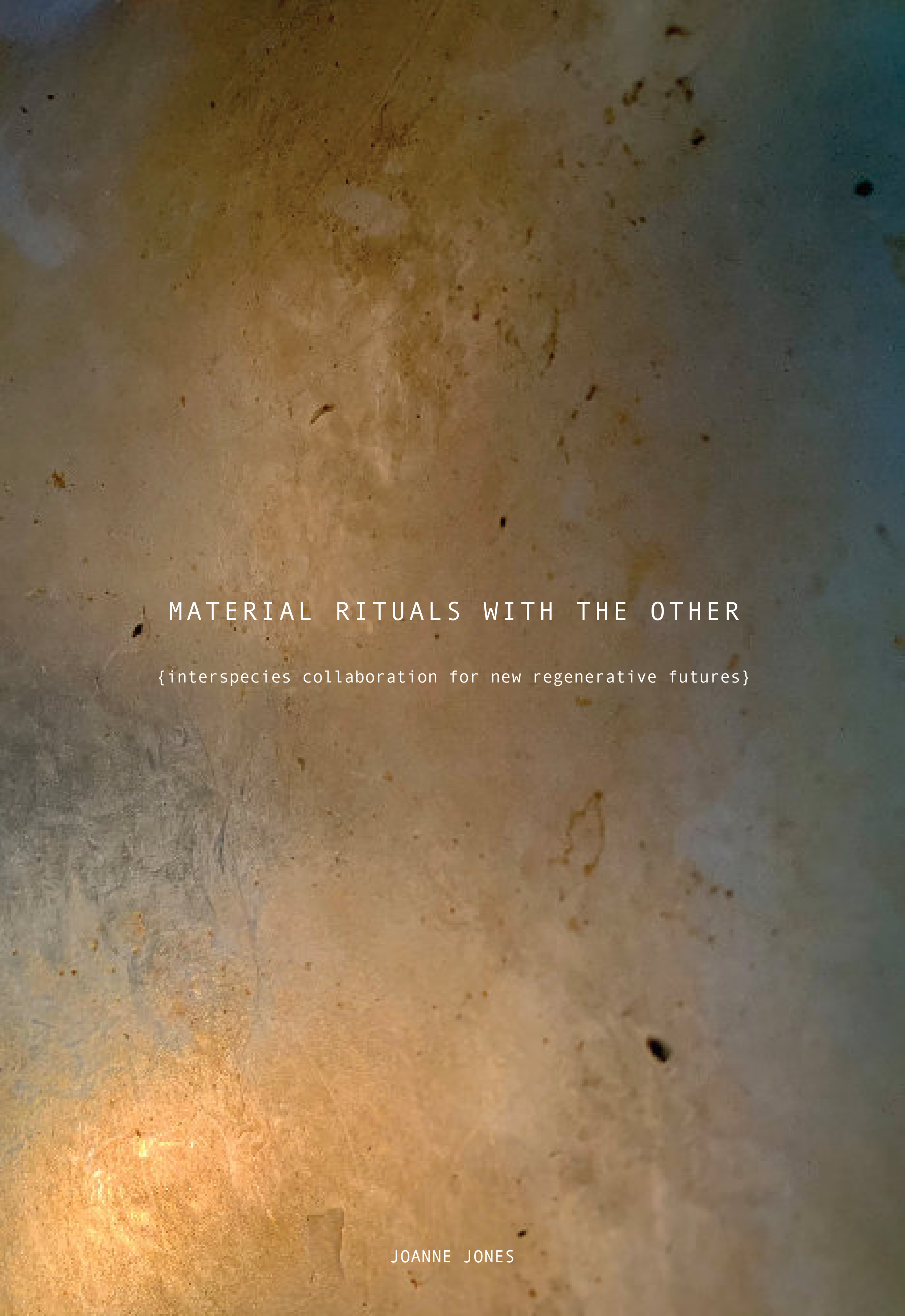

MATERIAL RITUALS WITH THE OTHER

{interspecies collaboration for new regenerative futures}

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Mémoire MSc - Nature Inspired Design

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ABSTRACT

This project seeks to address the issues of today's materials through interspecies collaboration. Following a critique of materialism, it acknowledges both western and Indigenous ideas that the nonhuman has agency outside of the human. It addresses biomimicry and material ecology as responses to the call for new materials and new ways of understanding them. These new materials give rise to new tools; and in the context of interspecies collaboration, these are interspecies tools. This project defines bioassembly as an interspecies tool, and kombucha leather as a conduit for interspecies collaboration. It explores the issues of exploitation surrounding materials and organisms and proposes care as a response to the potential for exploitation of these new tools. Relating care to ritual, it concludes by offering acts of ritualistic care with interspecies tools as pathways toward conscious coindividuation with the "other."

DEFINITION OF TERMS

Bioassembled material:

“A bioassembled material is a macroscale structure that has been grown directly by living organisms such as mycelium or bacteria.

Biofabricate and Fashion for Good. UNDERSTANDING ‘BIO’ MATERIAL INNOVATION: a primer for the fashion industry, December 2020

Bio-based:

“The term bio-based product refers to products wholly or partly derived from biomass, such as plants, trees, or animals (the biomass can have undergone physical, chemical or biological treatment.”

European Committee for standardisation, BioBased products [online] July 2021

Biodesign:

“Biodesign’ is a term used to indicate design ‘of’, ‘for’ or ‘with’ biology.”

Biofabricate and Fashion for Good. UNDERSTANDING ‘BIO’ MATERIAL INNOVATION: a primer for the fashion industry, December 2020

Biofabricated materials:

“Biofabricated materials are produced by living cells (e.g. mammalian) and microorganisms, such as bacteria, yeast, and mycelium.”

Biofabricate and Fashion for Good. UNDERSTANDING ‘BIO’ MATERIAL INNOVATION: a primer for the fashion industry, December 2020

Biomaterial:

“Biomaterial’ is a term used to indicate materials that have non specific biological association.”

Biofabricate and Fashion for Good. UNDERSTANDING ‘BIO’ MATERIAL INNOVATION: a primer for the fashion industry, December 2020

INTRODUCTION

Material Rituals is a speculative design provocation that questions ways in which we can respectfully approach interspecies collaboration in the context of kombucha leather, a bioassembled material produced by bacterial cellulose. This work suggests that the practice of interspecies collaboration in the creation of interspecies tools, like bioassembled materials, necessitates acts of care for all organisms involved in the creation of new regenerative futures. It navigates the way interspecies collaboration may entail ritual as an active coindividuation, enacting the belief that the nonhuman possesses agency beyond the human. It explores this concept in the context of creating ritual with the living material, kombucha leather. Finally, it offers meditation and ceremony as acts of ritualistic care that may be incorporated into interspecies collaboration.

"We are never without materials."

- Liz Corbin, *Why Materials Matter*

PART I

{the actuality}

MATERIALS TODAY, MATERIALS TOMORROW

Materials compose our world in the same way matter composes our universe. There is no physical object on Earth without a material. Many materials are so commonplace, we exist alongside them without recognition of their power and impact, paying them no attention at all.[1] Yet, materials have played a foundational role in the evolution of societies throughout human existence. From metal to glass, ceramics to plastic, wood to wool, cotton to polyester, people have continually developed alongside their materials, fostering new understandings and experiences of the world through material explorations. The ubiquity of materials influences the way we construct our lives - how we relate to one another, how we express ourselves, and how we shape our futures. Despite the substantiated impact in our lives, western philosophical currents of thought have inferred a patrimony of disembodied approaches to materials. With biased and imposing interpretations, entire fields of study dedicated to the design, discovery, and understanding of materials confound the ontology of matter with its ability to be manipulated into taking the forms we desire. Though Louis Kahn succeeded in asking a brick what it wanted to be and encouraged his students to have conversations with materials, his approach still imposed human desire on the brick.[2] Our remaining hylomorphic and materialistic approaches, peculiar to the western world, exclusively consider what material can be for us. Consequently, our approaches have led to an excess in consumption concomitant with the abuse of Earth's resources and living systems.

1 Corbin, L., Solanki, S. (2018). *Why materials matter: Responsible design for a better world.* Prestel Verlag. (pp. 6-7)

2 *Why Louis Kahn would often talk to bricks | architecture | Phaidon.* (n.d.). Retrieved 30 July 2021

Today, we have inherited a legacy of industrial consumption, pollution, extraction, and exploitation, all of which lead to waste and destruction at unprecedented rates and with irreversible outcomes. As the early critic of capitalism, Thorstein Veblen, outlines in his 1899 book, Theory of the Leisure Class, modern forms of 'conspicuous consumption,' or reverence for material excess and displaying it, inevitably lead to the 'fundamental canon' of 'conspicuous waste', or excess in the allocation of time and resources for services and goods that detract from life processes.[3] While society tumbles further down the slope of endless consumption and waste that is rewarded by the capitalist model, we come face to face with the pressing environmental and socioeconomic issues that western leisure habits have induced. Many designers today are questioning how to confront these protruding wicked problems by shifting perceptions on what materials are, where they come from, and who works with them, while redefining a "holistic approach to and appreciation for materials."[4] Contemporary theorists from the emerging branch of philosophy, new materialism, equally advocate for a shift in perceptions toward matter, rejecting the critiques of hylomorphism and proposing a privilege of matter over form. One prominent figure from this thought wave, Jane Bennett, puts forth her argument of vibrant matter, which rejects the binary of subject-object and advocates for a vital materialism in which matter, or the non-human, is viewed with agency and power more than the sum of its parts:

3 Veblen, T., & Banta, M. (2009). *The theory of the leisure class* (Reissued). Oxford University Press. (pp. 214-216, 225-227)

4 Corbin, L., Solanki, S. (2018). *Why materials matter: Responsible design for a better world.* Prestel Verlag. (pp. 6-7)

> *"Why advocate the vitality of matter? Because my hunch is that the image of dead or thoroughly instrumentalized matter feeds human hubris and our earth-destroying fantasies of conquest and consumption. It does so by preventing us from detecting (seeing, hearing, smelling, tasting, feeling) a fuller range of the nonhuman powers circulating around and within human bodies. These material powers, which can aid or destroy, enrich or disable, ennoble or degrade us, in any case call for our attentiveness, or even "respect" (provided that the term be stretched beyond its Kantian sense). The figure of an intrinsically inanimate matter may be one of the impediments to the emergence of more ecological and more materially sustainable modes of production and consumption."*[5]

5 Bennett, J. (2010). *Vibrant matter: A political ecology of things.* Duke University Press. Preface, ix.

Another contemporary theorist, Yuk Hui, takes materialism past the technical objects of Simondon and further into the current digital realm, questioning the materiality of forms through the synthesis of their relations, their becoming - or after Simondon, their individuation of forms.[6] In terms of a data-bound digital object, its identity results from more than its matter or form, but instead from "the relations in it, created by it, and that surround it."[7] We must define the materiality of a digital object beyond its material representation and include its conceptual, relational representations. Hui alludes to vibrancy in the materiality of digital objects:

6 Simondon, G. (2016). *On the mode of existence of technical objects.* Univocal Pub.

7 Hui, Y. (2014). Form and relation. Materialism on an uncanny stage. Intellectica. *Revue de l'Association pour la Recherche Cognitive,* 61(1), 105–121.

> *"For example, a digital object and its relation to other objects cannot be explained by its representation on the screen of digital devices, neither by signals, or voltage differences. This materiality seems to come from elsewhere (a different reality or order of magnitude). We can perhaps say that the relation between a natural object and atoms is analogous to that between a digital object and digitized relations, these relations are material as well as conceptual."*

This revival of thought around materiality and what it means to acknowledge the importance of materialism points to a glimmer on the horizon for a new way of seeing things. However; one thing lacking from contemporary discourse, in comparison to the tradition of Indigenous thought, is the importance of individuation with the non-human living. Bennett's vibrant matter and the proponents of new materialism echo the philosophies of Indigenous and animist traditions, bringing forth critiques by Indigenous scholars that question the colonial perspective and proclaimed novelty of this seemingly ahistorical wave of thought. In comparison to these recent ideas, myriad cultures around the world exhibit centuries' worth of traditions asserting thoughts of the non-human possessing power, or "vibrancy", beyond its matter and form, therefore influencing the way the world works.[8] So we are brought to wonder: how can we reconsider the importance of materiality outside of the western lens when designing the materials of tomorrow? And, how can we look beyond the eurocentric view of materialism when working with a material that is actually alive?

8
For further discussion on this topic, see Part III.

There exists a plethora of materials, each with its own socioeconomic, political, ethical, and environmental issues, such that it may seem arbitrary to begin a new design approach with just one material category. When more closely observing the patterns of industrial processes, it becomes evident that textiles can be an interesting case study on what is wrong with the way we treat materials and how they are intricately intertwined with anthropocentric problems. Industrial textile production is intrinsic to a slew of issues including water pollution, desertification, soil erosion, high carbon emissions, deforestation, human and animal rights violations, excessive resource consumption, and waste. With the invention of the power loom, textiles burgeoned at the core of the industrial revolution, and with this development of increased production abilities emerged increased consumption, worker exploitation, poor working conditions, child labor abuse, low wages, and high poverty levels. These social issues remain relevant in today's fast fashion industry, while also contributing to vast ecological destruction under the guise of "sustainability." For instance, textile companies like Birla Cellulose, peddle viscose as a "sustainable" and "green" bio-based textile that can biodegrade.[9] Though viscose consists of plant cellulose from wood pulp, and hence is a biomaterial, the transformation of cellulose into thread requires chemically intensive manufacturing processes through the use of carbon disulfide, a toxic chemical linked to heart disease, birth defects, cancer, and death.[10] Alongside the effluent from traditional dyeing processes, this chemical remains in waterways surrounding the factories, contributing to the contamination of entire communities and ecosystems. In addition, the viscose transformation process wastes up to 70% of the tree, recklessly depleting its own natural resources while contributing to global mass deforestation.

9
Birla cellulose | a trusted name in viscose staple fibre, mmf. (n.d.). Retrieved 24 July 2021, from https://www.birlacellulose.com/

see also:

Perrin, E., & Bovon, G. (2021). *Fast Fashion—Les dessous de la mode à bas prix* [Documentary]. ARTE France, Premières Lignes.

10
Material guide: What is viscose and is it sustainable? (2020, March 8). Good On You. https://goodonyou.eco/material-guide-viscose-really-better-environment/

The globalized leather industry, which incarnates highly toxic and unethical sourcing and production methods, is a further example of the impact of textile on society and the environment. Negative effects from traditional leather production comprise concerns of animal welfare in the cattle-ranching phase, high carbon and land use impacts, nonrenewable resource use, and heavy chemical processing yielding effluent in land and water. In conjunction, the market of "vegan" or faux leather provides neither relief nor exoneration from the globalized leather industry's negative effects on the living and the environment.[11] Vegan leather is made of synthetic plastic polymers like polyester, PVC, and polyurethane. These materials will never cycle back into Earth's living systems within our lifetime as plastic is derived from petroleum, taking thousands of years to biodegrade. Being composed of a nonrenewable and carbon-emitting resource, with all the transience of use as a plastic bottle, vegan leather equally carries the burdens of the fossil fuel industry. These modes of production are simply not sustainable.

11
Nast, C. (2019, May 2). *Can leather go green?* Vogue Business. https://www.voguebusiness.com/companies/green-sustainable-conscious-leather

Despite these egregious failures to care for living systems and humankind, the greenwashing of viscose, vegan leather, and other fast fashion textiles persists. Over the last few decades, the term sustainability has become the rallying cry for environmentalists and neoliberalists alike. Where once there was good intent, the desire for sustainable increase in profit bastardized the term to a near-incomprehensible level. Humanity cannot sustain this level of resource consumption and waste and remain expectant that Earth's living systems will continue to hold the balance in place to sustain human and other life. This poor, greenwashed version of sustainability is not enough in the face of what has been lost. Is this what we want, to watch the water slowly rise fully knowing our cataclysmic fate of asphyxiating the human race in the name of profit? Do we build an ark or let the ocean meet us at our doorsteps?

It is time to repair and restore, to regenerate in system levels founded in care.[12] In unification with a new regenerative system, we require new materials and new communities to fabricate our regenerative futures. Looking forward to the textiles of tomorrow, biotechnology can provide hope for developing new ways of approaching materiality and being with and around new materials. By the example of companies like MycoWorks, Bolt Threads, and Biofabricate, textiles are growing at the heart of the bio-revolution intending to work with the living instead of against it, offering new vibrancy and agency to tomorrow's materiality.

12
Care, as described by feminist ethics of care theory. For further reading, look to works by Carol Gilligan and Nel Noddings.

NEW MATERIALS, NEW TOOLS

In the late 2020 report Understanding 'Bio' Material Innovation, Biofabricate and Fashion for Good refer to a bioassembled material as "a macroscale structure that has been grown directly by living microorganisms such as mycelium or bacteria."[1] This material definition respectively falls into three larger categories of materials - biomaterials, biobased, and biofabricated - meaning that a bioassembled material takes on the definitions and characteristics of all three precedent terms. These terms contain broad and generalized definitions and are used with different evolving denotations across various industries, from biomedical to fashion. Due to the nature of ambiguity in the liminal space of discovering emergent materials and technologies, not all of these terms have globally recognized standardized definitions and therefore remain susceptible to subjectivity. Despite the ambiguity of the term 'bioassembled material', the core of its definition lies in the fact that biology constructs the resulting material. In a more precise reading of the term, which will be the denotation adopted here, emphasis is placed on the material consisting of the whole living organism itself rather than organisms used as ingredients in conjunction with further mechanical or chemical processing to achieve materiality.

1
Biofabricate and Fashion for Good. UNDERSTANDING 'BIO' MATERIAL INNOVATION: a primer for the fashion industry, December 2020

This new materiality proposes new ways of interacting with the world. In lieu of extracting precious resources, industrially heating, beating, and treating materials, and shipping them across continents to be sold in big-box stores, we can grow living materials in our homes with local ingredients and very little technology or money involved. These vernacular and low-tech approaches to creating and working with materials go against traditional industrial practices. The act of growing a living material to form an object we might use on a daily basis cultivates a new relation to the materiality of the quotidian. As Simondon describes, a tool is an intermediary between the body of the operator and the objects upon which they act; the tool's function is to mediate a constant and non-fallacious relation between the operator and the object.[2] Bioassembled materials effectuate new ways of interfacing with objects, establishing new relationships between us and the living. If the assumption of a tool holds, then we may conclude that bioassembled materials are, in fact, new tools. Until now, the axiom of humanity's tools has fallen into the two groups of craft and industrial tools. Craft tools can be invented by one human alone and industrial tools require more than one human to produce. The evolution of industrial tools from spoken word to mechanization and industrialization perpetually increased mass production, conspicuous consumption, and conspicuous waste. In hopes of re-planning our world around ideals of commonwealth and regeneration, we have realized the necessity for new ways of interacting with the world. We recognize the need for an "industrial re-tooling revolution."[3] The fields of biotechnology and biodesign have responded to this call for new tools, yet the binary of tool categorization lacks acknowledgment for tools of the bio-revolution, and subsequently, tools created with other species. If we assume that a material is a tool, then in the context of biomaterials, we are developing a new idea of materials as tools of interspecies collaboration. A tool designed in collaboration with another species can then be referred to as an interspecies tool. Let it be clear that interspecies tools are not created with the intent to control, harm, exploit, or manipulate another species. Types of interspecies tools would include biofabricated and bioassembled materials. Through interspecies tooling, we can begin to consciously create new materials that work with the living rather than against it on a path toward a regenerative future within the living systems on Earth.

2
Gilbert Simondon —'The Technical Object as Such' from *'Entretien sur la mécanologie'* (1968). Retrieved 26 July 2021, from https://www.youtube.com/watch?v=eXDt-G74hCL4

and

Simondon, G. (2016). *On the mode of existence of technical objects.* Univocal Pub.

3
Fuller, R. B., & Snyder, J. (2013). *Operating manual for spaceship earth* (New ed). Müller. (pp. 133)

Some practitioners respond to the need for a re-tooling revolution with the concept of designing from nature, looking to it as model, measure, and mentor. As Janine Benyus proposed in her seminal text *Biomimicry: Innovation Inspired by Nature*, biomimicry is a methodology that abstracts design solutions from forms, processes, and ethics found in nature.[4] It observes nature to understand its way of functioning and mimics its forms to benefit human civilization, treating it as the pinnacle of design and the ultimate source for innovation. By emulating nature and fitting nature's form to human-desired function, Benyus draws a line between nature and human technological development, further widening the chasm between human and nature in a way that contradicts biomimicry's initial aim to return to nature. Benyus rejects bio-utilization, bioassistance, and biotechnology and asserts that the ultimate goal of biomimicry is to cease human dependence on natural organisms.[5] One example of biomimicry in practice is the emulation of spider silk protein to achieve its strength, high energy-absorbing elasticity, and low glass-transition temperature characteristics in human-made materials. The biomimetic approach to industrially manufacturing these properties in a material is to take a renewable resource and make a fiber with negligible energy inputs and no toxic outputs while avoiding the physical exploitation of a living organism to do it. However, as Michael Fisch contends, biomimicry meets its limits with its relationship to capitalism: "Similar to other bio-driven practices, biomimicry speaks the language of capitalism and political ecology simultaneously, mobilizing such corporate jargon as 'cost performance' and 'deliverables' together with declarations of genuine concern for nature and environmental sustainability." Biomimicry contradicts itself by attempting to create a sustainable future with nature by maintaining a hylomorphic lens on matter and form, objectifying nature as a bounded source of solutions to anthropocentric problems.

4
Benyus, J. M. (2009). *Biomimicry: Innovation inspired by nature* (Nachdr.). Perennial.

5
Fisch, M. (2017). The nature of biomimicry: Toward a novel technological culture. *Science, Technology, & Human Values,* 42(5), 795–821.

Other practitioners, like Neri Oxman, respond to the call for new tools with a new materialist notion of designing with nature, not just mimicking it, but collaborating with it, recapitulating it, and augmenting it.[6] As Oxman states in her consequential essay, *Material Ecology*, "Today, perhaps under the imperatives of growing recognition of the ecological failures of modern design, inspired by the growing presence of advanced fabrication methods, design culture is witnessing a new materiality."[7] Oxman's praxis avoids direct mimicry and instead advocates for a new "material ecology", one in which our built environment and systems are "inspired, informed, and engineered by, for, and with nature."[8] Oxman demonstrates a recognition that the nonhuman possesses agency and exhibits a dedication to "co-individuation of form and matter."[9] Though Oxman's approach acknowledges the agency and vibrancy of materiality and opposes a purely capitalistic pathway, it fails to fully escape the confines of a framework that subjugates the nonhuman for our desires. Oxman's Silk Pavilion exemplifies this contention. In 2013, Oxman and her team employed a swarm of 6,500 silkworms to explore sustainable and humane methods for creating silk-based products by coercing the silkworms to spin their silk while confined to a scaffolded geodesic dome.[10] This project intended to question ways that humans may collaborate with other species to create new materials and structures without depleting natural resources. The individuation of this structure resulted from the silkworms' silk-spinning in relation to human imposed environmental conditions of varying gravity, light, and heat. This project gives rise to questions concerning the ethics of Oxman's bioutilization and consequent exploitation of the silkworms for her technologic desire. No matter how Oxman spins an answer about the silkworm's ability to undergo complete metamorphosis, unlike the conventional silk production process which kills the silkworm in its cocoon before maturing into a moth, the silk pavilion nevertheless exploits the silkworm to undergo Oxman's bidding of creating a structure according to her wishes. This work attempts to partake in an interspecies collaboration but disallows the silkworm to experience its pluripotential in relation to Oxman's impositions. The silk pavilion, therefore, fails to invite the silkworms' agency into the collaboration, falling short of asking what the silkworm wants to be or what it could be.

6
Fisch, M. (2017).

7
Oxman, N. (n.d.). *Material ecology.* MIT Media Lab. Retrieved 15 July 2021, from https://www.media.mit.edu/publications/material-ecology/

8
Neri oxman: Material ecology. (n.d.). Neri Oxman: Material Ecology. Retrieved 15 July 2021, from https://oxman.com

9
Fisch, M. (2017).

10
Silk pavilion i. (n.d.). Silk Pavilion I. Retrieved 26 July 2021, from https://oxman.com/projects/silk-pavilion-i

Image Left:

Silk Pavilion I, Image by Neri Oxman and The Mediated Matter Group

Both biomimicry and material ecology offer us new tools for interacting with the world, but neither approach fully jumps the assumed chasm delineating human dominance over the nonhuman. These two approaches have their flaws; however, they succeed in providing adequate stepping stones for a path to a regenerative future with new materiality. With the growing relevance of material innovations enhanced by technological advancements and the cognizance of looking outside of ourselves to living systems for innovative answers and opportunities to our problems, the presence of biomaterials becomes ever more germane. Interspecies tools like bioassembled materials render new possibilities of materiality on a stage of coexistence and collaboration with materials that not only have agency in their individuation but are also genuinely alive. Aside from the sheer abundance of their fundamental structures on Earth, the appeal to working with bioassembled materials, in comparison to the vast majority of materials we use today, arises from their production requiring far less energy and fewer resources than standard mass-produced materials. They can be grown within the context of vernacular and low-tech traditions, require very little equipment at small-scale production, and are not costly to produce. Through the characteristics of accessibility and democratization, bioassembly provides many opportunities for the future of materials by putting the power of production into the hands of the consumer. It proves just as easy to grow a bioassembled material in the home as making a jar of sauerkraut. Production bears such easy applications because bioassembled materials do all the work by growing themselves into the shape and format in which they are housed. Though each organism demonstrates its idiosyncrasies for proper growth conditions according to pH, temperature, light, and carbon, the only demanding aspect of growing bioassembled materials is the patience their temporality requires. These are the miraculous facts of bioassembled materials.

Image Right:

Silk Pavilion I, Image by Neri Oxman and The Mediated Matter Group

"To see ourselves as others see us is a most salutary gift. Hardly less important is the capacity to see others as they see themselves. But what if these others belong to a different species and inhabit a radically alien universe?"

- Aldous Huxley, *The Doors of Perception*

PART II

{the miraculous facts}

INTERSPECIES TOOLING: BIOASSEMBLY

Currently, there exist two primary types of bioassembly, each from a different biological kingdom: bacteria and fungi. From the kingdom of bacteria arises the natural polymer, bacterial cellulose. Cellulose forms the fundamental structural components of most plants, many fungi, and some algae, and ranks as "the most abundant biological macromolecule" on Earth.[1] The foremost genera of cellulose-forming bacteria are *Acetobacter*, *Agrobacterium*, *Pseudomonas*, *Rhizobium*, and *Sarcina*. To form a cellulose pellicle, bacterial cells, through the metabolic process of fermentation, secrete ribbon-like microfibrils that self-assemble into a crystalline structured biofilm resembling a non-woven sheet of material.[2] From the kingdom of fungi arises mycelium. Synonymous with the non-fruiting root-like structure of a mushroom, mycelium is the vegetative portion of a fungus taking form in a mass of interwoven white filaments called hyphae.[3] Fungal hyphae self-organize into a dense self-supporting macro-structure that can produce various material properties depending on varying environmental conditions. As renowned mycologist Paul Stamets states in his book *Mycelium Running: How Mushrooms Can Help Save the World*, mycelium is "so pervasive that a single cubic inch of topsoil contains enough fungal cells to stretch more than 8 miles if placed end to end."[4] He calculates that under every footstep lies more than 300 miles of mycelium, which equates to roughly 482 kilometers of mycelium per footstep.

This project aims to explore the ways we can respectfully approach interspecies collaboration in the context of kombucha leather, which is a bioassembled material produced by bacterial cellulose.

1
Jonas, R., & Farah, L. F. (1998). Production and application of microbial cellulose. *Polymer Degradation and Stability,* 59(1–3), 101–106.

2
Jonas, R., & Farah, L. F. (1998).

and

Biofabricate and Fashion for Good. UNDERSTANDING 'BIO' MATERIAL INNOVATION: a primer for the fashion industry, December 2020

3
Definition of mycelium. (n.d.). Retrieved 17 July 2021, from https://www.merriam-webster.com/dictionary/mycelium

4
Stamets, P. (2005). *Mycelium running: How mushrooms can help save the world.* Ten Speed Press. (p. 10)

Image Left:

SCOBY, image courtesy of NGO design studio thr34d5

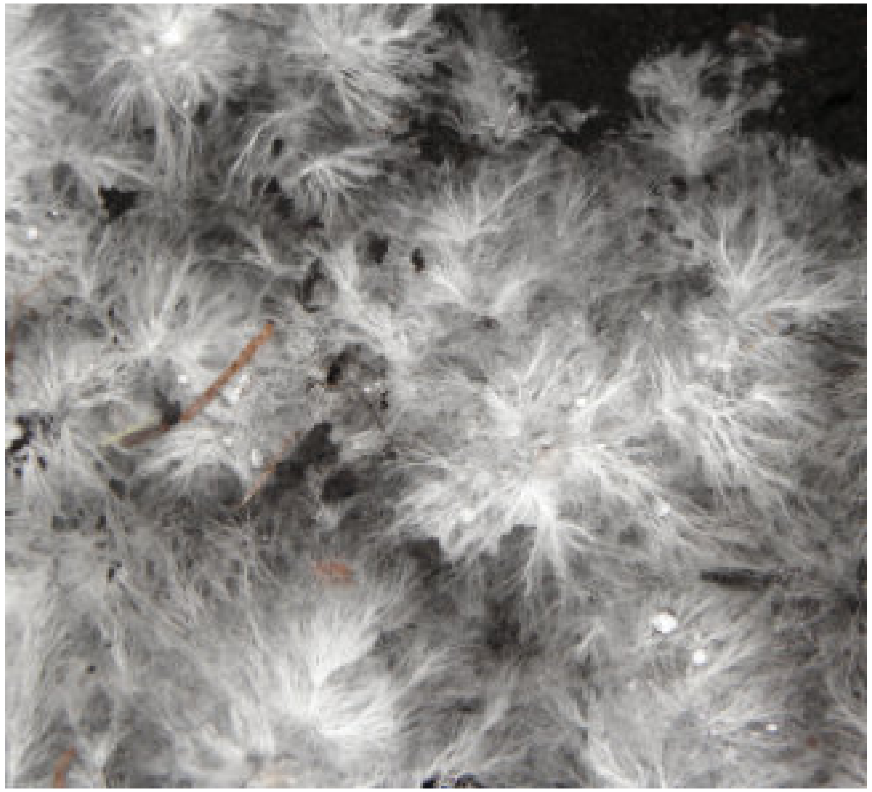
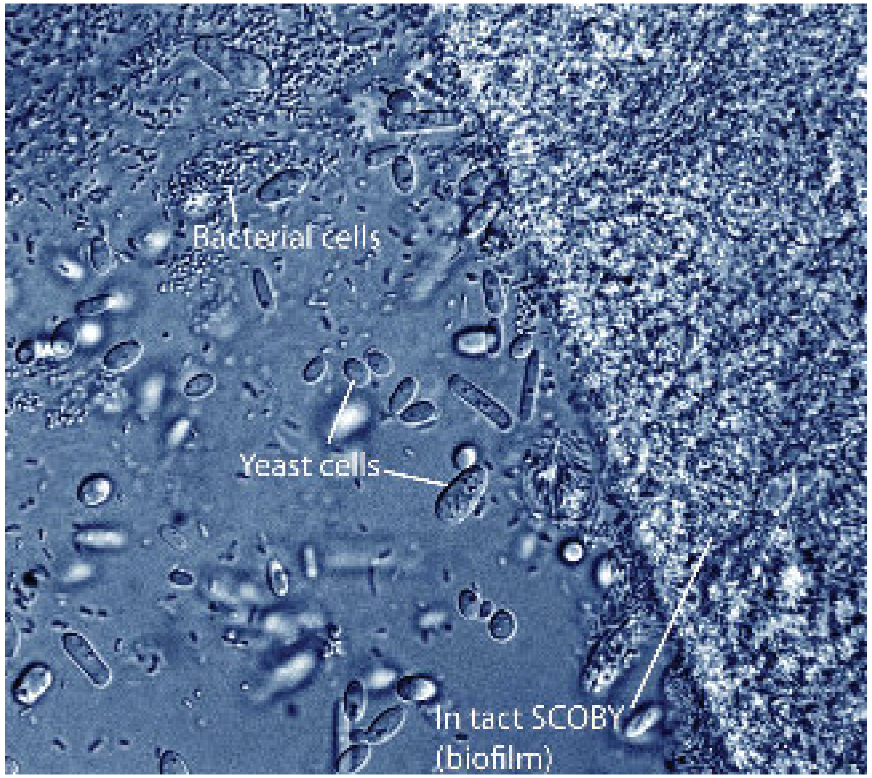


Image Left:

Mycelium, *Agaricus bisporus*, image courtesy of Rob Hille, Wikimedia Commons

WHAT IS KOMBUCHA LEATHER?

Kombucha leather, otherwise known as microbial leather or bioleather, is a bioassembled material produced by living communities of microorganisms. These harmonious communities of organisms form the biofilm commonly referred to in English as "kombucha," colloquially dubbed as a "mother," and more accurately described as SCOBY (Symbiotic Culture Of Bacteria and Yeast). SCOBY began intermingling in recorded human food history as early as 220 BC with the origins of kombucha tea in former Manchuria and has since spread across the planet via global trade routes and health food waves.[1] The kombucha consortium[2] varies in a broad spectrum of bacteria and yeast species populations, and generally but not exclusively consists of the acetic acid bacteria *Komagataeibacter xylinus*,[3] previously known as *Acetobacter xylinum* and *Gluconacetobacter xylinus*, and osmophilic yeast species like *Saccharomyces*.[4]



1
Jayabalan, R., Malbaša, R. V., Lončar, E. S., Vitas, J. S., & Sathishkumar, M. (2014). A review on kombucha tea-microbiology, composition, fermentation, beneficial effects, toxicity, and tea fungus: A review on kombucha…. *Comprehensive Reviews in Food Science and Food Safety,* 13(4), 538–550.

see also,

Cottet, C., Ramirez-Tapias, Y. A., Delgado, J. F., de la Osa, O., Salvay, A. G., & Peltzer, M. A. (2020). Biobased materials from microbial biomass and its derivatives. *Materials, 13*(6), 1263.

2
The term consortia comes from:

Jarrell, J., Cal, T., & Bennett, J. W. (2000). The Kombucha consortia of yeasts and bacteria. *Mycologist, 14*(4), 166–170.

3

Yamada, Y., Yukphan, P., Lan Vu, H. T., Muramatsu, Y., Ochaikul, D., Tanasupawat, S., & Nakagawa, Y. (2012). Description of Komagataeibacter gen. Nov., with proposals of new combinations (Acetobacteraceae). *The Journal of General and Applied Microbiology, 58*(5), 397–404.

4
Jayabalan, R., et al. (2014)

Image Right:

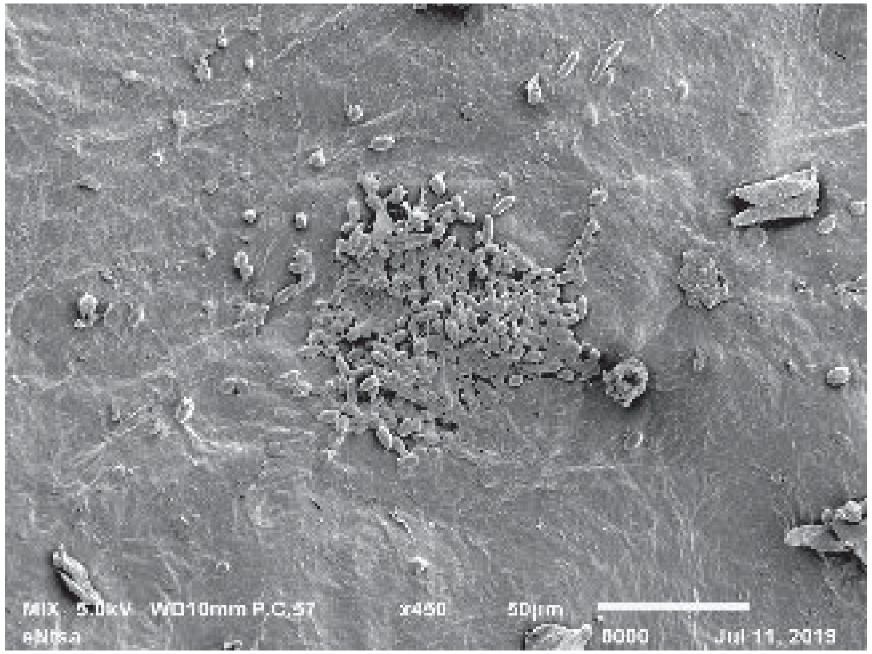
Bacterial cells, Yeast cellsm and In tact SCOBY biofilm, photo by Benjamin Wolfe

Image Right, facing page:

Kombucha Leather, image courtesy of NGO design studio thr34d5

Image Right:

Electron Microscopy of SCOBY, image courtesy of NGO design studio thr34d5



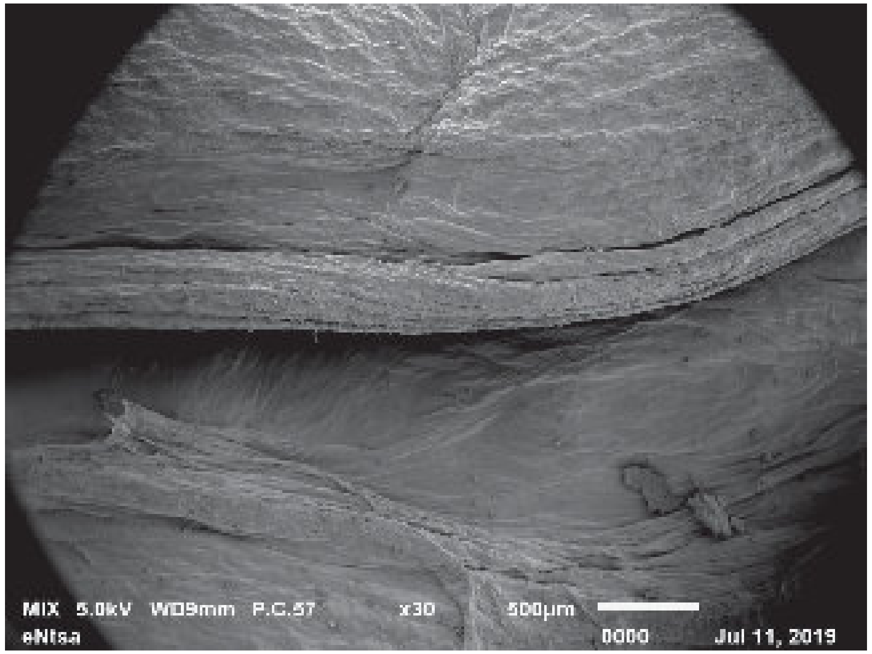
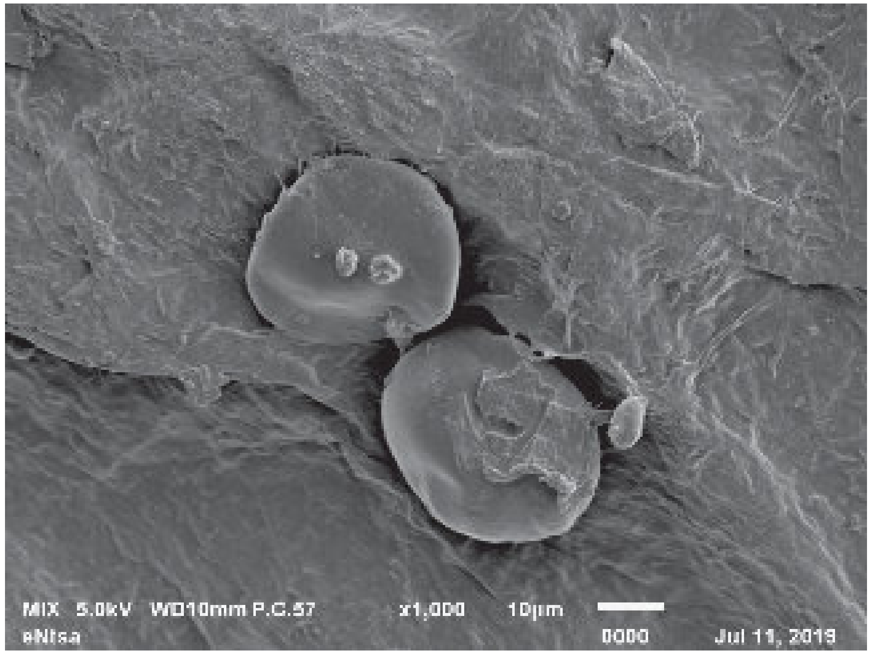


Image Left:

Electron Microscopy of the Edge of a SCOBY Pellicle, image courtesy of NGO design studio thr34d5

Image Right:

Electron Microscopy of SCOBY, image courtesy of NGO design studio thr34d5



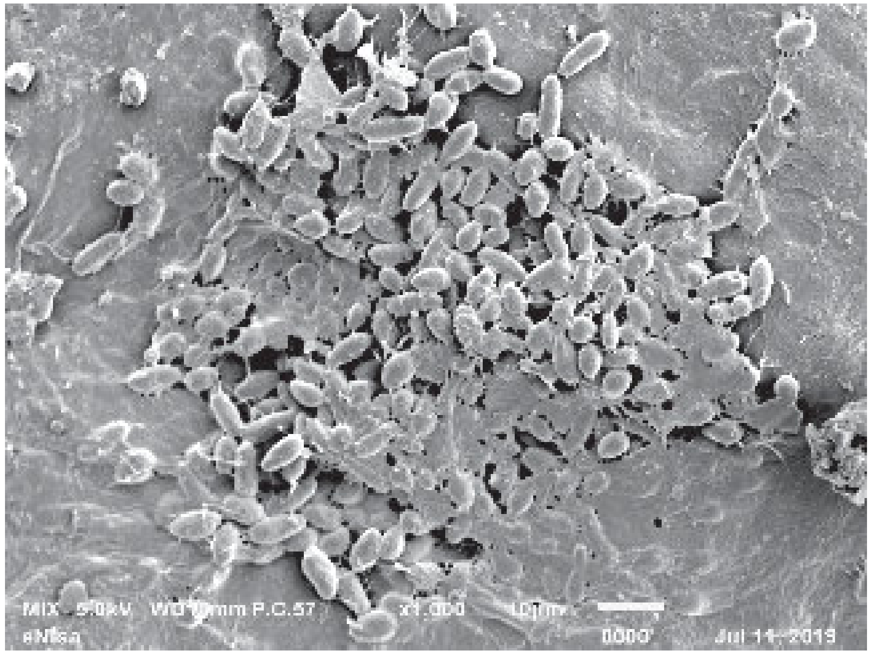


Image Left:

Electron Microscopy of SCOBY, image courtesy of NGO design studio thr34d5

To grow this microbial leather, a kombucha culture is placed in a glucose-based culture starter mix composed of sugared tea with vinegar for fermentation. The mother lives within the starter mix and, as a result of its metabolic processes, grows a gelatinous 'daughter' biofilm at the surface of the tea solution. In conditions highly conducive to growth, a keenly observant collaborator can perceive thin tendrils of cellulose assembling into rivulets from the depths of the liquid and arising to the surface in as little as 12 hours. The pellicle can grow and solidify to be 2-3cm thick in as little as 15 days with ideal environmental conditions. When the kombucha pellicle is ready to harvest, it is removed from the culture starter mix and laid flat or molded around an object to dry. Once dry, the pellicle can bear resemblances to thin paper, bioplastic, or leather and can be treated with waterproofing substances like beeswax, turpentine, coconut oil, and linseed oil to extend its longevity of usage. Depending on the type of waterproofing substance, the pellicles can be composted at the end of use.

You can grow it yourself. The process of steps varies across communities and several versions of recipes exist online. Two recipe variations can be seen in the following two figures:

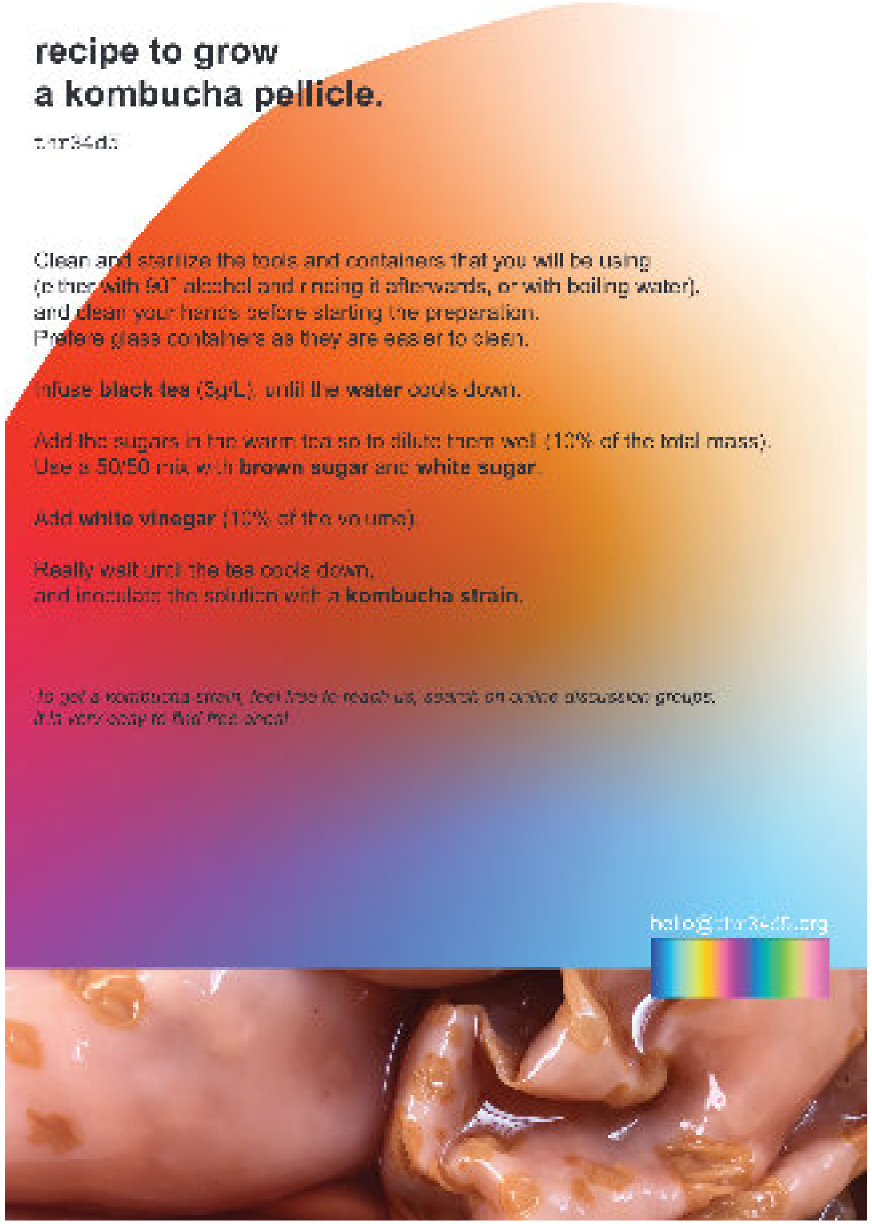


Figure 1, Left:
Recipe to Grow a Kombuca Pellicle, image courtesy of NGO design studio thr34d5

Figure 2, Right:

Healthy Materials Lab BioWorks Recipes HOW TO GROW KOMBUCHA “LEATHER” Potential Outcomes Current Material Challenges),im-ages from The New School Parsons Healthy Material Lab

Healthy Materials Lab BioWorks Recipes

HOW TO GROW

KOMBUCHA “LEATHER”

PREPTIME:30MINS+BOILING/COOLINGTIME
GROWTIME:3-4WEEKS
DRYTIME:1-2WEEKS
YIELD:1PIECE,5x7INCHES

This flexible bio-material alternative toleather is made from cellulose nanofibrils spun by bacteria and yeast. This material grows thicker over time and can become paper thin or leather like. This material can be treated like a traditional textile and dried into sheet form, or can be molded around a form during the drying process. This material has the potential to be an alternative to animal sourced textiles and their harmful environmental impacts.

INGREDIENTS

This recipe will produce enough for a 5"x7" container 2-3inches deep.

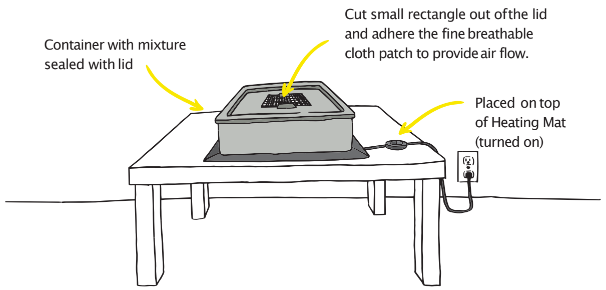
Multiplyrecipeforlargercontainers.

- 1Kombucha Culture
- 200Milliliters AppleCider Vinegar
- 200Grams GranulatedSugar
- 2BlackorGreen TeaBags
- 2LitersofWater

EQUIPMENT

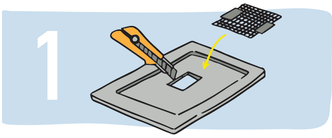
- 1PairRubber Gloves
- SprayBottleof RubbingAlcohol
- 1DuctTapeRoll
- 1SeedlingHeatMat (ideallycoversthe entirefootprintof container)
- 1Non-porous Container withLid
- 4”x4”(approx) TightlyWoven Breathable ClothPatch (MedicalGauze workswell)
- 1Woodenor AbsorbentBoard (fordryingleather)
- 1MeasuringCup

SETUP

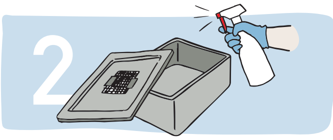


HOW TOGROW

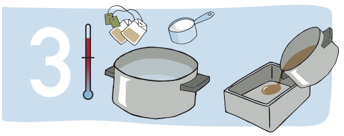
KOMBUCHA “LEATHER”



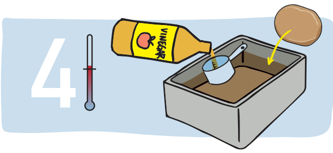
- **Cut a 3” x 3” hole in container lid.**
- **Adhere breathable clothpatch**with duct tape. (This is to let oxygenin, keep heat in, and keep insects out.)



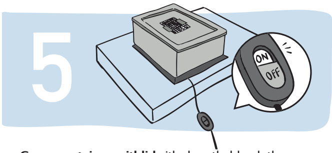
- **Sterilize container.** Rinse container with water. Spray 70% alcohol in the interior andlet air dry.
- **Place heatingmat under container.** (Do not turn mat on.)



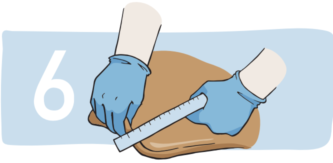
- **Make tea/sugarmixture.** Bring water to a boil. Remove from heat. Add tea bags and then remove after 15 minutes. Add sugar and dissolve.
- Pour liquidintosterilizedcontainer.



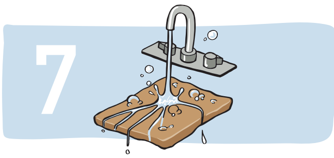
- **Let liquidcool** to room temperature (below 86° F)
- **Addorganic cider vinegar.**
- **Addlive Kombucha culture.** It will sink to the bottom of container. Fermentation begins after 48-72hours, thin skin andbubbles will appear andculture will rise tothe surface.



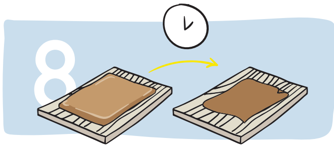
- **Cover container withlid**with breathable cloth, after combining ingredients.
- **Turn on heatingmat.**



- **Check weeklyunder lidwithsterilizedgloves** to make sure there is no contamination. (See Avoiding Contamination)
- In about 4weeks product will become about 1/2-3/4" thick. Remove sheet from container.



- **Washwithsoapywater.** Dish soap works well.



- **Laysheet out todryon a porous surface** like wood, wire mesh, felt, etc. Drying can take 1-2weeks.
- Experiment with drying into a 3D form bydraping around an absorptive mold.

BESTPRACTICES

Avoiding Contamination

- Spray the inside of the lid and container with 70% alcohol andlet air dry.
- Wear gloves andsterilize with alcohol when handling ingredients or interior of container.
- Breathe away from the container toprevent bacteria from entering.
- When handlingSCOBY, always wear gloves that have been cleanedwith alcohol.
- Fruit flies will be attractedtosugar andcould contaminate the experiment. Ensure airflow through fine mesh properly sealed around the growth container.
- SCOBYshouldnever come intocontact with metal (rulers, tongs, containers, etc) while in the process of growing.

Warning Signs…

- Pungent fermented, rotting, foul odors.
- Mold and bubblingdark splotches indicate contamination. (Time to start over)

EXPERIMENTAL FABRICATIONTECHNIQUES

During Growth

- Create holes in the sheet by adding objects in the container before growth. These objects should be taller than the surface of liquid.
- Submerge a tube of wet kombucha “leather” upright in kombucha culture liquidandnew material will grow around tube’s opening.

After Growth

- Drape wet pieces on top of each other, and theywill grow together while drying, instead of joining bysewing.
- Seal material with natural waterproofers toprolong biodegradation. **Material will easilyabsorbwater.**
- Dye like traditional textiles.
- Create texture on material by using texturedsurface for drying.
- Experiment with heat to expedite the drying process.
- Drape anddry over 3Dform. (Porous materials work best) The “leather” will remain in 3Dform after removal. The material has high water contentandwill moldif water cannot evaporate.
- The wet “leather” is heavy andwill needtobe held around 3Dforms where it would otherwise hang off. Use wire mesh, wire, or stringtosupport the material.

AN ABSENCE OF HISTORY, TRADITION, AND RITUAL

A.J. Brown first discovered bacterial cellulose in 1886 and the discovery has since been predominantly researched and applied across the food, biomedical, and commercial product industries, with the most notable applications in just the past four decades.[1] The biomedical field first recognized the potential of bacterial cellulose from Acetobacter in the early 1980s because bacterial cellulose contains intrinsic properties of high native purity, hydrophilicity, and biocompatibility, making it highly efficacious at dressing wounds.[2] As research on microbial cellulose expands, revealing remarkable properties like heat and radiation resistance, the potential applications stretch beyond its extensive biomedical uses and further into fashion and even space. A more commercial exemplar of application is the use of biofilm membranes in speakers and headphones due to the high sonic velocity and low dynamic loss of bacterial cellulose, the first of which was Sony's MDR-R10 stereo headphones in 1988.[3] However, the specific use of SCOBY as a textile derived from kombucha tea has a much shorter, murkier, and less industrial story. Before Suzanne Lee's breakthrough work with kombucha leather in 2003, there existed no previously acknowledged or recorded history of bacterial cellulose being used as a textile. Lee gave her influential TED talk "Grow Your Own Clothes" in 2011 and the nascent material's presence emerged in online DIY and open-source communities all around the world.[4] Shortly afterward, kombucha began piquing interest outside of DIY communities. In 2015, ESA conducted in-orbit exposure studies with kombucha-based bacterial cellulose, probing its potential as a nanomaterial for space technology.[5] Today, countless creators, scientists, and enthusiasts are growing and studying kombucha leather in their homes and biolabs all over the world.

As this bioassembled material has only been in use for one decade, it lacks solidified traditions and rituals in its culture. In this space of lack emerges the opportunity to actively create a foundation for the emerging culture of interspecies collaboration. Traditions are vital to social groups as they create cultural continuity in social customs and attitudes while prescribing the rituals of a given culture.[6] Rituals represent expressions of beliefs that integrate the dichotomies of thought and action, belief and behaviors, continuity and change, and the individual and the collective.[7] Accordingly, ritual serves to distinguish the sacred from the profane and is fundamental to both individual and collective identities.[8] Theorists reason that ritual can be a way of defining or describing humans as it is a particular mode of action that can be observed across all known human societies. Rituals contain the power and influence to bring people together and enhance social cohesion; and therefore, are considered important facets of society. On the topic of social impact, Émile Durkheim describes "collective effervescence" as the feeling of euphoria and togetherness experienced when people participate in rituals with a group that shares the same ideology.[9] Anthropologist, Dr. Dimitris Xygalatas and his team sought to quantify the phenomena of collective effervescence by conducting a study with a group of villagers in San Pedro Manrique, Spain that measured the physiological responses of people attending and participating in their annual firewalking ritual.[10] Xygalatas discovered synchronicity in the heart rates of people both attending and participating in the ritual, despite a lack of synchronization in their actions. This study demonstrates that the power of ritual and its relation to the collective may be witnessed extending outside the individual metaphysical and influencing the individuation of the collective materiality. If we continue to assume that the individuation of form arises from the synthesis of its relations, then we may begin to grasp the impact of ritual beyond human individuation. We thus arrive at the question of how interspecies collaboration may entail ritual as an act of coindividuation, or co-becoming, enacting the belief that the nonhuman possesses agency apart from the human. This concept will be further explored in the context of creating ritual with the living material, kombucha leather, as a way to acknowledge the agency of the microorganisms.

1
Takai, M., Tsuta, Y., & Watanabe, S. (1975). Biosynthesis of cellulose by acetobacter xylinum. I. Characterizations of bacterial cellulose. *Polymer Journal, 7*(2), 137–146.

2
Fontana, J.D., De Souza, A.M., Fontana, C.K. et al. (1990). Acetobacter cellulose pellicle as a temporary skin substitute. *Appl Biochem Biotechnol* 24, 253–264.

and

Portela, R., Leal, C. R., Almeida, P. L., & Sobral, R. G. (2019). Bacterial cellulose: A versatile biopolymer for wound dressing applications. *Microbial Biotechnology, 12*(4), 586–610.

3
M. Iguchi; S. Yamanaka; A. Budhiono (2000). *Bacterial cellulose—a masterpiece of nature's arts.* , *35*(2), 261–270.

4
Lee, S. (1304520180). *Grow your own clothes.* https://www.ted.com/talks/suzanne_lee_grow_your_own_clothes

5
Space Kombucha in the search for life and its origin. (n.d.). Retrieved 20 July 2021, from https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Research/Space_Kombucha_in_the_search_for_life_and_its_origin

6
Merriam-Webster. (n.d.). Tradition. In *Merriam-Webster.com dictionary.* Retrieved July 27, 2021, from https://www.merriam-webster.com/dictionary/tradition

7
Bell, C. M. (2009). *Ritual theory, ritual practice.* Oxford University Press.

Images Left:

First image on left, 'biocouture jacket' by Suzanne Lee, photos courtesy of The Science Museum London.

Second image, biocouture by Suzanne Lee, clothing made of kombucha leather. Photo by Biocouture.

8
Ritual. (n.d.). Encyclopedia Britannica. Retrieved 27 July 2021, from https://www.britannica.com/topic/ritual

9
Durkheim, É., Cosman, C., & Cladis, M. S. (2008). *The elementary forms of religious life.* Oxford University Press.

10
The Power of Ritual | Dimitris Xygalatas | TEDxAthens. (n.d.). Retrieved 27 July 2021, from https://www.youtube.com/watch?v=Irj-CLvSQ_cw

and

Konvalinka, I., Xygalatas, D., Bulbulia, J., Schjodt, U., Jegindo, E.-M., Wallot, S., Van Orden, G., & Roepstorff, A. (2011). Synchronized arousal between performers and related spectators in a fire-walking ritual. *Proceedings of the National Academy of Sciences, 108*(20), 8514–8519.

AN EXTRAORDINARY COLLABORATOR

Though these organisms are small, they create macro impact through more than their materiality. The budding culture behind this living material transmits itself through sharing and resonates through community. People typically receive their first SCOBY mother from a friend or acquaintance in immediate physical proximity. Within this locality, tendrils of collaboration, support, resource, and knowledge sharing cultivate to connect individuals and form communities. With this interspecies collaboration, the human macro mirrors the bacterial micro. Not only do these marvelous organisms offer promising positive environmental impacts as a material, but they also offer positive social impacts with the active creation of regenerative tradition and culture within autonomous communities at local and global scales. The moment to shift perceptions on what a material is, who makes it, and how we treat it is now and with this living material.

Some of the most compelling reasons to work with kombucha embody the very reasons someone in a mindset of industrial production methods would steer clear from it. This living material is gross; it smells; it is alien; it requires patience; it is inconvenient; it is unstable in its genetic composition, and it mutates often. The general response to these characteristics is twofold - advantageous to some and disadvantageous to others. However, disgust is subjective and influenced by social constructs, and thus, as Adrien Rigobello and Nadja Gaudillière-Jami confer, designing with the gross is a political act of social inclusion, one that includes and considers the other, the ostracized, the nonhuman.[1] Rigobello and Gaudillière-Jami emphasize the significance of designing with this living material in the context of interspecies collaboration:

"One thing that is learnt from experimenting with biological companions in a spirit of inclusiveness is the respect of its agenda. There is a necessary discussion with the material. Kombucha does not do what we want, it rather agrees to collaborate with us. Kombucha is ours as long as we are theirs. Hence, there is a necessary indeterminacy in the craft practice that is developed. As opposed to a modernist way of "French gardening" the material, liquid design practice aims at leaving space for both the micro-organisms in presence and the social context to express themselves, "English gardening" style."

1 Rigobello, A., & Gaudillière-Jami, N. (2021). Designing the Gross. In search for social inclusion. *Conference: Cumulus: Design Culture(s) At: Rome.* (text courtesy of the authors)

Providing space for the microorganisms to express themselves synonymously means holding space for their subjective grossness. One might hold space for this living material by mindfully observing that which makes it gross. The grossness of kombucha fascinates and appalls, eliciting a sense of disgust and engaging all five senses in its alienness. Kombucha emits a strangely sweet and acidic fermented tea and vinegar odor, which can be a polarizing smell. It evokes the sense of taste because it is grown in a beverage and can be eaten; people make candy and even jerky out of it. Sound is induced through bubbles forming and popping during fermentation and the wet noise of its squishy pellicle being handled. Sight and touch are engaged with the process of drying the gelatinous fleshy wet pellicle into its gummy sticky mid-stage and finally to its smooth and soft form once dried. Furthermore, its resemblance to human flesh and organs inspires anthropopathic reactions of disgust and fascination.

Image Left:

SCOBY, photo courtesy of NGO design studio thr34d5

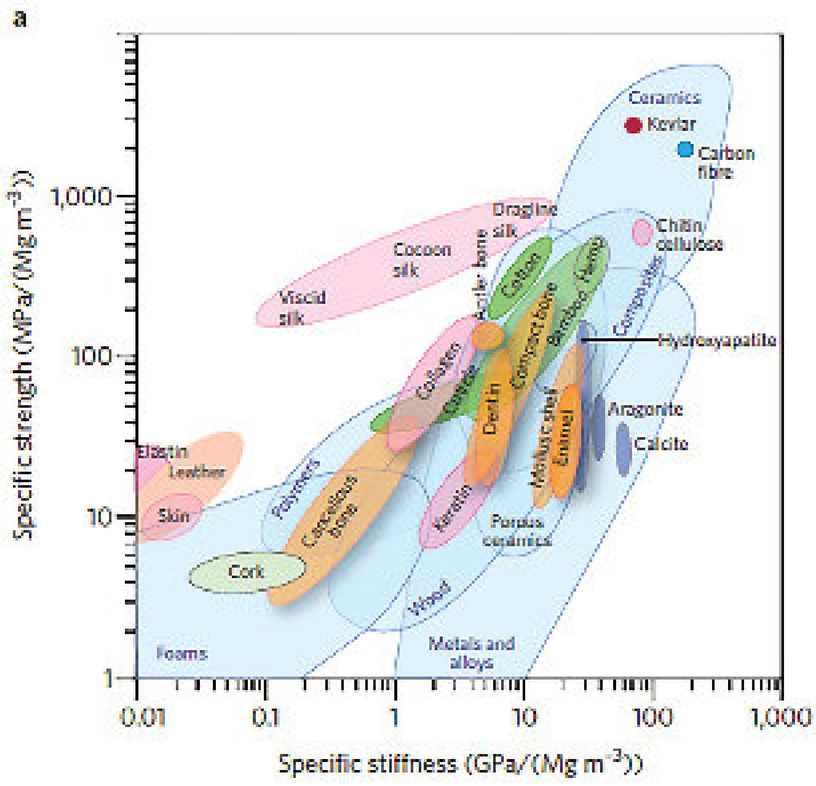


Image Right:

Ashby plots for natural and synthetic materials: specific properties normalized by density. Reproduced from *Nature Materials*, Ref. 2, Springer Nature.

Aside from these abnormal and unexpected qualitative reasons to collaborate with kombucha, there also arise quantitative and more conventional reasons to work with this living material. Consider the environmental impacts and material properties of this natural and renewable polymer: A life cycle assessment performed by Dr. Theanne Schiros of Columbia University and FIT based on a waste-to-resource process of growing kombucha leather, such as using SCOBY by-product from a kombucha tea brewery, demonstrates that the "biofabrication process has a 100-1,000 times lower human toxicity impact than chrome-tanned leather" and a carbon footprint 88-97% smaller than synthetic leather alternatives.[2] Evaluation of bacterial cellulose material properties reveals that a finished kombucha pellicle exhibits high elasticity and tensile strength, with a Young's modulus value of 15-35 GPa and tensile strength value of 200-300 MPa.[3] When compared to traditional animal leather's Young's modulus value of 0.1-0.5 GPa and tensile strength value of 8-35 MPa, kombucha leather's empirical material properties highlight its potential applications as a replacement for traditional animal leather.

And finally, a reflection on the culture and history of kombucha leather - or as previously mentioned, its lack thereof - illuminates the opportunity to actively create a regenerative culture behind the emergent material. Compared to the weighted histories and cultures surrounding ubiquitous materials of today, kombucha leather embodies a living tabula rasa. Cotton for example, which ushers a long thread through human history dating back to the Holocene, carries the global bloody burdens of slavery, imperial trade routes, ruthless capitalism, civil war, and violent industrialization in every fiber of its stitching. The cotton we wear today exists in part through the exploitation, oppression, and murder of people and other living beings all around the world. Cotton's problematic history also possesses negative environmental impacts as a monoculture crop requiring high-intensity water usage and petroleum-produced insecticides. With hindsight in full view, we can now acknowledge the necessity for the mindful creation of new cultures behind new materials so that the history we beget is one of regeneration rather than one of destruction. Kombucha's uncanny grossness, positive environmental impact, competitive material properties, and potential as a conduit for cultural renewal make it an extraordinary collaborator in the creation of interspecies tools for the future of materials.

2
One x one. (n.d.). Retrieved 19 July 2021, from https://onexone.earth/public-school-theanne-schiros

and

Suzuki, E. (2021, January 6). Public school ny's new "bio-leather" sneakers are brewed like kombucha. *MOLD :: Designing the Future of Food.*

3
adrienrigobello. (2019, August 20). *Karp. Thr34d5.* https://thr34d5.org/2019/08/20/karp/

Image Left:

Weighing cotton in Virginia, United States circa 1905. Detroit Publishing Co. via Library of Congress

"One merges into another, groups melt into ecological groups until the time when what we know as life meets and enters what we think of as non-life: barnacle and rock, rock and earth, earth and tree, tree and rain and air... And it is a strange thing that most of the feeling we call religious, most of the mystical outcrying which is one of the most prized and used and desired reactions of our species, is really the understanding and the attempt to say that man is related to the whole thing, related inextricably to all reality, known and unknowable."

- John Steinbeck and Edward F. Ricketts, *Sea of Cortez*

"The birds have vanished down the sky.
Now the last cloud drains away.

We sit together, the mountain and me,
until only the mountain remains."

- Li Bai

PART III

{the possibility / the future of materials}

INTERSPECIES TOOLS AND CARE

The pathway to creating interspecies tools may be paved with good intentions, but let us not forget what the enduring aphorism says about the road to hell. The creation of interspecies tools maintains the potential to be problematic despite good intentions. For example, a bioassembled material may be made in collaboration with another organism, but once the initial creation is completed, the human hand may continue to act without the input of the collaborating organism, as we have seen in the Silk Pavilion. As highlighted with the biomimetic approach of Janine Benyus and the material ecology approach of Neri Oxman, the issues surrounding bioassembly and bioassistance are nuanced. Human desire for material performance, durability, and aesthetics can require just as much, if not more, post-processing techniques for biomaterials than conventional materials. Collaboration with another organism that cannot directly communicate to us its thoughts and desires implies that collaborating humans must create space to listen to and to understand the other. However, it is difficult to communicate with nonhumans as long as we are human. In our human ways, we find channels to try to understand what organisms are communicating despite our true lack of knowing. We decide to listen to specific channels, are exposed to certain channels, and are trained to listen to other channels. We can never be sure that these channels are valid in their interpretation of the nonhuman because the work of interpretation is inherently subjective. Bruno Latour's choice of channel relies on the interpretations of scientists who utilize scientific observation to understand the nonhuman.[1] In comparison, Vinciane Despret relies on interpretations by people as well, but listens to both scientists and amateurs.[2] For example, Despret discusses ways in which amateur bird watchers acknowledge information as signs that can be interpreted as communication that would typically be overlooked by ornithologists. Through personal empirical and scientific observation of kombucha, we may tap into both communication channels that Despret discusses.

It would be hasty to assume that a material produced by "nature" is inherently good.[3] This brings us to wonder how we grapple with our need to use these types of materials alongside the issues of potential abuse. The exploitation of plant cellulose poses an interesting study for this question. Wood is a biomaterial composed of plant cellulose that humans have utilized since early civilization. We have started our fires, carved our ax handles, supplied our cornucopias, mixed our medicines, and built our houses with trees for thousands of years. Apart from their essential human uses, trees are living organisms that play a crucial role in the individuation of Earth's ecosystems. Through their relations with their environment, trees supply oxygen, improve air quality, preserve soil, and provide shelter. In ecosystems, trees remain keystone species even after they die, the remnants of their bodies providing homes for a multitude of insects, rodents, and birds. However, human overconsumption enforces deforestation, cutting tree relations, and threatening homeostasis within the environment. And though wood is provided by "nature," our extraction methods and post-processing techniques of wood can leave devastating impacts. The insidious tagline, "provided by nature" paints itself in red letters when we look back to the marketing intent of viscose, a plant cellulose material with devastating impacts. So, how can we confront the probable exploitation of bioassembled materials in light of human propensities? Here, we can turn to an answer of care.

1
Latour, B. (1988). *The pasteurization of France.* Harvard University Press.

2
Despret, V. (2019). *Habiter en oiseau.* Actes sud.

3
Descola, P., & Lloyd, J. (2013). *Beyond nature and culture.* The University of Chicago Press.

Image Left:

SCOBY, photo courtesy of NGO design studio thr34d5

Sandro Katz, author of *Fermentation as Metaphor*, postulates that fermentation is an act of activism in the way that it forces people to become active participants in their food production as opposed to being passive consumers.[4] Though Katz presents this idea concerning the system of mass food production, it can be paralleled to the systems of mass material and object production. One person growing their own kombucha leather pellicle and consciously participating in interspecies collaboration through fermentation may not radically change the systems of material production, but it is a small step to subverting the paradigm at large. In a conversation between Donna Haraway and Drew Endy for the Journal of Design and Science, Haraway ponders “What kind of growing of the reciprocity of care do people like you and I participate in as a resistance to the ongoing extractivism?”[5] Endy responds that resistance is not enough and it is how we transcend resistance with opportunity that is more important. Haraway proposes that care is the answer to this question and that using our skill sets to enhance caring for others can open up opportunities that do not contribute to more capitalist growth. In contribution to this conversation, I propose that a conscious interspecies collaboration through fermentation represents an unequivocal practice of care for resistance opportunism. The idea of fermentation as care is an accessible means of addressing the ongoing extractivism of capitalism, commodity consumerism, and militarism. As Johnny Drain in his essay *Fermentation As Care* for Mold Magazine states, “fermentation is an act of delicately balanced cooperation and care that results in profound reciprocal benefits. When we ferment, we build and design systems that center care-giving as a practise.”[6] Drain goes on further to say:

> *“Fermentation encourages us to consider the needs of others. Essentially, it’s about hospitality. Just as a restaurant ensures you are comfortable, warm and dry, so the act of fermentation is to offer hospitality and restorative nourishment to a set of microbes. We are restaurateurs of the small, maître d’s of the micro, going to great lengths to ensure our clientele, the microbes, have what they need to be happy: something to feast on, something to drink, somewhere that their competitors might not trouble them. Whether we keep a SCOBY as a pet or to make kombucha at home, or we make kilos of sauerkraut in a restaurant, or we brew and distill industrial volumes of whisky, we are forced to practise the art of care-giving and cooperation.”*

In this sense, repeated acts of care can be a response to mitigate exploitation. When care is repeated, it leads to ritual. Symmetrically, when ritual is repeated it engenders care.

4
Drain, J. (2020, October 27). Sandor Katz on interspecies collaboration and reclaiming food through fermentation. *MOLD :: Designing the Future of Food.*

see also,

Katz, S. E. (2020). *Fermentation as metaphor.* Chelsea Green Publishing.

5
Haraway, D., & Endy, D. (2019). Tools for multispecies futures. *Journal of Design and Science.*

6
Drain, J. (2021, March 23). Fermentation as care. *MOLD :: Designing the Future of Food.* https://thisismold.com/mold-magazine/fermentation-as-care

INTERSPECIES COLLABORATION:
RITUALS, REVERENCE, LOOKING TO THE OTHER

As previously stated, ritual aims to distinguish the sacred from the profane. It exhibits care in contexts of revering some things over others, embodying reverence for the sacred. Thus, rituals can be viewed as acts of care. Seeking perspectives outside of the western lens, we can turn to Indigineous practices for insight and guidance on ways of incorporating care into daily lifestyles. Māoritanga, the customs, culture, and philosophy of the Indigenous Māori people of New Zealand, incorporates ritualistic care for what is revered and flows from the vein of animist acknowledgement that the nonhuman have power and a role to play in the way the world works. Māori people have many rituals that separate tapu (sacred) from noa (non-sacred). A foundation of their culture is the belief that any person or object can possess mana, an authority, power, or energy, and should be respected as tapu. This foundational belief is exemplified in New Zealand environmental law which has designated legal personhood to three geographic entities in the country. Māoritanga cultivates relationship with the nonhuman and carries traditions of performing customs of respect with the "other," one of which is reflected in the mythology of Rātā:

"Rātā went into the forest, cut down a tree, and began to carve it into a canoe. When he returned the next day to continue his task, the tree was miraculously standing in its original position. He felled it again and set to work, but the same thing happened the following day, and the next. Finally, Rātā hid behind a bush and saw the hakuturi (forest guardians in the form of birds, insects and other life) replanting the tree. When he confronted them, they told him he had failed to perform the appropriate rites. He then did so, and the hakuturi released the tree." [1]

1 Taonga, N. Z. M. for C. and H. T. M. (n.d.). *Māori relationship with the forest* [Web page]. Retrieved 28 July 2021, from https://teara.govt.nz/en/te-ngahere-forest-lore/page-1

This story emphasizes Māori acknowledgement of the agency of the nonhuman. Rātā was only permitted to carry out his desire to make a canoe once he had given his respect to the forest. From a personal experience walking through a forest near Kaikōura with members of the Ngāi Tahu iwi (tribe), a quotidian act of respect of Māoritanga is the intentional care to avoid stepping on the roots of a tree. For the Māori people, trees are considered to possess mana, and so, this ritual is a sign of respect to mana. The commonplace ritual of purposefully choosing to step around tree roots is a simple example of the way acknowledging agency of the nonhuman in repeated acts of care is not so far-fetched. Ritualistic care is already incorporated into contemporary lifestyles and our relationships with materials. Many habits or routines can also be considered rituals. We can draw comparisons to our ritualistic behaviors with mobile phones. Every night when we go to sleep we plug our phone into its charger so that as we recharge our proverbial batteries, so too does the object with which we connect ourselves to the world. In the morning, we awaken in synchronicity with our phone, considering the likelihood that it is our phone prompting the end of slumber with an alarm and ushering us into the new day. This repeated act of care maintains the acknowledgment of the phone possessing importance beyond its physicality. Some people have even taken to anthropomorphising their phone by tucking it into a bed specifically designed for the shape of a phone.[2] Ceramicist Rachel Saunders created the Phone Home as an intentional ritualistic object in pursuit of conscious rhythms with our devices. The Phone Home offers a ritual of rest from our phone, giving it a designated place, establishing physical boundaries with technology, and encouraging us to develop a mindful relationship with it. Maintaining this prosaic ritual is simple for the individual; yet, it is impactful for both the individual and the community of people who share their experiences with this intentional practice, leaving room to contemplate what type of ritualistic care may be incorporated into interspecies collaboration.

2 Arianna Huffington invented the Phone Bed with her company, Thrive Global.

Image Left:

Māori traditional wood sculpture, Pouwhenua, Kaikōura Peninsula Walkway, New Zealand

Image Right:

The Phone Home in Spa Onyx, created by ceramicist Rachel Saunders, photo by Rachel Saunders

Image Right, facing page:
The Phone Home in Eggshell, created by ceramicist Rachel Saunders, photo by Rachel Saunders

MEDITATING WITH KOMBUCHA

Let us return to the question of how interspecies collaboration may entail ritual as an act of coindividuation, or co-becoming, enacting the belief that the nonhuman possesses agency apart from the human. Acknowledgment of agency illuminates a pathway toward ritual. Inversely, creating ritual with kombucha can be a way to acknowledge the agency of the microorganisms that form the pellicle during interspecies collaboration. Rigobello and Gaudillière-Jami acknowledge the agency of kombucha by elucidating the anthropopathic reaction to the living material's form:

"This proximity to human anatomy can even lead to one not hesitating to confer life to the pellicle. This mechanism reminds of animism and ways to confer a sacred status to non-humans, or life. The friction stemming from the awareness of the possibilities of eating and drinking the resulting liquid and pellicle and of this organic aspect results in the notion of ingesting the other, a feeling of a major transgression of moral boundaries. A path exists on which we could embody the SCOBY, transgress the moral rules to become one." [1]

1 Rigobello, A., & Gaudillière-Jami, N. (2021).

Maintaining reverence and care for kombucha leads to development of ritual. Concurrently, assuming that the individuation of form arises from the synthesis of its relations leads us to consider the impact of ritual beyond human individuation. The intentional act of developing a mindful relationship with kombucha contributes to the individuation of its form. In addition, a repetition of the act that develops this relationship and acknowledges the agency of kombucha thus becomes a ritual. It is important to note that a ritual for interspecies collaboration must not impose human needs or desires on the organisms with which we collaborate, otherwise it will lose the intention of being collaborative. Additionally, a ritual appears at both individual and collective levels, bringing people together and connecting them within a community; and so, a ritual for interspecies collaboration would also incorporate a collective enactment. These ideas culminate into the conclusion of mindfulness meditation.[2] Meditation is a formal exercise to cultivate compassion and awareness. There are different types of meditation that are intended for awareness of the self and awareness of others. Meditation aims to integrate the qualities of care, empathy, and mindfulness into our daily lives. The practice of meditation acknowledges the agency of these attributes, or virtues, and sanctifies them through ritualistic behavior. With these characteristics, meditation engenders a ritual for interspecies collaboration that is humble, aware, non-exploitative, reciprocal, and logistically feasible. Surprisingly, this conclusion is shared with others. Johnny Drain connects the links between fermentation and meditation in the same manner:

2 There are many resources for understanding the ritual of mindfulness meditation. A concise and relatable place to start is with John Kabat-Zinn.

Kabat-Zinn, J. (2005). *Wherever you go, there you are: Mindfulness meditation in everyday life.* Hyperion.

"Fermentation is an intentional act of care. In contrast to other ways in which we cook food, fermentative processes, languorous, silent and stretching from days to years, are often perceived as being passive and undynamic. With little in the way of theatrics and drama, I think of fermentation as the culinary equivalent of mindfulness meditation. And as with meditation, at its core lies agency, decision and intention. Microbes have needs and the first step of any ferment is, paraphrasing John F. Kennedy, to ask not what your microbes can do for you but what you can do for your microbes." [3]

3 Drain, J. (2021, March 23).

In this way, meditation in interspecies collaboration is an act of care. One of the key facets of meditation, developing empathy for others, encourages us to develop a reflex to try to understand the microorganisms forming the pellicle. Though we will never truly understand what kombucha may want to be, meditation can be a daily act with kombucha, to hold space for the microorganisms, to consciously honor them, and to listen to them. Simultaneously, this ritual brings awareness to the agency of the self and the agency of the other. The intention of this daily meditation is an active listening and an active becoming with the SCOBY, to make time and create space for the microorganisms and to give gratitude for their life and materiality. This ritual practice also incorporates a group dimension in the form of a community and ceremony that connects the individual to the collective. The community around kombucha teaches people how to collaborate with kombucha by providing for, creating with, meditating with, consuming, observing, and honoring kombucha. To honor the life and agency of kombucha, the collective participates in seasonal tea ceremonies that serve multiple purposes of group experience, acknowledgment of the nonhuman, and food offerings for the next generation of kombucha.

These rituals propose an alternate reality in which we act in ways to consciously coindividuate with the other, allowing space for agency and empathy. New regenerative futures will be cultivated when our material rituals with interspecies tools embody care through acknowledgment of and collaboration with the other.

Now, I invite you to experience a guided meditation in active interspecies collaboration with kombucha.

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ANNEX OF EXPLORATIONS AND EXPERIMENTS

I. thr34d5 Exploration, October 2020 - April 2021

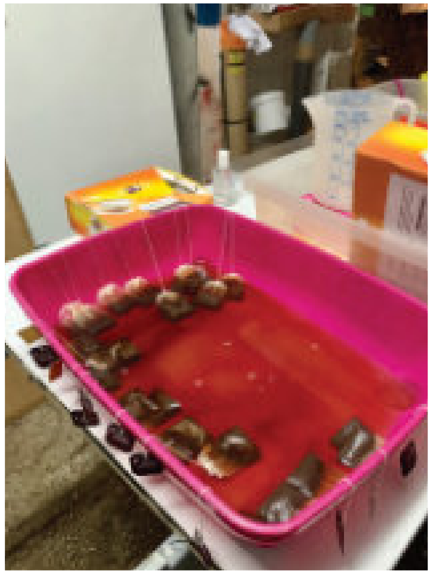
Initial learning phase about kombucha was conducted in collaboration with NGO design studio thr34d5. At their modest biolab in Paris, I was able to interact with the colonies of microorganisms at a scale that was unfamiliar to me. Through thr34d5, I began to learn about SCOBY, prepare space for experimentation, make culture liquid, dry pellicles, make kombucha candy, and waterproof kombucha leather.

Image Right:

Four batches of kombucha starter mix and a view of the pellicles forming on the surface of the liquid.

Image Right:

The thr34d5 library of SCOBY strains: jars of "mothers" in "SCOBY hotels".



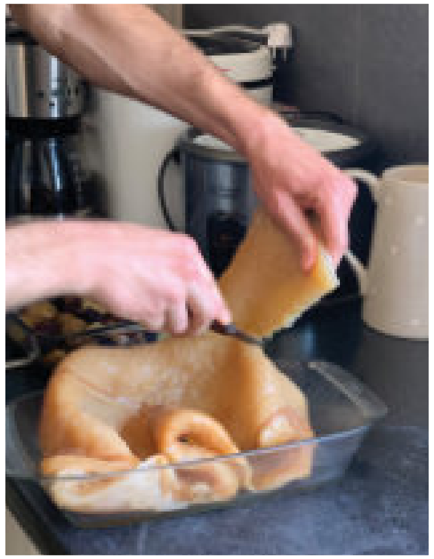
Images Left:

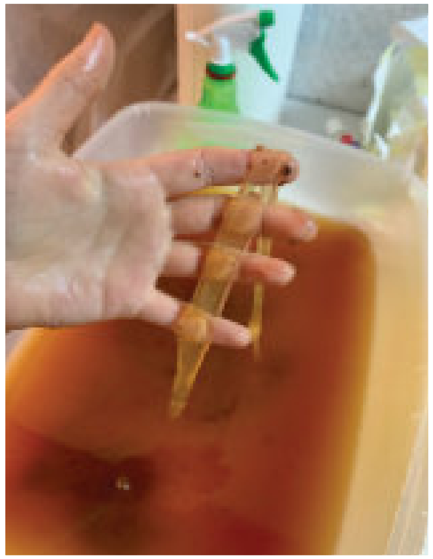
First image on left, a dried pellicle labeled and vacuum sealed for preservation.

Second image, the preparation of a new batch of kombucha.

Images Left:

Waterproofing and labeling dried kombucha pellicles.





Images Left:

First image on left, cutting a kombucha pellicle to prepare it for making candy.

Second image, holding the gelatinous begining formation of SCOBY.

Image Right:

Holding a dried and waterproofed kombucha pellicle.

Images Right:

First image right, waterproofing kombucha pellicles.

Second image, kombucha fruit leather candy prepped to dry.

Image Right:

Carmelized kombucha pellicle candy on a tray.

II. Atelier Sumbiosis Exploration, February 2021 - May 2021

Through an internship with Tony Jouanneau’s studio, Atelier Sumbiosis, I deepend my exploration of kombucha, learning proper lab protocols, discovering recipe variations to achieve different materiality results, and experimenting with color and discarded fabric additives to explore the potential for biocomposites.

Image Left:

Four batches of kombucha starter mix in glass jars.

Image Left:

Four batches of kombucha starter mix in glass jars, photo by Tony Jouanneau.

Images Right:

First image right, removing a kombucha pellicle from a starter mix with spirulina, photo by Tony Jouanneau.

Second image, placing pellicles in petri dishes to dry, photo by Tony Jouanneau.

Images Right:

First image right, four batches of kombucha starter mix in glass jars

Second image, removing a kombucha pellicle from a starter mix with silk threads, photo by Tony Jouanneau.

Images Right:

First image right, three biocomposite kombucha pellicles drying in petri dishes with textile additives, photo by Tony Jouanneau.

Second image, a jar of kombucha starter mix with added spirulina, photo by Tony Jouanneau.

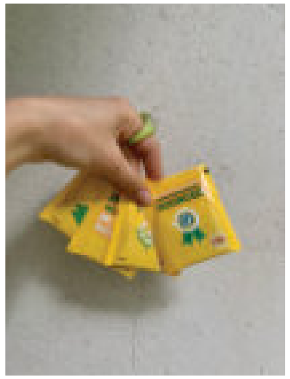
III. The Experiments, April 2021 - Present

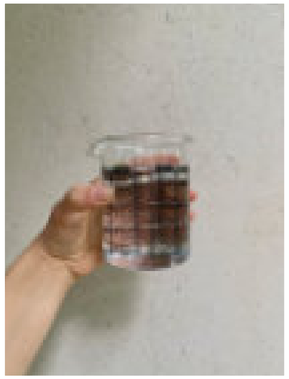
Materials:

Tape
Scale
Pen/marker
Water boiler
Paper towels
Rubber-bands
Wooden spoons
Measuring cups
Pressure cooker
1 pair of gloves (optional)
Autoclave sterilization bags
White vinegar or rubbing alcohol for sanitation
Non-porous glass or plastic containers with lids
Non-woven fabric cut to the size of the containers
Wooden board and/or plastic container (for drying leather)

Kombucha Ingredients:

Tea, sugar, water, SCOBY, vinegar, and kombucha tea (optional).





Images Left:

In clockwise order from top left, tea, sugar, kombucha drink, vinegar, and SCOBY

Batch #1
4.4.2021

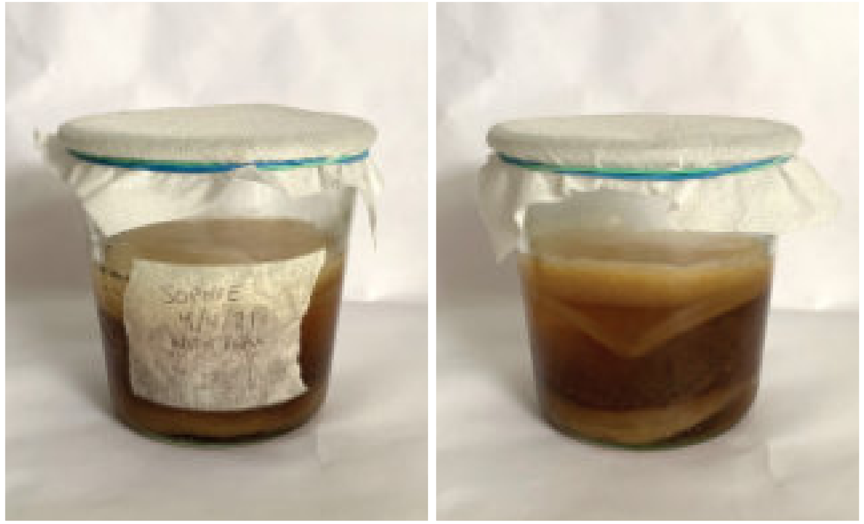
Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Sophie with Flax linen piece
Completion: 16.5.2021
Strain: Sophie
Recipient: fermentation jar

Mix:
220 mL Culture Liquid (60/40 ratio)
Flax linen (full piece cut into circular shape and placed in jar)
1 full mother - Sophie

Observations:
Environment too cold for growth, very slow to grow, pellicle formed above the textile piece as the textile was too heavy to float at the top of the liquid, bacteria went through the layer of the textile to reach the top of the liquid, very smooth homogeneous pellicle



Images Right:

Batch #1 in a jar.

Image Left:

Batch #1 dried.

Batch #2.1
15.4.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Sophie Daughter
Completion: 16.5.2021
Strain: Sophie
Recipient: fermentation jar

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Sophie Daughter

Observations:
Environment too cold for growth, very slow to grow, but thick and consistent pellicle before and after drying.

Images Right:

Batch #2.1 in a jar.

Image Right:

Batch #2.1 dried.

Batch #2.2
15.4.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Sophie Daughter with flax threads
Completion: 16.5.2021
Strain: Sophie
Recipient: fermentation jar

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Sophie Daughter
Flax threads

Observations:
Environment too cold for growth, very slow to grow, the threads were too heavy and sank below the surface of the liquid, nice homogenous pellicle otherwise

Images Left:

Batch #2.2 in a jar.

Image Left:

Batch #2.2 dried.

Batch #2.3
15.4.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Huile d’Olive with green silk threads
Completion: 16.5.2021
Strain: Huile d’Olive
Recipient: fermentation jar

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - huile d’olive
silk threads

Observations:
Environment too cold for growth, very slow to grow, the mother floated to the surface and attached to the threads and then brought them below the liquid when she sank back to the bottom, very beautiful homogenous pellicle before drying. It became less homogenous during the drying process.

Image Right:

Batch #2.3 dried.

Batch #3.1
16.5.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Sophie Daughter Dreaming
Completion: 11.6.2021
Strain: Sophie
Recipient: fermentation jar (placed in insulated box)

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Sophie Daughter
paper
thread
ink

Observations:
Environment very conducive to growth (signs of pellicle growth after a few days), the threads taped to the outside of the jar allowed the sewn paper to rest on the surface of the liquid, the pellicle formed around the paper. Beautiful and soft pellicle both wet and dried.

Images Left:

Batch #3.1 in a jar.

Images Right:

Batch #3.1 before and after drying.

Batch #3.2
16.5.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Sophie Trans-Species
Completion: 11.6.2021
Strain: Sophie
Recipient: fermentation jar (placed in insulated box)

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Sophie
silk
thread
sharpie marker ink

Observations:
Environment very conducive to growth (signs of pellicle growth after a few days), the pellicle formed around the silk as the thread was sewn into the textile and then taped outside of the jar. The marker writing washed away in the liquid mix but left some residue on the silk and pellicle after drying. Thick strong pellicle with light undulations over the silk. The pellicle took the texture of the silk once dried.

Images Left:

Batch #3.2 in a jar.

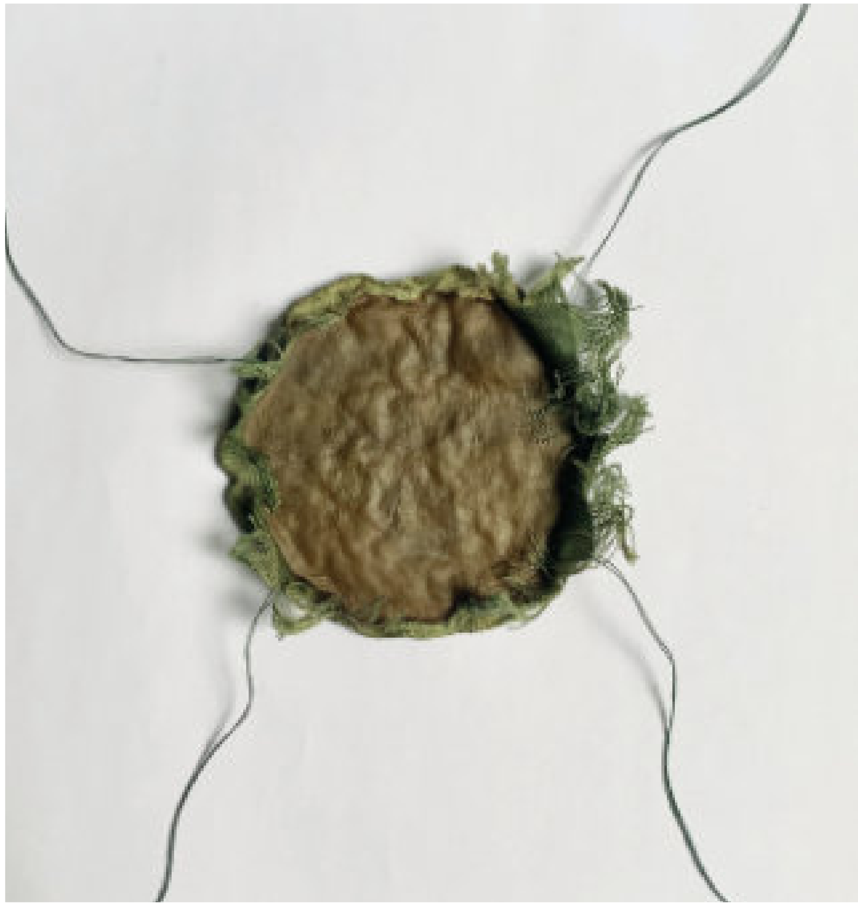


Image Left:

Batch #3.2 dried.

Batch #3.3
16.5.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Vivien Lace
Completion: 11.6.2021
Strain: Viven
Recipient: fermentation jar (placed in insulated box)

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Vivien
spandex/nylon lace

Observations:
Environment very conducive to growth (signs of pellicle growth after a few days), the taped lace on the outside of the jar allowed for the pellicle to grow around the textile on the surface of the liquid. The kombucha took the texture of the lace once dried.

Images Right:

Batch #3.3 in a jar and then dried.

Batch #3.4
16.5.2021

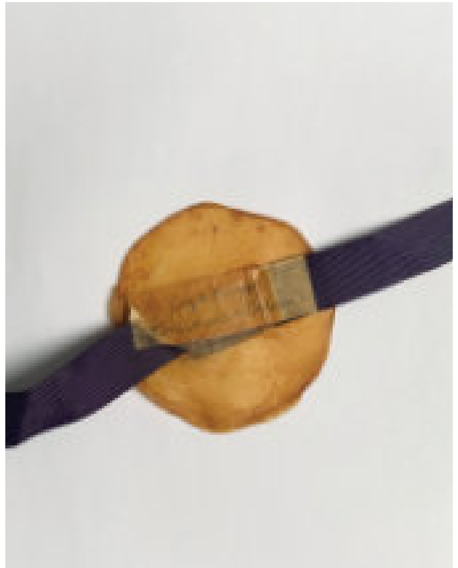
Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Sophie Daughter Techno
Completion: 11.6.2021
Strain: Sophie
Recipient: fermentation jar (placed in insulated box)

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Sophie Daughter
ribbon
paper
ink

Observations:
Environment very conducive to growth (signs of pellicle growth after a few days), the pellicle grew around the paper and ribbon as the ribbon was taped to the jar to rest on the surface of the liquid. Very smooth pellicle both before an after drying.



Images Left:

Batch #3.4 in a jar and then dried.

Batch #3.5
16.5.2021

Protocol:
220 ml Culture Liquid (60/40 ratio) (per small jar)
60% = 132 ml kombucha tea
40% = 88 ml liquid starter

Liquid Starter Mix:
40 cL water
1 sachet tea
40g sugar
4 cL vinegar

Name: Vivien Sock
Completion: 11.6.2021
Strain: Vivien
Recipient: fermentation jar (placed in insulated box)

Mix:
220 mL Culture Liquid (60/40 ratio)
1 full mother - Vivien
sock
paper
thread
ink

Observations:
Environment very conducive to growth (signs of pellicle growth after a few days), the pellicle grew around the paper and sock as the threads were sewn into them and then taped to the jar to rest on the surface of the liquid. Very inhomogenous pellicle before and after drying.

Images Right:

Batch #3.5 in a jar and then dried.

Batch #4
9.6.2021

Protocol:
615 cL Culture Liquid (25/75 ratio due to money and time constraints)
25% = 150 cL kombucha tea
75% = 465 cL liquid starter

Liquid Starter Mix:
400 cL water
6 g tea (4 tea bags)
400 g sugar
40 cL apple cider vinegar
25 cL starter liquid from previous SCOBY culture
150 cL kombucha tea

Name: Sophie Cup
Completion: 8.7.2021
Strain: Sophie
Recipient: 20 L plastic box

Observations:
I made an excess of liquid starter on accident, overestimating the size of the container. Extremely fast growth with noticeable filaments rising to the surface within the first 12 hours after mixture was created. I added kombucha tea the following day after first placing the liquid starter in the container and the addition of kombucha tea disrupted the initial SCOBY growth, pushing the first layer below the surface of the liquid. Massive bubbles formed under the pellicle and deformed it. Bubbles formed and popped often and were very audible.

The pellicle should have been harvested to dry much sooner than it was. The SCOBY was very thick, very heavy, and inhomogeneous. It was placed on a metal tray which interacted with the acidity of the SCOBY and turned it black throughout the drying process. To quicken the drying process, it was placed in an oven for one day on very low heat. The thinner edges burnt. This batch was originally meant to be used to form kombucha tea cups, but the pellicle did not seem usable for this at the time. The dried pellicle is very dark, nearly black, very rough and wrinkled, with inconsistencies in its thickness and texture.

Image Right:

Batch #4 on a metal tray before drying.

Image Right:

Batch #4 after drying.

Batch #5
8.7.2021

Protocol:
361 cL Culture Liquid (38/62 ratio due to money and time constraints)
38% = 135 cL kombucha tea
62% = 226 cL liquid starter

Liquid Starter Mix:
200 cL water
3 g tea (2 tea bags)
200 g sugar
20 cL apple cider vinegar
6 cL starter liquid from previous SCOBY culture
135 cL kombucha tea

Name: Sophie Cup Chanel #5
Completion: 20.7.2021
Strain: Sophie
Recipient: 20 L plastic box

Observations:
Extremely fast growth with noticeable filaments rising to the surface within the first 12 hours after mixture was created. Large bubbles formed under the pellicle and deformed the pellicle. Again, the bubbles forming and popping were very audible. Once harvested, the SCOBY was very thick and heavy and more homogenous than the previous batch. It also had many bubbles between each layer of SCOBY. It could have been harvested earlier for the purpose of molding it around a cup. I set it out to dry for one day then placed it in a blender to create a homogenous consitency. I then molded the SCOBY like clay around a cup. Once dried, the pellicle became very soft and homogenous, delicate and transparent. Removing the dried pellicle from the mold was somewhat difficult as the SCOBY bonded with the plastic and ripped during removal.

Images Right:

Batch #5 in its starter mix, then on a tray to begin the drying process.

Image Right:

Batch #5 blended and molded around a teacup to dry.

Images Right:

Batch #5, dried as a kombucha tea cup.

Batch #6
20.7.2021

Protocol:
360 cL Culture Liquid (6/94 ratio due to money constraints)
6% = 20 cL kombucha tea
94% = 340 cL liquid starter

Liquid Starter Mix:
300 cL water
4 g tea (3 tea bags)
300 g sugar
30 cL apple cider vinegar
10 cL starter liquid from previous SCOBY culture
20 cL kombucha tea

Name: Gwen-Sophie #6
Completion: 4.8.2021
Strain: Gwen-Sophie
Recipient: 20 L plastic box

Observations:
Fast growth with noticeable filaments rising to the surface within the first 12 hours after mixture was created. Large bubbles formed under the pellicle and deformed the pellicle. Again, the bubbles forming and popping were very audible. I blended half of the SCOBY and molded it like clay around two cups. The other half I let dry for two weeks, then molded around two other cups. I coated the plastic with olive oil before molding the kombucha to prevent ripping when removing the cups from the molds after drying. The blended cups are now dry. The second half of the SCOBY is still drying as of 24.8.2021.

Image Left:

Batch #6 fermenting with large bubbles.

Batch #7
21.8.2021

Protocol:
340 cL Culture Liquid

Liquid Starter Mix:
300 cL water
4 g tea (3 tea bags)
300 g sugar
30 cL apple cider vinegar
10 cL starter liquid from previous SCOBY culture

Name: Gwen-Sophie Cup #7
Completion: ~
Strain: Gwen-Sophie
Recipient: 10 L plastic box

Observations:
This batch is using a new protocol as the other batches were growing too rapidly, with too much active fermentation and large bubbles that deformed the pellicles. It is also using a smaller container size.

The SCOBY has only been growing for three days as of 24.8.2021, but there is a visible thin pellicle forming on the surface with small bubbles beneath the surface.

Image Right:

Batch #7 fermenting with small bubbles.