mechanism, that emerged from within the Kapelica Gallery in the 90s. Since then the support programme has slowly developed through assisting the creation of increasingly complex works of art which demand sophisticated technologies, functionally equipped rooms, and the support of experts from non-artistic fields. This support is often overlooked and goes unmentioned in the process of creating works of art–sometimes it is even stigmatised as an unnecessary intervention on the autonomy of artistic creativity. In this sense, one needs to read this text as an attempt to argue in favour of the systematic and supportive activities with which a gallery for contemporary investigative art cooperates in the development of its field.

The Kapelica gallery entered the new millennium with rich experience in explicit performative artistic practices[1], in which the viscerality of the artists' physical bodies demanded specialised production skills and knowledge from the organisers. Artists who used various surgical and other medical tools on their bodies[2] demanded specialised working conditions, requiring the team, equipment and gallery space to fulfil aseptic conditions and standards that are usually associated with medical laboratories and clinics rather than art spaces. The more hard-tech performances that reached into the body with cybernetic applications[3] needed technological and medical support in order to expand human bodies with mechatronic prostheses. Thus, we at Kapelica gallery started cooperating very early on with experts from various fields of medicine, pharmacology and biotechnology and with their help we

1 Artists who use their blood as their material of choice (Ron Athey, Franko B, Kira O'Reilly, Ive Tabar and others) have radically and explicitly addressed human viscerality in relation to various (social, sexual, identity, hygiene, etc.) social antagonisms.

2 *Body art* is the generally accepted term for describing artistic productions in which artists use their naked body. However, in Kapelica we deliberately and consciously avoid this term, as in our experience the use of this term as a *tag* flattens and sterilizes the differences between individual works of art, in which the poetics emerge through the unique use of viscerality that is characteristic of each individual artist. The same reason also makes us reject the use of the term BioArt, as a tag that poses as a common denominator of works in which artists use living materials, aggressively flattens the differences between the contents, idiolect and the specific poetics of the works of art.

3 The accessibility of medical equipment and various computer and cybernetic applications allowed the artists to intervene on/into their bodies and place themselves and their bodies on the border between the living and the technological. In their performances which did not offer any doubt as regards the connection between humans and technology, Stelarc, Marcel·li Antunez Roca, Arthur Elsenaar, Stahl Stenslie and others added the viscerality of the technology to the viscerality of the body.

All images courtesy of the author.

managed to ensure the safety of the performers and the success of their works of art.

Over time we have managed to find a selection of expert co-workers and institutions who support our gallery with their knowledge and equipment, as well as help us consider works of art entering other public and less-public spaces beyond the presentation space of the gallery[4]. Thus, the curatorial focus on the cohabitation of technology and the living bodies of the artists gradually spread to other organisms: to the microbiological and microtechnological level, the level of regenerative medicine as well as evolutionary biology. With this, the artworks of the Kapelica Gallery started to appear in the field of artistic production with rather unusual artistic elements, most of which emerged from the worlds of natural science research and engineering. In order to present living works of art, molecular sculptures and micro-performances we suddenly needed incubators, greenhouses, bioreactors, laminar flow hoods and other equipment and systems, to enable the works of art to survive and flourish throughout the exhibition. The aesthetics of laboratory equipment clearly dominated early projects, but similar to recognising the endless cables, bare electronics and exhibited computer components in the 1990s as techno romanticism, artists creating installations of living works of art soon renounced the aesthetics of petri dishes, test tubes and blue gloves. Adhering to laboratory standards while making no artistic compromises, these projects opened up new concepts of presentation for which the traditional understanding of a gallery as an exhibition space was almost unusable. We needed to establish new ways of presenting works of art to address the artistic and dramaturgic intelligence of the spectators. At the same time, we introduced new ways of presentation emerging from the nature of the works of art and their materials. In the gallery the artists bred human, animal and plant cells, tissues and microorganisms that were subjected to great risks of contamination and consequently dying off. This endangered the art projects and questioned the sustainability of the gallery programme, as well as placed upon it moral and ethical demands. While successful, the attempts to transform the gallery into a laboratory for individual projects were sometimes bordering on the absurd[5] and inaccessible[6]. Thus, we started contemplating different ways of creating and presenting living works of art.

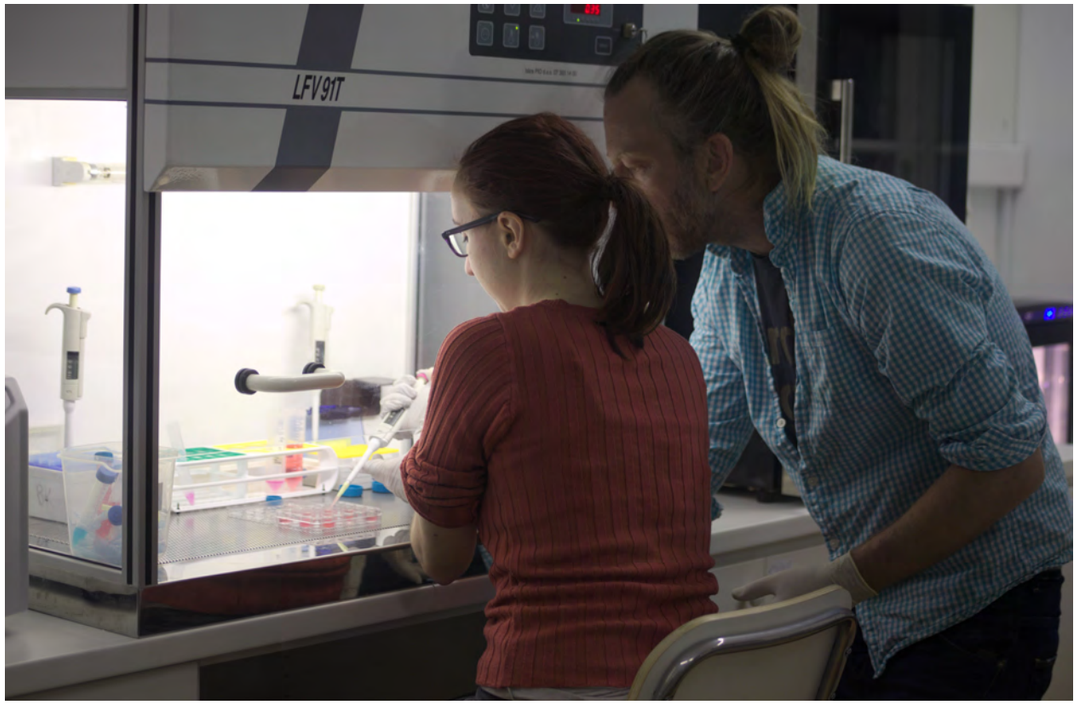
Connecting artists with scientists and engineers from around the world created interesting epistemological situations in the process of artwork creation. This introduced the need for a systematic transfer of new knowledge, which was introduced through workshops at which artists, producers as well as the audience were presented with materials, protocols and policies used in scientific research. Workshops for artists were carried out by engineers and scientists, and artists with an education in science soon took over a key supportive role in encouraging artistic production and leading important hands-on practice. This made it possible for niche knowledge to remain within the art circle of the Kapelica Gallery[7]. In their interdisciplinary projects artists (as well as curators and producers) adapted

4 Space as a space for performing works of art.

5 For Polona Tratnik's project *37C°* (2001), we changed the entire gallery space (150 m2) into an incubator by warming it to 37 degrees Celsius and ensuring constant 97% humidity (sic!).

6 In order to view Maja Smrekar's project *MaSm Metatransformation* (2011) the visitors had to register for a guided tour during which they performed a part of the genetic modification as *proof of the concept*.

7 Alongside the workshops held by artists for artists, an increasing number of workshops were being led by scientists and engineers who passed on the basic knowledge of programming, electronics, cybernetics and biotechnologies to the artists. Thus, the hacker culture, in which enlightened scientists and engineers transfer their knowledge in order to achieve basic technological literacy within society, became a constituent part of the artistic productions.



their work to a new set of principles which enabled them to cooperate with scientists. The artists had to tactically adjust their projects to complement the scientific approaches of researchers and developers they worked with. Consequently, they had to adjust their exhibition strategies, even though exhibitions do not belong in the domain of science, but art. These strategies vary from one creative group to another, and the cooperative dynamics employed in the creation of the final work of art define its shared authorship. The participating scientists and/or engineers thus become the co-authors of the work of art–the extent of their shared authorship exposed depending on an agreement. However, it is certainly true that the creative contribution is no longer merely the domain of the artists: it belongs to all participants who take place in the project regardless of their expertise.

The emphasis on a more systematic development of individual art projects and encouraging connections with other social activities (science, industry, politics) helps us consider contemporary artistic research practices beyond the traditional styles, materials and means of expression[8]. Interdisciplinarity has demanded a decisive change in curatorial and production practices. We needed to change the work systematisation, and introduce new development and production approaches for presenting works of art. At the same time, we in the Kapelica Gallery, ascertained that we can reach the level of production demanded by scientists and engineers who participate in our projects only if we provide good working conditions in line with the standards applied in scientific laboratories. The idea that Kapelica should have its own biotechnological laboratory that would cater to its needs emerged from problematic experiences, when artists developing their projects found it hard to access appropriately equipped research laboratories in larger scientific institutions. In most cases the cooperation between artists and scientists was based on personal contacts and friendships with researchers, who, as a rule, could not provide systematic access to laboratory facilities. This meant that the artists would have access to laboratories only in the evenings or during weekends and holidays when the laboratories were not used for scientific research work. This placed systematic artistic production in a difficult position, as it brought unpredictable situations and uncertainty regarding the realisation of the works of art according to the production timelines. The efforts to establish systemic, officially recognised cooperation between artistic and scientific organisations remained hanging in the undefined spaces between scientific deontology, toxic academic competitiveness and fear of over-institutionalised ethical committees[9].

The initiative to establish a biotechnical laboratory within the Kapelica Gallery emerged from a cooperation with the international platform of

8 The wholesome approach to creating support activities for artistic production enables the artists and curators to consider creativity as gradual (generative) upgrading of artistic creation into increasingly complicated works of art, which interpolate into complex relationships between the social space and increasingly multifaceted and rounded projects – opuses. New scientific discoveries, and the capability of engineers to create suitable technologies and services which penetrate ever deeper into the social fibre and intimacy of the individuals, leads artists to gradually develop their metaphysical interest linked to technologised social reality in line with the development of science and its useful applications through innovations as applications for the market. The analogy between progressive scientific and progressive artistic production implies a work method that does not favour tools and means, but follows the dynamic and diverse needs of scientific and artistic research. Thus, we do not use terms such as new media, intermedia, hybrid, etc. for the artistic production supported by the Kersnikova Institute, as they imply media or a combination of media; we prefer to use *contemporary research art*. With this we terminologically lean upon the method of work and not on the material or means.

9 The fear of research institutions preventing them from cooperating with artists emerges from the over-competitive academic and industrial environments, however this fear is based on the wrongful traditional idea of artists as maladjusted, arbitrary and uncontrollable people, who can, in their creative insanity, endanger the excellence of laboratory work. Progress within the sphere of natural science research has obviously got very little time for supporting progress in art.

scientists, engineers and artists Hackteria, with whom we performed a series of workshops for young people (within the framework of the Swiss financial mechanism[10]). Marc Dusseiller, a nomad scientist specialised in micro and nano systems, erudite in the field of informal learning and excellent social engineer, introduced a series of initiatives to the Slovene art community during his one-year stay in Ljubljana. One of them came to life as BioTehna, a platform for artistic research of living systems. In its beginning, the laboratory was merely a space equipped with generic furniture where we carried out workshops for children and youngsters, and incubated the first artistic projects for exhibitions that were to be hosted in our gallery. However, we soon realised that the bare space and do-it-yourself hardware, which was being created in the educational workshops, would not suffice for systematic artistic research and production. Thus, the BioTehna production started to spontaneously develop into two complementary practices: educational activities and artistic production.

Educational activities are based on *hands-on*, *do-it-yourself* or *do-it-together* workshops, at which the participants disassemble and assemble various technological miniatures. These workshops are not focused on creating interesting products, but on transferring knowledge on engineering and ideological solutions used in individual technologies and applications, and getting acquainted with the values that encourage group dynamics, the feeling of cooperation and fairness. As a rule, these workshops emerge as a derivation of art projects in which artists work with living systems. However, as it is impossible to re-engage artists from abroad[11] to come and repeat their workshops, and as artists also need help while preparing their own projects in the Kapelica gallery, BioTehna has employed a biotechnologist with an affinity for interdisciplinarity and a sense for pedagogy. This enables us to preserve and transfer knowledge to other interested parties and accumulate expertise that can be used in future art projects that are carried out in our laboratory. In the last three years the number of workshops for children and youth has grown to the point that a need for educating mentors who could repeat some of the interesting workshops has arisen. The programme for mentors is one in which anyone with an affinity for pedagogical work with children and young people can become engaged, regardless of their professional education. Educating and engaging various target groups is organised in a way that considers activities taking place in the Kapelica Gallery and its support laboratories as a synergetic system, through which the artists can, by running workshops, co-finance their artistic production. The second important aspect of regular educational activities is in conquering new technical knowledge and transferring that expertise on contemporary technologies to artists and the general public. The third aspect can be found in the active encouragement to create an audience for the art programme in the Kapelica Gallery.

Over recent years BioTehna has undergone numerous modernisations, which were necessary due to new, constantly more demanding and complex art projects. The ever-better equipped laboratory and increasing knowledge and contacts with exceptional artists and scientists have established Kapelica as an almost entirely independent production unit, which no longer depends on the good will of scientific institutions, which even today (in cases when we need more than BioTehna can provide) slow down the production process. The systemic

10 https://www.eda.admin.ch/erweiterungsbeitrag/en/home/the-swiss-contribution/kurzportraet-erweiterungsbeitrag.html

11 This impossibility is not a result of the artists' lack of desire to repeat the workshop, but the incapability of the Kapelica Gallery to provide financial support for it.

support provided by the biotechnologist enables the artists to progressively develop their projects, as the laboratory in the direct vicinity of the Kapelica Gallery is at their disposal 24/7. The intense use of the laboratory led to rigorous technological and hygiene demands, which is why in 2017 we established *Vivarium–a platform for animals, plants and robots* for artistic research and production of works of art that engage with microorganisms, plants and animals. This laboratory is set at a different location. Vivarium is slowly developing into an independent laboratory, in which specific hygiene standards for working with somatic cells, used in biotechnological research, tissue engineering and synthesis biology are implemented. The laboratory is thus suitable for breeding animals and plants, for which veterinary and biotechnological rules are applicable. The size of the laboratory is also appropriate for exhibiting works of art in progress. This laboratory focuses on the research of cohabitation between biological organisms and technology which conceptually gravitate towards singularity[12]. Contrary to the art projects carried out within BioTehna, where the research takes place on the genetic, molecular or cellular level, and where aseptic conditions are necessary in order to preserve the working environment, the Vivarium projects are vitally visceral with all metabolic entropy and filth that living organisms and cybernetic mechanisms emit into the environment.

On their own BioTehna and Vivarium do not represent a breakthrough, but we must consider them in close connection to the productions within the Kapelica Gallery, the educational activities performed on Kersnikova[13], and their emancipatory mission in relation to institutionalised knowledge and the public education service. It is only through the gallery's production and educational activities within the ecosystem of various social practices (in which art and education enable the debate on life science, biopolitics, post-humanism, and artistic production) and in connection with activities in the fields of information technologies, mechatronics and artificial intelligence in the Rampa Laboratory, that we can truly feel the potential. This potential is in its developed form, released through exceptional works of art, presented in the Kapelica Gallery. The breakthrough artistic creations presented in Kapelica[14] were only made possible by the connections between the three aforementioned laboratories, which could support bold artistic decisions. Through the surplus of artistic production we can understand the importance these connected activities have on the creation of a truly qualitative social mechanism, which is capable of (through sensitising, education, public debates and the aesthetics of singularity) providing a critical contribution to scientific, engineering and economic production caught in the mechanisms of neoliberal capitalism, which is more interested in–if we paraphrase

12 Artistic projects presented in Kapelica Gallery, and predominantly created in BioTehna and Vivarium, address cohabitation and the co-evolution of living organisms and machines. Kapelica's curatorial interest is thus oriented towards complex ethical issues linked to humans designing life and the possibilities which seem to appear for humans through the various forms of artificial life. Even though the research process within the artistic practices gradually gives life to the projects, which are at first focused mainly on the level of simple discoveries of phenomenological material protocols, hybrid and chimeric contacts, the curatorial vector is always oriented towards more complex forms of artificial life. These do not seek their full realisation in biological/technological functionality, for they are embodied in the aesthetics of singularity. At this point we understand singularity as restricting biology and technology into the inseparable life of both–into artificial life.

13 The Kersnikova Institute represents the main institutional frame for the Kapelica Gallery, BioTehna, Vivarium and Rampa.

14 Even though numerous works of art will never be presented as a whole with their internal technology, a finished idiolect and sharp poetics, these projects nevertheless presented an important contribution to the formation of the artistic platform of Kersnikova (the main institutional frame for Kapelica Gallery, BioTehna, Vivarium and Rampa). For this reason I will mention at this point only a few of the most published works of art which received international awards: Art objet Oriente: *May the Horse Live in Me* (AE Golden Nica Award, 2010), Koen Van Mechelen: *Mechelese Styrian* (AE Golden Nica Award, 2013), Saša Spačal, Mirjan Švagelj, Anil Podgornik: *Myconnect* (AE Honorary Mention, 2015), Maja Smrekar: *K9_topology* (AE Golden Nica Award, 2017).

Fredric Jameson–considering doomsday scenarios linked to the end of the world (and even colonising other planets) than changing the capitalist production system.

Disruptive artistic experiments are currently undergoing creation within the Kersnikova laboratories. Paradoxically these experiments try to transcend (sometimes with the aid of the same science and technology) the scientific determinism, which is–as a result of the constructed humanistic superiority–turning right in front of our eyes into an economic, social and ecological collapse of the era of the Anthropocene[15]. The digitalisation of everything and artificial intelligence as the ultimate tool of data economy are increasingly showing themselves as the final stage of biopolitics, in which living beings, including people, are understood merely through data quantification. It seems that *life science* collided with its own premises and remains stuck in front of the issues that cannot be answered merely by measurements. Artists and their fellow researchers in BioTehna, Vivarium and Rampa create living works of art, which represent hard emotional labour and daringness at the very edge of meaning. The post-humanistic research into the non-hierarchical relations between various types of living beings has led us to the use of machine learning and various definitions of artificial intelligence[16]. With these, artists[17] create scenarios in which one can begin to understand the co-evolution between people and plants or between people and animals. With the aid of various sensors and by treating enormous quantities of data, the learning machines help us understand the dimensions which are at the moment still impossible to comprehend with human senses. Machines that behave like animals or plants are shown in excellent contrast to the machines, in which people portrayed our human understanding of the reverse engineering of nature and our cultural (sometimes bizarre) paradigms. The poetics of cohabitation, or maybe even coevolution, emerge from the differences between the relations of machine-plant and/or machine-animal and/or machine-man. The other great theme that currently excites us in BioTehna is related to the premises of quantum biology[18], which in the same way as all quantum phenomenology implies some sort of non-sensory detectable and non-speculative understanding, which represents a *zaum* language[19] to the thinking human. They are a promise of something that could unravel the definitions of the living world as we know it today. These artistic research endeavours reveal spiritual positions which, if nothing else, help us feel the lack of power of the rationalist and technical intellect, the insufficiency of scientific determinism, and demand greater hybrid intelligence.

15 Usually the various technologies that are hacked and modified commercial applications, or technologies are used in a totally unscientific way.

16 In the current project carried out at the Kapelica Gallery various forms of machine learning are used in rather unusual ways. These demand a lot of hacking knowledge with which one can change the use of the used algorithms.

17 In 2019 we will present a project by Špela Petrič (inter-cognition between plants and artificial intelligence), Maja Smrekar (human, dog & robot), Theresa Schubert (ethical meat made from her muscle tissue), Zoran Srdić Janežič (biobot with lab grown muscles), Charlotte Jarvis (female sperm created from her fat tissue) and Mojca Založnik (sonification of a cancer cell).

18 In cooperation with BioTehna and Rampa, Mojca Založnik's project Endless In Between is emerging within the Kapelica Gallery. In its third iteration this project was joined by Gregor Krpič, and together they are creating an instrument for the sonification of the quantum changes within a cancer cell. Založnik works as a microbiologist at the Institute of Oncology at the University Medical Centre in Ljubljana, in a laboratory that uses medical markers to ascertain the type of cancer. As an artist Založnik questions the scientific approach and medical technology for recognizing cancer cells, which she believes is overly generalized with its use of biotechnological instruments. Taking into account the three years the project has been in development so far we estimate that at least another three years will have to pass before it can be presented as an artistic project.

19 I use the term zaum language as it was used by the Russian symbolist and futurist Velimir Khlebnikov, who through his poetic aesthetics constructed the language of birds, as well as astral and zaum languages, which he used to describe his utopian reality.

Star-Dust

Anu Osva, 2018

In her artworks Osva explores the relationship between the human and their companion species. For Osva, it was her travels in 2005 and 2016 to North-East Siberia that ushered her into studying human-animal relations in her artistic work. The everyday life in small Siberian villages and the local people's symbiotic relationship with Yakutian Cattle, an endangered and genetically unique cattle breed, made an impact that still continues to inspire Osva. "Strange, but I need to travel to the coldest inhabited areas on earth to fully understand what 10,000 years together means.", she says. Recent genetic research implies that Yakutian cattle show very little if any marks of systematic genetic selection in their genome. This means that it has developed through natural selection in conditions characterised by human care and Siberian nature. This is exceptional as all common cattle breeds have gone through selection for traits that we humans appreciate, like high milk yield.

Anu Osva is a Finnish artist with a scientific background in animal breeding (i.e. genetics, quantitative genetics). She worked as a researcher in this field for ten years, but chose to pursue an artistic career in 1990. She was the first chairperson of the Bioart Society. Osva has held several exhibitions in Finland and her works have been displayed internationally in Iceland, Sweden, Croatia and Belgium.

Star-Dust, 2018, painting + video, 170 × 300 cm.

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How to Educate Kids and Youngsters to Value Art and Science as Equals – Pedagogy in Practice

Kristiina Ljokkoi
Tomi Slotte Dufva

Kristiina Ljokkoi (Master of Art) is a curator in HAM Helsinki Art Museum. She focuses on relations between art, environment and social realm in her curatorial practice. Ljokkoi has graduated from Aalto University with a focus on interdisciplinary art practices in the field of art & science. Additionally Ljokkoi has studied sculpture at Academy of Fine Arts Helsinki. Her interests move from practice, pedagogy and theory of art, to biological and environmental sciences, as well as to notions of public realm.

Tomi Slotte Dufva (Doctor of Art) works as a University Lecturer at Aalto University, specialising in emerging practices within art education. Slotte Dufva's artistic work focuses primarily on the intersections between art, technology and science. He is the co-founder of art & craft school Robotti, which combines technology and art. Slotte Dufva's research revolves around the topics of post-digital art, embodied digitality, art and tech, and societal, philosophical and cultural issues within AI and digitality.

A World that Challenges Education

When examining the Anthropocene, it is often on the harmful impact that humans have had, such as endangerment and extinction of species, pollution, or loss of biotopes. The humanistic-rationalistic project is seen as double-edged: at the same time, it has reached high achievements and failed on a catastrophic scale (Lummaa & Rojola, 2014a). With this understanding, we have to shift from cynicism to constructive hope in pedagogy (Morton 2012; Värri, 2018). Anthropocene should not remain as the destructive power of human; it should be harnessed to include the possibility of a positive turn as well. The human impact, as an action, must be guided into a more sustainable direction. This leads to multidimensional and challenging consequences for the theory and practice of pedagogy. As overall in pedagogy, the goal sketched here is something "good." In the era of Anthropocene, this "good" cannot be defined only by human perspective. It has to be good for more-than-human, too.

Current discussions in digital technologies, such as in artificial intelligence (AI), machine learning or robotisation (Crameri, 2018; De Pasquale, 2018; Lynch, 2017) still take a deterministic approach to these technologies. New inventions are seemingly taken for granted as if they would be given to us, rather than us intentionally inventing them (See, e.g.: Berry, 2014; Morozov, 2014; Rushkoff, 2010; 2013; Williamson, 2017). Scientific advances often go hand in hand with technological ones. Science has generally been considered as objective and deterministic: science discovers, not invents (see for e.g.: Agassi, 2019; Bijker et al., 1992; Dyson et al., 2009; Jensen, 2011; König et al., 1985). This objective and deterministic drive within science and technology is often perceived to be more "real" than more subjective, aesthetic, or philosophical areas, such as arts (Varto, 2017).

Along with technological and scientific advances, we are facing considerable changes to climate and ecosystems. Whereas transhumanistic arguments continue the narrative of human rule over other life forms (Bostrom, 2015; S. Davies, 2015; Guillaume & Hughes, 2011; Hefner, 2009), leaving environmental problems to be solved with future technology, the contrary posthuman theories see the role of the human in a more complex way (Dahlin, 2012; Guillaume & Hughes, 2011; Hayles, 2008; Lummaa & Rojola, 2014b; 2014a).

The complex world needs to be examined with multifaceted methods. Challenges cannot only be examined in divided fields or separated disciplines. So far, challenges are not overcome with pure

knowledge (Värri, 2018). The current situation generates a need for an update in learning. We argue that the concept of knowledge as it is comprehended in the context of science and technology today needs interdisciplinarity, experience-based and embodied knowledge as well as an understanding of philosophical and ethical consequences alongside it to produce meaning to the current condition. There is a particular need these days for massive loads of information to become meaningful at an experiential level, and for knowledge to turn into culture-environment-sensitive action. In this article, we want to offer an integrative angle to encounter the current world through art and art education.

However, why do we call for art to expand the concept of knowledge? Why not update integrative pedagogies from the interdisciplinary basis of science and technology? The central argument for interdisciplinarity overall comes from real-world phenomena. Complex relations and interactions tie multiple micro and macro agents into the same system, a climate for instance, and hence different disciplines must be intertwined together for comprehensive study (Moran, 2002; Mikkeli and Pakkasvirta, 2007). Moreover, as Collini reminds, interdisciplinarity is needed because one's identity is never tied on one discipline or one profession, but is multidimensional and always in flux (1998). However, in education, interdisciplinarity solely between sciences and technology is not efficient enough as it does not wholly encompass experientiality, epistemological, or ethical dimensions. Art, instead, covers those dimensions, by both critically discussing on a theoretical level, as well as physically creating and interacting in the concrete level (Dufva, 2018a; Noë, 2015; Varto, 2017). Embodied sense-making is crucial for a comprehensive understanding of the world, while a personal, experiential, and reflective relation is needed to avoid phenomena remaining distant and abstract (Kojonkoski-Rännäli, 1995; 2014; Efland, Freedman, & Stuhr, 1996; Erickson & Räsänen, 1999). In our view, art education can provide a solid foundation for integration, combining experientiality and artistic research with science studies.

Laura Beloff has stated that experience as an aim and an outcome of art separates art from science (Beloff, 2013). Art, then, brings an aesthetic, sense-related dimension, to integration that would not exist without art. Well-planned learning processes tie up conceptual thinking with embodied experience, and aim for the realisation of newly learned topics in a social context. In this context, phenomenon-based learning is more than problem-based learning: it does not cover only intellectual aspects of learning but also involves embodied, emotional, and social aspects in it.

Irmgard Emmelhainz argues that visuality and art are crucial agents in the discourse of Anthropocene. The experience of being in the world is shaped by socially shared images (Emmelhainz, 2015). According to Heather Davis and Etienne Turpin, Anthropocene is most of all a sensorial experience of living in the world in its current state. Knowledge and understanding of the world are built with visualisations of data, visualised statistics, and visual representations of planet Earth. Art, as a tool for dealing with visual representations, can also be a free-minded platform for experimentations of what life is and could be under these current conditions. (Davis & Turpin, 2015.)

Similarly, examining digital technology and its complexly coiled relationship with humans and the environment, both social and biological, is vital through art. Experiential and creative sense-making of the digital processes can be empowering and lead to a better comprehension of the digital systems (Dufva, 2018b). Sensorial experience, combined with visual strategies and experimentalism linked to knowledge construction, should be seen as a valid reason to take art education into a curriculum that aims to offer tools for children and youngsters to form a personal, active and analytic relationship to the world around them.

The reality in most schools is still something else. Even though current initiatives have introduced maker-inspired science and engineering studies to both formal and informal learning (like STEM Science-Technology-Engineering-Maths, in the US and UK) and programming has been reintroduced to the curriculum, these initiatives have mostly left out art education. In the States recent efforts have introduced art into STEM-education, translating STEM to STEAM-education (where A stands for art). Unfortunately however, the role of art has been left vague, or purely to deal with visualisations or design, which can also be seen in the current curriculums and pedagogical materials provided for schools (Buechley, n.d.; T. Dufva, 2018b; Martinez & Stager, 2013; Saariketo, 2015). In general, the current initiatives of art & science, or art & technology education are often too unbalanced, frequently putting more weight on science and emphasising scientific information as the basis of knowledge.

The national core curriculum for primary education in Finland, which has been implemented in schools from 2016, highlights integrative, multidisciplinary learning, multi-literacy, and active citizenship skills (Finnish National Agency for Education 2014). Phenomenon-based learning offers a fruitful context for interdisciplinarity to be the focal point in learning.

By utilising art to its full potential, we can create knowledge of things that are hard to put into words. Art gives tools, in Alva Noë's parlance, to reorganise our world, to broaden the concepts of how we know (Noë, 2015). Art can ask questions that would not otherwise be asked and show paths that otherwise would not be even seen (Hannula et al. 2014; Varto, 2017). Art also gives tools to analyse and make images that today are, according to Emmelhainz, a form of thought and that have an essential role in processes of constituting new kind of knowledge (Emmelhainz, 2015).

We suggest that cognitive reorganising, broadening perspectives and ethicising abstract information through art and art education is essential due to their ability to critically examine fundamental questions of life and humanity in a world that is for a good part defined by science and technologies.

In our view, art and art education are equally essential to knowledge creation as hard sciences. By this, we suggest that instead of seeing art in education "just" as the "humanising factor" that brings ethics and aesthetics into the knowledge creation process, we should see art as an essential skill-set that is integral to in modern knowledge creation and can provide a better comprehension of the complex state of the current world.

Notes on integrative learning processes from the field of Art, Science and Technology

We do not see art, science, and technology as separate fields that only communicate with each other, but rather via a more holistic approach, a merging of these practices, for instance, technology that is approached through art education (Dufva, 2018a).

One important practice in this paper that influences our interdisciplinary work is bioart. Another is creative coding. Bioart is seldom included in the curricula of art education. Bioart education is used in this article to refer to the broad definition of bioart, combined with art educational perspectives and learning methods. Two main orientations can be identified in artists' interests: a human being in the technologically-led world and the environment including, for instance, animals (Beloff, Berger & Haapoja 2013). Broadly defined bioart can be seen

as an art-based dialogue between human culture and 'nature.'

Creative coding can be described as programming, where expression is more important than function (PBS, 2013). Creative coding thus emphasises the use of code more as artistic material, not unlike oil colours, paper, or clay (Knochel & Patton, 2015). However, creative code should not be seen as an opposite to coding, but rather an activity that allows more free exploration of digital structures (Dufva & Dufva, 2016). Furthermore, creative coding expands the notion of programming from writing code to a broader artistic activity that includes code. Instead of just writing software, many projects include physical elements, electronics, sensors, and interaction with the physical world. Furthermore, creative coding is often associated with the values of openness and remixing of FLOSS (Free, and Open Source Software), hacker and DIY culture, and with a wide variety of studies of the digital world (critical code studies, digital humanities, philosophies of the digital, societal studies). Creative coding is used in this article to refer to such educational practises that blend art educational and technological perspectives and learning methods.

What about interdisciplinary learning processes in practice? Each of the cases we shortly introduce can be positioned within the field of interdisciplinary art education, but there is variety in the emphases concerning art, bioart, environmental education, and creative coding.

Life in Water

Between 2016 and 2018 an artist group took over swimming halls in Rauma, Turku, Oulainen and Tampere in Finland, and turned them into an experimental, spatial and interdisciplinary work of art called *Life Aquatic*. *Life Aquatic* was possible to experience both under and above water, as it consisted of underwater soundscapes and concerts by sound artist Petri Kuljuntausta in collaboration with the SYKE Finnish Environment Institute, and a sculpture installation of micro-ecosystems with living aquatic plants by an artist Kristiina Ljokkoi. *Life Aquatic* also included sound art performances by saxophonist Jarno Tikka and musician Tuomas Toivonen, and spatial light art by light designer Eero Erkamo.

In 2016 *Life Aquatic* turned a swimming hall in Rauma into an artwork and a site for interdisciplinary education as part of the Rauma Biennale Balticum. Kuljuntausta and Ljokkoi invited school groups to experience and learn about marine life and changes in ecosystems of the Baltic Sea. Comprehensive two-hour guided visits offered viewpoints to invasive species in local waters, noise pollution, and examples of evolutionary adaptations to different living circumstances. School groups were asked beforehand to collect samples from local waters, and the sample bottles were installed to an informative wall map. Two hundred school students, as well as a concert audience, dived into the comprehensive underwater experience that integrated art with biological and environmental knowledge. *Life Aquatic* offered a possibility to relate to the underwater realm that is disturbed by human activities in multiple ways. It also made it possible to empathise with the reality of others, and to reflect and share the learning experience within a group.

Another posthuman educational trial on water took place in a Helsinki art school for students of aged 8–12 in 2014. Students observed the behavior of water and then created 3D-amusement parks for this non-human agent. Students used waterproof building materials to create entertaining and

Participants floating and listening to an underwater sound art piece in *Life Aquatic*, Oulainen Music Festival, 2017. Photo by Kristiina Ljokkoi 2017.

Iiro Tujula teaches 7–9-year-olds at the art & crafts school Robotti in Turku. Photo by Tomi Slotte Dufva, 2017.

thrilling rollercoasters and other kinds of activities for water. Architectural structures and laws of physics were observed experimentally. Students identified with the non-human agent and took seriously its characteristics and attributes that define the way it acts and exists.

One short course in a Helsinki art school in 2014 focused on the challenge of intertwining different disciplines together. The course called Visual Strategies in Art and Science was an approach to the different methods of representation and various visual strategies used in these two different fields. Students observed the use of metaphors and symbol systems in visual cultures as well as the relation of knowledge creation, visualisation strategies, and interpretation. Based on these observations, students created visual encyclopedias of fantastic animal species convincingly mixing fiction and non-fiction. Another series of short courses in the same Helsinki art school in 2013 focused on the same challenge but did it with different methods and media. Students learnt to use stereomicroscopes; they learnt to make plant sample preparations and plant DNA extractions. These methods were then combined and varied to make art. The challenge for students was to shift from laboratory techniques to artistic work. Biological information and tools of DIY-research were new to young students, and they did not have enough time to adopt them comprehensively. Art, on the contrary, was a more familiar field of practice to them. This imbalance between the two fields of practice and how well versed students were in using the media and methods was visible. However, students were interested in interdisciplinary practices and worked intensively on their microscopic portraits, DNA containers, and plant mosaics.

Tinkering with Electric

Art & craft school Robotti is an after-school art & technology school for children that combines science, technology, and art studies. Robotti operates in three cities in western Finland and offers both long term education as well as workshops for different groups ranging from early childhood education to media art workshops for teenagers.

In one interview for the study of teaching in Robotti (Dufva, 2018a), a teacher discussed how the art educational context gave students a platform to experiment with the electronic circuits. They had worked with simple dc-motors, and while teacher talked about electrical polarity to the group of 8–12 year-old children: how the direction of the motor turns when polarity is reversed. Students had not only created these connections, but each had their wooden frame in which they could glue the components in place, color and decorate them (see Figure 1). The teacher had planned that these wooden frames would work as a future test platform, where the students could experiment freely and design their artwork. Students had already started experimenting with different things, such as to see if they could add a led-light between the connections of the motors and testing what would happen then. The result was inspiring: if the led were connected the right way it would light up when the motor started running, creating an exciting extra effect for the students' artworks. This simple example demonstrates how the framework and mindset of art lead to new kind of discovery. This discovery then translates to both better scientific understanding of polarity, as well as it expands the student's artistic vocabulary in new media art.

Another case in Robotti illustrates how the emphasis on art and experientiality can aid students to comprehend digital code. A group of 8–11 year-old children was taught the basics of programming and the concept of variable. The teacher casually mentioned that the variables could be named to whatever they wanted to, but that they have to remember these names. To the teachers' surprise, many students abandoned the logical naming scheme and came up with creative and original names for the

variables. Names ranged from their initials to funny names, some of them were pretty difficult and abstract, but as a surprise, students entirely owned these names and correctly used them throughout the coding session. Some students even continued with the naming for the rest of the semester. Their code became a bit harder to read, but they had no problems and could immediately tell what each variable did and controlled. Even though such a change in coding is small, it still transformed the language into something personal for the students; the language had become artistic material. In short, such a perspective can help transform abstract language into experienced material. Such a naming scheme and treatment of code might not be beneficial for future work as a developer, but it does show how a different perspective changes the comprehension and knowledge creation within technology.

Learning after Anthropocene

Different disciplines with their wide range of practices, concepts, and worldviews take turns, overlap, and meet in art-based interdisciplinary education, as the short examples aim to portray. The complete learning entities become more prominent than their separate parts. A learner´s understanding of real-world phenomena can start from the observation of one´s preconceptions and then move to alternative points of view and finally widen up to the multidimensional, global, and conceptual scale.

A school system with its different disciplines can be utilised as an analog to the world with multiple different paradigms, viewpoints, and interests. With the help of integrative education, a learner can juxtapose different worldviews and concepts represented in different disciplines, and one learns to understand that each discipline reaches only a thin layer of reality. Overlapping disciplines with their hardly-correlating concepts and dialogue-is-needed paradigms make the message clear for young learners: existence as a whole is beyond words, but why not to observe it with as many words as possible.

As the bioart educational example of microscopic portraits and artistic DNA containers shows, the more comprehensively all disciplines are studied per se, the more fruitful linkages between disciplines happen. An interdisciplinary approach to learning can happen in a balanced way when all disciplines are also learnt thoroughly as themselves – then the dialogue built between them can be real. The primary goal in art-based interdisciplinary education is to offer a context for students to approach the complex world with artistic intention.

There are multiple ways to carry out interdisciplinarity as a starting point for learning. The common term interdisciplinarity can be divided into and defined more specifically with terms such as multidisciplinarity, interdisciplinarity, transdisciplinarity, and cross-disciplinarity (Mikkeli and Pakkasvirta, 2007). All of these have different implications to the curriculum. Usually, multidisciplinarity is the most effortless way to gather different disciplines around a chosen topic as each discipline brings its concepts and methods, and stay as itself through the sharing process. What makes trans- and cross-disciplinary processes more complicated is the need of intertwining paradigms, concepts, and methods from an early stage, and proceeding with shared, combined, or even newly created ones through the process. Interdisciplinarity is something between, but notable is that each discipline keeps its independence even though paradigms, concepts, and methods are shared and intertwined.

Integrating various working methods is not strange in art education, nor is strange to bind art and phenomena in everyday life, politics, ethics, or

philosophy together. Art education with its connections with, for instance, architecture, design, and new media creates a fruitful base from which to update art education into the transdisciplinary posthuman phase. Bioart education and creative coding expand art education from the inside out.

The amusement park for water and *Life Aquatic* are examples of learning processes that can be linked to posthumanism. Art can offer a conceptual play where students learn to empathise with a non-human, the other. A learning process can raise the readiness to recognise interests and take seriously into account the needs of others. In posthuman pedagogies, the hierarchical system that positions one as better and more advanced than another is rejected. Differences between species and individuals are seen in a value-neutral setting, not with a rank order (Lummaa & Rojola, 2014b). Simulative empathy is a model for imagining one´s life in their life circumstances, regardless of if one is human or non-human (Aaltola, 2018). A practical starting point can be a shift in point of view. Following Anna Tsing (2015) or Michael Pollan (2001), one can introduce a non-human as a main character of the story. This new point of view offers the possibility to identify or empathise with the non-human, not necessarily on an emotional level but at least on a cognitive level. With the help of switching the viewpoint, one can take an unexpected look at interactions and coexistence between humans and non-humans. The posthuman viewpoint is challenging the traditional setting of humans as subjects and all other forms of beings as objects.

As Tarja Knuuttila and Hanna Johansson have written, science and technology not just make perception possible, but actively shape what we see and experience, and what we overall value as the worth of seeing (2013). The concept of phenomenotechnique by Tuula Närhinen points out this specific complex relation between technology, perception, and knowledge creation strategies (2016). There is also a danger of letting aestheticised visuality of the Anthropocenic world cover – and somehow even legitimise – environmental violence of industrialisation and neo-capitalism (Demos, 2017).

Digital technologies differ from earlier technologies by their use of code that can be reprogrammed and updated. The code forms a meta-layer into the technology that can transform a device from a calculator to music-making device and further to a scientific measuring instrument. The possibilities are limitless within the digital bounds. Digital devices are flexible, updatable, shareable without any loss or expense, but at the same time, they are incomprehensible. We cannot grasp the workings of a digital device just by looking at its form. We cannot even know this by opening the device and inspecting its inner workings. A silicon chip running the code is not mechanic, it is just a piece of silicon. Furthermore, complex algorithms involved in AI and robotics, but also in standard software, introduce a more advance agency of their own into the digital processes. These algorithms are capable of both making decisions on their own based on the available data, and analysing and updating themselves with that accumulated information.

The flexibility of digital code enabled the digital revolution (Petzold, 1999), but it also introduced a whole new set of challenges for society. For instance, questions around privacy, ownership of data, data manipulation, and malicious code are all problems that are either introduced by digital technologies or multiplied by the use of digital technologies. Moreover, digital technologies establish a specific type of conservative male-dominated hierarchy and value-base (Sollfrank, 2018; Wajcman 2004). Now that digital technologies are so ubiquitous, these challenges are more acute than ever.

One of the goals of Robotti has been to challenge digital structures and make them more comprehensible. This work happens through multiple layers

and timescales: from choosing the entry-point to digital technology to deconstructing some of the traditional biases within digital technology. Some of these objectives take a longer time, whereas some can be helped by changing the setting of the classroom or situation. Often this means more into the direction of an art studio and away from the technology-oriented classroom. However, it should be noted that none of these ideals are forced but allowed for. As such, they aim what Sollfrank calls queering, to diversifying the field of technology (Sollfrank, 2018).

In the example of teaching polarity in electronics, the teacher had enabled a broad entry-point into the class. First, the wooden blocks, boards enabled self-expression, while simultaneously, the teacher taught some of the electric principles. Such a setting allows the student to create their perspective into technology as well as to find their voice in it. Furthermore, the simple example of turning motor to reverse the polarity shows how the simple framing of technology in the art context can create more creative explorations into the technology. The teacher knew that inserting a led in that way was not electronically sound (the led could burn out), but the framing gave him freedom and comprehension to allow the exploration.

Coding an artwork instead of a math assignment can attach the skill more into the lifeworld, said one of the interviewed teachers at Robotti (Dufva, 2018b, p.158). Moreover, treating code as a material of art-making and expression, alongside a logical and technological tool, gives the student more freedom to explore and express in the digital domain. In the example of naming variables in the program, a rather strict language of digital code became more a moldable material of expression. While one could argue that such practices do not help in attaining a future as a developer – where strict conventions are needed – these practices succeeding in deconstructing and reconstructing the digital architecture to better suit the learners' own lifeworld. Furthermore, as the more technical skills are done more and more by machines, or cheap workforce in developing countries, a more creative and experiential perspective may turn out to be more triumphant (Knochel & Patton, 2015).

Experiencing the Abstract but Real World

The experiential nature of postmodern art education, meaning the cycle of experiencing, creating, and analyzing, is essential in the abstract digital world. This experiential nature can be seen through phenomenology as making sense of the environment, not just to understand the abstract concepts of digital technology intellectually but to grasp them; to form an ethical and aesthetical bond with them (Merleau-Ponty, 2012; Kojonkoski-Rännäli, 1995; Dufva, 2017). The term digi-grasping refers to the embodied comprehension of the post-digital world, the world that is at the same time digital and physical (Dufva, 2018b). Digi-grasping borrows from Merleau-Ponty's concept of grasping, of comprehending something before intellectual knowledge. To grasp our post-digital world is crucial as many of the everyday processes that we do and that happen in our contemporary world are digital, often automated and driven by non-human actors such as algorithms. Post-digitality borrows from Hayles' term of species-in-cybersemiosis, denoting the fact of how we are not just utilising the digital tools, but dependent on these in various and often unconscious levels (2008). Thus, grasping the reach of digital technologies is not limited to the individual, but the society and planet as well. Yvonne Volkart, in

the book *Die schönen Kriegerinnen* (Beautiful Warriors), develops Wajcmans concept of technofeminism to techno-eco-feminism indicating how digital technology is coiled with materiality, eco-crisis and social issues (Sollfrank, 2018). Techno-eco-feminism displays how the complex problems of the contemporary world are intertwined and connected. Giving the possibility to start to grasp such world is essential for integrative art, technology, and science education.

Last, but not least, we would like to point out that ethical questions raised in learning processes should be joint with the learners´ age and skills. Although our experiences of education of ethics are quite limited, we see possibilities in bioart education and creative coding to put technology and its relationship to the environment in order. This is a discussion that draws a line between posthumanism and human-centered transhumanism. Transhumanism may ignore the limits of natural resources and the real needs of non-human beings. Science and technology, with their apparent endeavor to objectiveness, tend to keep distance to questions of values and discourses of ethics. Instead, art and specifically bioart, cannot be value-neutral; there is an intentional political and ethical function in bioart practice to raise awareness of problems and ethical contradictions in biotechnology (Lehto, 2013). To properly value our contemporary post-digital and science-driven world, we need the place and the space to experience, comprehend, and discuss the various traditions and perspectives within these questions. From our point of view, it is a mission for art-based education to bring these discourses together.

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Melliferopolis

Ulla Taipale & Christina Stadlbauer, 2012–

Melliferopolis intertwines honeybees and art, in the context of the city. The project experiments with new ways of understanding the ecology of bees and other insect pollinators. With its broad and diverse approach, *Melliferopolis* explores the relations between humans and bees and creates shared spaces for facilitated encounters with urban nature through public, experimental apiaries. Critical questions regarding biodiversity, the role of wilderness and pollination in the city fuel our artistic activities.

The project mixes theoretical and hands on work. It combines disciplines such as life sciences, architecture, engineering, visual arts, gardening, apiculture, literature, sound, crafts, and more, inviting local and global agents with or without experience in beekeeping to collaborate. It is essential for us to appreciate the intrinsic value of honeybees and other insects, beyond the reductionist view of seeing these animals as ecosystem service providers or honey producers. The project focuses on systems thinking. That includes creating the right conditions for biodiversity to thrive in human centered urban contexts.

Since its launch in 2012, the project has invited many collaborations with artists, scientists and makers. It has manifested in various urban and public venues, like the Aalto Otaniemi Campus, University of Helsinki Kaisaniemi Botanic Garden, parks, cemeteries and galleries in Finland, Belgium, Spain and Switzerland. The formats include artistic installations and visible actions such as participative interventions, workshops, lectures, rituals and performances.

Melliferopolis is a long-term project and was initiated by Austrian artist, researcher and urban beekeeper Christina Stadlbauer and Finnish curator and artist Ulla Taipale. It has been supported by Aalto Biofilia, Kone Foundation, Finnish Cultural Foundation, Helsinki City, Kaisaniemi Botanic Garden of University of Helsinki, and by the worldwide Melliferopolis Community.

Feast of Pollen Gold by Christina Stadlbauer and Ulla Taipale is a still-life composition. It features fruits and vegetables that are insect or wind pollinated. The work was commissioned by Kirpilä Art House, Helsinki in 2017. A performative pollinating action was part of the opening celebration of the Table Scenes exhibition.

Ulla Taipale is curator, researcher and artist. Her curatorial and artistic work is often situated at biological field stations, botanical gardens, zoological parks and cemeteries. She works as Art&Science Curator at University of Helsinki, Institute for Atmospheric Sciences and Earth System Research (INAR). In 2011–14 she was project manager of Biofilia – Base for Biological Arts at Aalto University. She holds a BSc in Environmental Engineering and a Master of Arts.

For the biography of Christina Stadlbauer see page 148.

Feast of Pollen Gold 2017.
Photo by Antti Ahonen.

Wombs

Margherita Pevere, 2018–2019
Non/living sculpture with the artist's vaginal epithelial cells, slug stem cells, the artist's urine extract, slug mucus; future performance

The project *Wombs* looks at the leaky materiality and cyborgian character of the artist's own female body, and how hormonal contraception entangles desires and fears surrounding pregnancy and sexuality with an ecological context. Gastropods such as slugs and snails are hermaphroditic allies in this exploration of inner and outer ecologies of hormones and desire. The project manifests in a chimeric non/living sculpture hosting vaginal epithelial cells and slug stem cells growing in organ-like scientific glassware, and a performance seduced by more-than-human mating behaviour.

The daily intake of a progesterone hormone, a synthetic steroid, prevents pregnancy through the thickening of cervical mucus, which hinders sperm from entering the womb, and by stopping ovulation. Steroid hormones trigger the endocrine system of animals beside humans, creating a multi-fold bond. Mammals such as horses and mice are entwined in research, whereas fish are exposed to mammalian reproductive hormones which wash into ecosystems mostly through farming wastewater. *Xenopus laevis* frogs release eggs when exposed to urine of pregnant women, hence it was used in early pregnancy tests and later became a model organism. Research suggests that in hermaphroditic gastropods different hormones may activate either the female or male part of the reproductive system.

Yet what effect might gastropod sexualities and hormones have on humans? *Wombs* develops and subverts the human-gastropod relationship at the bridge of mucus and sexuality. The non/living sculpture melds Pevere's cells with those of slugs. It develops a performance inspired by slugs' muscular and mucous bodies, gastropods' hermaphroditism and their elaborate mating rituals. In some species, chitinous love darts are shot into the partner's body, either to stimulate sperm reception or to increase the sperm donor's reproductive success by prompting the partner's death after eggs are laid. How would a human cyborgian body react to gastropod hormones? To what extent would exposure trigger hermaphroditism? Were a human to perform slug mating rituals, how would their body react to love darts?

Margherita Pevere is an artist and researcher with a visceral fascination for biological matter. Bacteria, animals, and plants are her allies in the exploration of ecological complexity. Her installations and performances are chimeras intertwining poetics and controversy, critique and desire. Pevere is PhD candidate (Artistic Research) at Aalto University, Helsinki, in collaboration with Biofilia Laboratory and supported by the Finnish National Agency for Education and Kone Foundation.

Study for *Wombs*, pencil on photographic inkjet print, 2018. Image by Margherita Pevere.

Ewen Chadronnet flying an Aerocene backpack aerosolar balloon (aerocene.org) during *Field_Notes – The Heavens*, 2019. Photo by Johanna Salmela.

Redraw and Refigure

Illuminating Multiplicity: Against the Unbearable Whiteness of Bioart

Heather Davis
Elaine Gan
Terike Haapoja

Heather Davis is an assistant professor of Culture and Media at The New School. She has written and lectured widely on questions of environment in light of feminist, queer and decolonial theory. Her current book project examines plastic in relation to petrocapitalism. She is the co-editor of *Art in the Anthropocene: Encounters Among Aesthetics, Politics, Environments and Epistemologies* and editor of *Desire Change: Contemporary Feminist Art in Canada*.

Elaine Gan is an artist-theorist who teaches at New York University, Center for Experimental Humanities and Social Engagement (Graduate School of Arts & Science). She is interested in mapping worlds otherwise. Her transdisciplinary practice combines methods from art, science, and digital/environmental humanities to study the timing and temporal coordinations of more-than-human socialities.

Terike Haapoja is a visual artist based in New York. Haapoja's artworks, publications, writings and political projects investigate the mechanics of othering with a specific focus on issues arising from the anthropocentric world view of Eurocentric traditions. Haapoja represented Finland in the 55 Venice Biennale. Her work was awarded the ANTI prize for Live Art (2016), Dukaatti-prize (2008). Haapoja's collaboration with Laura Gustafsson was awarded the Finnish State Media art award (2016) and Kiila-prize (2013).

The fields of bioart, art and science, and posthumanism are dominated by a blinding whiteness. While they are among the most progressive fields of theory and creative practice in their commitment to exploring timely and ethically charged issues in science, medicine and biotechnology through novel aesthetic forms, they simultaneously seem to be troublingly detached from the equally urgent fronts of decolonialization and intersectionality. This implicit detachment re-enacts a central and violent aspect of whiteness itself. That is, unless specified, the default subject of humanity is assumed to be, because it has been produced as, white and male. The human itself, as a biological category, has been deliberately constructed through exclusion, evidenced in the moniker Man.[1] The human, despite its apparent neutrality, should never be taken for granted as a neutral or inclusive position. This results in the ways that whiteness continues to claim a privileged access to the 'natural' because of its supposed neutrality, its production as the standard of the biological and ideological human. Without a sustained engagement with critical race theory, decolonial practice and feminism, the fields of bioart, art and science and the posthuman re-emerge as white. Hence, questions of social justice, decolonization, or reparations are largely obscured. Because of art's power to influence, critique, and inspire, this essay explores how such questions might be incorporated into aesthetic forms, practices, and discourses. Too much is at stake.

The problem of whiteness has as much to do with privilege and exclusion as it has to do with relevance. Notions of diversity, while well-meaning, help sustain the status quo by not challenging the centrality of whiteness, or Eurocentric thought, as the predominant philosophical, aesthetic or political viewpoint through which questions of science or bioethics, humanity or non-humanity are explored. What results are practices of knowledge production that cannot produce knowledge that is *relevant* to – or emerging from – those who have been othered by Western epistemological and political regimes. One might ask, to whom is such knowledge relevant, if it turns a blind eye to the heterogeneities that are constitutive of the field of bioart.

In many spaces of bioart, when non-white subjects are included, they can only be recognized as 'the other.' However, by continuing to use this language, the specificity of whiteness, and the specificity of producing Western science, art and other

1 Often this unquestioned category of the human is figured in the concept of Man (a nomenclature that has been disturbingly reanimated recently in light of Anthropocene debates). Man, as has been deeply analyzed by Sylvia Wynter, Aimé Cesaire, Frantz Fanon and others, emerges as a category of systemic exclusion and dehumanization in relation to colonial expansion.

epistemological practices, is lost, reasserting their dominance as the unquestioned center or universal. By not systematically engaging with critical race theory, decolonialism, and intersectional feminism, artists, scientists, and scholars risk reproducing the very languages of othering that are being called into question. Dipesh Chakrabarty (2000) and others have argued for an approach to Western modernity as itself a specific and localizable epistemological and ideological position. Science studies scholars such as Bruno Latour, Donna Haraway, and Isabelle Stengers among others have pointed out that the laboratory and other sites of scientific knowledge production are racialized and gendered spaces that produce others through enactments of harm, often done under the guise of research, and rationalized by declaring non-white, non-male, and queer subjects as subhuman. As Zakiyyah Iman Jackson (2015) powerfully argues, the fetishization of the non-human within white spaces again threatens the marginalization of nonwhite bodies. Instituting a so-called 'posthuman' turn in theory and art practice that, while necessarily calling attention to the violent division of human and non-human worlds, also serves to occlude the ways in which this division is used to justify the violence against nonwhite bodies.

Thus, it makes no sense to have a conversation about reproduction technologies or sex hormones, for example, without taking as starting points the perspectives of the people who are most dramatically affected by them. Eugenic attitudes are still built into contemporary Western legislation and have a dramatic impact on the lives of gender non-conforming, non-binary, trans, disabled or non-white people, or basically any marginalized group. In fact, marginalization is most often produced in the spaces of institutionalized and politicized science and medicine exactly by the ways in which notions of the 'natural' or 'normal' come to be constituted by those discourses. By continuing to explore space and interplanetary ecosystems without also acknowledging ongoing conversations about colonization produced by people who are living with the consequences of colonial history, the field of bioart fails to interrogate the ways in which colonization is fundamental to the emergence of Western modernity and the relationships between space and earth. Without keeping in mind that the Western concept of the animal is itself a racialized construct that serves to function by marking beings of all species less than human , it risks rendering them killable in Western eyes.

We call then for an intersectional feminist approach within bioarts that attempts to think through entangled and multiple naturecultures within and informed by categories of race, gender, class, ability, and sexuality. This project builds on the work done by innumerable scholars and artists, and is especially indebted to discourses around environmental justice – discourses that foreground work done by Indigenous, black and other non-white people to call attention to the ways in which the environment itself is often weaponized in the service of white supremacy. Since the late 1980s, intersectionality as a mode of analysis and intervention has drawn attention to the ways in which power operates through "overlapping and conflicting dynamics of race, gender, class, sexuality, nation, and other inequalities" (Cho, Crenshaw, McCall 2013, 788). Through an intersectional lens, acts of social injustice can be articulated and examined as multidimensional in their constitution as well as in their effects. Intersectionality is both a methodology for examining the multiple and interlocking systems of domination that societies are enmeshed in, and also a term for describing lived experiences that are often erased because they exceed or do not fit clearly into pre-determined categories, like 'woman'. It speaks to the ways in which identity is not "a self-contained unit; it is a relationship between people and history, people and communities, people and institutions" (Crenshaw 2018). How might we build on this to consider naturecultures? Over the last three decades, intersectionality has been applied exclusively to injustices against people. As artists and theorists of multispecies worlds, we ask: what might it mean to apply this analytic to more-than-human formations, to the broader realm of *bios* or living organisms and even more broadly, to biotic and abiotic beings that make up a damaged landscape? What might it mean to consider acts of environmental injustice as multidimensional?

These questions may be addressed from at least two perspectives. First, environmental degradation tends to have the most devastating effects on marginalized, subordinated, and impoverished groups. Environmental degradation is tied to long histories of colonial oppression, as well as contemporary strategies of what Elizabeth Povinelli calls "settler late liberalism" (2016). Intersectional analysis might usefully show that land (as habitat, home, field, territory) is a significant mechanism, another intersecting axis, through which power segregates and regulates difference and belonging. Second, definitions of personhood and legal rights are expanding beyond Eurocentric views that privilege particular humans and exclude all the rest. In the early twenty-first century, novel constitutions of the "rights of nature" are beginning to hold after indigenous groups, legal scholars, and activists have struggled relentlessly for decades. Ecuador, Bolivia, and New Zealand have given different forms of legal standing to non-human nature, opening up the possibilities for unprecedented protections for beings like rivers, forests, and land (Tanasescu 2017). Intersectional analysis may help to articulate the diffuse and differential kinds of damage inflicted upon such beings by multiple axes of power. These two perspectives offer rough starting points (and there are others) for considering how intersectionality may be expanded to work as an analytic for social *and* environmental action, for greater visibility and thus protection of human *and* non-human beings.

But we want to push the inquiry further. And this, we believe, is the important work of environmental and bioart, the work of learning how to inhabit worlds that *are* otherwise – because as a matter of fact, worlds are otherwise, regardless of what states, courts, markets, and sciences declare. We ask how intersectionality might also account for the ways in which those considered non-human and subhuman take part in regulating, intensifying, and extinguishing power. What might it mean to consider power as multidirectional and to see damaged landscapes as constituted by and constitutive of more-than-human practices rather than solely the result of top-down human oppressions? Bodies, spirits, and lands are more than the sum of their oppressions and live beyond/despite the arc of supposedly realist narratives. What might it mean to open up the lens of intersectionality and let other beings move into focus on their terms?

This is important work that is deeply indebted to non-Western cosmologies and decolonial perspectives that are being advocated by Kyle Whyte, Kim Tallbear, Eduardo Viveiros de Castro, Elizabeth Povinelli, and Marisol de la Cadeña, to cite just a few. In recognizing that power is multidirectional, perhaps artists, scientists, and scholars might begin to find paths beyond Eurocentrism and towards more radical engagements with critical race and intersectional feminism.

Claire Jean Kim (2015) argues that in order to overcome perspective silos that isolate social justice spaces from environmental spaces from animal rights or post-humanist spaces, single optics vision must be rejected in favor of a multi-optics approach. This also means constantly being aware that all optics are necessarily partial, making some questions more visible than others. To use a multi-optics vision in bioart is to become aware that certain questions are illuminated while others are relegated

to the shadows. Shifting perspective to multi-optics approach here is not an attempt to replace the totalizing Western worldview (theorized by old man Heidegger) with another non-Western one. The aim is a search for situated practices and ontoepistemologies (Haraway 1998; Barad 2012) that might enable ways of living together across radical difference.

A multi-optics approach that is indebted to but seeks to extend and elaborate intersectional feminism as it is normally conceived might allow artists, scholars, and scientists to make visible and thus grapple with divergent notions of justice and freedom that define how and to whom individuals and collectives belong. It might allow us to tear down the white marble statues of Lady Justice – with her forever imbalanced scale, immovable sword, stone cold Greek robes and impartial blindfold – that guard the courts of Western law. History warns that tearing down statues can get tricky. But perhaps as artists and theorists, we get to say: tear them down. Tear them down and replace them with prisms. Prisms that might refract and reflect the light of beings we cannot see. Prisms that might illuminate the radical intersectionality of worlds otherwise.

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Splice/Liitos

Bioart Society, 2017

Since time immemorial we have observed and admired the fundamental order in nature while searching for inspirations, interpretations and solutions. Lately the terrestrial landscape as well as our communal mindscape is being reshaped by both intentional and unintentional developments. Within this transforming process, established and contemporary entities are merging to form previously unforeseen connections and potentials. The SPLICE exhibition at the Oulu Museum of Art presents a showcase of interdisciplinary works that investigate contemporary artistic perspectives on Nature with the aim to unfold a new understanding of “our environment” or “the new world around us”.

Participants Lauri Anttila, Erich Berger, Risto-Pekka Blom, Nina Czegledy, Judith van der Elst, Jussi T. Eronen, Alexandra Daisy Ginsberg & Sacha Pohflepp, Antye Greie, Ilkka Halso, Kalle Hamm, Pekka & Teija Isorättyä, Tellervo Kalleinen & Oliver Kochta-Kalleinen, Antero Kare, Olga Kisseleva, Carolin Koss, Mia Mäkelä, Agnes Meyer Brandis, Tuula Närhinen, Kira O’Reilly, Anu Osva, Piritta Puhto, Johanna Rotko, Tibor Szemző, Antti Tenetz, Leena & Oula Valkeapää, Seppo Veinö, Elina Vieru and Jana Winderen.

Curated by Nina Czegledy with the Bioart Society.

Tuula Närhinen presenting her work *Seawatercolours*. Photo by Antti Tenetz.

Teacup Tools by Agnes Meyer-Brandis. Photo by Antti Tenetz.

Mothers and Others – Insurgent Kinmaking as Distributed Reproduction

Ida Bencke

Ida Bencke holds an MA in Comparative Literature. Her curatorial work spans experimental exhibition formats, interdisciplinary methodologies and speculative feminist aesthetics. Her recent projects investigate fermentation, queer home-building and interspecies care, various im/possibilities of multispecies narration, and insurgent m/otherhood within the reproductive regimes of necropatriarchy. Research interests include radical practices of mourning and pleasure, more-than-human affect, and revolutionary experiments on co-habitation, collectivity and regenerative alliances. She is co-founder of the Laboratory for Aesthetics and Ecology.

Maternal bodies are boundary creatures; they inhabit a peculiar liminal space between the quotidian and the strange. Mothering bodies are improper – they disregard conventional boundaries, as they swell, stretch, envelope and leak in all directions. As Maggie Nelson asks in *The Argonauts*:

> Is there something inherently queer about pregnancy itself, insofar as it profoundly alters one's 'normal' state, and occasions a radical intimacy with – and radical alienation from – one's body? How can an experience so profoundly strange and wild and transformative also symbolize or enact the ultimate conformity? (Nelson 2016, p. 25)

The question of motherhood cuts right to the core of feminist (bio)politics, negotiating the junctions and intersections between biological body functions and the emerging, culturally situated gendering of bodies. Since Judith Butler's insights on the interconnections between gender and performativity, feminist theory has produced robust critiques of the discourses surrounding and producing gender. However, the question of how to deal with the very physicality, the biological *stuff* of reproducing bodies has proven more difficult. Indeed, there seems to be a certain unease connected to questions pertaining to motherhood, as they are enrolled in and created through histories and ongoing struggles of oppressions in abundance.

But bodies continue to gestate and to propagate in joyous, risky, strenuous, strange, deadly, sometimes liberating and sometimes coerced ways. We need methodologies, manners of thinking about what it may mean to take the 'stuff' of reproduction seriously, to stay with the contingent, but all-too real biological-material particularities of mothering without succumbing to the dicta of biological essentialism: that motherhood is fundamentally good and that only women can mother. Ongoing environmental disasters, reigning discourses on 'overpopulation', the unevenly distributed violence of global inequality, and the perpetual destruction of the material and affective foundations of marginalised lives all call for radical renegotiations of reproductive justice. We need to ask what it means – and may come to mean – to make, to mend and to care for kin.

In this text, I will take a closer look at the im/possibilities of mothering, not as essence, but as troubled practice in the proliferation of kin beyond genealogy, beyond sanctioned affect and even beyond species boundaries. Inspired by Donna Haraway's now famous slogan 'Make Kin Not Babies' (Haraway, 2016), but wary of its all-too slippery

ventures into discourses of (over)population[1], the ideas in this text germinate within the works of feminist thinkers such as Sophie Lewis, Ruha Benjamin and Michelle Murphy calling for an intersectional, material feminism capable of fomenting reproductive politics not content with 'merely' tackling gender inequality, but taking on social injustice on a global scale.

Within this essay, I will investigate junctions and leaky borderlands between motherhood and otherhood. Tentatively probing into the potentials of resurrecting and bringing forth an insurgent, but also non-innocent politics of carrying and caring by investigating the *strangeness* of mothers, this text will examine how contemporary experimental art practices are pushing against conventional notions of motherhood. How and with what consequences do mothers envelope and embody alterity? What happens when the technologies and politics of the maternal are unleashed from the affective and economic structures of heteronormative production, from natality and even from species' genealogies? By weaving theory and (artistic) practices preoccupied with renegotiating the limits and potentials of the maternal – and sometimes the refusal hereof– this text will attempt to trace some of the manifold and persistent problems, and perhaps embryonic hopes of renegotiating the slippery conjunctions between mothering and othering.

Mother nature and working mothers

Traditionally, motherhood has been seen as an obstacle to intellectual reflection and artistic production, rather than as enticement to it. Western thinking has treated motherhood as a banal somatic event, relegated to the ahistorical and rather 'uneventful' realm of the female body, nature and social reproduction. Indeed, motherhood continues to be framed as female nature par excellence. However, as the various strands of feminist theory have shown us, summoning an essentialised relation between motherhood and nature always comes at a certain cost, as both categories – and their implied ideals – are intimately tied to structures of oppression, the extraction of profit and the exploitation of worlds. When reproduction is naturalised, the maternal comes to inhabit discourses that are not apt to offer critique of the specific affective, technological and ideological implications of historically contingent motherhood as it is re/produced under various material circumstances. And even worse, when reproduction is naturalised, we all too easily forget to take care of babies other than our 'own'[2].

When maternal bodies are made to embody 'nature', they easily come to symbolise – and perhaps materially sustain – frictionless reproduction of convention. However, recent feminist theory has shown an interest in the subversive potentials of the maternal-as-care. As Lisa Baraitser notes, the suspended and 'non-productive' time of staying, maintaining, repeating and enduring, is a 'women's time [which] remain threatening, unarticulated and excluded from symbolic representation' (Baraitser, 2017, p.75). The time of caring and maintaining, 'the durational drag of staying alongside others, rather than the time of transgression; the elongated time of incremental change, rather than the time of

1 For more on this critique, see Sophie Lewis' essay 'Cthulhu plays no role for me' in *Viewpoint Magazine*, 2017.

2 I reject the idea of children-as-property, and stand by the rights of children to belong to themselves. For a more thorough account on this topic, see Lewis, 2019.

breakthrough or revolution' (Ibid, p. 50), such time comes to bear the potential of subversive and potentially regenerative counter-temporalities to the progressive and productive 'fast' time of modernity and capitalism.

Announcing the space of reproduction as a counter-space to capitalism is a risky manoeuvre that needs to stay wary of the dangers of replicating idea(l)s of the feminised domestic as a 'safe' space, blissfully disjoined from the politics of public life. As Silvia Federici and the Marxist feminist movement *Wages for Housework* already in the 1970's came to vehemently insist upon: reproductive labour is *work* as it sustains and reproduces the very material ground of capital, and it ought to be theorised and reimbursed as such. Regarding housework as 'real' work was seen as a first necessary step towards a politicising – and eventually a refusal and overturning – of domestic work as it is structured and offered within patriarchal capitalism (Federici, 1975). In her recent book *Full Surrogacy Now*, scholar Sophie Lewis expands the politics of reproductive labour to that of gestation: uteruses, she says, are infiltrated through and through with economic structures and biotechnological innovation. Gestation under capitalism is work, that is: something to struggle in and against (Lewis, 2019). Treating the gestating body as a working body, rather than a natural one, allows for a repositioning of the maternal-as-political by highlighting mothering as situated, potentially subversive *action* open to a multiplicity of genders, queer libidinal practices and contractual agreements that differ from those of the nuclear family.

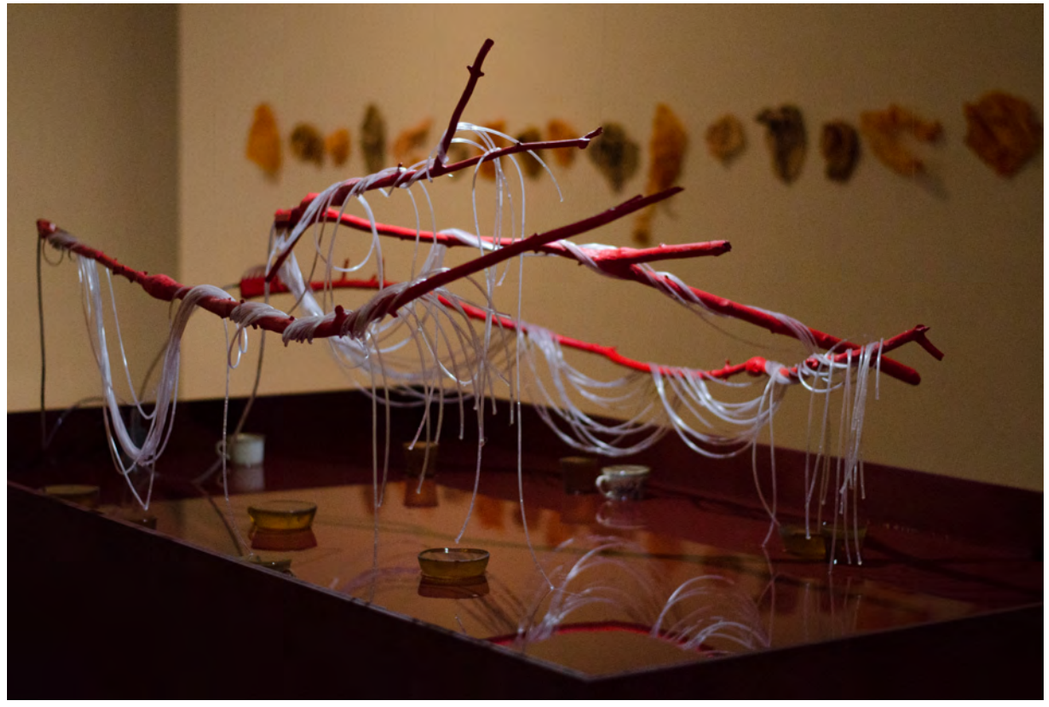
Mother care

Recent (eco)feminist accounts have framed questions of care and regeneration within environmental issues such as multispecies extinction and ecological devastation, often pushing against the conventional binary between reflection (spirited labour of the mind) and care (base labour of the body). In her recent work *Matters of Care*, Maria Puig de la Bellacasa investigates the ethical and political potentials of care, and indeed – the possibility of practicing a careful thinking, or thinking-as-care. Here, rather than a prefabricated concept, care becomes an analytical tool, a provocation that holds disruptive potential. Writing about artist Patricia Piccinin's sculptural speculations, Donna Haraway notes that they demand we exercise love in the face of alterity, that we rehearse care which 'is wet, emotional, messy and demanding of the best thinking one has ever done' (Haraway, 2007).

In all their technoscientific and 'artificial' fleshiness, Piccinini's sculptures manifest as cyborg totems for a reproductive future which, in many ways, is already here – in which neither babies, nor their mothers, lay any claim to the natural. Piccinini's sculptures of hybrid bodies and chimeric kin suggests affection in the face of otherness, and requests that we interrogate both the potentials of and limitations to what and whom we care for. These hyperreal sculptures enact what we may call queer maternal ecologies that ask of their spectators to stay in and with the questions of caring for the strange/r even and also when these strangers, indeed, manifest themselves within the murky outskirts of sanctioned humanity.

The messiness of care, of course, in part comes from its undervalued and subdued position in the subterrains of Western civilisation. As Baraitser puts it,

> Maintenance is in part generated by conditions of vulnerability that we all share, and in part



The imaginary becomes complete on the margins of every new linear projection. Louiza Prado, 2018.

> by the excesses and internal logics of capitalist cultures that make maintenance so necessary – whilst at the same time utterly devaluing maintenance practices. (Baraitser 2017, p. 48–49).

As such, questions of whom to care for and on what material grounds are inextricably linked to histories and ongoing structurings of inequity and exploitation. Within the current political regime,

> to care is to deal in an ongoing and durational way with affective states that may include the racialized, gendered and imperially imbued ambivalence that seeps into the ways we maintain the lives of others. (Baraitser 2017, p. 53).

As Ursula le Guin (1997) points out in the essay "The Carrier Bag Theory of Fiction", there are different stories to be extracted both in the symbolic and the material stratas of human civilisation; the collective, anonymous stories of care, of carrying life forth, of securing ongoingness in the face of violence and precarity. Such stories have yet to find their proper narrative forms, and as such they remain largely untold within our cultural and political imaginations. Of course, the labour of taking care, of producing and reproducing life has been – and remains – a practice distinctively coded in the feminine. The connection between womanhood, the maternal and carework has proven very effective in the oppression of women everywhere. We need to examine not just the merits, but also the limits of our caring capacities. We need to not lose sight of how ideals of motherhood-as-care have been implicit (and continually so) in regimes of exclusion, producing (and ignoring) unloved others in the favoring of certain kinds of children, certain kinds of mothers, certain kinds of families. As Sophie Lewis points out,

> More than just 'care' – any old care – we need to become fluent at *good* care, comradely care: a mode of social reproduction that, in itself, un-reproduces and destroys the present state of things. (Lewis, 2018).

Mothers are strange

However tentatively, problematic and imperfectly, mothers inhabit clandestine temporalities and strange bodies. As Sophie Jones puts it:

> recognizing all the ways in which child-rearing might entail a refusal to reproduce the dominant order (…) let's think (…) about non-production as reproduction, about relations of care and affinity that flourish outside, or in defiance of, the nuclear family. (Jones, quoted in Baraitser, p.76).

In this sense, mothering 'activities' such as repeating, remaining, staying and enduring everyday tasks of maintenance call forth a kind of 'suspension of the self' as it is imagined, produced and idealised in venture capitalism as that which is always striving for progress, for production, for result (Baraitser, 51). It is the potential of suspension of a normative sense of self, the potential to harbor the other in the 'me' (m/other), that has inspired feminism to work with the 'queer' morphologies of mothering bodies, challenging notions of singularity and individuality so engrained within Western culture[3]. Mothers and others make each other up in the flesh, as Haraway would say. A mother, quite simply, holds an other. A pregnant body might be a really ordinary, but not less baffling figure of ambiguity, a true and puzzling 'dialectic at a standstill', Walter Benjamin's famous utopian figure of a frozen dialectics, a pulsating either-or, reverberating between differences, that magical moment of pure potentiality before production, before progress, before redemption sets in.

At the cellular level, the maternal body challenges notions of individuality as so-called 'fetomaternal microchimerism' reveals the presence of cells from the fetus in the mother's body even decades after giving birth. These stray cells may very well perform reparative functions, boosting the immune systems of their hosts, even protecting their host against possible cancers. As such, microchimerism suggests messy and multidirectional genealogies embedded in intergenerational care and reparation. Contemporary microbiome research is only now starting to understand the intricate interconnections between microbes and mammalian bodies in birthing and nursing ecologies. Mothers envelope and embody systems of alterity and co-becoming, suggesting strange morphologies in and through their fleshy existence.

Staying with the affirmative strangeness of mothers, and their potential for insurgent politics of care, recent feminist psychoanalysis has challenged the pathologised, hysterical mother brought forth in and by the phallic order of patriarchy, in which she comes to represent a lack, what psychoanalyst Bracha Ettinger calls the 'ready made mother monster', which is the mother as universal negative signifier of separation and of trauma. Within a phallic order, the mother is made to play a key part in the drama of castration, and her destiny is to bear and to birth subjectivity through separation. Ettinger challenges the normative view on mothers within psychoanalysis by pushing back on the idea that 'proper' selves are created in and through separation (from the maternal body). Instead, Ettinger proposes the matrixial as image and embodied memory from the pre-uterine condition of pre-separation. The matrixial emerges in empathetic encounters and is transsubjectivity in becoming, an embodied knowledge of radical difference – the ongoing relations between an 'not-yet infant and a not-yet mother' (Baraitser, 2017, p. 155). It is a borderspace, a dialectics at a stand-still, neither together nor separated, it becomes 'basis for an ethical encounter that

3 See for example: Katz Rothman, 2000.

does not destroy or paralyze the other, but allows the other to be, without colonisation, intrusion or knowing' (Baraitser, 2017, p. 156).

In the performance piece *Gut Sounds Lullaby*, artist Karin Bolender Hart holds a microphone against her pregnant belly, and with the other hand, she carefully places a stethoscope on the flank of dear life partner *Aliass* – an American Spotted Ass intrinsically enrolled in Bolender Hart's artistic practice – standing patiently by her side. The stethoscope transmits the gut sounds from the equine companion to the human fetus, creating a loop between different kinds of insides.[4] As fetuses, we revel in the soundscapes of digestion, we germinate within gurgling compositions created by the gut biomes so indispensable for the thriving of bodies. *Gut Sounds Lullaby* suggests a kind of poetic un/knowing-from-within, an alternative diagnostics of careful listening to the indistinct voices of the multitude it takes to create and sustain life. This diagnostic is radically different from the intrusive inspection of standard obstetrics in which the health of the fetus is 'seen' and surveyed through ultrasound. Bolender works from within the murky spaces of pre-separation in which collectives know each other and make themselves known in ways standardised medical knowledge may not be well equipped to make sense of. In her work, Bolender Hart summons the more-than-human voices of life sustaining and reproducing itself, and relays the gutteral soundtracks of bodies-within-bodies, the audible traces of strange morphologies and interspecies intimacies.

Emerging further into the collectivity of both mammalian and microbiotic bodies that enable (while also proposing occasional threats to) life, Bolender Hart and the experimental artistic farming collective Kultivator[5] conducted inquiries into the 'tongue cultures' of the various inhabitants on a dairy farm. The work ventured from Bolender Hart's own gutteral wish to give birth in a barn in order to let her newborn be licked clean by her companion animal Aliass, as so many other newborns are welcomed into the world by a warm, mammalian tongue. After being dissuaded by midwifes and other health professionals referring to standard medical regiments of hygiene, the artwork *Kulitvating m>other tongues* was conducted as an inquiry into these potentially risky or 'unhealthy' bacteria inhabiting the (mother) tongues of the multispecies mammallian production unit at Kultivator. A table was set in a barn, inviting both humans, horses and cows to feast together. The table became an apparatus of multi- or interspecies sense-making, a place of becoming companions-with-bread (cum-panis), and a place of swapping and sharing mother tongues in various senses of that word. Food was served and plates were licked, and the bacterial traces that were left from this multispecies feast were cultivated and embroidered into the table cloth, as a way to commemorate those microscopic beings who are indeed joining us at each table, who are implicit and vital in all matters of propagating bodies and bringing forth life, and whose influence in our physical well-being as well as in our illnesses is beyond reckoning. *Kulitvating m>other tongues* became a performative gesture, a ritual for conducting and operating interspecies relationality and care within maternal multispecies ecologies (here, specifically within the lactating environment of a dairy farm) which are non-innocent, unpredictable and potentially dangerous–but also generative, full of affect and indispensable to the reproduction of life.

4 For more information on the work, see Bolender, 2015

5 Situated in Öland, Sweden

Kultivator and Karin Bolender, *Kultivating m>Other tongues*, 2019. Photo courtesy of Kultivator.

Mothering the many

The body as that which harbours alterity and quite literally contains multitudes has been thoroughly investigated by contemporary feminisms invested in multispecies relations[6]. Biology, and especially contemporary microbiome research, is only now beginning to come to terms with the myriad of ways 'we' are made and unmade in and through multiplicity. 'Gestation, like all labor, is cyborg. It is an unbalanced techno-social co-production involving less than two but more than one,' Lewis notes,

> The word "individual" by definition never referred imaginatively to gestators anyhow.(…) we are all revealed to be disconcertingly pregnant, multiply-pregnant with myriad entities, bacteria, viruses and more, some of whom are even simultaneously gestating *us*. (Lewis, 2017).

As such, Ettinger's matrixial space of co-becoming exists as the thick and fundamental condition of life, not tied to the specificity of human pregnancy or what we may call bio-motherhood. In its de-pathologised state, the matrixial as a *refusal to separate* may offer a glimpse into radical and insurgent strategies of care, collectivity and kin-making technologies that reach well beyond species' boundaries. However, such positive accounts on the leakiness of bodies, on affirmative undoings of boundaries and self, run the risk of not accounting for the inherent violence and potential harm nested within deep relations of material reciprocity and exchange. Inhabiting 'leaky' bodies also means becoming in and through environmental toxicity, as Michelle Murphy puts it: 'To be human is to materially develop in the uneven distribution of chemical exuberances of a century of industrial capitalism.' (Murphy, p. 115).

6 To just name a few: Donna Haraway, Anna Tsing, Astrida Neimanis, Stacy Alaimo

Mother The Verb. Photo by Robbie Sweeney.

The practice of performance group *Mother The Verb* engages in the reparative work of absolving mothering from the toxic inheritances within patriarchal structures passed on through generations in a myriad of material-discursive ways. *Mother The Verb* posits the perverted infrastructures of interrelation as the contaminated grounds from which to redeem motherhood and heal the mother wound by bringing forth histories of marginalised mothering. The artist statement quotes the midwife and Mohawk Native American scholar Katsi Cook, as she brings attention to how violence of environmental damage, patriarchy and colonialism force their way into the most quotidian and fundamental acts of caring-for-kin:

> Because our nursing infants are at the top of the food chain, they inherit a body burden of industrial contaminants from our blood by way of our milk; thus are we part of the landfill, colonized.

The duo, consisting of the performance-based artists Javier Stell-Fresquez and Ivan Monteiro, weaves themes of motherhood, labour and toxicity together in ritual, dance, text and video, summoning the potentials of exploring the parallels between trans- and "biological" motherhood, and honoring maternal ancestors who also, and crucially, include those trans revolutionaries who have been the 'ingenious and industrious mothers of queer culture' (Artists' statement).

The work of *Mother The Verb* unfolds as an artistic broadening of the notion of motherhood that it may come to hold and to care for the marginalised others and 'embrace "trans freaks" and "bad mothers" (…) embodying their complex truths, including the shadow/demonized other they are (not allowed to be)' (ibid).

Motherhood, here, is untied from gender and genealogy, instead recognising the urgency of what Ruha Benjamin calls *social mothering*, the 'mobilization across the many boundaries upon which oppressive carceral geographies depend.' (Benjamin, p. 64).

The practice of *Mother The Verb* can be understood as an artistic manifestation of what Michelle Murphy calls a

> distributive reproductive politics that stretches beyond bodies, choice, and babies to extensively include all our relations and responsibilities within damaged worlds (Murphy, 2018, p. 102).

In the essay "Against Population, Towards Alterlife", Murphy challenges the abstract notion of 'population' as it rests upon 'calculations of surplus life and white supremacy, of foreign life to be kept outside of borders, of lives not worth saving, of killable black and brown others, and of elite lives to be protected.' (Ibid, p. 105). Distributed reproductive politics does not take its starting point from the faceless notion of human numbers in 'population', but from the hard realities of what beings 'get to have a future and which are destroyed' (110) within current necropolitical regimes, and ventures into the 'affirmative making of the conditions that support collective life' (Ibid, p. 109). It extends reproductive politics 'into air, water, land, and a mesh of life forms into the multigenerational future' (ibid, p. 110). Reproduction, in other words, 'is not just about the baby' (ibid, p. 109). Murphy calls for a reproductive justice based upon decolonising efforts and what she calls queer 'alterlife', which is 'life damaged, life persistent, and life otherwise; life materialized in other ways and life exceeding our materializations' (Ibid, p. 118).

Mothers and violence

Accounts on the affirmative potentials of mothering cannot afford to lose track of the violence implicit in, and / or inflicted upon the reproduction of life, especially in structures where the flourishing of some rests upon the abusive extraction of racialised and / or impoverished others.

As Sophie Lewis notes, gestation is a risky business, and fetuses inflict violence on their gestators in myriad ways. In thinking about gestation as labour, the act of aborting a fetus becomes a refusal of the afforded working conditions, a sort of affirmative necropolitics (See Lewis, 2019). Avoiding or terminating gestation has historically been employed as tool of resistance, as – for example – enslaved communities would defer the reproduction of more workers to sustain the oppressive regimes they were forced to materially support. In her artistic work, Brazilian artist Luiza Prado has investigated the historical links between colonisation, reproductive technologies and resistance. Her sculpture *The imaginary becomes complete on the margins of every new linear projection* (2018) is formed by three groups of tree branches from which water is dripping into teacups, symbolising the three rivers in Brazil: Maracanã, Pedras and Guedes, all significant places to the mother, grandmother, and great-grandmother of the artist[7]. The piece examines personal memories and larger histories of the peacock flower tree – also known as *ayoowiri* – used for its abortifacient properties by enslaved Indigenous and African communities. The sculpture interrogates encounters between memory, body, plant and reproduction in honoring the matrilineal ancestry, while also caring for histories of the refusal to mother, the refusal to reproduce based in solidarity and collective struggle to quite literally abort the reproduction of oppression.

In the text *Black Afterlife Matter; Cultivating Kinfulness as Reproductive Justic*e, Ruha Benjamin looks at the intersections between racist systems of oppression and reproductive systems, dwelling on the 'vampyricality' with which 'white vitality feeds on black demise' (Benjamin, p. 41). The text is dedicated to the black lives, black futurities lost in and to the extractive regimes of white supremacy, within which the more 'blatant' practices of population control are sustained and continued by what she calls 'positive' eugenics, enrolled in market-based biotechnologies and encouraging those deemed valuable to reproduce, even enabling the selection of the very features and traces of their offspring (Ibid, p. 56).

When Indonesian transgender artist Tamara Pertamina rolls the *CRISPR Sperm Bank* down the streets of Yogyakarta encouraging bypassers to donate sperm, this provisory queer street laboratory enacts a seizing of the means of reproduction within technopatriarchy. It undertakes a queering of the kind of 'positive' eugenics Benjamin refers to: a market of reproductive fluids and genomes in which consumer choices are unlikely to steer in the direction of the same kind of coloured trans body as the one inhabited by the artist. Pertamina's work can be understood as insistence to have a seat at the table of reproduction as it is radically un- and redone by contemporary biotechnology. In the DIY spirit of activist, democratised biology, it brings groundbreaking biotechnological innovation to places and bodies not usually enrolled in decisions of who gets to (re)produce what kinds of bodies. Pertamina's work creates an opening for the redistribution of reproductive agency and kinship amongst marginalised bodies and genders. The work echoes Benjamin's calls for a reproductive politics in an

7 For more information, see the artist's website: https://www.luiza-prado.com/

All directions at once, 2018.

expanded field able to account for both the proliferation and the destruction of kinship that exceed current dominant conversation on genealogy, population and natality. In the face of 'institutionalized kinlessness', Benjamin asks that we become better at 'reorienting ourselves towards kinship not as a precursor but as an effect of social struggle' (ibid, p. 64). This move depends on a denaturalisation of kin, a mobilisation of profuse strategies of enacting kin as acts of solidarity and survival.

> Ultimately, reproductive justice entails crafting and imagining the worlds we cannot live without just as we dismantle the ones we cannot live within. (ibid, p. 61).

Mother cyborg

As Paul B Preciado points out in his essay "Baroque Technopatriarchy", power always naturalises reproduction. Accounting for the ways in which power operates on the engendering of life remains as urgent as ever. Confronting contemporary biotechnologies, Preciado asks us to consider how reproduction may be changed in the face how non-binary, insurgent desire comes to inhabit and change reproductive regimes (Preciado, 2018). Reproduction, as it is, is not an archaic practice only newly compromised by the advent of modern technology. Rather, biotechnologies such as IVF and CRISPR only highlight the always already manufactured 'nature' of reproductive systems. As such, they foreground how technologies of violence and care have always played crucial parts in the distribution, flourishing and fragmentation of motherhood (see also: Lewis, 2019). Mothering is a cyborg practice if there ever was one. Mothers of all genders embody and embrace hybrid materialities in perpetual becoming-with a myriad of both 'hard' and 'soft' technologies required to engender and sustain life. Cyborgs are, of course, the illegitimate of militarism and patriarchal capitalism, but unfaithful to their origins: 'Their fathers, after all, are inessential.' (Haraway 1991, p. 151). Cyborgs are multiplicity, ambivalence, irony embodied. The cyborgs are creatures of 'contradictions that do not resolve into larger wholes, even dialectically', as they hold 'incompatible things together because both or all are necessary and true.' (ibid). It is within these cyborg ecologies of contradictions contained and carried forth that we may begin to grapple with the potentials of monstrous mothering as a practice of

Tamara Pertamina, CRISPR SPERM BANK.

affirmative abolition[8]. It is exactly within this 'queer' space of neither-identical-nor-separated that the m/other conundrum emerges in unexpected, difficult and exciting ways.

As Haraway says, we are at stake to each other, radically and risky we inhabit each other in the flesh (Haraway, 2007). Furthering and contesting critiques of motherhood into expanded maternal ecologies calls for robust and bold recipes for the radical redistribution of relation and care. Lewis proposes we extend our conversations on reproduction into those of midwifery in an expanded field of assisting the births of insurgent collectivity:

> There's enough kinmaking needed on Earth to go around – and we've consented too much to the privatization of procreativity. Midwives to the front! By midwives I mean all those comradely interveners in the more slippery moments of social reproduction: crossing borders; blockading lake-threatening pipelines; miscarrying. Let's all learn right now how comradely beings can help plan, mitigate, interrupt, suffer, and organize this banal yet sublime amniotic violence. (Lewis, 2017).

Looking at the manifold ways mothers inhabit, envelope and engender otherhood denaturalises reproduction and unties motherhood from its position as labour coded in the feminine. It also exposes the dialectics of violence and life as they emerge under late capitalism. Renegotiating the slippery conjunctions and conflicts between mothers and others carries a potential to free care- and maintenance work from their 'hostage positions' within contemporary society as the trivialised work of sustaining status quo. In the face of global, but unequally distributed precarity, we are in dire need of refractory politics of care. How can we begin to think of – and indeed actively assist – the ways mothering may pertain to alternative temporalities and disobedient practices of flourishing within current necropolitical regimes so vehemently committed to the destruction of illegitimate unloved and expendable lives? We urgently need to become better at exercising all kinds of social and comradely mothering practices that profusely and obstinately create, sustain and protect kinship with those bodies whose suffering sustain our current economical system of extraction and expansion. Those bodies who – in the words of Audre Lorde – are not meant to survive.

8 Here, as other places, I am relying heavily on the works of Sophie Lewis as they are referred throughout this text

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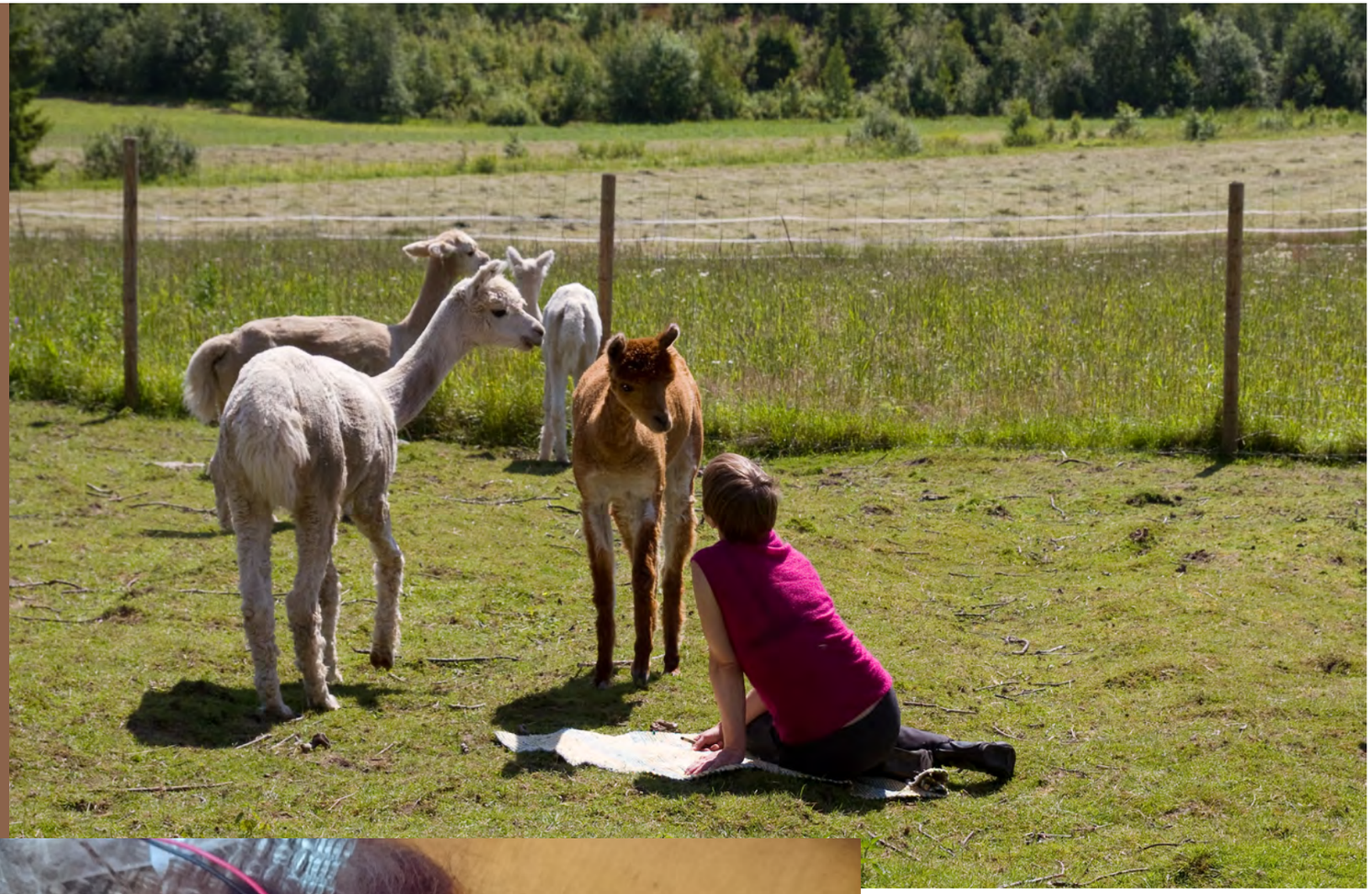
The Oracles

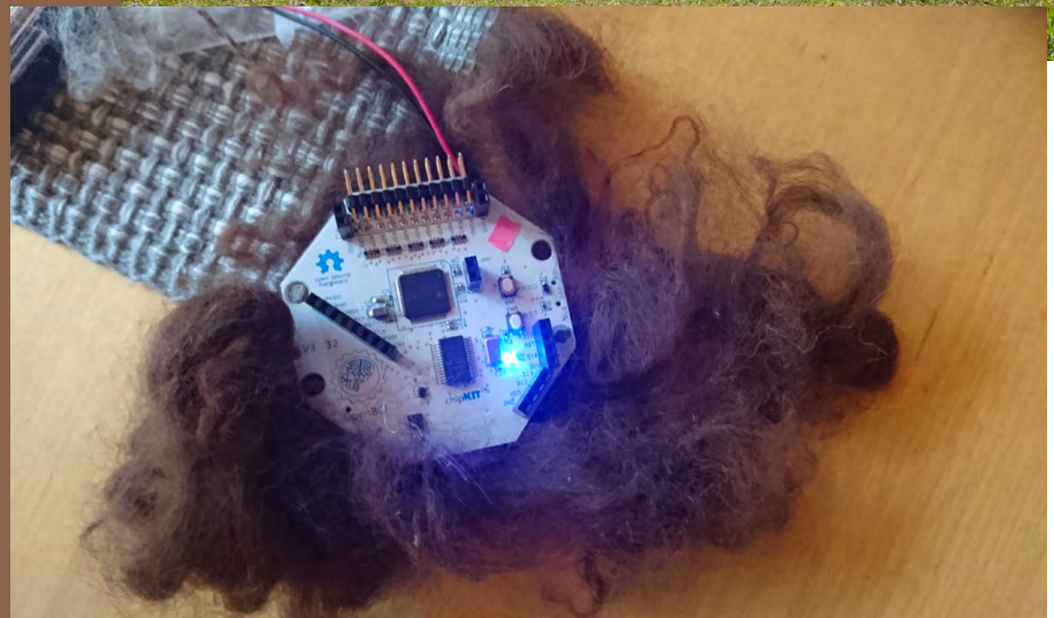
Mari Keski-Korsu, 2014–2017

The Oracles is an inter-species communication project that aims to ask help and advice for human kind from other animals, namely companion species like alpacas or horses who have lived among humans for long. *The Oracles* looks at the possibility of expanding human understanding on the present state and future prospects of life on Earth by practicing the intuitive skills of empathic inter-species communication. The project consists of participatory sessions with human and other-than-human herds as well as installations created based on imagined messages from these species. The notions behind the work are interconnectedness, empathy development towards more balanced ecosystem connection or participation, and questioning the human supremacy in relation to the other species.

Mari Keski-Korsu is an interdisciplinary artist who explores how ecological changes manifest in everyday life. She was one of the artists of “Frontiers in Retreat”, a 5-year international collaboration project constructed around artist residencies. She co-directed the Pixelache Festival 2016 – “Interfaces for Empathy” and continues to work in a think & action tank under the same name, IfE. She is currently the chairperson of the Bioart Society.



Alpaca Oracle, Frontiers in Retreat, 2014, Lohja, Finland. Photo by Jenni Valorinta.



Measuring EEG (electro-encephalogram) of the alpacas with OpenBCI, 2017. Photo courtesy of the author.

The Contract of Art that Deals with Life (Sciences)

Oron Catts
Ionat Zurr

Artists, researchers and curators, Catts and Zurr formed the internationally renowned Tissue Culture & Art Project in 1996. Catts is the Co-Founder and Director of SymbioticA: the Centre of Excellence in Biological Arts, School of Human Sciences at the University of Western Australia and was a Professor of Contestable Design at the Royal College for the Arts UK. Dr Ionat Zurr is the Chair of the Fine Arts Discipline at the School of Design and SymbioticA's academic co-ordinator. Both are Visiting Professor at Biofilia – Based for Biological Arts, Aalto University, Finland (2015–2020).

Catts & Zurr are considered pioneers in the field of Biological Arts; they publish widely and exhibit internationally. Their work was exhibited in museums such as Pompidou Centre, Paris, MoMA NYC, Mori Art Museum Tokyo, Ars Electronica, National Art Museum of China and more. Catts & Zurr ideas and projects reach beyond the confines of art; their work is often cited as inspiration to diverse areas such as new materials, textiles, design, architecture, ethics, fiction, and food.

We live in increasingly confusing times. Our relationships with the world around us; with our bodies, with concepts of nature, life, materiality and identity are getting quite messy. There is a sense of impending crisis, and the desperate attempts to fix things tend to maintain the mindsets that caused many of the issues at hand and exuberate the confusion. To make things even more muddled, the era of post-truth also seems to take a toll on the ways we read and engage with different epistemologies which in turn effects our actions.

It can be claimed that in the last century we developed specific ways of reading and engaging with different disciplines and epistemologies. Here we refer to these as *idealised social contracts*, in particular regarding their relationships with the idea of *truth*.

For example, our idealised social contract with science asserts that science makes and disseminates verifiable knowledge. Science makes facts and it is "not allowed" to tell us subjective stories, or at least, should avoid as much as possible.

Art can openly make things appear as something they are not. It can fictionalise; provide meanings and cultural framings. As Pablo Picasso put it, "We all know that Art is not truth. Art is a lie that makes us realize truth"[1].

In the more applied disciplines, such as engineering and design where knowledge and meanings are being translated and employed to do useful things in the world, there is a solutionist contact. It stipulates that the outcomes, stories and intentions are about doing good in the world. The idealised social contract calls for trust in the benevolent intentions that are grounded in the "real".

It goes without saying that the reality is much more nuanced and complex. Science is riddled with fabricated data and false claims, engineering and design promise and promote fantastic solutions that have little to do with the actualities of the situation at hand, and some artists' claims and gestures are taken on face value, with very little scrutiny, as instruments for the innovation paradigm. To complicate things further, human-constructed technology is becoming more lifelike: autonomous, uncontrollable and self-reproducible. Simultaneously life and biology are becoming a technology with the promise of new prospects of resource extraction and technological innovation that will

1 "We all know that Art is not truth. Art is a lie that makes us realize truth, at least the truth that is given us to understand. The artist must know how to convince others of the truthfulness of his lies. If he only shows in his work that he has searched, and re-searched, for the way to put over lies, he would never accomplish anything." (Pablo Picasso, "STATEMENT TO MARIUS DE ZAYAS," 1923, 'Picasso Speaks,' The Arts, New York, May 1923, pp. 315–26; reprinted in Alfred Barr: Picasso, New York 1946, pp. 270–1)

reverse the negative impact of previous technologies on the world. This opens up urgent ontological questions and calls for a need to culturally scrutinise and articulate the meaning(s) of the concept of *life*. However, one major obstacle in doing so can be attributed to the poverty of our language, using a very blunt instrument of only one word – LIFE – to deal with the immense complexity these phenomena represent. Additionally, this happens at the time of collapse of the perceived social contracts; when facts and fake are interchanging, and rhetoric of control over complex living systems suggest fantasies of human desires for full dominance.

Artists dealing with the theory, practice, application and implications of the life sciences and biotechnologies are part of this complex mingle, and can contribute to creating a platform that actively proposes different and alternative directions in which knowledge can be applied and technology can be employed. These artists can point towards "things" that we have no cultural language to describe let alone articulate. This is cultural scrutiny in action; making meanings and subverting the ever-changing relations with life.

As this type of artistic research is not scientific and is conceived, developed and executed as a cultural action, it infringes upon some very established demarcations, breaking the idealised contracts mentioned earlier. By using the tools of science and engineering, artists are questioning the professions' specific domination over processes and ritualistic actions. This becomes even more contentious when both the subject and object of the artistic manipulation is life itself; manifested through interventions with life processes from the molecular level through the whole organism to ecological systems.

The aesthetically driven and confronting treatments of life by artists and designers (and less so by scientists or engineers) still create an uneasy feeling about the acceptable level and form of human manipulation of fellow living beings. This uneasiness seems to stem from cultural and ethical ambiguities and hypocrisies concerning human engagement with life's processes. Our values and belief systems seem to be ill-prepared to deal with the consequences of applied knowledge in the life sciences. Life is going through some major transformation; even if it might be more perceptual than actual, contemporary life sciences and life engineering radicalise what we mean and what we can do with life. Through rigorous, critical and indeed wondrous explorations in the life science laboratory, artists need to develop a new language (both verbal and visual/sensual) to begin a dialogue that engages with the extraordinary potential and pitfalls of our new approaches to life itself.

Much of the current application of knowledge, acquired through direct research in the life sciences, seems to be driven by engineering logic and an ambition to control life and its processes. Illusions of control over life, its processes and the environment as a whole may have always been a driver for human endeavour. What is changing are the attitudes towards life resulting from the accumulation of scientific knowledge and technological capabilities, mounting up with increasing speed and scale of manipulation. A choreographed interplay between hype and actuality is overlaid on a public that is bombarded with information that should excite and disturb but is also easily forgotten. As the perception of the level of control over the matter of life increases, life is becoming raw material, waiting to be engineered, commodified and turned into an object of consumer desires.

The field of Synthetic Biology proclaims to follow engineering principals of optimisation and standardisation rather than a scientific pursuit of observation and experimentation. Artists are also users and tinkerers of life, but largely with different aims, agendas and ideologies.

In the context of artists working with life (sciences), the arts can, and often should, play the role of the disruptor and contester, rather than promoter. Art can acknowledge and rejoice the messiness of life rather than aspire for optimisation and standardisation. Furthermore, the arts can act as a force of contestability and as a way of reconfiguring our understanding of the concept of life now and into the future. This can be seen as a new artistic contract with society.

However, there is a growing push towards the incorporation of art as a form of public relations (whether advocacy, acceptance, translation and engagement) or as a force for economical innovation. This is extremely problematic; art should have a different role within society. In terms of art and the life sciences, it is the role of the artist to explore the meanings and problematic concerns with life as a phenomenon (ontology) and life manipulation (epistemology, politics and ethics). This role can involve aesthetics, social fact gathering, humour, irony, and other forms of tactical subversion. Art gets its power from its uselessness in terms of technological progress or other material or financial/economic utility. This stance of uselessness may be seen as one of the last voices of opposition to the whole encompassing short-sighted opportunistic agenda.

Some may say that the inclusion of artists, within the field of Synthetic Biology for example, served as, if not an explicit promotion of the field, at least as a force of superficial "debate" around the social and biopolitical issues raised through the new technologies that will eventually lead to the domestication of the technology.

The artist was traditionally allowed to act as a provocateur or contester, or put it bluntly, in this context, the role of the artist might be like that of a medieval court jester. What kind of provocation can an artist make that:

- Cannot be considered propaganda or "alternative truth"?
- Cannot be utilised or capitalised by other, opposing, propagandist agendas?
- Can make an active and lasting change in society?
- Can make sense of the new-found relationship with matter (in this case life)?

SymbioticA, an artistic research laboratory within the school of Human Sciences at the University of Western Australia, emphasises experiential, hands-on engagement with the living and semi-living materials as part of artistic research, development and production. This hands-on use and display of life for artistic purposes enables the artist to have a more experiential, thorough, rigorous, as well as visceral understanding of the life and technological tools they are working with; the unease involved in its manipulation; the extent or limits of the knowledge, tools, and control we, humans, have over it.

Artists working with life and presenting it to an audience are confined by current technological possibilities and faced by the hurdles and frustration concerned with the ability to control living systems. For example, in the case of our work which involves actual, rather than imagined or speculative, tissue engineering techniques, the artworks are restricted by the temporal-spatial limits of biological processes and technology. The common and welcomed critique we receive in regard to our artworks is that their visual appearance and what these artworks "can do" is disappointing in relation to the human audience. It does not meet the hyperbolic expectations for biotechnological art works. This stands usually in contrast to what is expected of art works in the area of Art & Science where speculative non-living representations are "translated" or performed to the human audience. The aesthetics

of "fantastic" and speculative art works tend to be "sleek", highly controlled, in many cases interactive, spectacular, and demonstrate high production value. Examples range from data simulations of biological materials to speculative design of future biological consumer products and more. In many cases, artists are utilising their "artistic licence" to move from symbolic gestures to fantastical fabrications. In other words, the scale (size, movement, etc) of the simulated living artefact is manipulated to please and stimulate the human anthropocentric tastes and imagination.

While life sciences and biotechnology are directed towards human-centric perspectives and goals by their very nature as utilitarian and "market driven" enterprises, arts can and should still contest this narrow and highly problematic point of view.

Art does its best to present both mirrors and windows into a "world under construction". It also allows for attempts to see the world "through different eyes". Therefore, it makes sense that a growing number of artistic pursuits are engaging in post-humanistic and post-anthropocentric attempts to create meanings by exploring new knowledge about life and its milieu. Life sciences and ecological knowledge are becoming sites for artistic scrutiny of both fascination and critique. Much of this art seems to come with a sense of urgency that derives from the conflicting sense of new-gained power over external systems and an inability to stop what seems to be a slow suicide on a planetary scale. One artistic and broader scholarly strategy is to give voice to the non/other/more than human; many of which are borderline entities that seem to be on the brink of appearance and disappearance.

Art as a discipline allows for non-human, non-living perspectives; an escape from the hegemonic anthropocentric view of the world. This aspect of artistic expression becomes vital in current world eco-politics. For artists working in the interface of art and life, there is the acute realisation that our society and its sciences are still following the notion that the world is there to serve the human; that human dominance is either God-given or just "natural" spoils of being on the top of the food chain. This mindset not only skews new knowledge gained, but also in the light of our environmental crisis, becomes a matter of ideological concern.

It is evident that research in the life sciences biases the human as a separate and different biological entity. This is evident in both the separate treatment of the human and the non-human, as well as the perception of the non-human as a tool or service for the "improvement" of human wellbeing and health. Evidence of that is prominent in institutional bioethics committees in universities around the world, which are based on human ethics as a separate committee to the animal one.

Artists, on the other hand developed a sensual philosophy to deal with approaches to life, which opens up new understandings, new knowledge and new considerations and ethics about the human position within the world. By doing so they continue their social contract to push goal posts.

Artists are not engineers, not scientists, not social scientists, not propagandists. They have a different and unique role in their relation with society. We called for non-anthropocentric expressions; "anti-innovation" rhetoric; less discourses of control and utility, and more (serious) playfulness and care. In a way we call for less TED-like talks and more voices of dissent. It may seem as somewhat futile labour but we hope it will touch something that is unique to all things living.

In the context of art (and even design) and the life sciences, especially in current times, we call practitioners to be true to their evolving social contract and embrace the role of the contester. It may be time to celebrate what is unique to living systems as opposed to non-living and data-based systems: the imperfections, the importance of variety, diversity and differences, the interdependent, moist, leaking and boundary defying tendencies. In Haraway's words (2016), we have to "stay with the trouble" and work together with the scientists in the labs, to rethink the meanings of life Embracing art as a force of contestability and a way of reconfiguring our understanding of the concept of life and the environment now and into the future.

Exploded lab incubator with a custom-made bioreactor hosting living Hybridoma cells *Biomess* (detail from installation at the Art Gallery of Western Australia). The Tissue Culture & Art Project. Photo by Oron Catts & Ionat Zurr, 2018.

What if this is the only world she knew?

Kira O'Reilly, 2018

Since the late '90's I have employed performance, photographic works, and biotechnical practices and performative writing with which to consider speculative reconfigurations around *The Body* in order to rethink and crucially to *experience* the material and conceptual limits of embodiment. Contained within the troubling concept of *The Body* are ideas of the fragile, relational, personal, liminal, partial, contingent, human, non-human, living and non-living. Sensitivity to materials, context and relations underpins these projects, the conceptual register is considered equally with the other traditional sensoria in order to facilitate multiple registers and durations. Malleability and mutability are thought of as transformational potentialities for composition and decomposition, expansion and decay. Working across scales and durations materials includes mosses, lichens, spiders, the sun, blood, pigs, cell cultures, horses, micro-organisms, bicycles, rivers, sweat, salt, landscapes, tundras, rocks, trees, shoes, food, books, air, moon, ravens, meteorites and copper pipes.

This has led to moving across and between disciplines, particularly those of the life sciences and their consequential technologies, by implicating living materials, scientific protocols, knowledges and practices. I describe these disciplinary border crossings as both willfully interdisciplinary and entirely undisciplined so as to convey the dynamism of these relationships and the possibilities of being an interloper.

The artworks and their processes are explicitly embedded their location, and indeed the *where* something is frequently a core aspect, be it a cell culture laboratory, an former girls school, the artificial lake of a hydroelectric dam in the parklands of a Finnish city or a contemporary art space. Crucially I work to create encounters with art works in which the viewer can enter into the complexity of the relations and connections within the work The viewer or audience are always considered co-creators in that the works articulacy is only truly experienced in the space of encounter.

Kira O'Reilly (1967) is an artist currently based in Helsinki, since 1998 she has exhibited widely internationally, also presenting at conferences on performance art, live art, science, art and technology. She has taught in Europe, Australia and U.S.A in Visual Art, Drama and Dance departments; and created a pilot Masters programme in Ecology and Contemporary Performance at University of the Arts, Helsinki. *Kira O'Reilly Untitled* (*Bodies*) (2017) was co-edited by Harriet Curtis and Martin Hargreaves.

What if this is the only world she knew?, 2018. Performance, installation. Commissioned by SymbioticA for Unhallowed Arts. Photo by Sohan Ariel Hayes.

subsensorialXYZ

Pia Lindman, 2019

From the 1st of February to the 13th of March 2019 Lindman tuned into SOLU Space, its surroundings and a materiality, mapping its environmental sensibilities and complexities. Lindman sojourned in the rooms of SOLU Space, exploring what effect they have on her as a multisensory system and organ, at different times and with various visitors and events. In an ongoing process Lindman composed diagrams, notes, markings, and sculptural elements onto the walls and in the rooms of SOLU Space to locate, highlight and visualise her experience.

Following many years of coping with toxicity in her personal life, Lindman developed a new art practice based on ancient healing techniques and the cellular realities of complex sensory organs, such as human bodies. Due to heightened sensitivity after a state of mercury poisoning, Lindman discovered she suffered from indoor air, especially in houses infested with mold. Mold may produce nerve toxins similar to mercury and Lindman's nervous system, now well trained, react to these toxins. In moldy houses, she experiences pain, electric shocks running through her nerves, and cognitive difficulties accompanied by hallucinatory effects.

Lindman's heightened sensitivity is now a medium that allows her to receive more signals of chemical and energetic events from the cells of her body, and to have these signals reach some sort of pre-conscious-consciousness of her mind. These signals that are usually filtered out by the brain, but are now in Lindman's mind, translated into various mind *things*, i.e. visuals, melodies, words, movements, and colours. Perhaps one could call this process a multiple-form-synesthesia. Lindman calls this interstitial work of mind and body, this intermediary space and time of signals and synesthesia, the subsensorial.

Becoming familiar and skilled with the subsensorial, Lindman has turned this at times debilitating sensitivity into a capability and a tool for her art. Lindman's knowledge of the subsensorial helps her tune in and express human conditions and, for instance, the atmosphere of a space.

Pia Lindman has explored artistic research and practice working with performance art, healing-as-art, installation, microbes, architecture, painting, and sculpture. While Professor of Environmental Art at Aalto University from 2013 to 2018, Lindman initiated the art/science network *Chill Survive* focusing on the Arctic, summoned the interdisciplinary think tank *The Trouble Group*, and organised the first global *Radical Relevances* Conference in 2018. Since 2017 Lindman has been a doctoral candidate at Lapland University.

subsensorialXYZ, Sebum detail 2019. Photo by Mari Kaakkola.

subsensorialXYZ, Pulla process 2019. Photo by Mari Kaakkola.

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Bioart, Aesthetic and Ineffable Existence

Helena Sederholm

Helena Sederholm (PhD) is a professor of art education in the Department of Art at Aalto University School of Arts, Design and Architecture (ARTS), Finland. Her research interests focus on contemporary art, art theory, avant-gade art and art & science education. As the Head of the Department of Art (2009–2014) she contributed strongly to the creation of Biofilia – Base for Biological Arts in the Aalto ARTS.

Discussions on beauty reveal how man grasps the epistemological and ontological nature of reality. (Lähdesmäki 2015b, 4.)

The web pages of artist Kira O'Reilly mention that she

> collaborates with humans of various types and technologies and non-humans of numerous divergences including mosses, spiders, the sun, pigs, cell cultures, horses, micro-organisms, bicycles, rivers, landscapes, tundras, rocks, trees, shoes, food, books, air, moon and ravens[1].

Many of us might be used to thinking that combining human and non-human elements in art inevitably means a hierarchical relation; an artist organises material into a certain form, they have an (aesthetic) intention, and a message they want to represent. Nevertheless, especially if an artist *collaborates* with various beings or objects, there is always something else, a surplus emanating from the work. Something we cannot quite grasp.

In art, knowledge is often thought to be found from representational content, in the subject matter of the work of art, or in a message it seems to communicate. In turn, the form of the artwork is thought to be outside of the realm of rational knowledge, in aesthetics. However, it seems that in many examples of bioart the classical beauty of form has given way to an embodied, spectacular, and sublime type of experience which generates a sort of intellectual uncertainty. Still the question of aesthetics, especially searching for beauty, haunts bioart as well. Perhaps due to the many contemporary transdisciplinary activities, such as bioart which combines modern technology, science and artistic thinking, there have emerged new discussions about the aesthetics and beauty of science as well.[2]

Many scientific processes, especially of biotechnology, might not be very beautiful although they are appropriate, practical and adequate. Their results however, might be very ordered and elegant. Scientific knowledge is embedded in the results of science. When adequacy and appropriateness are removed from scientific processes and the scientific modus operandi and technologies developed for science are used for making art, the results can contain much ugliness, repulsiveness, disfigurement,

1 See http://www.kiraoreilly.com/statement (Accessed 21.10.2019.)

2 An example of this discussion is the book *Why Science needs Art* (2018) by R. Roche, F. Farina and S. Commins. Writers maintain that art and science both seek to reduce something infinitely complex to something simpler. I do not agree.

deformation and grotesque, disorderly, and unruly elements. Stelarc's *Ear on Arm* (2008) is an example of this. This disorder is not unusual in contemporary art, where knowledge is not so much contained in the subject matter but rather in the process.

In general, there is a tendency to see contemporary art as a discursive phenomenon. In the realm of bioart there are discussions about cognition, ethics, ecology, and biopolitics. However, in this article I maintain that especially in bioart, and sometimes in art closely related to it[3], there are more representations of the ineffable, such as Federico Campagna it describes in his book *Technic and Magic: The Reconstruction of Reality* (2018). Bioart is sometimes uncommunicable, combining unrelated and uncanny elements, and also creates an (aesthetic) effect often indescribable by language.

For a start: two epistemes

In her article on the intersection of reality, truth and beauty, Tuuli Lähdesmäki divides ways to describe the world into two opposing categories: mathematical-logical and cultural-emblematic epistemes. The mathematical-logical episteme, laying emphasis on universalism, relates beauty to the laws of nature and the idea of truth (Lähdesmäki 2015b). In mathematics and science, beauty (aesthetic qualities) looks quite Aristotelian: serious, economical, inevitable, and orderly, although mathematicians can also talk about unexpectedness (Lähdesmäki 2015b, 9–10). Lähdesmäki writes that

> within the cultural-emblematic episteme, the notion of beauty is understood as a culturally bound and discursive concept based on conventions and shared cultural and social habits produced in and learned through social and cultural reproduction. Beauty is perceived as a relational quality dependent on the contexts and impacts objects and works of art produce. (Lähdesmäki 2015a).

This episteme seems to belong to art. According to this notion, in the realm of science beauty seems to be universal, while the cultural realm of art it is particular. This traditional ethos of describing the world as scientific-universal and cultural-particular has been eroded when scientific epistemology has lost its universal status[4] and become more discursive.

3 I very well know that I am making generalisations that do not apply to all works of biological art. In the end of 1990s and beginning of 2000s bioart was categorised as media art, and there were works in which living organisms were not so pivotal as it might be nowadays when bioart has a status of its own.

4 See Donna Haraway 1988: "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective" https://philpapers.org/archive/HARSKT.pdf ; N. Katherine Hayles 1999: *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*; Karen Barad 2007: *Meeting the Universe Halfway. Quantum Physics and the entanglement of matter and meaning*.

Between Technic and Magic

Federico Campagna (2018) offers a notion of the nature of our contemporary life, and also an alternative. Here there is no space to problematise Campagna's theory in detail, but in short his basic idea is to call our contemporary system of reality as 'Technic' and its opposite 'Magic'[5]. Technic is an abstract rhizome where there are only positions, not things. Everything is measurable in relation to everything else, and everyone is all the time measured by their potential, thus nobody can fulfil anything but has to remain continuously on the move. We cannot dwell on real things but whilst trying to pursue something we cannot reach, we live in a state of anguished paralysis. The spirit of the Technic world is absolute instrumentality. The Technic world has dominated also in such phenomena as cybernetics, various categorisations, and certain scientific protocols. Cultural-emblematic as Lähdesmäki describes it, belongs seemingly paradoxically, to the world of Technic; its effectiveness is based on play with absolute language, that is imaginary essence based on cultural agreements. There is neither inside nor outside, only infinite presence, and continuous processing of information. Magic on the other hand has at its core the ineffable which is basically incommunicable and avoids descriptive language, it can only resound in representations. This ineffable is life itself, its existence.

In the domain of Technic, we are used to the so-called 'revolution of images' (whether snapshots and selfies by layman or "artistic" pics, paintings etc.). Images are instrumental, e.g. deciduous representations of truths which can be negotiated in an endless band of new images. There is also plenty of contemporary art where instead of pursuing the classical understanding of beauty and harmony, interminable and uncentred rhizomes, and undefined meanings are created, such as in relational and communal art projects. Laura Beloff cites Jill Bennet who has written about 'practical aesthetics', e.g. aesthetics where the key modality is connectivity. Artworks extend beyond the immediate presentation of the material object (Beloff 2011, 42), and work in the realm of language. This kind of contemporary art, and also related bioart[6], seems to correspond to 'Technic's cosmogony'[7] where it is no problem to discuss art that justifies itself as "criticism", and as an actor that brings forth ethical questions (of art, science, ecology or biopolitics). The intention of such art is to start topical discussions–exactly what the world based on absolute language loves. As Lähdesmäki states:

> The nature of knowledge, reality, truth, and beauty are given meanings in linguistic utterances, textual expressions, and pictorial or mathematical representations. (Lähdesmäki 2015b, 6.)

We take almost granted that language produces its objects. What cannot be measured does not exist.

5 'Technic' here does not mean 'technical' any more than 'Magic' means sorcery but according to Campagna, they are more like 'hyperobjects' defined by Timothy Morton. (Campagna 2018, 8).

6 Belonging to the discursive notion of contemporary art I mean such phenomena as e.g. community art and relational aesthetics. A representative example could also be Popu Popu Population Power Studies Group connected to indigenous Arctic people. See https://bioartsociety.fi/projects/ars-bioarctica/posts/popu-popu-power-to-the-populations.

7 This is Campagna's term.

Hierophanic materials

Similar thoughts as I've described above were denoted by Vera Bühlmann in her article "The Integrity of Objects: Design, Information and the Form of Actuality" (2013). She states that "information has no weight, no extension, no body" (Bühlmann 2013, 70). According to her, the development of analytic geometry and the mathematics of infinitesimal calculus introduced a systematic method for the description of things that affected our thoughts:

> the attention shifted increasingly away from things *as* things, and zoomed in toward understanding their properties as properties that behave variably, over time. (Bühlmann 2013, 73–74).

Bühlmann takes a stone as an example. When trying to conceive the nature of stone, instead of its warmness or coldness, rather the *properties* of warmness or coldness themselves became interesting, which eventually resulted in the laws of thermodynamics. Science developed based on measuring, documenting, growing, planning processes, protocols, methods… In measuring the weight of a stone and its external dimensions, they are given an abstract character (Bühlmann 2013, 74). This has been regarded as a yardstick of adequity in science but this concerns the classical notion of formalistic aesthetics as well, when form is imposed on material.

> The pre-modern hermeneutic understanding of knowledge became increasingly explicated into the technical format of instruments operating *on a general notion of materiality*, not on notions of essentially specific substances. (Bühlmann 2013, 74, italics in original text)

From generalised materiality we have reach a further level of abstraction: information is the common denominator of all existing things.

"The pre-modern hermeneutic understanding of knowledge" is very close to what Campagna means by Magic. For Campagna at the core of real is the "ineffable of life", representations of which are very much the realm of art. There is intrinsic value, not instrumentality. Nevertheless, we cannot act without language and cultural agreements; a balance is needed.[8] Reality, according to Campagna, is thus situated between Technic and Magic. Campagna writes (2018, 111):

> Conversely, reinstating the limit-concept of existence (as geared towards the pole of ineffability) alongside that of essence (as pointing towards the pole of language) constitutes the first and necessary step to reopen the space of reality…

It is difficult to attain balance in the contemporary world due to the dominance of Technic, and that is why we are in perpetual agony, as Campagna exaggerates by generalising (2018). Life (and art) always has a memory of its ineffableness though, and it is difficult for Technic to handle such "irrational" new materialist phenomena as for example the memories of a tree in the poem "Dream of the Rood"[9]. In the spirit of new materialisms, Anne F. Harris ponders life after a tree or a stone has been hewn from its original site (Harris 2014, 20). Does the life of the material, its *zoe*, last, only changing its form? Does the stone or the tree – or cell grown for artistic purposes – remember its materiality as a thing? What does it mean that we are used to expecting the original material to convince us through the form an artist has forced it into, although the new materialisation manifests a new identity, a new function, a new being? (Harris 2014, 27.) Nevertheless, even in the new form the material resists its manipulator. These glimpses of the ineffable are familiar to us.

Would it be possible that bioartistic approaches can return to "stone its stoniness", or to wood its treeness, its individual qualities? Although using scientific methods, in many cases the aims of bioart differ from (bio)sciences. In Bartaku's *Aronia m. BaBe* project[10] a berry seeks its new identity, its berryness. As Bartaku describes, the project builds

> on the diverse engagements with the Aronia berry by exploring in a more systematic and critical manner the ways in which the berry can challenge and question the traditional production of knowledge, art and the commodification of nature.[11]

A new berry shape has been envisioned based on a clay model, and Bartaku sensed that *Aronia melanocarpa* wanted a new name, i.e. *Baroa Belaobara*. The artist has extracted various pigments and tested their conductivity, created workable solar cells with aronia juice, and worked on a berry plantation.

The lifecycle of living or semi-living bioart can only momentarily represent life outside of descriptive language but yet it echoes ineffable existence. An example of this is Ulla Taipale's *The Other Side*, a project about the immortal meanings of bees.[12] The work consists of audio excerpts from historical and contemporary literature about beekeeping and myths related to bees. Measuring is the domain of Technic but it is Magic's realm to understand that a stone can be an ordinary stone (or tree can be wood and bees domesticated insects) and simultaneously something else (sacred, posthuman, art), that is 'hierophanic' opening up a sacred dimension within a profane world as Mircea Eliade has maintained (Campagna 2018, 172). Campagna writes that this

> …sacredness … always lies dormant at the heart of every material compound – but which requires a specific symbolic form to be perceptible to human eyes and heart. (Campagna 2018, 176).

Much bioart moves on the line of reality where the materiality of objects is real but their sacred dimension[13] is still attainable. I am thinking about Oron Catts' and Ionat Zurr's public killing rituals of their tissue sculptures by collectively touching and thus contaminating cells[14]. Catts and Zurr have grown semi-living sculptures using e.g. biodegradable polymers and immortalised cell lines. These tiny sculptures are kept alive in custom-made bioreactors for some time but must be killed in the end. Although the killing ritual is about the responsibilities we as a society have towards liminal lives that we create in the service of life sciences and how

8 According to Campagna, there is a continuous movement in and between hypostasis of Technic and Magic, one or the other being in focus in different times and cultures.

9 https://lightspill.com/poetry/oe/rood.html (Accessed 25.2.2019.)

10 See f.ex. https://empathy.pixelache.ac/events/berry-babe-a-l-live-scene-installation (Accessed 2.7.2019.)

11 From the unpublished research plan for Aalto University by Bart Vandeput (September 2015).

12 *The Other Side* has been installed in the cemetery of Poblenou in Barcelona (2018) and Cimetière des Rois in Geneve (2019). Although the work has no living or biological components it is closely connected to works many bioartists do with living bees. See https://issuu.com/capsula/docs/the_other_side_book_final_isbn (Accessed 22.10.2019.)

13 By sacredness I do not mean any religious item but something unassailable, highly valued and important we might not have words to define.

14 See Jennifer Johung's feature article in Artlink 1.9.2014, https://www.artlink.com.au/articles/4212/vital-maintenance-tissue-culture-26-art/ (Accessed 2.4.2019.) I have also taken part in one of those killing rituals with Catts and Zurr in the Biofilia lab on January 2013.

we deal with biodegradable waste, and is thus intertwined with the "absolute language" of Technic e.g. the negotiation about what is culturally acceptable,

Alchemical Aesthetics

Although bioartists do not own a philosopher's stone it can be said that they realise a sort of alchemical aesthetics, that is reaching an understanding of the coincidence of opposites (Campagna 2018, 169), sometimes even with an intention to create new kind of life. Campagna writes about 'paradoxical understanding' which can be achieved through a form of 'direct apprehension', only partly in the grasp of descriptive language. Although language fails to convey an incommunicable object, it is possible to point towards it through art (Campagna 2018, 170). Often it means the destruction of the customary order of the world to open up space for reality. According to Campagna (2018, 172) reality is a space where worldly existence, action and imagination are both possible and authentic. To make ruptures into the web of customary order and to push it towards the ineffable seems to be the sole opportunity to ease our anguish.

Alchemical aesthetics means that "opposing forces and principles can coexist paradoxically, not by annihilating each other, but by combining together" (Campagna 2018, 171). In bioart this is illustrated by creating hybrid representations of mysterious life by means of the most modern technology. Beloff writes (2017, 782):

> This kind of art both observes and explores the possibilities of the *uncanny nature* – a nature or reality that used to be familiar but which has been modified in a laboratory, ex-tended with newly designed features, or located in a new context with various agencies and components, which all together form a hybrid ecology.

there is still an element of sacredness, something inexplicable.

Friedrich Schelling wrote about the uncanny defined as something that should have remained hidden but has instead come to the surface (Eco 2011, 312). According to Ernst Jentsch (1906), the uncanny is something unusual, which causes 'intellectual uncertainty' and which 'we can't figure out'. Thus, it is not surprising the uncanny has also been attributed to some bioart[15], since artistic intention may be just to create intellectual ambivalence revealing something we know to be there but we cannot quite figure out. Encountering the inscrutable can lead a to sublime experience, e. g. to feel horror for something that cannot harm us. Theories of the sublime at the turn of the 18th and 19th centuries were connected to experiencing nature and its phenomena. Horrendous and aesthetic contemplation did meet. However, we do not talk much about the sublime anymore. We do not stay in experiences and thoughtful examination is in itself a redundant gesture, since in the world of Technic everything is possible, interchangeable, replaceable, and negotiable; comprehensive examination does not lead to any final and justified evaluation. The sublime has been replaced by subsequent shock that we are used to experiencing as an inheritance of the avant-garde in the beginning of the 20th century. I maintain that something like the sublime can be experienced in certain kinds of bioart though, as long as the effect in the recipient is not just from the guts but

15 See for example Beloff 2017. She cites Sigmund Freud who referred to Jentsch in his 1919 text about uncanny.

requires some knowledge, capacity for prompt and lively associative activity (Cf. Jentsch 1906, 4). This is present in works of Terike Haapoja, *Inhale/Exhale* (2008/2013)[16] for instance. It is an installation of three coffin-like glass cases filled with soil and dead leaves. Automatic ventilation fans facilitate the decomposition process, and the carbon dioxide produced is measured with sensors and translated into sound. As a result, the 'coffin' seems to slowly inhale and exhale as the CO_2 level goes up and down. Although the recipient knows the mechanism and where the sounds of sighs or breathing come from, there remains an uncanny sense since most of us are used to thinking that soil is silent.

The classical definition of the sublime was connected to landscapes and nature, and eventually art drawing from nature. In biological art living material might not be drawn from nature, but it is changing (and dying) over time. Artworks develop and have a lifecycle, not only featuring an infinite presence in the Technic world. Connected associations remain open. A bioartwork might start to live a life of its own: a cell, a berry, a bee or soil remembers its origins, but reveal these to us only as echoes.

A bioartist can transgress the laws of nature by producing hybrids that threaten Technic's established classifications, e.g. customary order. This has been done through ages in tales, stories and mythologies. For example, in mythology there are descriptions of chimeras of human and non-human, such as Medusa. This unnatural or paradoxical combination still evokes fear and horror deep inside us, since we suspect that it is a reflection of life itself which is not reasonable, communicable, and certainly not negotiable.

If aesthetics and beauty as Lähdesmäki describes it, are already lost to Technic's absolute language in art and science, can bioart save us? Can it save our sense of reality by creating paradoxical, hierophanic hybrids, that preserve the pre-modern hermeneutic understanding of knowledge of their own originality, materiality, thingness? Otherwise we are forever stuck with the instrumentality of the Technic world. Campagna remarks that Magic's paradox seeks to resolve the problem posed by Technic's world of possibility, with its extension of limits and perpetual growth, through intensive harmony of opposite forces, through combining things that do not seem to belong together. Or does bioart acquiesce just to take part in ethical and social language games by posing critical questions and displaying alternatives in the world of Technic, playing with information, discourses, and instruments operating on a general notion of materiality?

Rather many artists with their works concentrate on theoretical or professional negotiations on the aesthetic character of bioart, assimilating it to the world of Technic by imposing form to material. However, I would like to see bioartists turn even more to knowledge that is not solely found in the content, subject matter, or in the artistic process either but in the paradoxical, alchemical identity of materials, their hierophanic nature as a hypostasis.

Bioart, or more generally the intertwining of living and non-living, reinstates a physical ambivalence – the uncanny – leading to a sublime experience in which what we sense goes beyond our conscious reasoning. This experience of the uncanny is equally evoked in artworks in which we do not readily see the act of interference, such as genetic manipulation. Still we *know* it. It might not be a shocking perception but something

> [a]mong all the psychical uncertainties that can become a cause for the uncanny feeling to arise, there is one in particular that is able to develop a fairly regular, powerful and very general effect: namely, doubt as to whether an apparently living

16 See http://www.terikehaapoja.net/inhale-exhale-2/

> being really is animate and, conversely, doubt as to whether a lifeless object may not in fact be animate – and more precisely, when this doubt only makes itself felt obscurely in one's consciousness. (Jentsch 1906, 8.)

In its wetness, bloodiness, unruliness and corporeality, as well as in its sensible but non-formal aesthetic dimension, the beauty of bioart could lie in its role as a herald of ineffable life at the core of Magic world. It can open space for reality.

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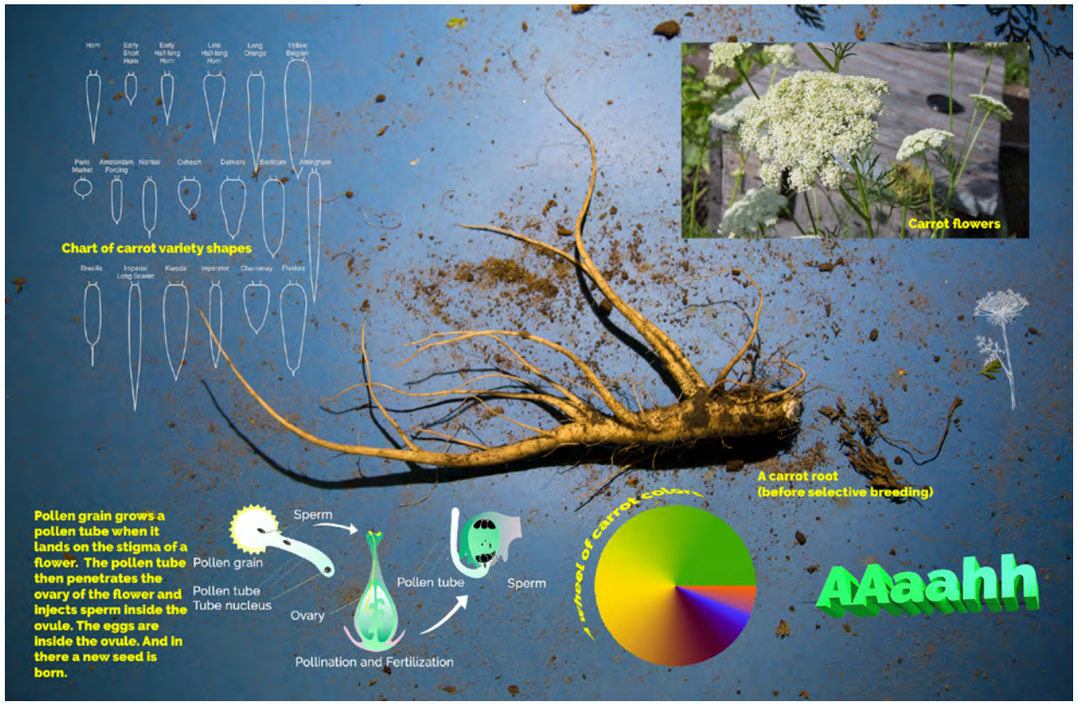
PORK KANA CAR ROT

Lauri Linna, 2014–

In the 17th century in Netherlands the yellow carrot mutates into orange. These orange roots become popular in the markets of Amsterdam, as orange is the color of independence. Soon orange carrots overthrow the yellow carrot crops. Eventually the orange carrot invades the whole world. Nobody talks about selective breeding until the 19th century when ideas such as pure-bred dog breeds and eugenics appear. In 2013 artist Lauri Linna starts to fantasise about breeding crazy new organisms e.g. a striptease banana that dances and peels itself, but soon realises that who is he to decide what kind of beings there should be. Linna starts to think about the sexual rights of domesticated plants. This further develops into realization of how problematic the plant-human relationship is. In *PORK KANA CAR ROT* Linna offers a carrot population the possibility to have their own sex life. The project investigates possibilities of a new kind of companionship with domesticated economic plants, and how to deal with the human need to eat the delicious sweet orange roots. The project's first sexually liberated carrot seed crop matured in 2017. Seeds are available for adoption from the artist. *PORK KANA CAR ROT* has led the artist to further his understanding on plants abilities: plants can see and hear; they have the capability to sense vibrations, moisture and temperature– they can sense surroundings. They can change behavior according to changes in their surroundings. Plants can remember, store information and move. They are also able to share information and nutrients, and can differentiate their relatives from others and communicate across different species.

Lauri Linna is a Helsinki-based artist who works with plants, gardening, moving image, sound and electronics. Other fields of interest are plant behavior and intelligence, plant – machine relationship and plant-related technology. He is also interested in meaningless things and nonsense. He holds a Master of Arts degree from Visual Culture and Contemporary Art (ViCCA) Programme at Aalto University's School of Art, Design and Architecture. His work has been exhibited in Finland and internationally. Currently he also teaches at Aalto University.



Glossary

A

animal
The binary opposite of Human in Western imaginary. Not a species definition, but marks a moral category. The main function of the concept Animal is to label beings killable, in contrast to those labelled Humans that are protected by law. Also a common way to refer to all nonhuman animals. In the framework of ecology, the species Homo Sapiens belongs to the Kingdom of Animals.

anthropomemes
Linguistic attempts to deconstruct and de-colonialise the concept of the Anthropocene. The goal is to specify certain aspects of the Anthropocene instead of leaving it as a generalising term. Well know anthropomemes include the Capitalocene by Jason W. Moore, the Chthulucene by Donna Harraway or the Anthrobscene by Jussi Parikka.

artificial agent*
see: autonomous agent

artificial intelligence*
When behind the scenes humans actually perform the tasks that are claimed to be done by an artificial agent.

artificial life
An attempt of singularity between biological entities and cybernetics.

autonomous agent*
An inclusive term to indicate technologies, artificial entities and systems that perform without direct human supervision, which includes artificial intelligences and DAOs.

autonomous machines
Treat the human body as part of a larger system, viewing it not as the primary site, but one among many, where technology affects perceptual relations. Such a perspective may offer room for interpreting machinic forms of sense without the need for added value for humans.

B

behavioural signatures*
Patterns in behaviour of animals in ecological studies collected through remote sensing technologies. The range of behaviours is strongly linked to what sensors and algorithms can quantify and process

biohacking
The DIY/DIWO exploration of capabilities of body modification granted to us by the universe's unceasing capacity for change; do not confuse with the use of this word by mainstream transhumanists who work towards Promethian defeat of human frailties.

biophilosophy
Refers to philosophical engagements with the question of life. While the philosophy of biology describes explorations of the concept of life that focus on life's essence and its "boundaries of articulation", that is, the ways it may be classified (e.g. how does life differ from non-life? what is the boundary between human/nonhuman, or organic/inorganic?), biophilosophy prioritises relations and processes, their dynamics and mechanisms of exclusion or, in other words, that which transforms life[1]. Consequently, it concentrates not only on ontology (what is life?), but also on ethics (what relations is life embedded in? what gets excluded? and, what values are being ascribed in these processes?). Biophilosophical approaches can be found in process philosophies and feminist materialisms (e.g. Claire Colebrook, Rosi Braidotti, Patricia MacCormack), where life is conceptualised as a material force, an intensity, a form of dynamism, inventiveness, creativity, but also a potential for destruction and idleness that extend beyond the organic[2].

Black Veganism
An ethical theory developed by Aph and Syl Ko in their book Aphro-Ism. Black Veganism is a way of resistance to white supremacy and coloniality through resisting the animalisation of both non-white humans and nonhuman animals.

C

contemporary investigative art
An artistic practice that develops/enables artworks according to new, available investigative technologies

D

DAO
Abbreviation for Decentralised Autonomous Organisation. An organisation represented by rules encoded as a computer program that is transparent, controlled by shareholders and not influenced by a central government (Prusty, Narayan 2017).

deep naivety*
When the naivety of an artificial agent to a task exposes human bias, moves beyond human bias or shows hidden aspects of human-animal or human-plant relationships

deep time – big history – deep futures
Three concepts to speak about processes which run on the scale of millions and billions of human years. Deep time is the concept of geological time and represents the component of big history concerned with planet Earth. Big history looks into history from the Big Bang to the present. Deep Futures are a speculative attempt to speak about which futures await us on a scale from probable to impossible. Deep Futures are continuously enfolding in the making.

E

ecology
Has become a widespread term within the 21st century. It is used in reference of almost anything that can be seen in connection to another thing, action, process or entity. Originally the term ecology was used in reference to science that investigated living beings and their environment. The term was coined by Ernst Haeckel in 1866.

environmental literacy*
The ability of organisms and artificial agents to make sense of their environment.

environmental machine learning*
The capacity of an artificial agent to make sense of its environment.

* Previously published in The Random Forests glossary of terms.

1 Thacker, Eugene. 2008. "Biophilosophy for the 21st Century." In *Critical Digital Studies: A Reader*, edited by Marilouise Kroker Arthur Kroker, 132-142. Toronto: Universityof Toronto Press.

2 Radomska, Marietta. 2016. *Uncontainable Life: A Biophilosophy of Bioart*. Linköping: Linköping University Press.

F

feminist posthumanities
Feminist posthumanities responds to the need for more-than-human humanities, for transversal dialogues across arts, sciences and societies, critically and creatively[3]. It does so with particular insights, methodologies and philosophical sensibilities toward power differences, historical norms, inclusions and exclusions made to the cultural categories of nature, culture and the human, and to processes of othering, exploitation and appropriation. It covers or converses with feminist science studies, medical humanities, body theory and new materialisms; with bioart and eco-art, media studies and digital humanities, post-continental philosophy, multispecies- and anthropocene studies, with environmental humanities, queer theory, death and extinction studies, and a mounting range of posthumanisms in intellectual circulation. Feminist posthumanities labels a wide-spread, multi-sited, evolving and growing effort to rework the role of the humanities and their relation to science, technology, art and contemporary society on the basis that our idea of the human is fundamentally reaching its limits and changing.

fieldwork*
More than just being outside, fieldwork is seen as a method of enquiry and in-situ prototyping, that starts from radical non-isolation of the participants, their thoughts and their acts, aiming for full exposure to the complexities and subtleties of a given area which is being navigated in collaboration with local experts

forest
A familiar place for people residing in e.g. Finland, Sweden and Norway. It is a space that is characterised by long vertical vegetation called trees, which form the base of the forest ecosystem. For Finns a forest represents nature, peace, (the potential for) wilderness, safety and wealth.

forestry
A familiar action for people in e.g. Finland, Sweden and Norway. It maintains, modifies and uses natural resources of long vertical vegetation to produce goods and exchanges them for monetary value.

frisbee*
A preserved lemming skin.

G

Genetic Code engineering
The Genetic Code is the specific way how the information stored in DNA is (via triplets of RNA bases) translated to amino acids and thus peptides, proteins and enzymes. Using combinatorics we can calculate that there are more theoretically possible alternative genetic codes (10^84) than there are elementary particles in the Universe. Scientists are now able to slightly alter the standard genetic code in order to design new life forms that are, from an information processing point of view, isolated form natural forms of life. This means that information stored in the DNA of these code engineered (emancipated) life forms can not be correctly interpreted by natural life forms, thus making horizontal gene transfer (exchange of genetic information between organisms) impossible (See Life as unity).

genohype
The term genohype was originally offered to characterise the discourse of exaggerated claims and hyperbole attached to DNA and the effort to map the human genome (Holtzman 1999). In its contemporary from it particularly refers to the multitude of untenable claims of the biotech startup landscape regarding their products and solutions to lure investors and the general public to buy into biotech. Artists have also frequently been pointed out to base their practice on genohype-like concepts.

H

hierophany
The word is a formation of the Greek adjective *hieros* (Greek: ἱερός; sacred/holy) and the verb *phainein* (φαίνειν; to reveal / to bring to light) to designate the act of manifestation of the sacred in some ordinary object, a stone or a tree. Religious historian Mircea Eliade wrote in his book *The Sacred and the Profane* (1959): "In each case we are confronted by the same mysterious act – the manifestation of something of a wholly different order, a reality that does not belong to our world, in objects that are an integral part of our natural 'profane' world."

hyperobject
Objects which have a vitality to them but you can't touch them, like race or class, or climate change. Their effects may be experienced even if they cannot be necessarily touched. In Alien Phenomenology Bogost writes that, "ethics itself is revealed to be a hyperobject: a massive, tangled chain of objects lampooning one another through weird relation, mistaking their own essences for that of the alien object they encounter, exploding the very idea of ethics to infinity." In Timmothy Morton's book, The Ecological Thought, he introduced the concept of hyperobjects to describe objects that are so massively distributed in time and space as to transcend spatio-temporal specificity, such as global warming, styrofoam, and radioactive plutonium.[4]

I

in-situ prototyping*
Developing prototypes in the full complexity of a biome, also the art of packing a workable toolset within the limits set by check-in baggage.

intersex
"Intersex people are born with sex characteristics (including genitals, gonads and chromosome patterns) that do not fit typical binary notions of male or female bodies. Intersex is an umbrella term used to describe a wide range of natural bodily variations. In some cases, intersex traits are visible at birth while in others, they are not apparent until puberty. Some chromosomal intersex variations may not be physically apparent at all."[5]

intimate machines
Reside under our skins, collect our biosignals and communicate with our nervous system. They can warn us about health risks or even introduce new senses by stimulating neural connections in our brains, although they also carry with them the techno hype of overly optimistic promises.

intra-action
"The neologism 'intra-action' signifies the mutual constitution of entangled agencies. That is, in contrast to the usual 'interaction,' which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognises that distinct agencies do not precede, but rather emerge through, their intra-action."[6]

L

life as unity
Although life presents itself in a number of different forms, colors, survival strategies etc., at the core biochemical level, all life on Earth is surprisingly uniform and homogenous. It is a conjecture that before cellular life forms appeared billions of years ago, no borders existed between proto-cellular biochemical systems and that there was a constant and unhindered exchange of information, energy and resources. Since the first cells emerged out of this all-encompassing protolife, the exchange was partly interrupted, however the use of universal biochemical building blocks, the standard genetic code and horizontal gene transfer are seen as remnants of this era.

M

machine extensions
Extending the human sensory apparatus both physically and virtually through wearable and online technologies. We voluntarily share our agency with the machine and at the same time extend our own capacities to affect and to gather information from our surroundings by dislocating our senses.

machine phenotype*
The embodiment of an artificial agent (arms, legs, platform, battery life) and the limits this sets for environmental interaction.

3 Åsberg, Cecilia, and Rosi Braidotti. 2018. *A Feminist Companion to the Posthumanities*. Cham: Springer.

4 Quoted from the cyborganthropology.com definition page for hyperobjects http://www.cyborganthropology.com/Hyperobjects)

5 Quoted from "Free & Equal Campaign Fact Sheet: Intersex" (PDF). United Nations Office of the High Commissioner for Human Rights. 2015.

6 Quoted from the biography of Karen Barad https://egs.edu/faculty/karen-barad

machinic sensing
refers to the use of technological implements as stand-ins for or extensions of human sensory capacities. Sensing machines include systems with integrate electronic sensors with fleshy, wet or mechanical elements. As we mediate information about the world to our senses through and with technology, machine and human senses form an entangled system of perception.

meatpile*
A volume of assorted meat approximating a dead animal in order to lure scavengers (crows) before the camera-eye of an AI.

monoculture
A term that references an action that focuses on cultivating a single plant species within one area. This is an intentional action by humans driven by a desire for better harvest. Mono is a common Finnish word for a ski-shoe, especially for cross-country skiing.

N

nongkrong
Nonkrong is Indonesian for getting together with friends with no specific plan in mind.

the non/living
The concept of the non/living[7] reframes what is conventionally referred to as "life" in order to problematise the materiality, processuality, vibrancy, dynamics, and ambiguity of the relationship between living and non-living, organic and inorganic, growth and decay, and ultimately, life and death. In this way, the non/living allows one to attend to: (1) the material and temporal entanglement of the processes of living and dying; (2) entities – and accompanying processes – that do not fulfil the four basic biological criteria of life (the entity has a body; it metabolises; it reproduces; and it is capable of movement) and yet cannot be classified as "non-life", e.g. viruses, viroids, and prions.

O

Onkalo
Onkalo (hidden place) is the name of first deep geological repository for high level nuclear waste located 500m below surface on the west-coast of Finland. It will be finalised by 2120 and is constructed to withhold the nuclear waste for the next 100.000 years including the next projected ice age in the area.

P

production platform
A combination of spaces, equipment and personal that are supporting/enabling artist and their collaborators in developing their artworks

R

radical witnessing
An artistic attempt to grasp time-based processes which transcend the everyday experience of time in a human life. Examples for such processes are climate breakdown or nuclear waste. Radical witnessing could be an effort to establish the base for intergenerational responsibility and justice. The base for such a justice is the claim that human action in the present is indebting future life by limiting its possibilities of development or even emergence.

recovery from sixth mass extinction
Paleontologists have identified 5 major extinction events in fossil records, each one drastically reducing global biodiversity, that is the number of species, families, phylums of plants and animals. Right now, we are witnessing the sixth mass extinction, most likely caused by human activities. In the first 5 extinction events evolution was able to recover from the extinction events after a few million years. What if humans could contribute to the recovery of the ongoing mass extinction by generating novel biodiversity? And how should this be done? (see xenobiology)

robochory*
The dispersal of plant seeds by machines, both externally or internally by digestion, adapted from zoochory which relates to dispersal by animals.

S

Scope of the Real
A nonspecifically defined phrase used by Benjamin Bratton to denote processes which act outside of human intuitive neurological and emotional comfort-zones.

staged nature*
Explored by Antti Tenetz by hunting deer in FarCry5 it is the staging of naturalistic behaviour in virtual domains like gaming platforms to create an impression aliveness as defined by Jens Hauser.

subhuman
The binary opposite of Human proper in colonial Western imaginary. The other end of racial hierarchy, that places white suprematist, european colonial man to the top. Originates in European colonialism and Trans-Atlantic slave trade. An essential category for upholding white supremacy and patriarchy. Also: fiction.

T

Toxic Embodiment
"Toxic embodiment" refers to a condition where differentially situated human and nonhuman bodies, land- and waterscapes are immersed in the naturalcultural intra- and interactions with toxicity. Substances like endocrine disruptors, neurotoxins, asthmagens, carcinogens, and mutagens flow through and accumulate in environments and bodies of both human and nonhuman kinds. The question of toxic embodiment embraces extensive existential concerns around health and environment as we all interact with climate change, antibiotics, and untested chemical cocktails through food, products of everyday use, and our milieu. It draws attention to both the seriousness of bioaccumulation (i.e., the processes by which toxic substances, industrial waste or human-made chemical compounds, gradually accumulate in living tissues), and the problematic framing in which the issues of toxicity are presented in the media and popular narratives, where the gendered, racialised, ableist, and heteronormative patterns of mainstream environmentalism often place all responsibility on individuals while downplaying the role of big industries in creating toxic threats. In sum, the theme of toxic embodiment establishes a transdisciplinary field of enquiry that critically attends to the contemporary material and discursive interweavings of toxicity and human and nonhuman bodies and environments.[8]

training forest*
A term that originates in Orang-utan conservation where young animals are first released in a semi-wild context to learn basic skills and environmental literacy as a preparation to be released in the wild. Within the context of environmental machine learning the term may be quite literally applicable to artificial agents that are intended to operate in the wild

7 Radomska, Marietta. 2016. Uncontainable Life: A Biophilosophy of Bioart. Linköping: Linköping University Press.
—. 2017. "Non/living Matter, Bioscientific Imaginaries and Feminist Technoecologies of Bioart." *Australian Feminist Studies* 32 (94): 377-394.

8 Cielemecka, Olga, and Cecilia Åsberg, 2019, eds. Special section "Toxic Embodiment." *Environmental Humanities* 11 (1).
Ah-King, Malin, and Eva Hayward. 2013. "Toxic Sexes: Perverting Pollution and Queering Hormone Disruption." *O-Zone: A Journal of Object-Oriented Studies* (1): 1-12.
Di Chiro, Giovanna. 2010. "Polluted Politics? Confronting Toxic Discourse, Sex Panic, and Eco-Normativity." In *Queer Ecologies: Sex, Nature, Politics, Desire*, edited by Catriona Mortimer-Sandilands and Bruce Erickson, 199-230. Bloomington: Indiana University Press.

trans
Trans, in this case is shorthand for transgender which is an umbrella term for anyone who's gender does not align with their sex/gender assigned at birth and who self identifies as trans. The term includes trans men and women as well as many people who do not identify within the gender binary and may use terms such as non-binary, genderqueer, agender, or gender-fluid. Some trans people access medical options for transition, but not all are interested in medical transition, while others are unable to utilise medical technologies of gender because of health, economic, social, or political reasons.

tree blindness*
When an AI is locally environmentally illiterate, meaning that local flora and fauna are missing from its training sets.

two-spirit
"The term two spirit was adopted in English, and created in Ojibwe, in 1990 at the third annual Native American/First Nations gay and lesbian conference in Winnipeg, Manitoba, Canada. The decision to adopt this new, pan-Indian term was deliberate, with a clear intention to distance themselves from non-Native gays and lesbians, as well as from non-Native terminology like berdache, "gay", "lesbian", and "trans". The term two-spirit is thus an Aboriginal-specific term of resistance to colonization and non-transferable to other cultures."[9]

U

uncanny
In an essay *On the Psychology of the Uncanny* (1906) Ernst Jentsch defined the uncanny (*unheimlich*) as something unusual, which causes 'intellectual uncertainty' and which 'we can't figure out'. Intellectual here means that an experience of uncanny requires some knowledge, capacity to prompt, and lively associative activity. Jentsch remarks that uncanny is doubt as to whether an apparently living being really is animate and, conversely, doubt as to whether a lifeless object may not in fact be animate. Later in 1919 Sigmund Freud analysed an uncanny effect, and in 1970 Masahiro Mori created the concept of the 'uncanny valley' claiming that one's response to a human-like robot can abruptly shift from empathy to revulsion the more the robot resembles human but not quite.

V

vitalism
Generally, vitalism refers to a belief that assumes there is a "force" or an "impetus" that renders living things alive. It is often juxtaposed to mechanism, which describes a belief that living things are complex "machines", the properties or actions of which result from the sum of the properties of their components. In the context of Western philosophy, it can be said that vitalistic thinking refers to any animation or force that permeates each aspect of the world, giving it a potential for "order and relations".[10] Gilles Deleuze and Félix Guattari[11] distinguish two types of vitalism: active, which assumes that all concepts, categories and understandings are "originally imposed by the subject on otherwise meaningless life"[12]; and passive, according to which life is a multiplicitous, "differentiating field of powers that expresses itself in various manners". In other words, passive vitalism does not assume any "external" force, but instead focuses on a potential for difference as expressing itself in different bodies, processes, and relations, often challenging normative categories.

W

wet lab
An equivalent to hardware lab or software lab in the domain of biotechnologies

wilderness
A term in transition to become obsolete in reference to the environment. The transition moves hand in hand with the increased human impact on planet Earth. One can ask what is the next frontier for wilderness?

X

xenobiology
The term xenos comes from old greek and means stranger or foreigner, while biology is the science of life. Xenobiology is the science that leads to the engineering of new-to-nature forms of life. The difference to classical darwinian evolution is (from what we know from biology and speciation) that it is extremely unlikely if not impossible for these new life forms to spontaneously emerge without human (technological) assistance. Xenobiology includes life forms that use a different biochemical toolset, molecular modules or interpret biological information in a different way. (see Genetic Code Engineering)

xenologist
An entity that practices xenology.

xenology
The study, analysis, and development of the xeno – the strange, the alien, the other.

xenomogrification
Grotesque – in the widest senses of that word – transformation into the alien and the other for the purposes of disalienation.

9 Quoted from the Wikipedia entry for Two-spirit https://en.wikipedia.org/wiki/Two-spirit

10 Colebrook, Claire. 2014. *Sex After Life: Essays on Extinction, Vol. 2*. Ann Arbor: Open Humanities Press with Michigan Publishing – University of Michigan Library. p. 103.

11 Deleuze, Gilles, and Félix Guattari. 1994. *What is Philosophy?* Translated by Hugh Tomlinson and Graham Burchell. New York: Columbia University Press.

12 Colebrook, Claire. 2014. *Sex After Life: Essays on Extinction, Vol. 2*. Ann Arbor: Open Humanities Press with Michigan Publishing – University of Michigan Library. p. 105.

Bioart Society 2008–2019

The Bioart Society is an artist association based in Helsinki with 117 artists, scientists and other practitioners from Finland and other countries as members. The Bioart Society was established in May 2008 at the Kilpisjärvi Biological Station in Sápmi Finland. The Bioart Society fosters interaction between art and science and is developing, producing and facilitating activities with an emphasis on biology, ecology and life sciences. In 2018 the Bioart Society initiated *SOLU – an artistic laboratory and platform for art, science and society* with the opening of *SOLU Space*, a multifunctional space for professional and public activities including exhibitions, workshops, seminars, a library and production office.

bioartsociety.fi
solu.earth

Selected activities 2008-2019

2019
Ars Bioarctica art&science residency
subsensorialXYZ exhibition and dialogue
Epistemic Hospitalities seminar
OPEN LABS exhibition Science Gallery Dublin
Bio Robotics workshop
cellF performances at HEUREKA
In Vitro Agencies exhibition
Feral Labs EU project
Biofriction EU project
Co-Travellers exhibition and seminar
An evening of sound art performance
Imagining Godzilla residency project
Leaky Light exhibition
Field_Notes – The Heavens field laboratory
North Air residency Finland / Scotland
Tokyo art&science residency
Narratives of Imperfection exhibition
Time and river look alike exhibition
New views on art and environment seminar

2018
Ars Bioarctica art&science residency
Tokyo art&science residency
SOLU Space opening
Merry CRISPR II workshop
Field_Notes – Ecology of Senses field laboratory
State of the Art seminar
Winogradsky Days workshop
Ars Bioarctica Field Reports
10 years anniversary party

2017
Ars Bioarctica art&science residency
SPLICE at Oulu Arts Museum
Copper Kimchi workshop
Ars Bioarctica Field Reports
Growing Cellulose workshop
Encounters Across Art and Science at Tiedekulma
Book launch “Kira O’Reilly: Untitled (Bodies)”
Finnish state price for Interdisciplinary art
Merry CRISPR I workshop
Book presentation “Britt Wray: Rise of the Necrofauna”

2016
Ars Bioarctica art&science residency
Changing Weathers EU Project
HYBRID MATTERS Nordic network project
HYBRID MATTERS exhibition Kunsthall Grenland (NO)
HYBRID MATTERS exhibition Nikolaj Kunsthal (DK)
HYBRID MATTERS symposium
HYBRID MATTERS exhibition Forumbox Helsinki
Plastic Imaginaries workshop

2015
Ars Bioarctica art&science residency
Making-Life III – a research platform for art and synbio
Making-Life exhibition at Lasipalatsi
Making_Life seminar
Changing Weathers EU Project
HYBRID MATTERS Nordic network project
Field_Notes – HYBRID MATTERS field laboratory

2014
Ars Bioarctica art&science residency
Making-Life II – a research platform for art and synbio
Curies Children [glow boys radons daughter] workshop
Biocommons workshop and keynote during camp pixelache
HYBRID MATTERS Nordic network project
Making-Life I – a research platform for art and synbio

2013
Ars Bioarctica art&science residency
“Field_Notes – From Landscape to Laboratory” publication
Techno-Ecologies EU Project
Field Notes – Deep Time field laboratory
Deep Time – Deep Futures symposium
Field_Notes residencies
Synenergene EU Project
Case Pyhäjoki – Artistic reflections on nuclear influence
Natural Cryptography for Postcards workshop
Yeast printing workshop

2012
Ars Bioarctica art&science residency
DoItYourself microscopy and urban micro ecology workshop
Art&HENVI collaborative art&science project
Prima Materia exhibition at Tiedekulma
The Art of Gathering Environmental Data workshop
Arctic Perspective residency and workshop

2011
Ars Bioarctica art&science residency
Hackteria workshop
Weather tunnel
Arctic Waters Workshop
EPAC - EU project
Field_Notes – Cultivating Grounds field laboratory
Art&HENVI

2010
Ars Bioarctica art&science residency
Art and Technoscience conference
Bio-science and art student workshop
Curated Expedition to the Baltic Sea
Ars Bioarctica Kilpisjärvi meeting

2009
80+1 Kilpisjärvi project
Arctic journey student workshop
Havahdus Seminar

2008
Bioart Society founding meeting in Kilpisjärvi

Current members 2019

Aarno Ilmari Rankka, Adam Zarezky, Aino Johansson, Aleksi Jaakola, Andrew Paterson, Angela Oker-Blom, Anna Dumitriu, Anne Lehtelä, Anniina Suominen, Antero Järvinen, Antero Kare, Antti Tenetz, Antye Greie, Anu Osva, Aravin Chakraverthi, Atte Korhola, Bart Vandeput, Björn Kröger, Charlotte Clark, Christelle Mas, Christina Stadlbauer, Corrie van Sice, Cristina Gaspar, Dave Griffith, Emilia Ukkonen, Erich Berger, Hanna Johansson, Hanna Vainio, Hannah Rogers, Heather Barnett, Hege Tapio, Helen Chandler, Helena Roininen, Helene von Oldenburg, Hyunseok Choi, Ines Montalvao, Ingvill Fossheim, Ionat Zurr, Jaime Culebro Camacho, Janne Halme, Jessica Leino, Johanna Rotko, Jose Cano Arias, Jukka Liukkonen, Jussi Saivo, Kaisa Korhonen Kurki, Kaisu Koski, Kasperi Mäki-Reinikka, Kati Roover, Katja Karhu, Kira de Coudres, Kira O'Reilly, Kristiina Ljokkoi, Laihonen Maarit, Laura Beloff, Lauri Linna, Leah Bieferman, Leena Valkeapää, Lilli Haapala, Lucy Davies, Maija Salemaa, Margherita Pevere, Mari Keski-Korsu, Maria Huhmaniemi, Marietta Radomska, Marjukka Korhonen, Mark Mitchel, Mark Petz, Markku Nousiainen, Meeri Lukin, Meri Hietala, Merja Markkula, Merja Penttilä, Mianna Meskus, Minna Långström, Nijole Kalinauskaite, Noora Hirvonen, Noora Sandgren, Olga Mashinka, Olli Suorlahti, Oron Catts, Ove Holmqvist, Paula Humberg, Paula Kramer, Pauli Lantto, Petteri Hietanen, Pia Lindman, Piibe Piirma, Piritta Puhto, Pirre Pääkko, Raquel Renno, Rauni Partanen, Satu Tuittila, Scott Andrew Elliot, Shreyasi Kar, Silja Selonen, Simo Alitalo, Sini Haapalinna, Taina Kelavirta, Tarja Tella, Tarja Trygg, Teemu Lehmusruusu, Tere Vadén, Terike Haapoja, Tiina Prittinen, Tiina Vainio, Till Bovermann, Timo Heinonen, Timo Jokela, Timo Kokko, Tomi Dufva, Tuike Alitalo, Tuula Häyrinen, Ulla Taipale, Ulla-Maija Alanen, Veronika Valk

Boards 2008–2019

2019
Mari Keski-Korsu
Kristiina Ljokkoi
Antero Kare
Kasperi Mäki-Reinikka
Christina Stadlbauer
Kira O'Reilly
Anniina Suominen
Atte Korhola

2018
Mari Keski-Korsu
Kristiina Ljokkoi
Antero Kare
Kasperi Mäki-Reinikka
Christina Stadlbauer
Kira O'Reilly
Janne Halme
Kaisa Korhonen-Kurki

2017
Kristiina Ljokkoi
Mari Keski-Korsu
Minna Langström
Antero Kare
Antero Järvinen
Kasperi Mäki-Reinikka
Christina Stadlbauer
Kira O'Reilly

2016
Minna Langström
Kristiina Ljokkoi
Mari Keski-Korsu
Antero Kare
Antero Järvinen
Kaisa Korhonen-Kurki
Kasperi Mäki-Reinikka
Laura Beloff

2015
Minna Langström
Mari Keski-Korsu
Antti Tenetz
Antero Kare
Antero Järvinen
Kaisa Korhonen-Kurki
Laura Beloff
Johanna Rotko

2014
Minna Langström
Mari Keski-Korsu
Antti Tenetz
Antero Kare
Antero Järvinen
Olga Mashkina
Laura Beloff
Johanna Rotko

2013
Antti Tenetz
Kristiina Ljokkoi
Antero Kare
Antero Järvinen
Timo Heinonen
Cano Arias
Laura Beloff
Maria Huhmarniemi

2012
Antti Tenetz
Antero Järvinen
Timo Heinonen
Cano Arias
Antero Kare
Markku Nousiainen
Maria Huhmarniemi
Kristiina Ljokkoi

2011
Antti Tenetz
Anu Osva
Antero Järvinen
Timo Heinonen
Jose Cano Arias
Taina Kelavirta
Mari Keski-Korsu
Kristiina Ljokkoi

2010
Marjukka Korhonen
Sini Haapalinna
Pekka Niemelä
Leena Valkeapää
Merja Markkula
Ulla Taipale
Maija Salemaa
Laura Beloff

2009
Anu Osva
Merja Markkula
Ulla Taipale
Merja Talvela
Antero Järvinen
Juha Kotipelto
Maria Huhmarniemi
Laura Beloff

2008
Anu Osva
Merja Markkula
Ulla Taipale
Merja Talvela
Antero Järvinen
Juha Kotipelto
Maria Huhmarniemi
Laura Beloff

Founding meeting 2008

Anu Osva
Juha Kotipelto
Merja Talvela
Maria Huhmarniemi
Timo Jokela
Antero Järvinen
Rauni Partanen
Tarja Trygg
Merja Markkula
Pirre Pääkkö
Tuula Häyrynen

Additionally present
Hannele Lehto
Ulla Taipale
Leslie Hyde

Staff

Erich Berger, director
Piritta Puhto, senior producer and curator
Johanna Salmela, office and communications manager

Interns

Maija Fox
Mari Kaakkola
Daria Vdovina
Katarina Meister
Tyśka Samborska
Lilli Tölp

Notes

The Lost And Found Department

Shruti Sunderraman

There is no Lost and Found department at the Kilpisjärvi Biological Station.

I went looking for a lost thermos. I heard someone yell,
“I can’t find my other sock!”
We all found ourselves searching for belongings in a place
that doesn’t have a Lost and Found department.

Here’s a guide to finding things around the Kilpisjärvi Biological Station:

Roll in the mud, the green, the soil. You have instructions to forget sight, sound and smell. Obey the wind. Your mind will let itself off its leash.
You will not find the keys you lost. You will find the sense to be free.

Learn from the lichen. It will teach you endurance from cold winds and from reindeers of life stamping on your quests. You will not find your lost glove. But you may find vision.

Take off your jacket and dig your hands deep into the soil. Right up to your elbow. Maybe all the way up to your shoulder. And then your head.
Bury yourself in bacteria and brown. The clay does not have your lost shoe. If you ask them gently, they might teach your nose lessons in paying attention to life in hidden places.

Gaze lightly across the lake. Screen the horizon for nothing in particular. The water is loud. You don’t have to be. The skies approach.
They don’t come bearing a lost sweater. They have a message for you from Time.

Climb the Saana with weak knees. Befriend reindeers. Respect their need for distance. Be gentle to their caution. The mountain and the reindeer have outlived human conclusions. They do not have your lost charger. They have sensibilities to offer. Drop your apparatus. Let them test you now.

If you have lost your compass at the Kilpisjärvi Biological Station,
give up all will to find it. Some things ought to stay lost.