

**Symbiotic Shift: Transcultural Explorations of Community-Guided CRISPR
Biotechnology Development**

by

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B.S Human Biology
University of California San Diego, 2018

SUBMITTED TO THE PROGRAM IN MEDIA ARTS AND SCIENCES, SCHOOL OF ARCHITECTURE
AND PLANNING, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MEDIA ARTS AND SCIENCES

AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SEPTEMBER 2021

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Submitted to the Program in Media Arts and Sciences, School of Architecture and Planning, on
8/23/2021 in partial fulfillment of the requirements for the degree of

Master of Science in Media Arts and Sciences

Abstract:

This master's thesis focuses on sharing the experience of working collaboratively across the Sculpting Evolution Group at the MIT Media Lab and Indigenous researchers, elders, and community members in Aotearoa (New Zealand) to spearhead community-guided CRISPR biotechnology development— a new way of creating the next generation of CRISPR gene editing biotechnologies that values cultural knowledge and intentionally seeks guidance from the communities that these biotechnologies may impact in the far future. Although this specific conversation focuses on ecological editing biotechnologies, it is a broader mediation on the expansion of knowledge systems used to charter the course of present and future technologies. Throughout this thesis, I weave in narratives shared by our collaborators in order to illuminate our collective learnings, challenges, sources of inspiration, and outcomes.

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SYMBIOTIC SHIFT

transcultural explorations
of community-guided crispr biotechnology development



sculpting evolution group, mit media lab

anika nawar ullah

[Listen to Hutia te Rito here.](#)

if you pluck out the centre shoot of the flax,

where will the bellbird sing?

it will fly inland, it will fly seawards

if you ask me

what is the most important thing in the world?

I will reply,

the people, the people, the people!

- Hutia te Rito, a waiata (traditional song) about the harakeke plant.

[Translation](#) by Joan Metge, Victoria University of Wellington

The harakeke plant is one of the most ancient plant species that exist in Aotearoa and on planet Earth. An ecological hub and sacred cultural plant in Maori culture, it cultivates a home for many earthly beings, from bellbirds to shorttailed bats. It also offers a variety of incredible characteristics for material use, such as in textiles, medicine, basket weaving, and ornamentation. In Maori culture, it represents the family—the outer leaves are ancestors from generations past, protecting the younger shoots growing from the center. The title of this thesis, ‘symbiotic shift,’ is an embodiment of the spirit of the harakeke plant and the way it nurtures multitudes of life on this planet. I hope to inspire deeper thinking on how we can shift into new ways of being that promote synergistic relationships with all kinds of life in this mysterious multiverse.

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SATELLITE VIEW

CHAPTER 1 :: Homogeneous | Heterogeneous

Through the analogies of cancer and cultural dysbiosis, this chapter paints a picture of the role that colonialism, capitalism, and cultural domination have played in driving the existential threats that humanity and planet Earth face today. It urges us to move past binaried understandings of technology and illuminates our responsibility to learn from pluralities of cultural wisdom to guide biotechnologies—technologies that mediate life.

CHAPTER 2 :: Genealogies of Global Gene Editing

Diving into the lineages of gene editing around the world, this chapter looks at the way gene editing has historically been used for applications in agriculture and public health across regions of the Global South, and acknowledges key issues that have arisen—unequal power dynamics, physical, cultural, and socioeconomic landscapes of monoculture, and mistrust. It begins to discuss a new era of gene editing technologies—ecological editing—in relation to its promises and challenges, and potential to offer more just biotechnological futures.

CHAPTER 3 :: Co-Creating CRISPR in Aotearoa

This chapter is the primary focus of the thesis—a case study of community-guided CRISPR co-development with the Indigenous Maori Nga Puhī Iwi in Aotearoa. Building upon Dr. Kevin Esvelt's principles of community-guided biotechnology development, it explores how fieldwork with Maori collaborators can offer guidance on deepening collaborations between scientists, technologists, and Indigenous peoples.

CHAPTER 4 :: Architecting Action

This final chapter discusses contributions to making community-guided CRISPR development with Indigenous and Global South communities more accountable and robust. Efforts include an exercise in speculative imagination on decolonial biotechnologies with Dr. Riley Taitingfong from the SING Indigenous Genomics Consortium and Berkeley, CA based Indigenous Guatemalan food justice organizer Rene Revolorio Keith, and a collaborative paper written with Dr. Riley Taitingfong on empowering Indigenous peoples in public deliberation for gene editing in the wild.

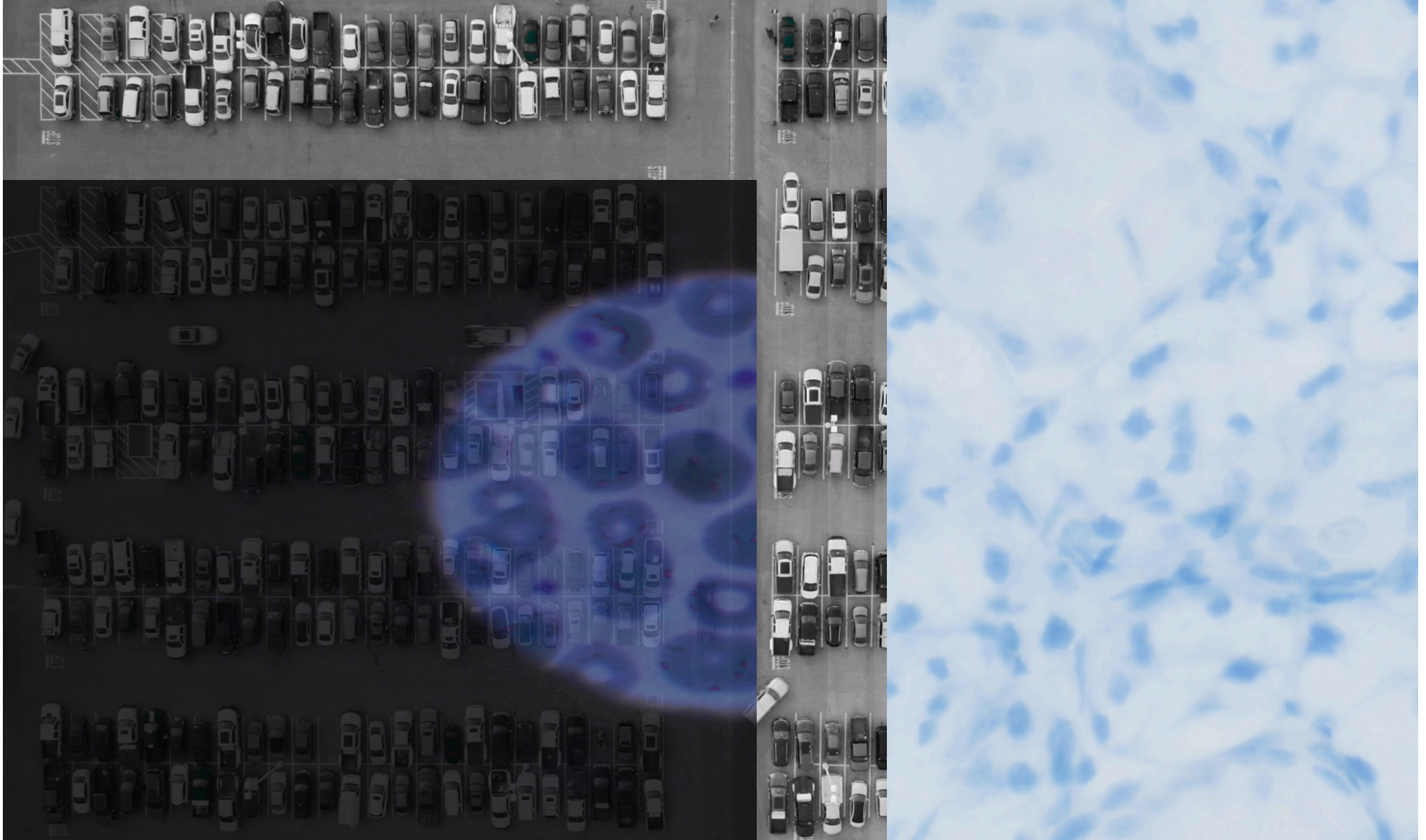


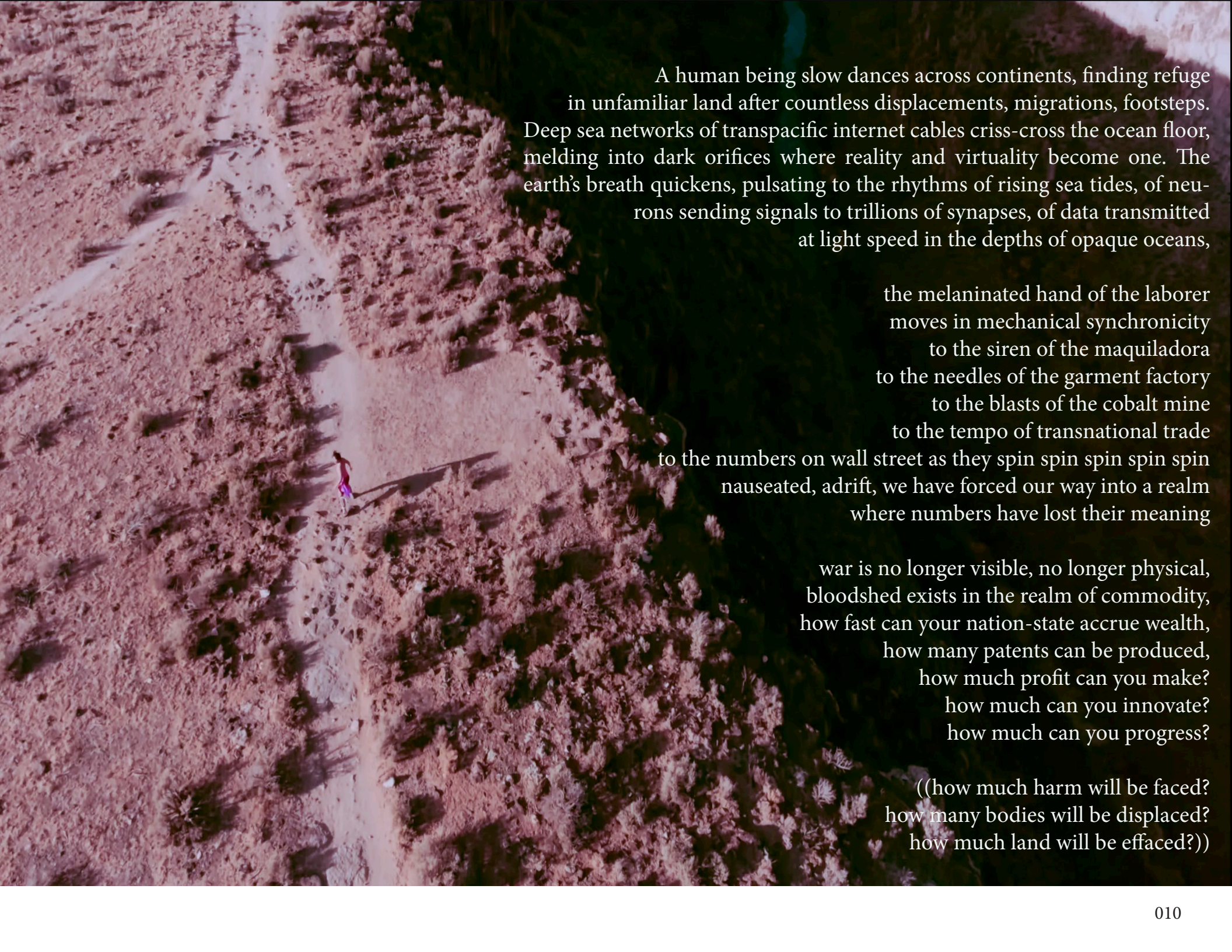
homogenous

heterogeneous

accelerations

watch the accelerations short film [here](#).





A human being slow dances across continents, finding refuge in unfamiliar land after countless displacements, migrations, footsteps. Deep sea networks of transpacific internet cables criss-cross the ocean floor, melding into dark orifices where reality and virtuality become one. The earth's breath quickens, pulsating to the rhythms of rising sea tides, of neurons sending signals to trillions of synapses, of data transmitted at light speed in the depths of opaque oceans,

the melaninated hand of the laborer moves in mechanical synchronicity to the siren of the maquiladora to the needles of the garment factory to the blasts of the cobalt mine to the tempo of transnational trade to the numbers on wall street as they spin spin spin spin spin nauseated, adrift, we have forced our way into a realm where numbers have lost their meaning

war is no longer visible, no longer physical, bloodshed exists in the realm of commodity, how fast can your nation-state accrue wealth, how many patents can be produced, how much profit can you make? how much can you innovate? how much can you progress?

((how much harm will be faced? how many bodies will be displaced? how much land will be effaced?))

8

4

7

3

2

THE QUANTIFOCENE

THE QUANTIFOCENE

THE QUANTIFOCENE

THE QUANTIFOCENE

THE QUANTIFOCENE

THE QUANTIFOCENE

THE QUANTIFOCENE

THE QUANTIFOCENE

in the age of the quantifocene, nothing mattered except the numbers, and in the process we became number and number while the narratives we were fed through the screens the big screens, the medium screens, the screens that didn't even look like screens, anesthetized our consciousness with fiction and fact and everything in between



what does it mean to live in a globalized world?
what becomes of identity,
with the constant fragmentations
hyphenations
conglomerations
all the -ifications of people, place, space?
heterogenous to homogenous



INDIGENOUS →	INDIGENOUS →	INDIGENOUS →
REFUGEE ↔	REFUGEE ↔	REFUGEE ↔
MIGRANT ≡	MIGRANT ≡	MIGRANT ≡
HY-PHE-NATION	HY-PHE-NATION	HY-PHE-NATION
↪ Hy8R!DiTiY	↪ Hy8R!DiTiY	↪ Hy8R!DiTiY

they say that there are six hallmarks of cancer:

1. sustainable proliferative signaling
2. evading growth suppressors
3. activating invasion and metastasis
4. replicative immortality
5. inducing angiogenesis
6. resisting cell death

everything starts out normal. the body is working harmoniously to its usual metabolic rhythms, lub-dub. lub-dub.

but at some point, a cell begins to malfunction. it begins to divide and divide and divide, evading the normal regulatory checkpoints of biological design. each of these new cells, determined that division is the only path forward, continue to aggressively produce more of their own kind.

Uncontrollable growth. Limitless expansion.

there comes a point where a budding colony of these cells—a tumor—decide that they need more resources to survive. where will they go?





they migrate. they build new roadways, blood vessels, tunnels, transatlantic shipping routes to other parts of the body they deem foreign

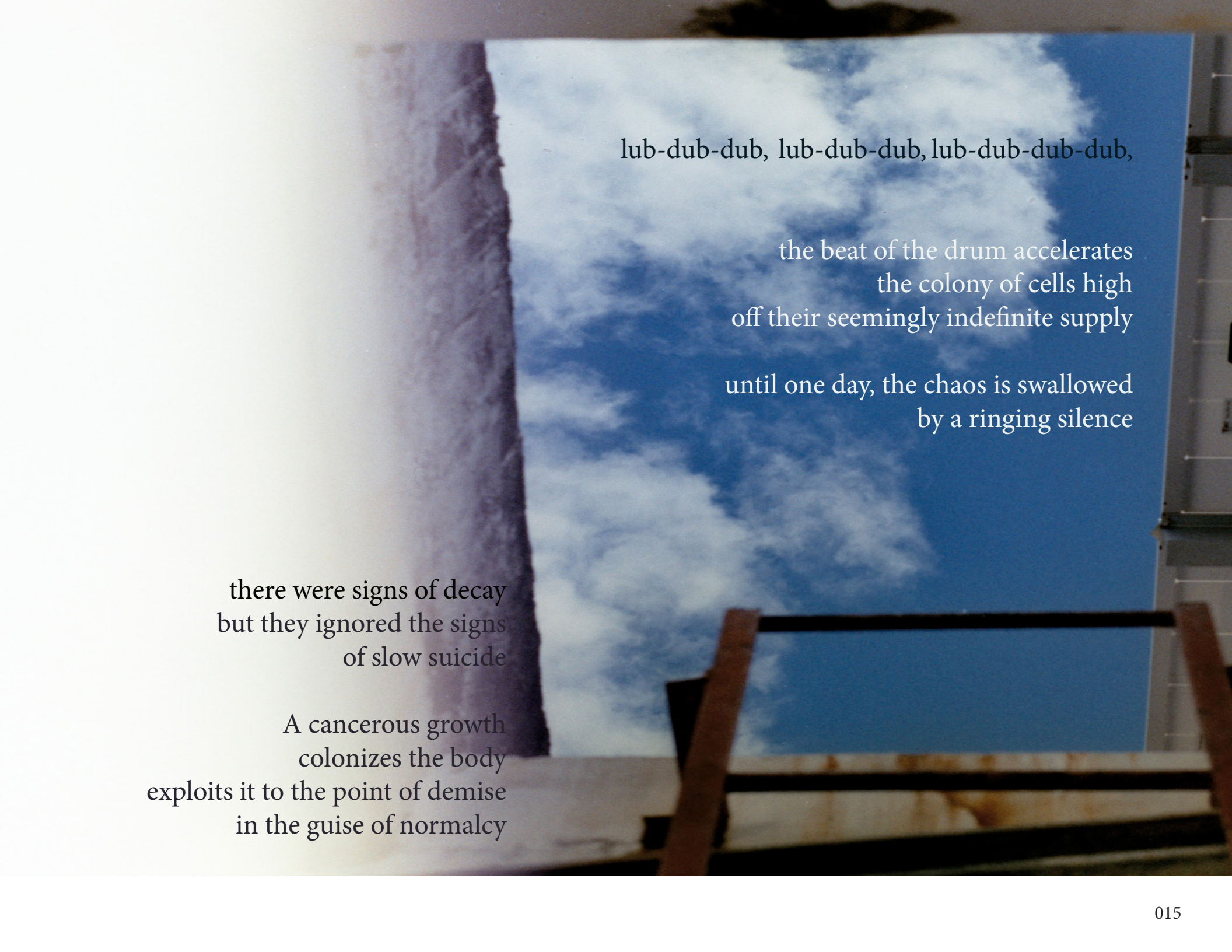
and they come to these new lands with the promise of fresh blood, state-of-the-art oxygen, more nutrients, progress, better futures,

“if you join us, you too can be great, immortal, limitless,” they whisper. “let us show you how to exploit the potential of your surroundings. there is no greatness without bravery.”

yet, while they were giving their elaborate speeches, they had already begun to strip away the lifeblood of the local land

with ‘limitless’ resources at their disposal, they begin to build an empire. and in the process, they create amazing things.

the heart, which once was driven by a slow leisurely, lub-dub, lub-dub, ascends into frenzied rhythms of power,



lub-dub-dub, lub-dub-dub, lub-dub-dub-dub,

the beat of the drum accelerates
the colony of cells high
off their seemingly indefinite supply

until one day, the chaos is swallowed
by a ringing silence

there were signs of decay
but they ignored the signs
of slow suicide

A cancerous growth
colonizes the body
exploits it to the point of demise
in the guise of normalcy

in proliferations of cells, human beings, societies,
the colonization of one specific type of bacteria in the digestive tract, microbial
dysbiosis, leads to disease. the domination of one specific agricultural crop yields
a nutrient depleted environment. the violent expansion of an empire predicates
its collapse. under capitalism, the dollar favors modernity, skyscrapers, and
McDonaldization of the planet.

We see this principle play out, over and over and over again,
across different domains of life.

The imposition of a certain way of life unto others—cultural domination—
yields extinction of biodiverse species, of human languages,
of foods, of cultures, of pluralities, of existence.

with the capitalistic climate apocalypse inching closer to us,
how do we subvert human and planetary domination
from homogenous to heterogenous?

**how do we cultivate the necessary foundations of life,
complexity, richness, and variation?**

cultural dysbiosis

If you asked Bryce Walker, Indigenous Maori elder from the Nga Puhi Iwi in Aotearoa, about why and how humanity arrived to such a catastrophic state today, he would whip out his whiteboard markers and ask you if you are ready to hear the story of the four sets of twins.

FOUR SETS OF TWINS AND CULTURAL RESPONSIBILITY

BY BRYCE WALKER

“This culture here has a responsibility to other cultures around the world. Beginning with that relationship first, unfortunately, science is isolating our culture from the rest of the cultures around the world. I appreciate the acknowledgement of the uniqueness of our culture. I’d like to begin with expressing that uniqueness and why it’s there, because that’s been identified.

This culture here has a responsibility to other cultures around the world, and that’s what makes it unique. In today’s thinking, other cultures would appear to have no relationship to ours. What it looks like today, cultural responsibility is being rendered down to a very, very small part of one another’s culture and responsibility to one and another. But our culture and our responsibility to your culture [motioning to Anika] actually does exist. And our culture in your culture does actually exist [points to Sebastian]. And your culture [points to Sebastian] in her culture [points to Anika] actually exists.





My culture's responsibility since the beginning of time is to sustain life.

Your responsibility [referring to Anika and Asian culture] since the beginning of time is to sustain knowledge on all of our behalf—history. Your cultural responsibility [referring to Sebastian and African culture] is to sustain whakapapa [genealogy and heritage], to look after where we came from. It knows the beginning of all of us. We Maori don't take responsibility for all those things.

Where did the beginning of these relationships come from?

One of our colleagues speaks of the four sets of twins. Two sets of twins are male, or paternal, and two sets of twins are maternal. And they separated themselves. Two went there, two went there, two went there...[motioning to signify twins spreading to different parts of planet Earth]. Because they were aware of the process that was coming...

History began with all of us. Life began with all of us. We can't move forward without one of us not there, or we'll be making the same mistake.

We're gaining momentum back, okay? Our cultures are, because science has run its time."

This story narrates a tale of cultural dysbiosis. Similar to the story of the splitting of pangea into continents, the story of the four sets of twins grounds humanity in our shared relationships to one another and distinct responsibilities to humankind. In later dialogues Bryce links these notions of cultural responsibility, particularly the responsibility of Maori culture to sustain life, to an assertion that the cultural monopoly of the West is a threat to the collective survival of humankind and this planet. This is the 'mistake' and 'process' that Bryce mentions at the end of the tale of the four sets of twins, and in chapter three, *tuku korero* :: the narratives, he further elaborates on how the singular progression of Western culture and its salient paradigm of knowledge production, the institution of science, have driven this existential threat.

beyond biotechnological binaries

It is estimated that Indigenous peoples protect an overwhelming 80% of global biodiversity that remains on Earth today. What are the technologies that Indigenous people used and continue to use today in order to guard these essential resources? In the fields of ecology, conservation, and architecture, there is growing recognition that the kinds of strategies and systems that Indigenous peoples use to steward lands are indeed technologies. Julia Watson’s “Lo-Tek Design by Radical Indigenism” offers global case studies on contemporary Indigenous technologies and socioenvironmental management systems that have withstood and adapted to rapidly shifting environmental conditions. From the Bengali people creating the innovative Bheri wastewater aquaculture systems that repurpose plastic to Khasi people weaving together living roots of the Areca tree to create the Jingkieng Dieng Jri Living Root Bridge system, these examples illustrate the need for cultural reorientation around how we define technology. The methods and tools that Indigenous peoples use have existed for thousands of years, and have been fine-tuned through local cultural evolution across several generations, in situ with the land. What’s unique about these Indigenous technologies is that they foster a different kind of progress—one that is beneficial to not just the advancement of humankind, but also the protection and resilience of the environment, other life beings, and local ecologies. If the land is a living laboratory, Indigenous peoples are the scientists and innovators who create symbiotically with it, out of a need for survival, joy, and life purpose. While innovation may exist in an abstract playground for scientists from the Western hemisphere (often without physical consequences), innovation for Indigenous peoples necessitates a consciousness about the long-term health and environmental impacts of their experimentation, because their foods, cultures, homes, and livelihoods directly depend on the sustained viability of the lands that they live on.

While the currency of scientific knowledge is academic publication, Indigenous cultures harbor and cultivate their traditional ecological knowledge through a wider array of forms, such as songs, rituals, cultural practices, and narratives. Western knowledge production typically prioritizes text, while Indigenous knowledge production emphasizes body, experience, and the sensory world. Textual forms carry more visible physicality than sensory forms; imagine, what does society deem as a more robust and rigorous source of knowledge, a two hundred page book or a two hundred minute film?

Extending this analogy, perhaps this is why technology was assumed to only encompass tools with a saliently physical nature until the emergence of information technologies. If we consider digital technologies to be true technologies despite their virtual nature, why do we generally not extend the same status to tools, systems, and cultural strategies for mediation that Indigenous peoples use to innovate in this world? This broader conceptualization of technology as not just a physical tool, but a *way* is essential to discussions about Indigenous concepts of technological creation, deployment, and evolution.

“While we are drowning in this Age of Information, we are starving for wisdom.”

“Indigenous technologies advance Darwin’s theory of ‘survival of the fittest’ to ‘survival of the most symbiotic.’”

- Lo-Tek Design by Radical Indigenism, by Julia Watson

In light of the global challenges posed by the coming decades, many herald genetic engineering biotechnologies as key to mitigating transnational issues rooted in ecological decay. Examples include the production of genetically engineered salt-tolerant crops, which will be able to grow in land waterlogged by rising sea levels, genetically fortified ‘golden rice,’ which seeks to mitigate vitamin A deficiency related child malnutrition, and genetically engineered sterile mosquitoes to stem vector-borne diseases like malaria.

At first glance, these efforts may seem to offer the panacea to humankind’s most formidable challenges. But do they really? Can technological innovation single-handedly fix systemic issues driven by centuries of global resource exploitation and pollution? Or are they simply bandaids on bullet holes?

From the cotton gin to the green revolution, the combustion engine to the information age, why do we frame technology as the singular driver of revolution, utopian progress, and savior of humankind’s maladies?

Although idealism and altruistic notions of societal advancement often guide technology development, perhaps we have cultural amnesia that technology does not exist in a silo—it is often militarized, or used as a tool for exploitation and commodification on a societal level. From the cotton gin and its role in expanding the institution of slavery, to social media platforms that accrue and profit off personal data while increasing the power of state surveillance, recent decades have exposed that with new technologies come new issues to contend with.

On the opposite side of the spectrum, some view technology through a techno-dystopian lens, vilifying it as the genesis of humankind's challenges. They point to technologies such as nuclear energy, hydroelectric dams, and chemical warfare, which have already caused a myriad of harmful effects, ranging from displacement to mass destruction and the potential extinction of humankind and our planet. Others believe that the advent of human genome editing will pave an exponential pathway to cataclysmic health inequity.

As with all binaries, there are elements of truth on both sides. Acknowledging that technology is nuanced in its intentions, development, and long term impacts, we can look closely at these truths to learn from them and architect a more just path for our futures, which will be shaped by the technologies we create and the different kinds of relationships that these technologies engender between humankind, other life beings, and our shared environment.

**Thus, in this thesis I hope to move past
such binaried visions of technology
and pose the following questions**



How did humankind arrive at the disheartening global condition we face today?

What role does technology play in creating these issues, and in potentially addressing them?

What is progress?

Can we separate the physical aspects of technology from the cultural norms they are imbued with?

What counts as technology and who has the power to create it?

Whose and what kinds of knowledge inform technological innovation and implementation?

Would our planet be better off without some technologies?

Amongst our singular acceleration towards technological progress, what are our mechanisms for reflection and deliberation?

What practices can we use to consider if the technologies we strive to create will be truly beneficial to this planet and the beings who inhabit it?

What methods can we engage with to minimize potential harm arising from the technologies we create?





Who is offered a seat in the biotechnological decision-making processes that shape our futures?



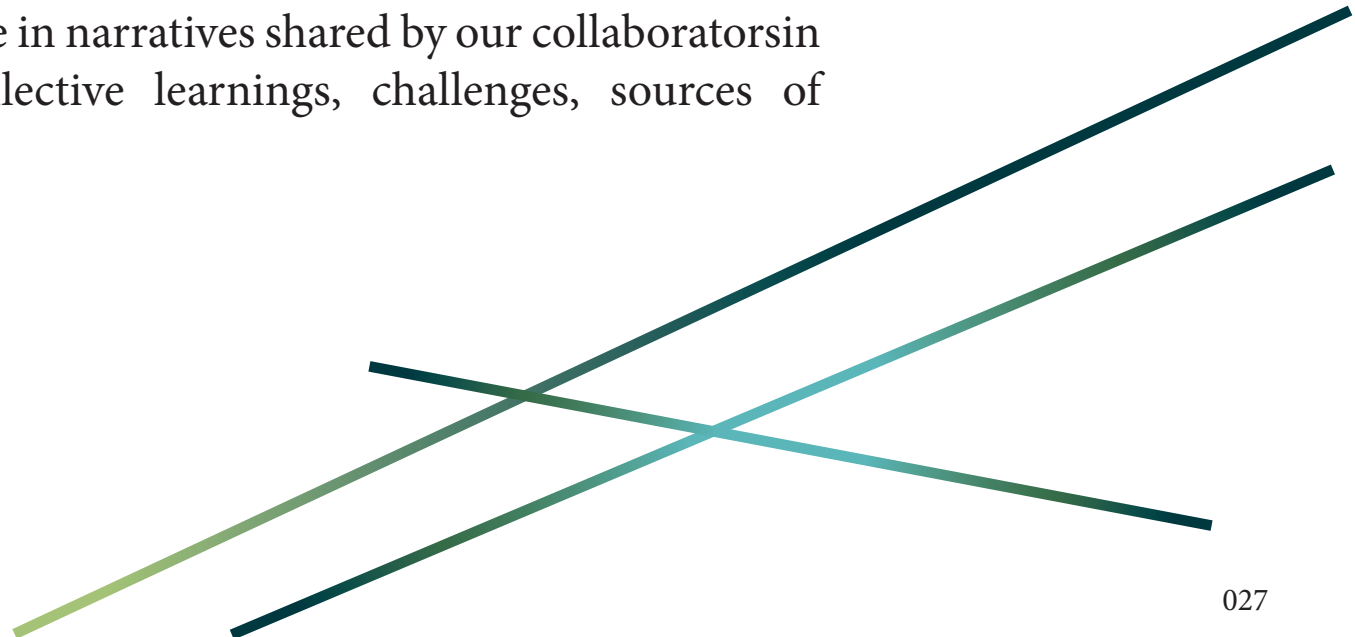
“Take up the tools of the pakeha [colonizers] and turn your hearts to the treasures of your ancestors”

- proverb from Ngati Porou Iwi, shared by Anezka Hodgkins

ABSTRACT

This master's thesis focuses on sharing the experience of working collaboratively across the Sculpting Evolution Group at the MIT Media Lab and Indigenous researchers, elders, and community members in Aotearoa (New Zealand) to spearhead community-guided CRISPR biotechnology development— a new way of creating the next generation of CRISPR gene editing biotechnologies that values cultural knowledge and intentionally seeks guidance from the communities that these biotechnologies may impact in the far future. Although this specific conversation focuses on ecological editing biotechnologies, it is a broader mediation on the expansion of knowledge systems used to charter the course of present and future technologies.

Throughout this thesis, I weave in narratives shared by our collaborators in order to illuminate our collective learnings, challenges, sources of inspiration, and outcomes.

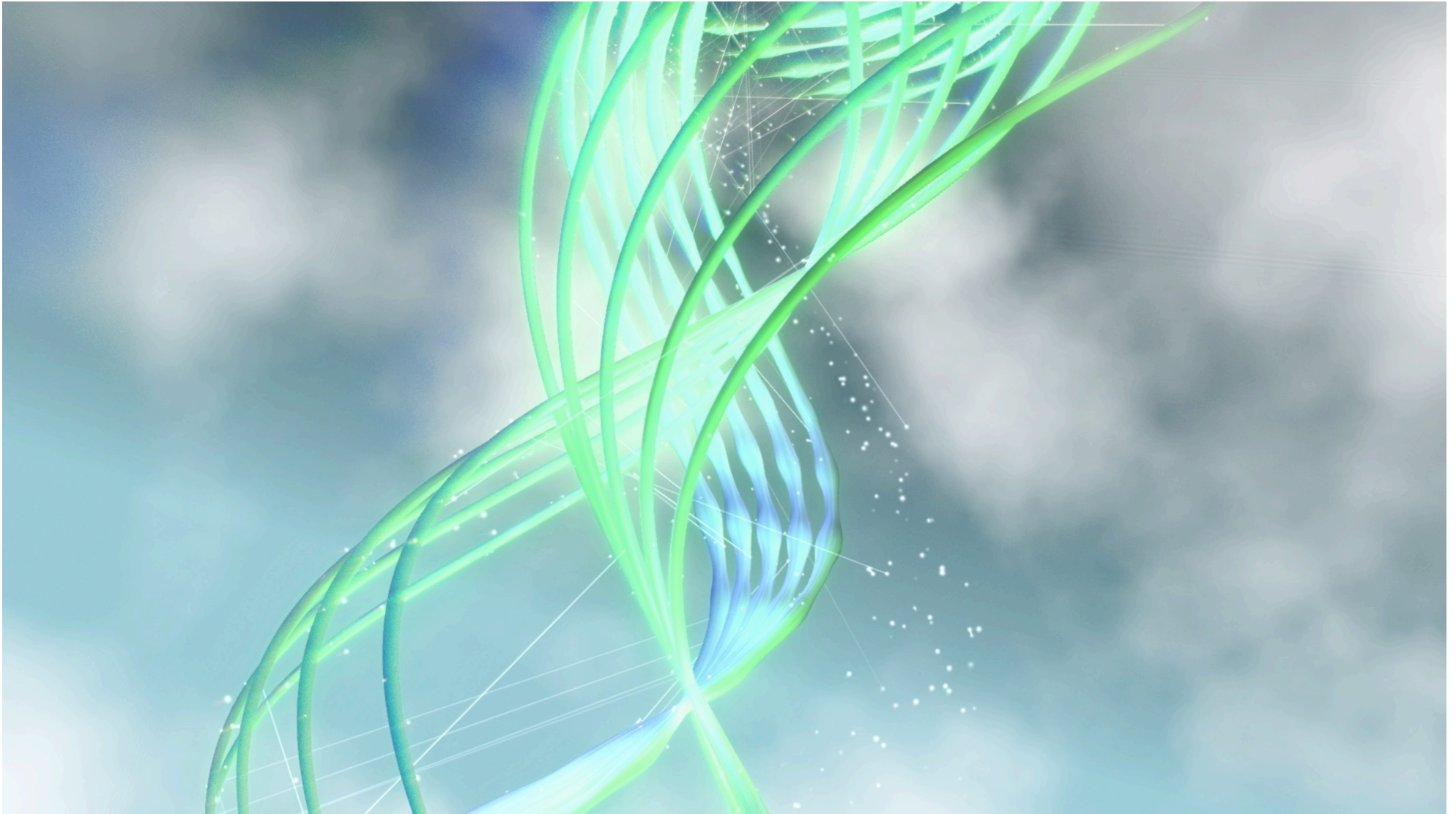




genealogies of global gene editing

:: chapter two :: chapter two :: chapter two ::

biocultural being



Who we are, what we are, and how we are is influenced by our environment. At the most basic level, the air we breathe, the food we eat, the water we drink, and the materials we derive from the physical environment to create objects such as tools, clothing, and housing are essential to our survival.

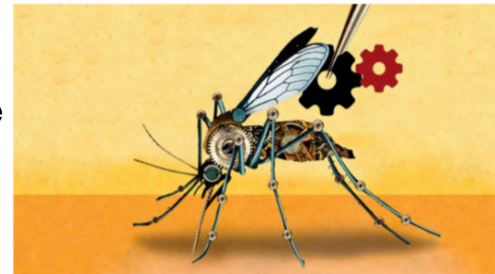
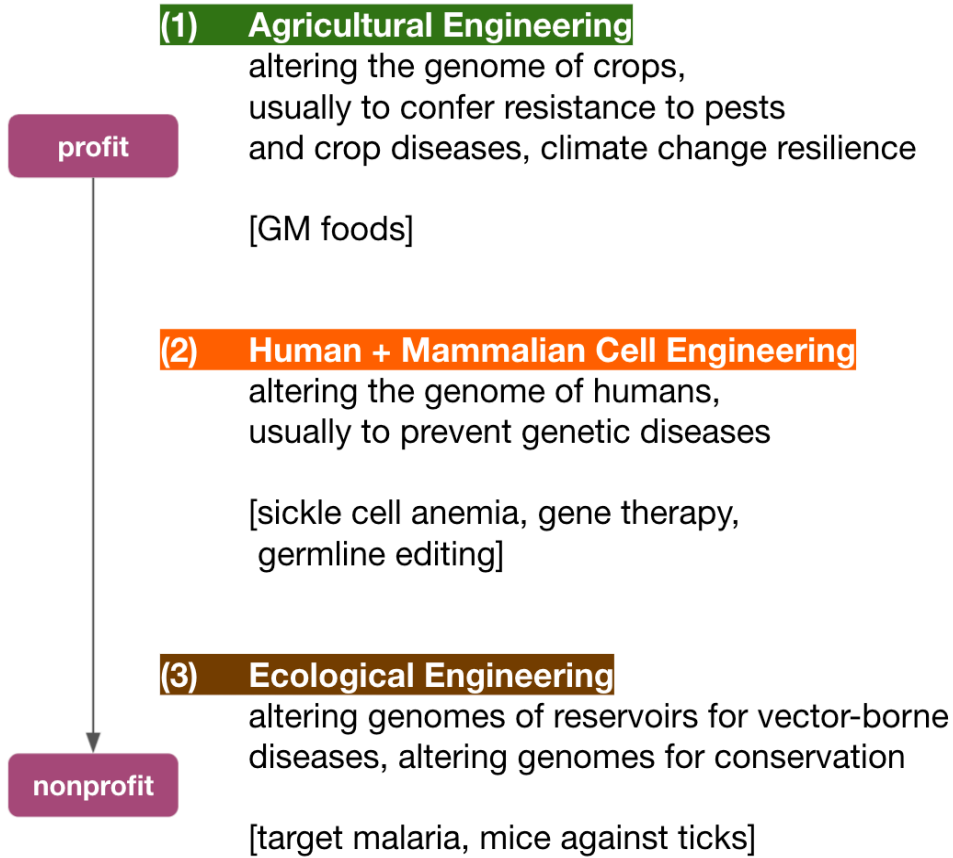
In a broader sense, the landscapes our social identities are formed in, the way the sound of birdsong can shape our languages, the hues of the river that form our visual vocabularies, and the ecological stories we witness that configure our collective memories symbolize some of the more subconscious and transcendent ways in which nature designs our notions of self and culture.

With an understanding of how important it is to sustain the vitality of the larger ecosystem, it makes sense that many are concerned about emerging ecological editing biotechnologies because of their power to directly mediate our shared environments.

In tracing the genealogies of genetic engineering, there are three spheres in which these biotechnologies have been developed:

- (1) agricultural engineering
- (2) human and mammalian genome editing
- (3) ecological engineering.

Three Spheres of Genetic Engineering & The Global Imagination



When most people hear the phrase ‘gene editing,’ ‘genetic engineering,’ or ‘genetic modification’ their minds jump to human genome editing. Films such as *Gattaca* (1997) and science fiction, such as Aldous Huxley’s *Brave New World* (1932) have propelled concerns surrounding the consequences of human genome editing into the public consciousness over the last century. “What if parents could control the biological sex of their children? Their eye color? Their intelligence?” These are common fears that surface from the general public.

When thinking of gene editing, others may reflect on agricultural genetic engineering and recall the second green revolution and controversial nature of genetically modified foods, Monsanto, and Big Agriculture since the early 2000s. Yet there is a new era of gene editing on the horizon—ecological gene editing.

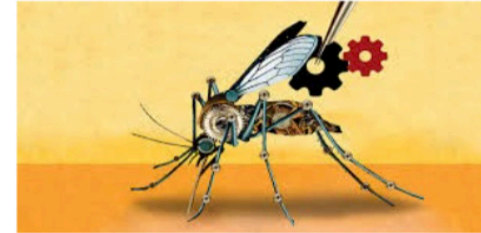
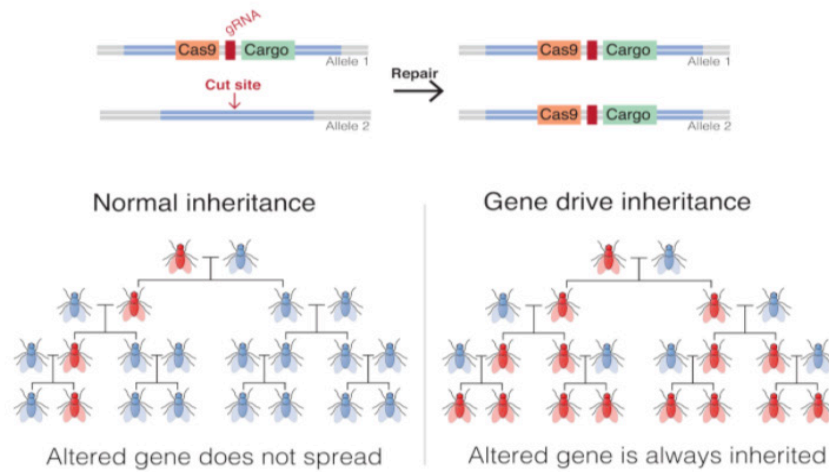
In some ways, the advent of this new biotechnology is very different from its predecessors because of the way it shatters artificial divisions we typically operate under that treat environment, human, and animal as discrete beings. Because it seeks to alter the shared environment, it becomes necessary to engage in public deliberation of such biotechnologies. However, there are several similarities to its predecessors of human genome editing and agricultural engineering, which we can study to understand what issues arose and how we can grapple with improved approaches. Thus, the following chapter takes a deep dive into the histories of gene editing in the global south, to set foundational context for the contemporary conversation around community-guided gene drive with Indigenous Peoples in Aotearoa.

gene editing in the global south

In reference to the histories of gene editing around the world, this chapter looks at the way gene editing has historically been used across agriculture and public health in the Global South and the issues that have arisen—unequal power dynamics, physical and environmental landscapes of monoculture, and global mistrust. It begins to discuss a new era of gene editing technologies—ecological editing—in relation to its promises, challenges, and potential to offer more just biotechnological futures.

ecological editing

Ecological Engineering: CRISPR-Based Gene Drive with Applications in Global Health + Environment



natural population suppression: mitigate vector-borne disease, control crop pests and invasive species

“We should find the most minimal intervention that might solve the problem. We should actively invite suggestions, concerns, and guidance from interested local communities who know their own environments best.”

“It’s fair to say that our laboratory is as much about safeguarding biotechnology as using it.”

“We should hold ourselves accountable for the consequences of our work, which is easier when our work is identifiable.”

- Dr. Kevin Esvelt, Principle Investigator of Sculpting Evolution Group

For the past several years, biotechnologist and pioneer of gene drive, Dr. Kevin Esvelt, has been advocating for open, transparent community-guided science.

His efforts range from conducting open town hall style meetings to invite public feedback on his lab's biotechnology research, advocating for open-access and pre-registering experimental plans, working with Indigenous leaders to see how traditional ecological knowledge can inform biotechnology design, supporting capacity building for scientists in the Global South, organizing a registry to ensure adherence to biosecurity practices, and penning op-ed pieces about the essential nature of open research.

Specific to the context of ecological editing biotechnologies such as gene drive and how their use is built upon potentially permanent alteration of the shared physical and ecological environment, Esvelt and the broader academic community stress the importance of engaging with public guidance for these biotechnologies.

Esvelt's orientation is in alignment with a broader global trend in institutions of science to open its processes of producing knowledge and making findings accessible to non-discipline specific research communities and the broader public (UNESCO, Open Science).

The advent of CRISPR based gene drives in the last decade has catalyzed critical global dialogue about the impacts and safety of ‘ecological editing’, which involves altering the genomes of wild populations of organisms to change the local ecosystem. The intended applications of this biotechnology are to address pressing public health and conservation issues that have not been feasibly addressed through other means, such as reducing the incidence of malaria by curtailing the population of mosquitoes, as is the goal of the Gates Foundation funded Target Malaria project, or humanely reducing rodent populations, which are major pests, sources of agricultural and ecological damage, and are often reservoirs for infectious diseases. Virtually all of the scientists, nonprofit organizations, and companies spearheading the development of these ‘ecotechnologies’ are in the Global North and are piloting on-the-ground implementation in the Global South. It is a complicated reality that the majority of vector-borne diseases occur in the Global South and that these regions are also some of the most economically impoverished regions in the world; some are apprehensive about the ethics of testing these emerging technologies without adequate safeguards and the methodologies used to investigate collective community consent. However, a dire need to explore new technologies that can oppose significant disease burden in highly vulnerable populations continues to drive CRISPR based gene drive research forward.



co-creating crispr

methodology + contributions

METHODS

I would like to expand upon the praxis of ‘community-guided biotechnology development’ by exploring the use of culturally-responsive methods of dialogue, expression, and knowledge production: anthropological observation, interview based dialogue, storytelling, embodied experience, sensory filmmaking, and participatory art-making. I hope to gain a deeper understanding of Maori worldviews that inform specific perspectives on community-guided biotechnology development and see what broader guidance our collaborators can offer on ecological editing, beyond technological design considerations.

To undertake this research, I spent approximately three weeks in Aotearoa conducting field work, filmmaking, and media curation (sound recordings, film photographs, drawings, participatory art-making) across the North and South Islands. In chronological order, there were four settings in which this field research was conducted; (1) the 2020 SING Indigenous Genomics Conference, (2) the hui, a town hall style community meeting organized by Kevin Esvelt with leaders from the Nga Puhi Iwi (tribe), (3) diverse natural environments in Aotearoa, and (4) the Nga Puhi Iwi marai (community meeting center). In the following section, Dimensions of Dialogue, I will dive deeper into specific dimensions of research methodology and reflections on each of these four settings.

Colleagues Sebastian Kamau and Octavius Jones were also present; Sebastian Kamau helped collect sound recordings of these dialogues and Octavius Jones supported acquisition of B-roll footage and drone footage for the accompanying participatory short film.

RATIONALE

The Western paradigm of public deliberation, typically the ‘town hall’ style meeting, elicits a very narrow scope of particular kinds of information and understanding, especially when working with people from Indigenous cultures. Participatory art-making and collective storytelling offer more open-ended strategies for this kind of facilitation, because they are rooted in acts of creation rather than reaction. They don’t restrict the conversation to the specific topic at hand, and instead cultivate a blank space for the collaborator to express whatever they would like to express. The labor then falls upon the researcher to understand how whatever was expressed relates to and informs the specific matter at hand, rather than to the collaborator for making their world view fit into the reductionist confines of the niche topic of discussion.

Beyond debating the ethics of if we should or should not include Indigenous communities in public deliberation on gene editing, this work focuses on the how—what it looks like to work collaboratively with Indigenous Peoples and what insights we gain, challenges we face, and political complexities we must contend with.

ACKNOWLEDGEMENTS

I would like to acknowledge that it is an immense privilege to be able to conduct this kind of work. For many scientists, having time, funding, and capacity to do community engagement on a deeper level is exceedingly difficult. Furthermore, coming from an institution that privileges concrete outputs and quantifiable knowledge poses ever more challenges for researchers who must justify to their institutions what kind of benefits deep community engagement can offer. We must be open to the possibility of having our worldviews challenged head on. It can be emotionally difficult to realize the extent of historical trauma that entire populations have been forced through, and hold the weight of this knowledge in your body. But it is our responsibility to listen, to learn, to do the painful labor of understanding where harm comes from, so that we don't repeat the same mistakes. It is the least we can do, face-to-face with people who have carried and overcome magnitudes of harm through generational resilience. It is a gift to learn from people whose ancestors have lived in continuity with a specific place, taking care of that place over hundreds to thousands of years of ecological and cultural evolution.

I hope that the following narratives show a glimpse of the multitudes of wisdom that one may be gifted with if we make the time and effort to open our hearts and listen.

dimensions of dialogue

2020 SING INDIGENOUS GENOMICS CONFERENCE

The research trip began with attending the 2020 SING Indigenous Genomics Conference, which was the first international Indigenous genomics conference convened in global history. During the conference, I prioritized listening, observing, and participating in discussions in order to orient myself around the way emerging Indigenous scientists discuss the practical, culture, socio-economic, and ethical dimensions of genomics research conducted with Indigenous peoples.

THE HUI

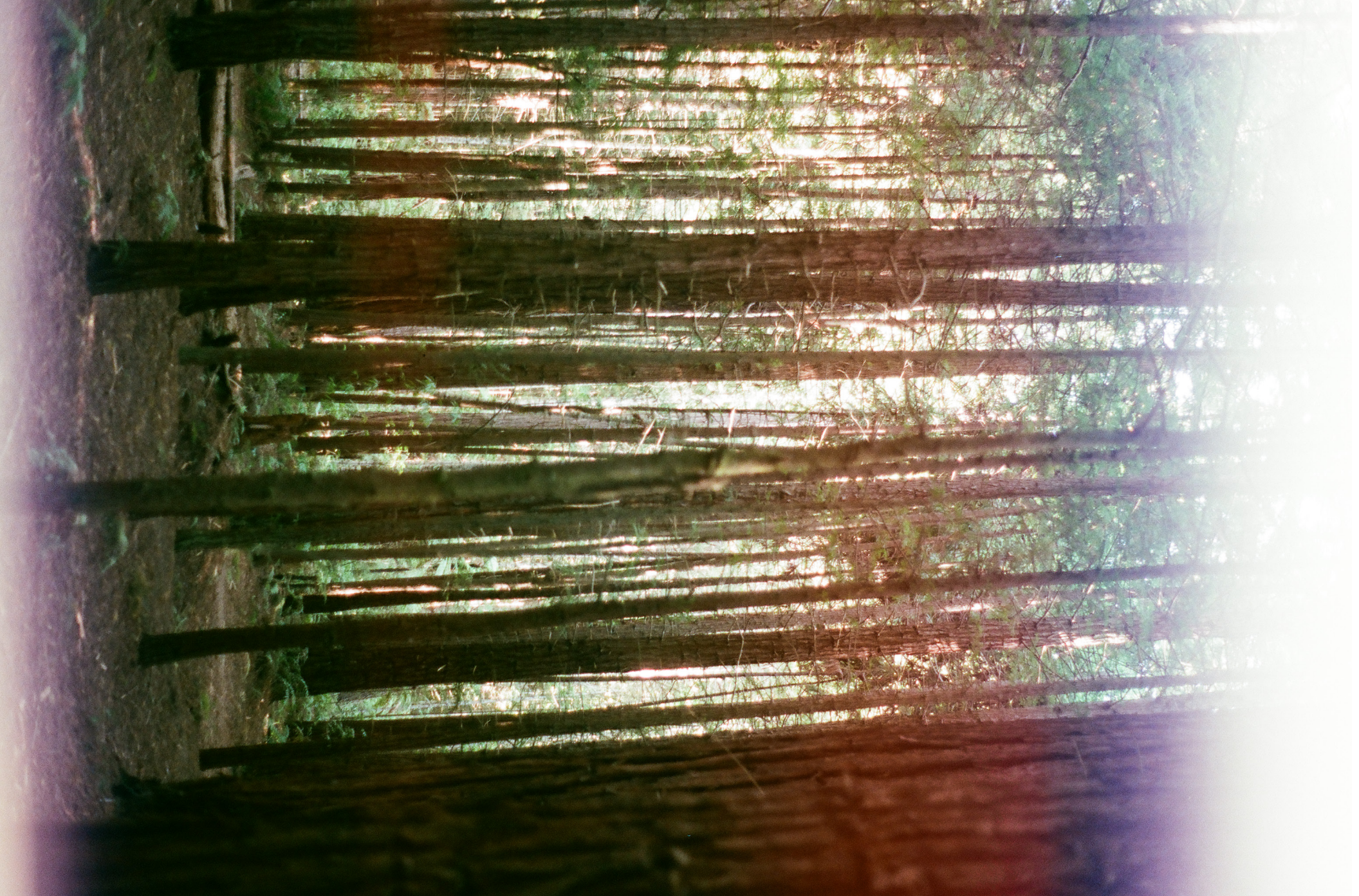
Dr. Kevin Esvelt annually travels to Aotearoa to conduct a series of hui (gatherings), with several Indigenous Maori iwi (clans), researchers, and community members to convene dialogue on the potential development and use of ecological editing biotechnologies in Aotearoa. The purpose of these open dialogues are to seek community guidance, feedback, and criticism on topics ranging from emerging technical developments in Dr. Esvelt's laboratory. Goals include understanding how traditional ecological knowledge can inform the technology design process, listening to residents' perspectives on the potential social and political ramifications of such biotechnologies as they may be implemented in the future in Aotearoa, and the long-ranging vision for how these technologies should or should not operate in the real world. During this particular hui, we traveled to the marai (community meeting center) of the Nga Puhi Iwi in Kaeo, New Zealand on the North Island.

Similar to my mode of participation at the SING conference, I prioritized listening, observation, and light participation in the hui in order to focus on understanding how Dr. Esvelt typically conducts them and what kinds of dialogue, concerns, questions, and ideas arise in that space from resident community members. After leaving the hui, I remember feeling that the conversation mostly focused on sharing research updates and soliciting broad perspectives on design considerations for the ecological editing biotechnology being developed in response to the issue of rat overpopulation. In post hui discussion with Dr. Esvelt, he mentioned difficulty grasping the full extent of certain cultural concepts that were mentioned during the meeting, particularly the Maori perspective that science needed to consider the spiritual principles of the rat. Therefore, although Dr. Esvelt needed to return to his laboratory in the United States at the time, I decided with Maori elder and Nga Puhi community leader Bryce Walker to return in a few weeks with my colleagues to continue the dialogues in a more focused manner with the purpose of elucidating the foundational cultural concepts underlying expressed perspectives during this hui.

THE LOCAL ECOLOGIES

Next, with my colleagues Sebastian and Octavius, we took a week long filmmaking road trip across North and South islands to gain a sense of the diverse local ecologies and document the extreme environments of Aotearoa that Indigenous Maori had co-existed with for approximately a thousand years. Film photography, video footage, and sound recordings were collected to create the sensory ethnography film vignettes and other media used throughout this thesis project.







THE NGA PUHI IWI MARAI

After concluding our road trip back up to the northernmost region of the North Island to attend Waitangi Day (national day of New Zealand when the Treaty of Waitangi was signed), we returned to the Nga Puhi Iwi Marai. Wanting to extend our dialogues deeper than the town hall style meeting, we focused on speaking directly with Bryce Walker and any other Nga Puhi community members he recommended that we talk individually with, such as his son, sisters, and friend Stan.

Over the course of the week living in residence at the marai, we spent several hours each day listening to, digesting, and recording the stories that were shared with us. Bryce Walker took the lead in deciding which narratives he wanted to share with us, what context was important, and through what forms he wanted to share with us. The topics spoken about ranged from Maori cosmology and concepts of time to commentary on current social issues in their community and guidance offered for scientists who sought to work with people from global Indigenous cultures. The forms of teaching included narrating traditional stories, drawing live diagrams and symbols on the marai whiteboard to accompany the narratives, singing songs, showing us images, textiles, and other artifacts that illustrated content in the narratives, and reflexive check-ins throughout these dialogues to see our level of comprehension. Additional detail on how the narratives from the open dialogue sessions were sorted are presented in the following section, Layers of Meaning.

Hard on the Take easy on the relationship.

MOTHER

I — 72

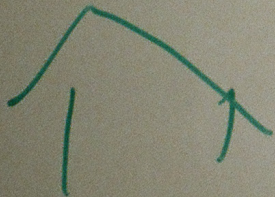
M — PROCESS

TANE — HINE TITAMA

TANE → HINE AHI ONE

WOMAN

HINE NUI TE PO



RANGIHI HAKA

TANE

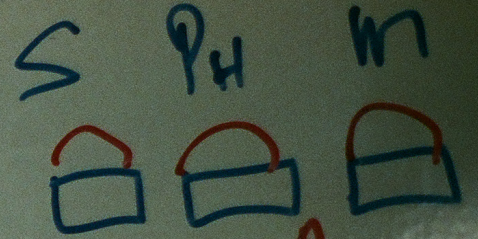
TUKU

TE AOTU ROA

TANE MAHUTA

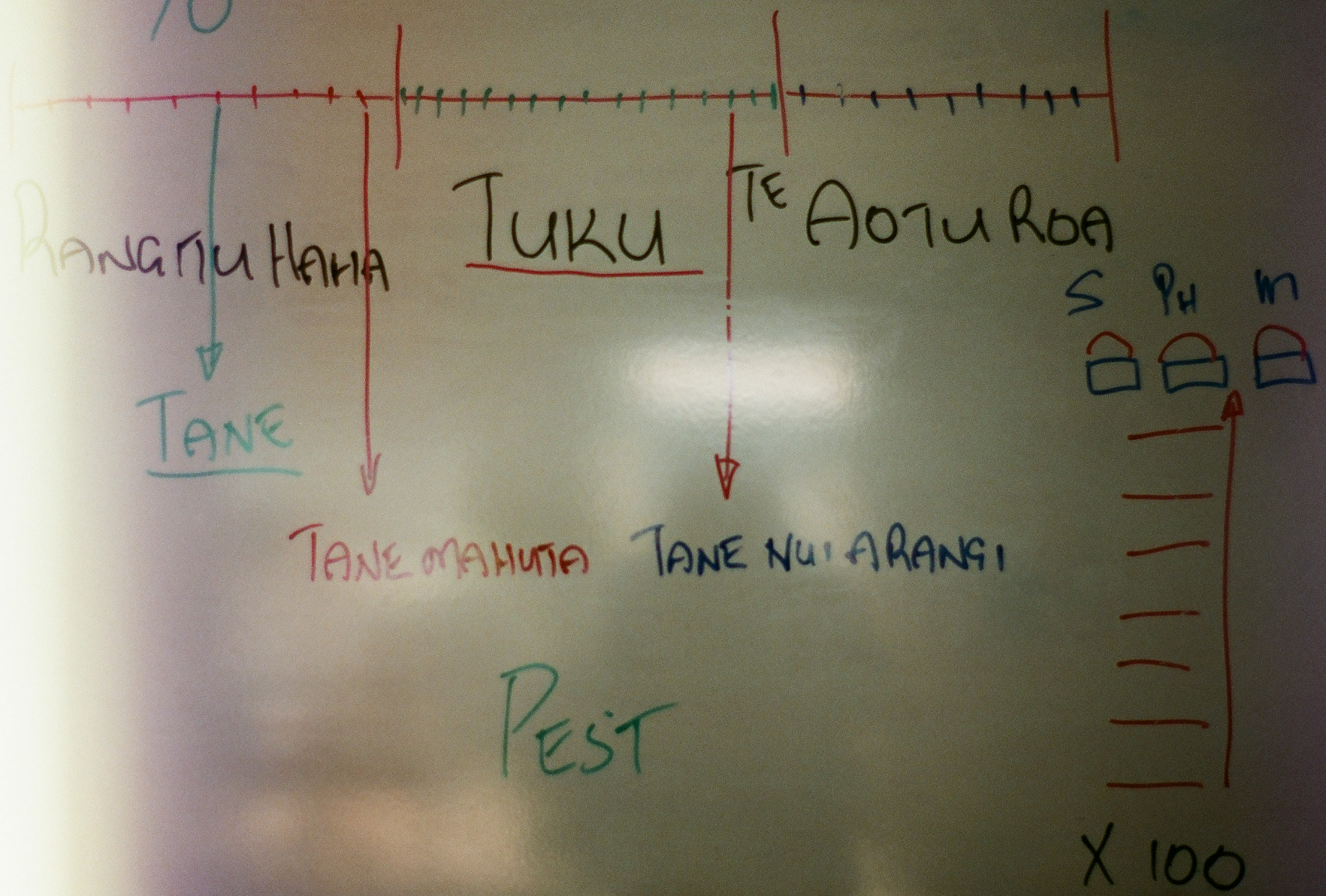
TANE NUI ARANGI

PEST

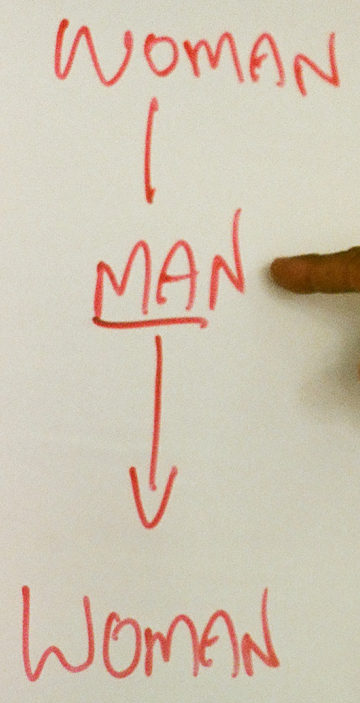
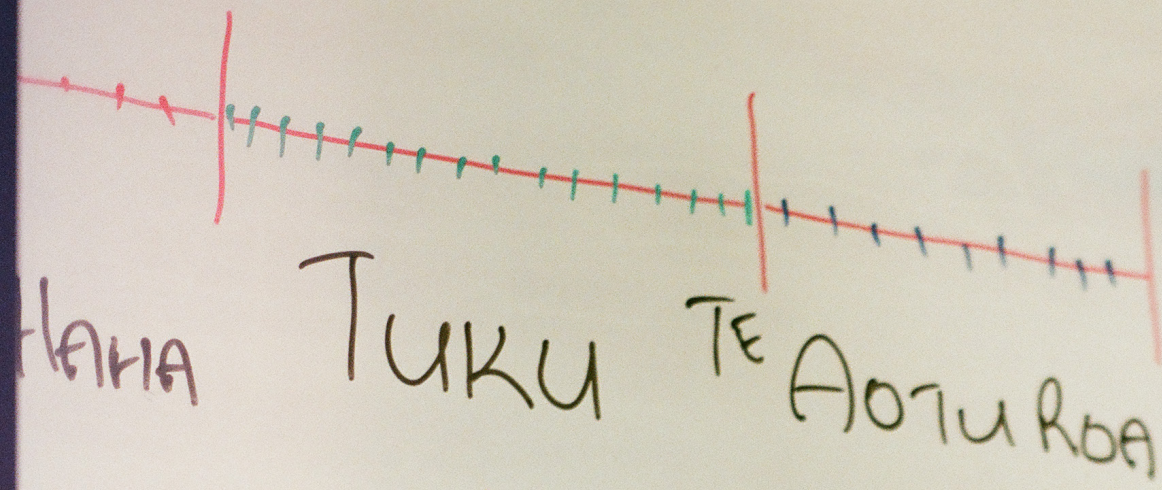


X 100

MODS
70

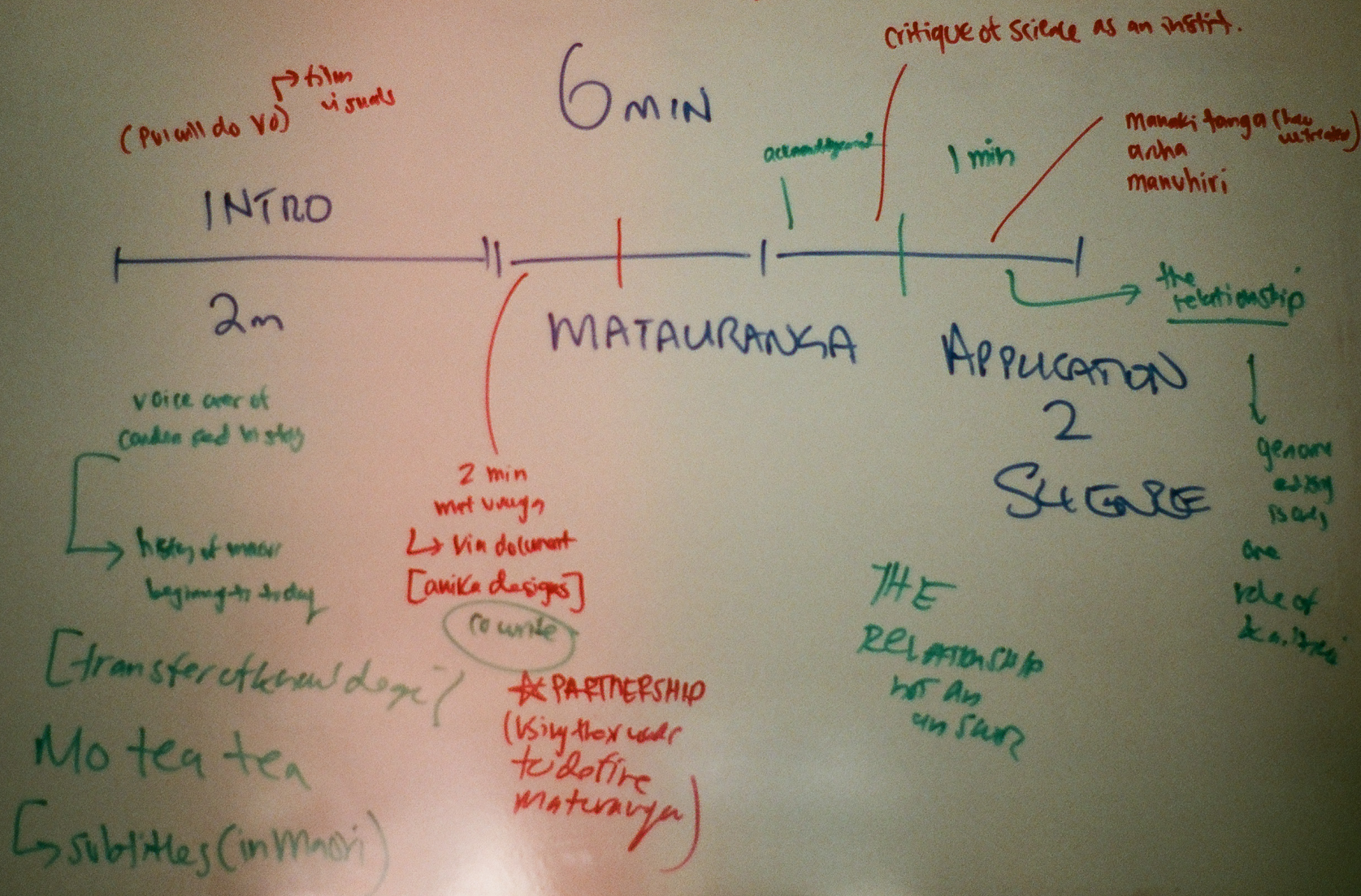


PEST



After completing these open-ended dialogues, we worked with Bryce Walker to collectively identify central parts of the narratives shared with us and co-create a script for an imagined six minute short film that could offer a representation of our dialogues and a takeaway message. The narrative we decided to highlight was the story of Maori Matauranga—the baskets of knowledge, the story of how they were acquired, and how their distinct elements must be incorporated into the scientific process when scientists wish to work with Maori communities. In the creation of the documentary fiction style short film, Bryce Walker played the role of Tane, the Maori deity who was responsible for collecting Matauranga (the baskets of knowledge). The location of shooting was also decided by Bryce Walker, and took place in a forest that he described as being significant to his own life and the Nga Puhī Iwi.

Hard on the Take easy on the relationship.



kinship

watch the kinship short film [here](#).



tuku korero :: the narratives

In Te Reo (the language of Maori people), the phrase tuku korero can be loosely translated to mean ‘giving evidence’ through storytelling. Tuku is to transfer, share, set free, release. Korero are oral narratives, discourse, and information. In alignment with these Maori methodologies for sharing knowledge, in each of the sections I will first include a verbatim account of the oral narratives that our collaborators have shared with us, then follow up with my own interpretations and takeaways relevant to the broader scientific and technological communities. I hope that in this way, I can uphold the original narratives shared with me in their most authentic form, only edited for clarity, and guide you towards forming your own interpretations and insights about the following ideas.

The following narratives have been grouped into three focal themes. The first three narratives, (1) toheroa and the pingao, (2) maori culture | western culture, and (3) the evolution of cultural knowledge highlight the successes, challenges, similarities, and differences when working across Indigenous Maori and Western scientific ways of knowing. Then, the paired narratives (4) objectification | extermination and (5) matauranga | the scientific method begins to offer specific guidance for scientists and technologists to shift their work into more sustainable relations with different beings. The final section, (6) re-imagining relations, offers concepts and practices from Maori culture that are not only essential for working with Maori communities, but helpful in working with global Indigenous cultures.



**"I'M NOT VERY LINGUISTIC, IS THAT ALL RIGHT?
THE REASON WHY IS BECAUSE I REFUSE TO ACCEPT IT. [LAUGHTER].
IN MY CULTURE, WE CALL IT A SOUND, A VIBRATION."**

- BRYCE WALKER, ELDER FROM NGA PUHI IWI

Oral transmission is one of the “five verbal forms of matauranga Maori,” the other four being “whakapapa (genealogy), waiata (songs), whakatauki (proverbial sayings), and kupu whakari (prophetic sayings).” In the following narratives, we find references to each of these forms of matauranga, and I have sought to highlight their presence via the organization of content.

NARRATIVE, MYTH, MEANING

Anthropologist Claude Levi-Strauss defines science as a “field and institution [that has] defined itself in opposition to the sensory world.” Strauss discusses how myth and stories are shaped by our environments, and how they are modalities for sustaining local ecological knowledge. Only with the rise of European enlightenment and its spread through colonialism did writing become the dominant and sanctioned vessel for knowledge. Much of the world still cultivates its knowledge set through the creation, modification, and sustainment of stories. The story can be understood as a different kind of science—a manifestation of a particular way that a certain group of people living in a specific place developed their philosophies about how and why the world works around them.

In the following narratives, there is often use of language or phrasing that may seem vague or inconclusive to a reader who is unfamiliar with the epistemologies of Indigenous peoples. But just as one must read between the lines to grasp broader themes and meaning in prose, it will be essential for the reader to dispense with any predispositions for reading text at face value. The use of metaphor, simile, analogy, and subtext are critical to understanding the underlying concepts in the following narratives and philosophies practiced by the Nga Puhi Iwi.

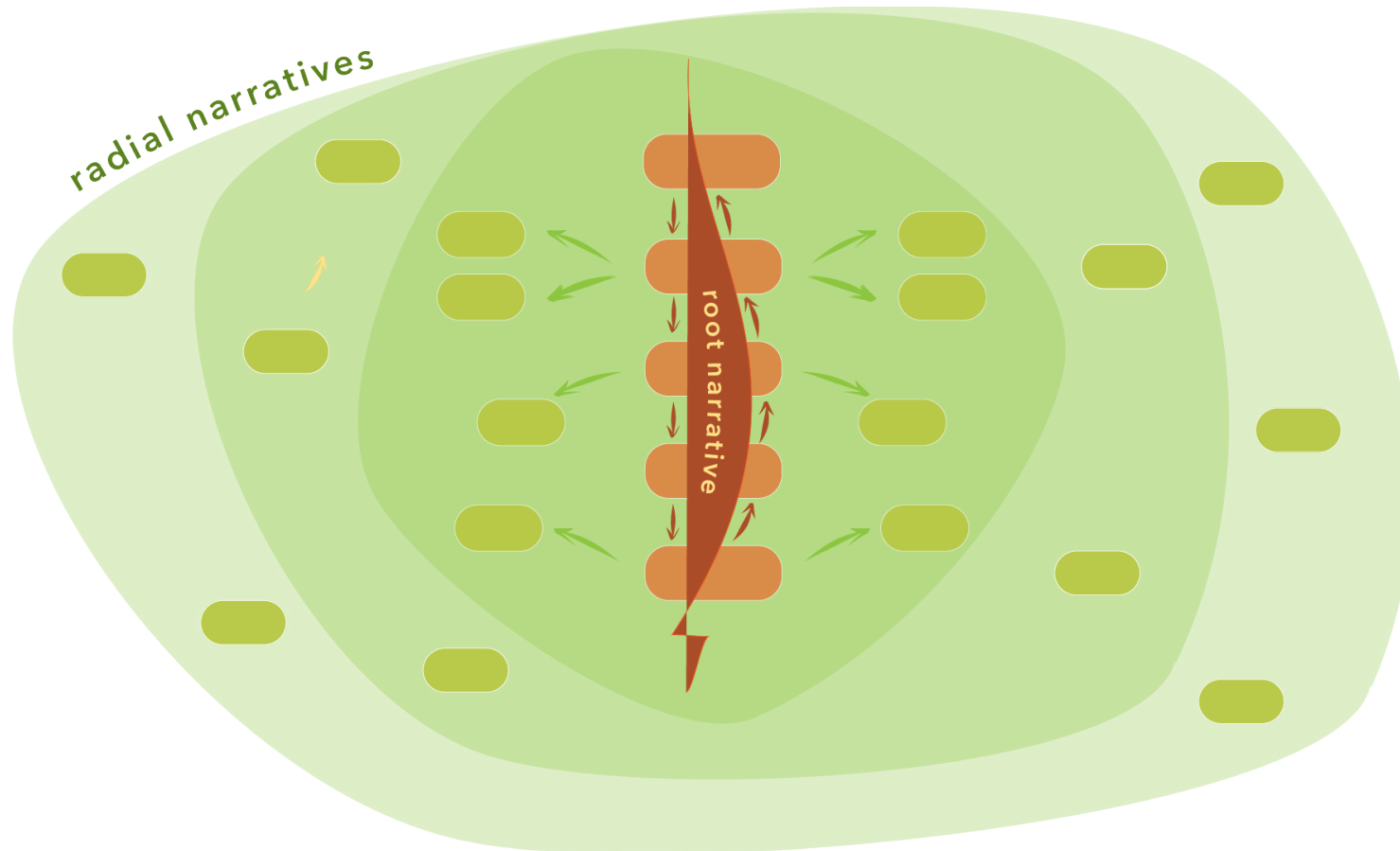
LAYERS OF MEANING

Just as how music must be experienced in its cadences, rhythms, sequences, and relations to one another (rather than as separate notes), that is how the knowledge woven into these stories must be experienced. Stories may not make sense on their own, and meaning is only emergent from their connection to one another. The way a mythological character acts in one story strengthens the understanding of how they act in a related story, while reinforcing a growing cognition of truths embedded in the world around them.

The interconnectedness of the following narratives embodies relational thinking in Maori culture, and more broadly, global Indigenous cultures. Relationships are central to Maori epistemology, and are evident in narratives ranging from Maori cosmology, Maori ways of interacting with the environment, and Maori lenses on cultural responsibility.

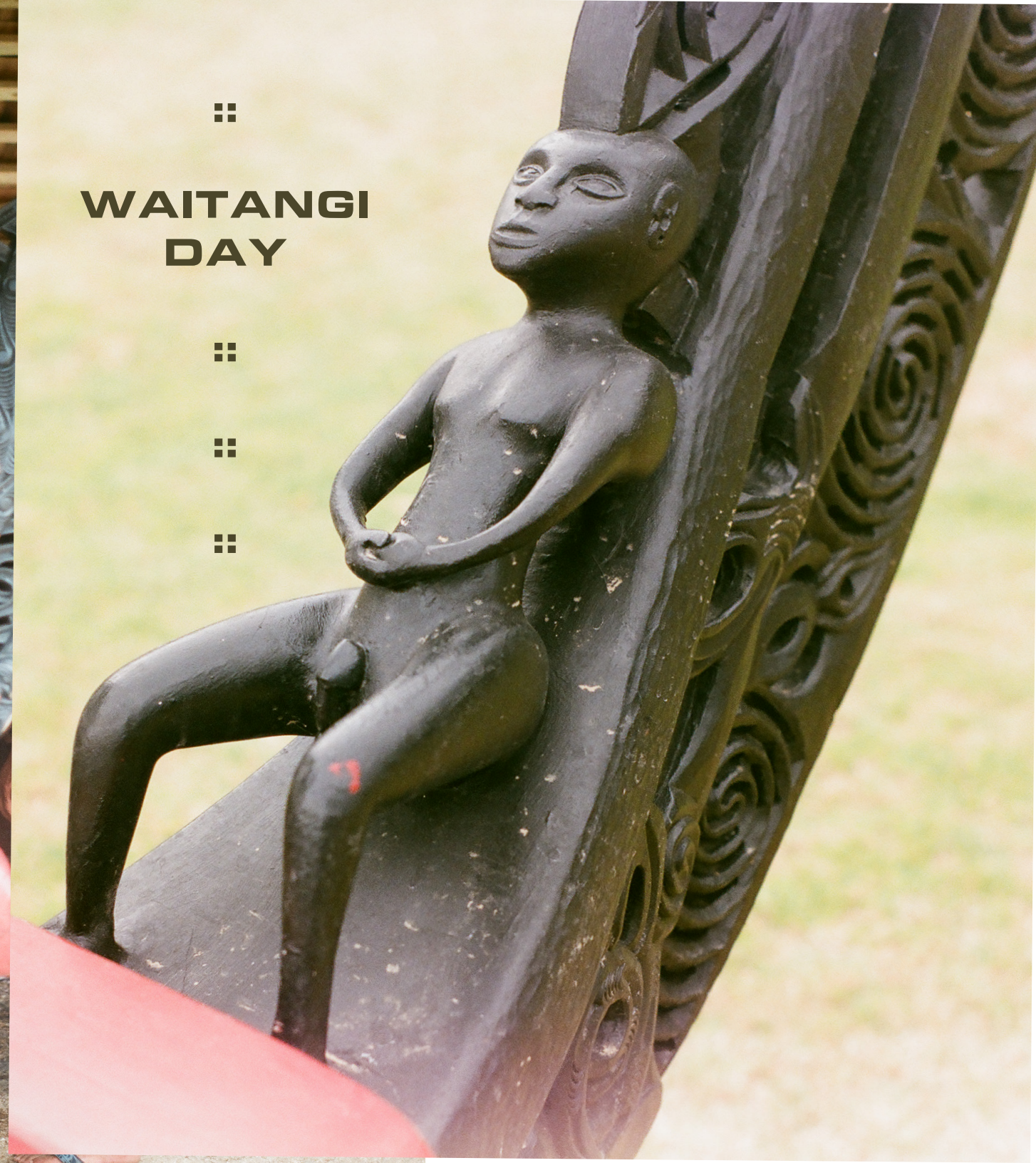
I wanted to challenge myself so that the storytelling of our collaboration was radial, layered, and concentric in alignment with the Maori way of knowing the world, but still told in a way that can make sense to those less familiar with this method of thinking. Thus, I decided to craft a storytelling approach that weaves together a network of clustered, interrelated narratives, and embodies the relationality underscoring complex ecological narratives (see schematic below).

Due to the physical constraints of a written thesis (which is typically presented in a linear PDF format) the structure and presentation of the subsequent narratives follow the simplified linear progression of select magenta squares shown in the above schematic. However, after submission of the written portion of the thesis, I am working with creative web developer and decolonial design expert Bobby Joe Smith III to create a non-linear, interactive transmedia storytelling website with multiple, intertwined storylines that will comprise all of the narratives depicted in the above schematic so that the general public can explore this narrative realm with their senses, and with agency.





❖
**WAITANGI
DAY**















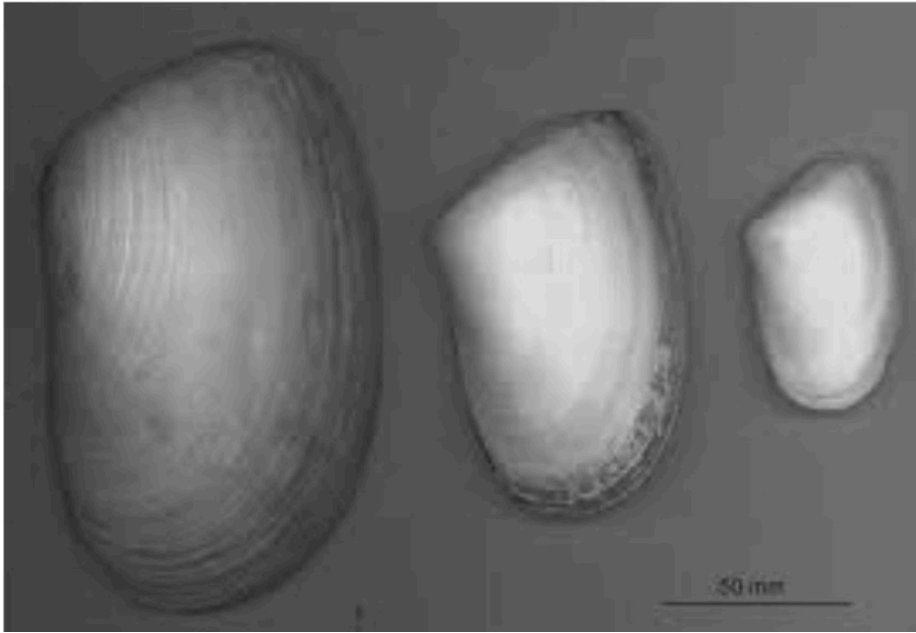
A NEW JOURNEY BEGINS





toheroa and the pingao

narrated by Bryce Walker



left: toheroa, the 'brother,' also known as the endemic surf clam

right: pingao, the 'sister,' also known as the miniature flax plant, grows at the boundary between forest and sea.

A gentleman named Jim Te Tuhi, he's a tohunga (expert) in our world, in our environment here. In his responsibility of sustaining life, he works with one ingredient of whenua (land) called a toheroa. A toheroa is a shellfish, and it was becoming extinct. And there are lots of reasons why. The first step in the process for us [Maori], was to go back, right? We couldn't, say, blame, blame, blame, blame. That wasn't getting us anywhere. What Jim Te Tuhi did, was that he eliminated the concept of blame and took it back to his responsibility, where in fact the neglect was. He brought the family concept in, and explained that the toheroa has a sister, called a pingao.

Without this coexistence, you're going to get an elimination. Now, science couldn't comprehend that. Okay? In simple natural law, what [usually] happens at a moment in time of spawning, or creation, is the sister needs to be present to assist with the creation. An egg came from the brother to the sister. The maternal leaves of this pingao were needed to provide the nursery [for the toheroa egg] and science wasn't aware of that, it couldn't see that.

So what Jim Te Tuhi did, he merely went and got one of those leaves, pinched it off that plant, the sister, and took it into that world there [of Western scientific culture]. He said [to the scientists], "on that leaf, when you look through it... I'll call it just for the sake of explanation, is a genome editing process." That's how small that is.

So he said to these scientists, "I want you to literally pick the leaf [of the pingao] from the beach, take it back to your laboratory, and there will be 1000 little babies on the nursery that the sister is caring for." So the scientists had to use technology to see the leaf and what existed on it. Without Jim Te Tuhi having any microscope, without Jim Te Tuhi having any technology to isolate these components, he knew of the relationship [between toheroa and pingao]. But when the scientists went back to the laboratory to do their investigation, they came back and said to Jim Te Tuhi, "No. You're wrong, there was only 998."



**“WE SEE A SYMBOL OF NATURAL LAW, WHICH EXISTS EVERYWHERE IN OUR DAY TO DAY LIVES,
BUT THEY FAIL TO ACCEPT IT.”**

- BRYCE WALKER, ELDER FROM NGA PUHI IWI

You see? It was a process that was very quickly slammed by the governing authority of that paradigm [Western scientific culture], because it had exposed the relationship of our knowledge [to the natural world]. And this barrier here wouldn't allow us to participate in offering our knowledge.

Why? Let's talk about the concept of a person we call Tawhirimatea, the wind. In the western world, the compass was developed to merely identify which direction the wind was coming from—north, south, east, west—mainly for the purpose of seafaring. To utilize the strength of the wind to get from A to B.

In our philosophy, in our creation, a north blowing wind was talking. The wind was having a conversation with its siblings, with the sea, with the land, with the birds.

When the bird felt the wind coming from a certain direction, it was being told by the wind, “it's time to fly South.” So there's a communication there today between the wind and the bird. And that communication has never been eroded, right? But nobody understands that the wind and the birds are actually talking to one another. So in saying that we have a wind blowing in a particular direction, and I'm just going to say for the sake of explanation right here, right now, that wind is now talking to us here and it's giving an instruction. And we can understand what the wind is saying because, millions of years ago, our ancestors knew what was going to happen, and put together a dictionary so that we could understand [the natural world and] what they were saying. More importantly—this is where science needs to play a part in accepting the explanation Jim Te Tuhi gave—we were able to talk back [to the natural world].

Jim Te Tuhi responded with this in front of science. Okay? That's when [scientists] began avoiding him, and then your culture and mine were called witchcraft, sadly. And he realized that science was not going to help him anymore. Because of the first barrier, called, I'm saying, ego. Or arrogance. Which was sick. Because this paradigm, the western world, actually has the same ability— it's just not listening to its mother. When it came to the toheroa and the relationship of the pingao, there was one moment in this cycle where breeding took place, right? Given the position of the moon, the position of the sun and so on and so on and so on and so on. That was done naturally, within the natural environment, and it was accepted. No one had control over that. So to repopulate, or to save one of our tūpuna [ancestors] that were becoming extinct? What Jim Te Tuhi did, he spoke to that particular God and he formulated a breeding process that took place every month of the year.

You understand what I'm saying here? He spoke to that species or heard that tūpuna [ancestor] and said,

“We're in a dire situation here, and we need your help.”

So he communicated with the Rangatira (tribe chief) of their whenua (land), who called the tohera, and the toheroa spread the word throughout and said, “We've got a mahi to do, or a job to do, and that's to repopulate.” And he was able to make it happen every month, to repopulate, and then he stopped. He said right, that's it. Unfortunately, science came back into the mix only after he had done this, because they didn't want to accept that witchcraft did it, not science.

Out of frustration, Jim Te Tuhi met up with a woman named Betsy Young, a tohunga [expert] of the sister [pingao], because the pingao were gone from the coastline. They were removed by the economic philosophy of...well, today they call it 'federated farmers growing beef.' Back in the day, the way to move large herds of beef stock was down the beach. At certain points in time, they allowed the beef to graze. And the only thing that was needed for them to graze on was the pingao, unknowing to the farmers. So Betsy Young got together with Jim Te Tuhi and started repopulating the beaches with the sister to allow [the relationship to return].

So if you go to that beach, they've now got too many toheroas. Uncle Jim's got a problem (laughter).

All of that communication is done naturally, without the assistance of Jim Te Tuhi. So when a toheroa is literally taken from that beach, it has a process in its DNA, it's taken to another beach, and it naturally just does it, eh? But in saying that, Betsy Young was required to put the pingao back first, the sister. And then fortunately, put conservation measures in place to stop people destroying that sister, to allow the pingao [to repopulate].

That's a beautiful story, there, the evolution of the pingao, and the evolution of this development here.



Now, this knowledge here that I'm trying to explain are some of the tools in Nga Kete Matauranga, or the baskets of knowledge. They offer an actual visual of Nga Kete Matauranga and why they are important to us. And no way are we going to expose them to the Western world, right? Because that's our responsibility to do that, to sustain life. If we did do that, then we'd be breaching an agreement or a creation that happened here that nobody can compromise with.

So Jim Te Tuhi eventually got science and government agencies to the table, and had discussions of how technology and tikanga [Maori governance] would work together. Okay? And that's important. Today they say technology and matauranga. So we're now working with the Environmental Protection Authority, giving them concepts of matauranga to base their decisions on, which we are very, very appreciative of. That wasn't done by just this person Jim Te Tuhi, that was done by a long line of elders. Okay? So we're just at a point in the scale of a process. So, in saying that, we know how much we have to do before the next generation picks up this responsibility and takes it to the next step.

This is making sense? I actually wish Kevin was here.

You see, this is the same story as the rat. Let's find out the relationship here [between the rat and other beings], that manages the...you understand what I'm saying?



**"THE WORLD ITSELF HAS ITS OWN POSITION ACCORDING TO MAORI TIKANGA (GOVERNANCE),
AND THAT WORLD IS THE EXACT OPPOSITE TO THE WESTERN VIEWPOINT.
WE VIEW THE WORLD WITH THE SOUTHERN HEMISPHERE BEING UPMOST."**

- BRYCE WALKER, ELDER FROM NGA PUHI IWI 076

maori culture | western culture

narrated by Bryce Walker




The difference between the Western paradigm and our culture, is the Western paradigm based their knowledge on evolution. And science is a contemporary evolution of their philosophy of where they came from. If I can say it like that, it's been suggested another planet. I'm saying no, another system altogether and they blew here on a solar wind as genomes [laughter]. And the unique part of our planet is, one ingredient can come from space, land on the planet, and the planet will create itself to fit it in. You know what I mean? Yeah. This planet here is very unique. So the Western world philosophy, if I can use that with respect, the Western world philosophy bases, its creation, no, its presence, on evolution.

Yet it doesn't base its future on evolution, it bases its future on control.





 **DANGER POISON**

**SODIUM FLUOROACETATE
TOXIC to PEOPLE and ANIMALS**

Bait Description
Sodium fluoroacetate cereal baits are cylindrical in form and dyed green

will be present on the ground from: **9 - 1 - 20**

- DO NOT TOUCH poison bait
- WATCH CHILDREN at all times
- DO NOT EAT animals from this area
- Poison bait or carcasses are DEADLY to DOGS

In an emergency, dial 111

 For more information, contact: Operation Supervisor, Greymouth
02115 06905 0508 141 268

Unauthorised removal of signs or baits is an offence

Our cultures fortunately can prove and sustain that we're creators of our presence here. We created it. It wasn't a process of hoping for the best, which is what science is about. You understand? Because evolution, you know, evolution meaning apparently we swung from trees for a time and prior to that we came out of the ocean, right? And after swinging from trees, one of us decided to stand up on two feet. In our culture, how you see me today is how I was created right from the beginning. So we now have a conflict of paradigms. So we need to consider that science has already made a clear statement that it's not interested in creation because they don't—that philosophy of science does not believe that the cultures, Indigenous cultures of this planet, have that kind of power or authority in regards to Whakapapa [our genealogy].

The sun is a great, great, great, great, great, great grandfather of mine.

And that was what created us. So I just wanted to make that point very clear. The conflict that we have is, one is a creator, right? A creator of all the events that took place. And one's a gambler, standing there contemplating whether to push the double or nothing button on the gambling machine, hoping for the best. Waiting forever. So, the paradigm of the Western world is actually gambling that our creation will include them, and in fact, it does. But they choose not to acknowledge the cultures that created evolution, which was created for them to exist here. And that's what our culture does— all of our [global Indigenous cultures]. Ours allowed them to exist...if we could just put their barrier down for a minute and consider it.

As far as science is concerned, science has only captured 1% of our culture. They are ignoring the other 99%.



“NOW THIS PLANET HERE IS WHAT’S UNIQUE, NOT OUR CULTURE.”

- BRYCE WALKER, ELDER FROM NGA PUHI IWI

Anika:

What you said is really interesting, this contrast you make between creating and gambling. Something I've been thinking a lot about is, this new form of biology, some people call it synthetic biology, gene editing, bioengineering, whatever name for it we use.... what makes this type of science feel radically different than prior sciences is that the tools are centered around creation. It's more a philosophy of creating than of distilling down, than of reductionism. Because you're right, the institution of science has historically revolved around finding a complex situation, simplifying the parts, distilling it down to see what we can comprehend, then taking a gamble that this simplification is representative of the complex system. With bioengineering, it's kind of an opposite philosophy, where you stop and look to see, what are the elements I have at hand? What tools are available to use from the natural world? How do I understand these elements? What am I yet to understand about these elements, how can I play with these tools to watch what emerges?

Bryce:

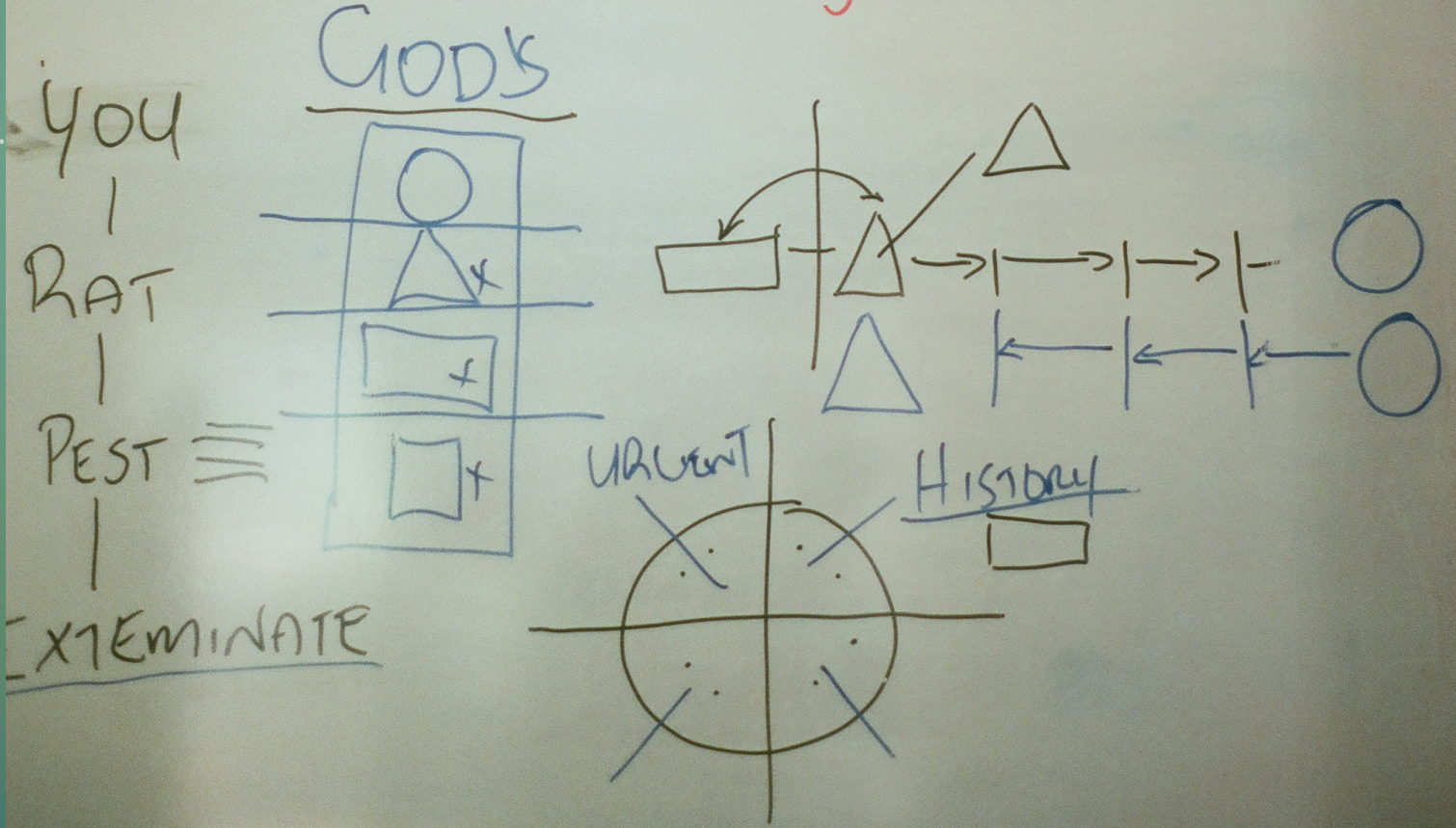
I understand what you're indicating here. You're appreciatively maternal and you're considering their behavior and trying to make it fit and work. I understand. So if I can, I'll go to the whiteboard because I like drawing pictures. Is that all right? Okay...

the evolution of cultural knowledge

narrated by Bryce Walker



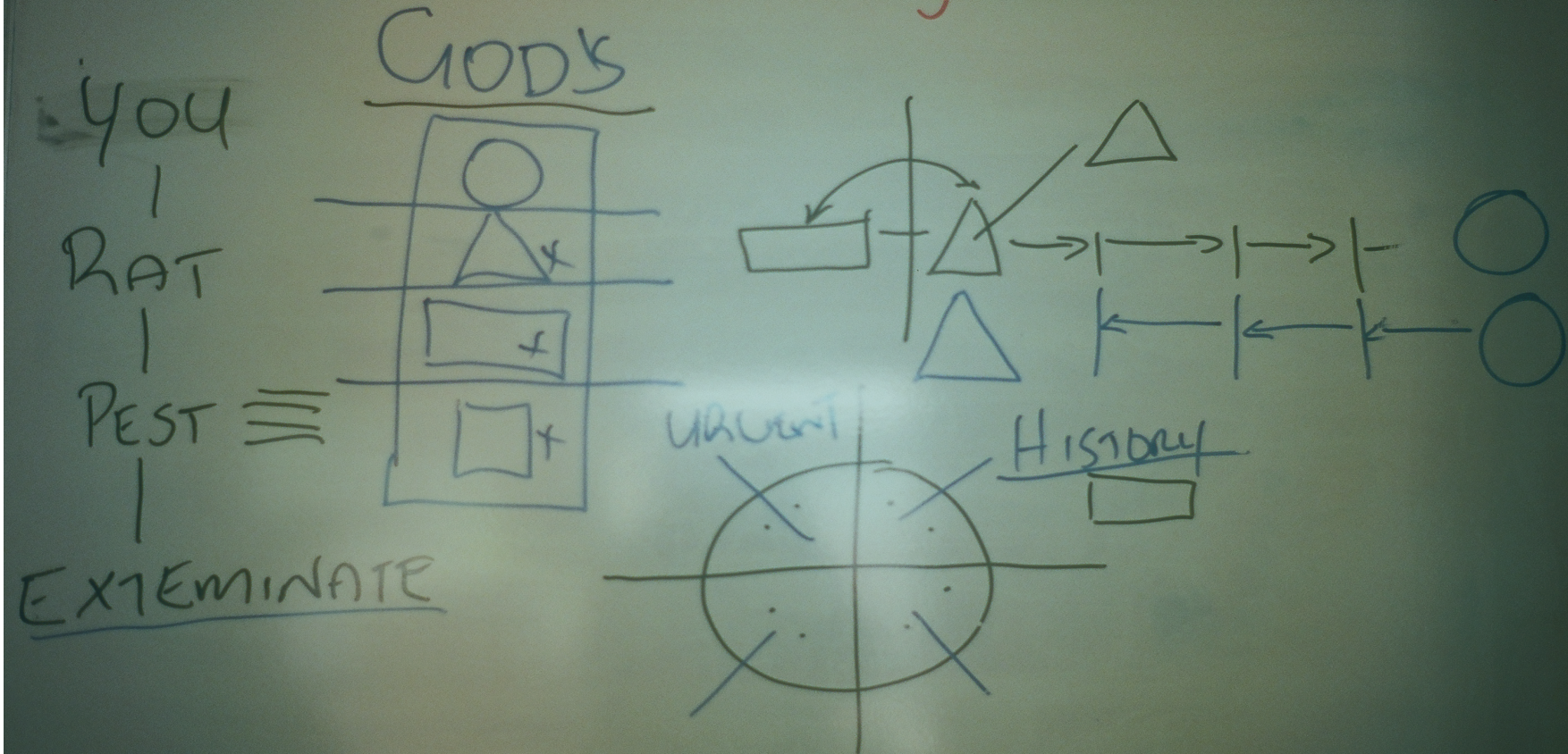
Hard on the Tāke easy on the relationship.



[refer to the above diagram by Bryce Walker for the following dialogue]

The basis of nga kete matauranga (the baskets of knowledge) are symbols. Now, symbols in the Western world paradigm are not allowed. Okay? Yet those symbols are important parts of our dialogue. So if we use symbols like this as a total body... [draws a circle, triangle, rectangle, and square in a column on left side of the whiteboard], the Western world has decided that it will base its theory of philosophy on just one of those symbols [draws an isolated triangle on the right side of the board] and then it will begin a process of gambling. And it gets to a certain point in time, over here... [sketches arrows showing the progression of the isolated triangle to a circle on the right side of the whiteboard] where they can't even recognize that original symbol anymore. So now it looks like that [points to circle on right side of whiteboard]. And what we've got now with the Western world, is we've got a brick wall that natural law won't let them go past [draws a line symbolizing a wall on the left of the isolated triangle]. Because in our creation over here [points to column of circle, triangle, rectangle, and square on left side of whiteboard], in natural law, there was a creation of "don't go any further" because the world isn't ready for that. The world won't allow that to happen, meaning individualization. So what science actually has to do is it has to make its way back to the beginning [motions from isolated circle on right to column of shapes on left]. That barrier there, or that point in time [pointing to line to the left of isolated triangle] is the biggest barrier that science has. It assumes it's God. That's the first barrier science has to eliminate from its own mind....arrogance. Hate. Anger. Only then can science get back to creation. They need to realize they are part of this philosophy as a whole [points to column of circle, triangle, rectangle, and square on left side of whiteboard, representing the philosophies of global Indigenous cultures. So if we go back to here, [the earliest part of the cultural knowledge spectrum], no explanation of ours is going to appease science, because it has these dialects [points to isolated circle on right of board].

Hard on the Take easy on the relationship.



In their explanation science has already defined them to be that certain way. But it's different from that [the earliest part of the cultural knowledge spectrum] and they don't realize.

Science has written a dictionary on that isolated philosophy only, so any other dialect, like these ones here [of global Indigenous cultures at the earliest part of the knowledge spectrum] are going to be ignored, not going to be understood.

It won't fit into their paradigm, and it's as simple as that in a nutshell.

So if I can take us back to the meeting the other day [the annual community dialogue with Kevin Esvelt], it was concluded that rats ate poison, rats went to traps, and if they survived, they would become shy. They're in that symbol [points to isolated circle on right side of the whiteboard].

Their paradigm didn't consider that a rat is intelligent because it's part of its survival, in relation to our culture and our role in sustaining life.

And that's a big barrier for science. It won't accept that. In here [motions to the earliest part of the cultural knowledge spectrum] the rat has whakapapa [genealogy] to me. So in mautaranga's creation, it was given all of these tools because of our responsibility to sustain life. If we draw the planet, or let's use a symbol called a circle [draws circle in lower half of whiteboard], we split it into areas of responsibility. Our contribution to this philosophy [motions to the earliest part of the cultural knowledge spectrum] was you're not going to get rid of the rats Mr. Kevin, because we demanded that they have this attribute of survival.

objectification | extermination

narrated by Bryce Walker

YOU \rightleftharpoons RAT \rightarrow PEST \rightarrow EXTERMINATE
YOU \rightleftharpoons RAT \rightarrow PEST \rightarrow EXTERMINATE
YOU \rightleftharpoons RAT \rightarrow PEST \rightarrow EXTERMINATE

Remember the four sets of twins, maternal and paternal [representing cultural responsibility]. So I can't give a perspective on rats without all of the symbols [knowledge from global Indigenous cultures]. These symbols [motions to the earliest part of the knowledge spectrum] actually include science, as science has studied this rodent.

But what blows it out of proportion, making [the rat], a creature that fits into our society become a plague?

They [pointing to earliest part of the knowledge spectrum] haven't done that.

This paradigm here [pointing the the paradigm of science at the right of the knowledge spectrum] also hidden symbols and those hidden symbols were carried there by Indigenous Peoples okay? We don't work alone and ... these symbols are trying to talk to them but they ain't listening to it. Because the scientific paradigm here has lost the dialect that can talk with the rodent. So if we begin with whakapapa, let's start with the rat. That's what we call it, right?

And then someone decided to call it a pest, which is derogatory, right? How would you feel as a creation?

And then, because of this interpretation... [draws a line from the word 'pest' on the whiteboard to the word 'exterminate'].

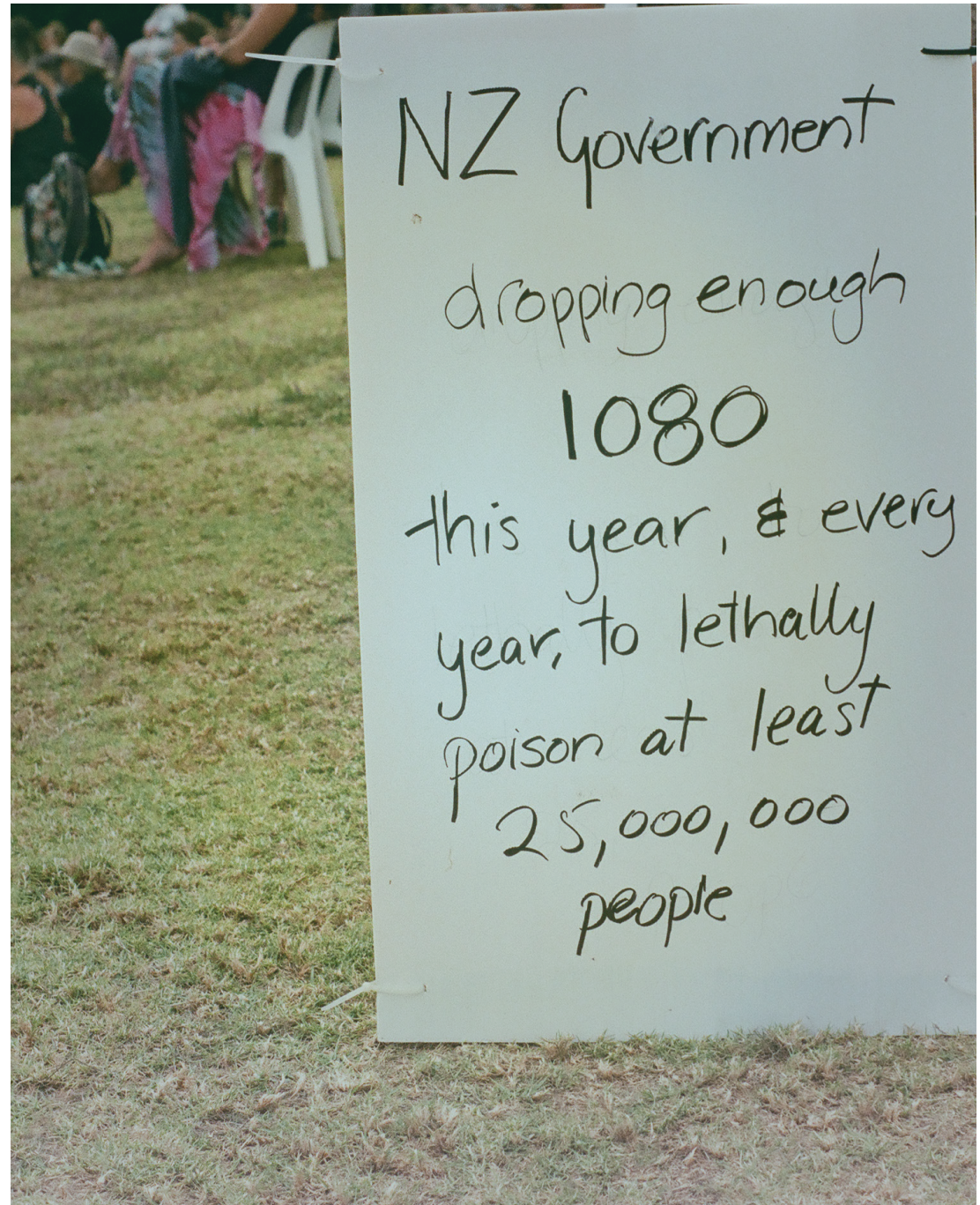
Anika:

You see similar patterns with humans, Indigenous people, migrants and refugees, right?

Bryce:

Yes. The whole paradigm of the Western world...you can change this to you. [changes the word rat to "you"]. Or me. The philosophy is the same. It's because of their wisdom...what makes them angry and arrogant is they have come to believe that their existence was a mere gamble by evolution, when in fact it's not. They have a responsibility. They are one of the sets of twins, the Western world.

And unfortunately they've alienated us. They're not interested in our knowledge, or the proof that they want to exterminate everything. They're not interested in knowing who they are. That's what's happening.



If I advocate in this paradigm of Western science, because that's the dialect that we know today, that dialect only allows blame to happen [referring to blaming the rat as a pest]. And when we use this Western science paradigm to advocate for blame and those kinds of concepts, we find ourselves being victims, right? Having none of this relationship here [of creationism, motioning to earlier part of the knowledge spectrum] whatsoever. If we begin to use a dialogue of victimhood, we acknowledge the success of this paradigm [the eminence of Western culture].

Our rivers are polluted, we begin to blame, and quietly the colonizers were sitting there going, "Yay, we've done that. We achieved that goal. We put them into a state of despair," which is a sequence in colonization, right?

The first sequence of colonization is to remove the Indigenous culture in its entirety. Its beliefs, its social structures, its political structures, its hope, and it begins by applying this process. And for our culture, the first term they used to blame us was "savage," right? "Cannibalism," "unstructured," "needing our attention to help them." But this way of thinking removes our own responsibility, we have to keep it in the context of cultural responsibility in that spectrum. So Jim... the toheroa was becoming extinct. And there are lots of reasons why. And the first step in the process for us [Maori], was to go back, right? We couldn't, say, blame, blame, blame, blame. That wasn't getting us anywhere.

All I'm trying to advocate from this perspective [motions to the earliest part of the knowledge spectrum] is that we are aware that it's only Western culture that is blaming and saying "urgent problem," right? It's only them, it's not us. We are actually going to be okay, because our knowledge bases [referring to global Indigenous cultures] at each moment in time, have the ability to create the next step. But we can't do that without us all. History began with all of us. Life began with all of us. We can't move forward without one of us not there, because we'll be making the same mistake.

the baskets of knowledge

watch the baskets of knowledge short film [here](#).

















HARA KEKE KETE (FLAX BASKET), WOVEN BY KAREN SMITH, NGA PUHI TRADITIONAL WEAVER

mautaranga | the scientific method

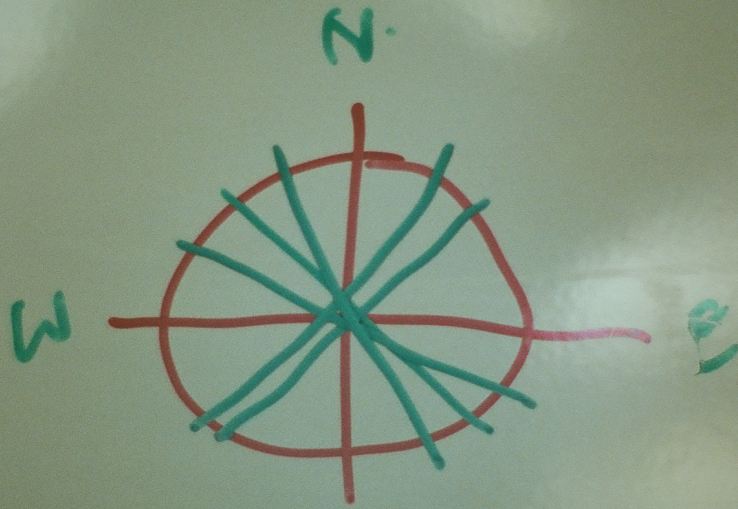
narrated by Bryce Walker

If you ask me, Kevin has come to us because he is trying to find that lost dialect between Western science and the natural world, okay? You won't find it in a microscope. Or in a laboratory, in containment.

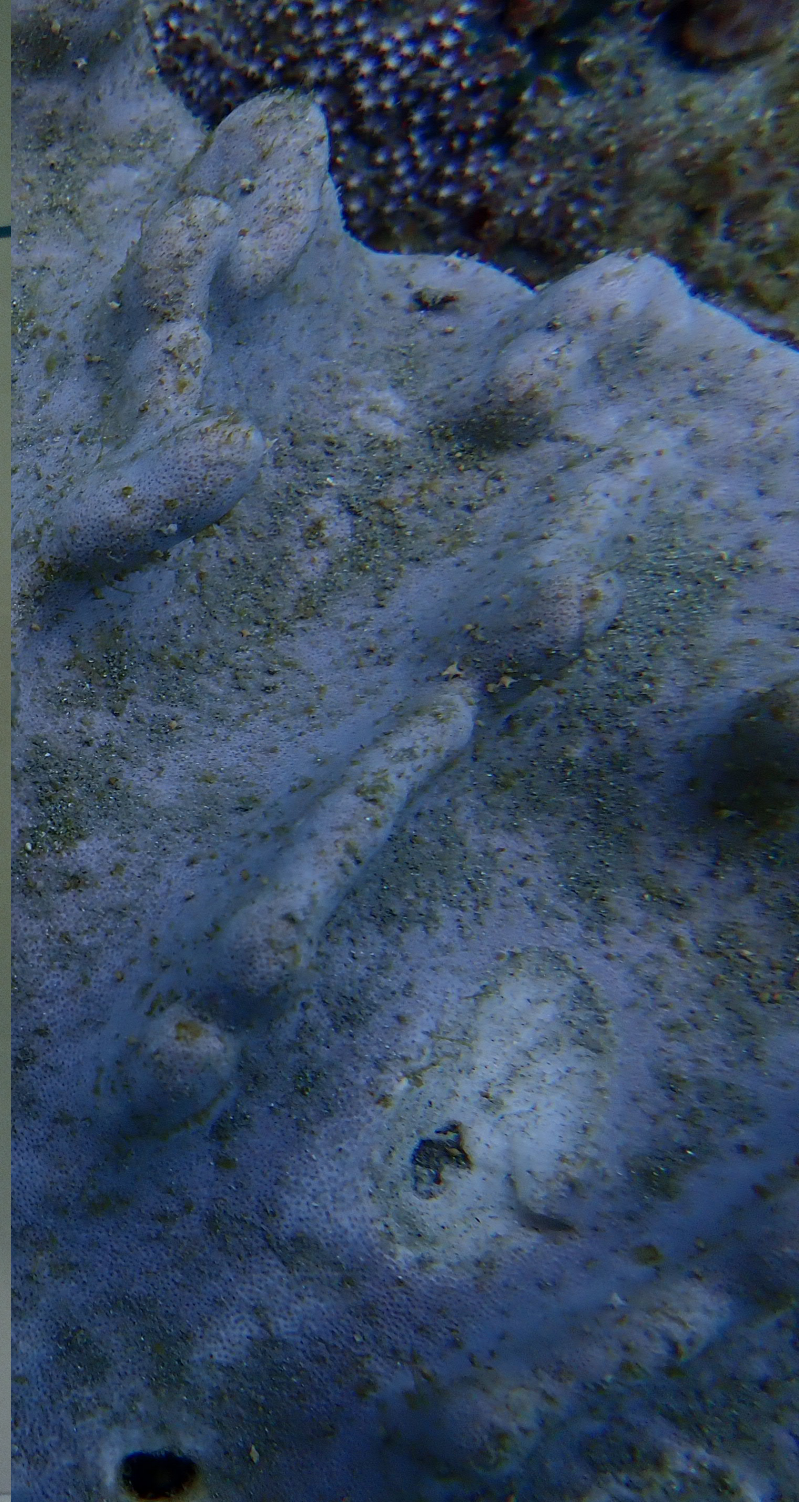
Because in the laboratory you can't feel the wind, you can't feel the temperature of the sunlight, which are all [key] components. All of them make a decision.

You can't take the wind direction as being an instruction on its own. You have to add the temperature of the sun. You have to add the position of the moon, where it was... and all of those other components. So in this area here, a dictionary was developed by them [Gods], keeping in mind that the creation of mankind, at that point in time, they even instilled in the air, the ability to understand this dictionary and the ability to respond. Now keeping in mind this is our maternal, right? And what is the most important thing a mother would want for their child? To be able to communicate, right? So they call that dictionary a Maramataka (Maori lunar calendar). It's a dictionary of dialects. Seventy different dictionaries—a dictionary for the wind, the sea, the land, and how to utilize them. All the dictionaries were so full that we took full advantage of the provisions that were being provided.

TAWHIRI MATEA



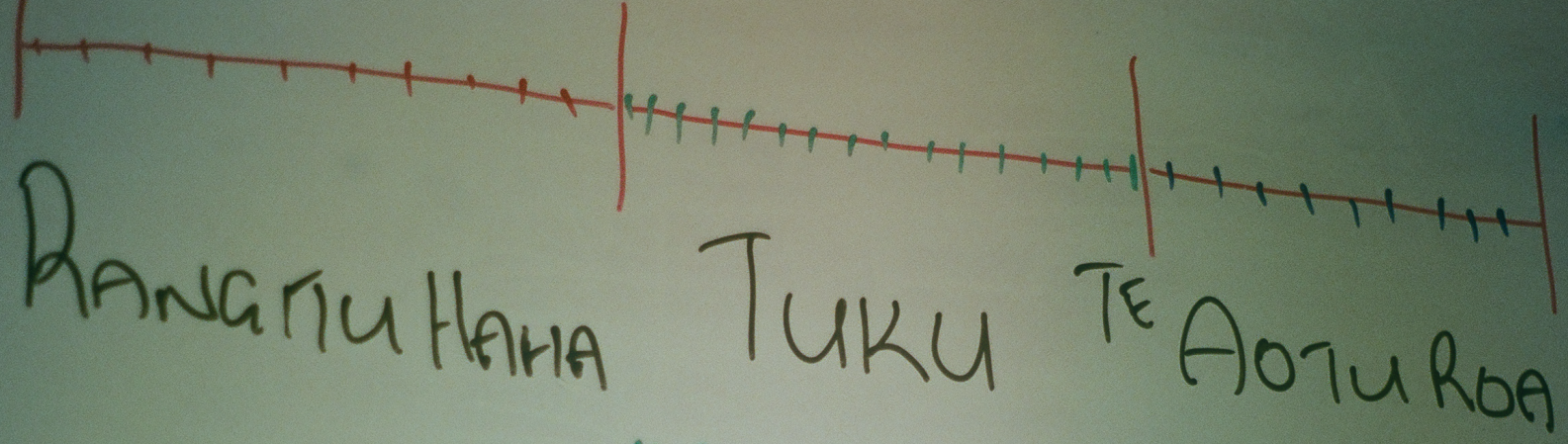
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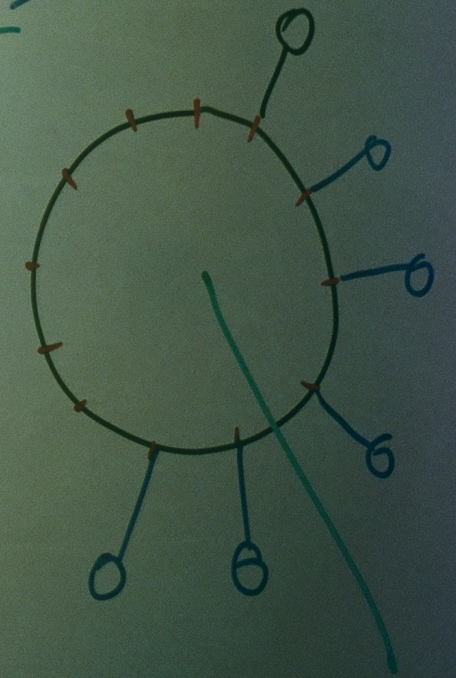
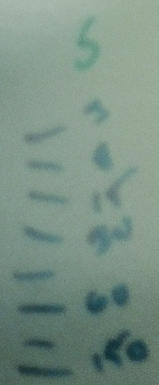
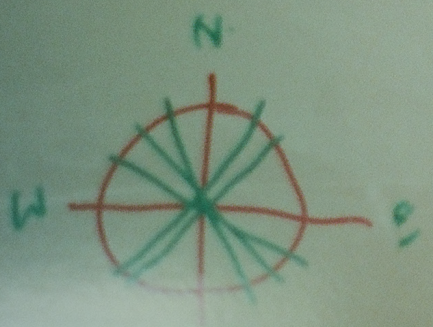
And I use the word exploit, right? They provided opportunities where we had to exploit. These are living things. Okay? So that's also part of the explanation to get to the action that Jim Te Tuhi did to repopulate the pingao.

That's the maramataka, the dictionary of dialogue with nature, the language of exploiting during abundance.

If we use the astrological symbol, that's one year, right? I'll use that calendar phrase for this explanation. In that one year, it has certain seasons and certain days and certain months, certain minutes and minutes can be broken down into, for the sake of explanation, can also be broken down into genome minutes, can be broken down into nano minutes. Okay? Where our people, with the use of this, had the ability to appear to slow down time. Or make it go faster. In the astrological world, they talk about two points in time, and unfortunately using one paradigm to say that time travels in a straight line from one o'clock to two o'clock...the appreciation from the Western world has proven to accept this philosophy of what I'm talking about, it has accepted that in its investigation of our creations in our solar system, time could be bent. And it could take longer, right? Or it could be shortened. Because that's what the solar system provided when they looked through their telescope, right? So that can be done on earth with humans. And we base our decisions of when to exploit at the right time, during moments of abundance.



TAWHIRIMATEA ← MARAMATAKA →



TAWHIRIMATEA, THE WIND :: MARAMATAKA, DIALECTS OF NATURE

bryce's message

watch the short film, bryce's message [here](#).



re-imagining relations



Co-produced with Bryce Walker, the following statements are brief take away points for scientists and technologists who hope to engage Maori and other global Indigenous communities in research. These principles are expanded upon in the paper written with Dr. Riley Taitingfong, Empowering Indigenous Knowledge in Deliberations on Gene Editing in the Wild, in the following chapter.

1. Time for “Tuku Korero”

Understanding that it must be the right time, place, person for Indigenous peoples to feel comfortable sharing their knowledge. These circumstances can only be determined by the community you hope to work with.

2. “We Are Not an Option” :: The Politics of Choice

Before asking Indigenous peoples to share their perspectives, consider how you will treat the knowledge that is shared. What happens if knowledge shared is contradictory to Western scientific knowledge? What responsibility do you commit to upholding if you ask for this knowledge? Why would a community share their perspectives with you if they do not believe that their voices will be sincerely listened to, or that their perspectives will not carry the potential of shifting the course of your work?

3. Muru :: Principles of Restorative Justice

Undo the harm that has been done. Colonize, decolonize. What does restorative justice look like for the people you hope to work with? For any beings you seek to impact (in the case, for the proposed genetically engineered rat, who has been labelled as a pest?) How do we see things from the rat’s point of view and how it has been treated by humans? How do we begin and end our work by interrogating what injustices created the issue that we hope to mediate?

4. Pluralities of Perspective

Acknowledge that you will come across a diversity of perspectives both across different Indigenous cultures and within a specific Indigenous community. How will you design engagement with Indigenous Peoples so that you seek out pluralities of perspectives, and how will you balance the influence of these distinct perspectives on your research?

5. Manaaki, Manuhiri, Aroha :: Principles for Reciprocal Partnerships

- i. Building trust in a relationship requires time
- ii. Respect limitations on time of research involvement with Indigenous community members
- iii. Deeply educate yourself about the people you hope to work with before approaching them
- iv. Work to include global Indigenous cultures; do not create conditions for cultural erasure, isolation, or divisiveness by asserting that one group of peoples are more ‘Indigenous’ than the other
- v. With their invitation, meet Indigenous peoples at *their* lands. Bring your care, love, and respect.

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**MANAAKI
MANUHIRI
AROHA
MURU**



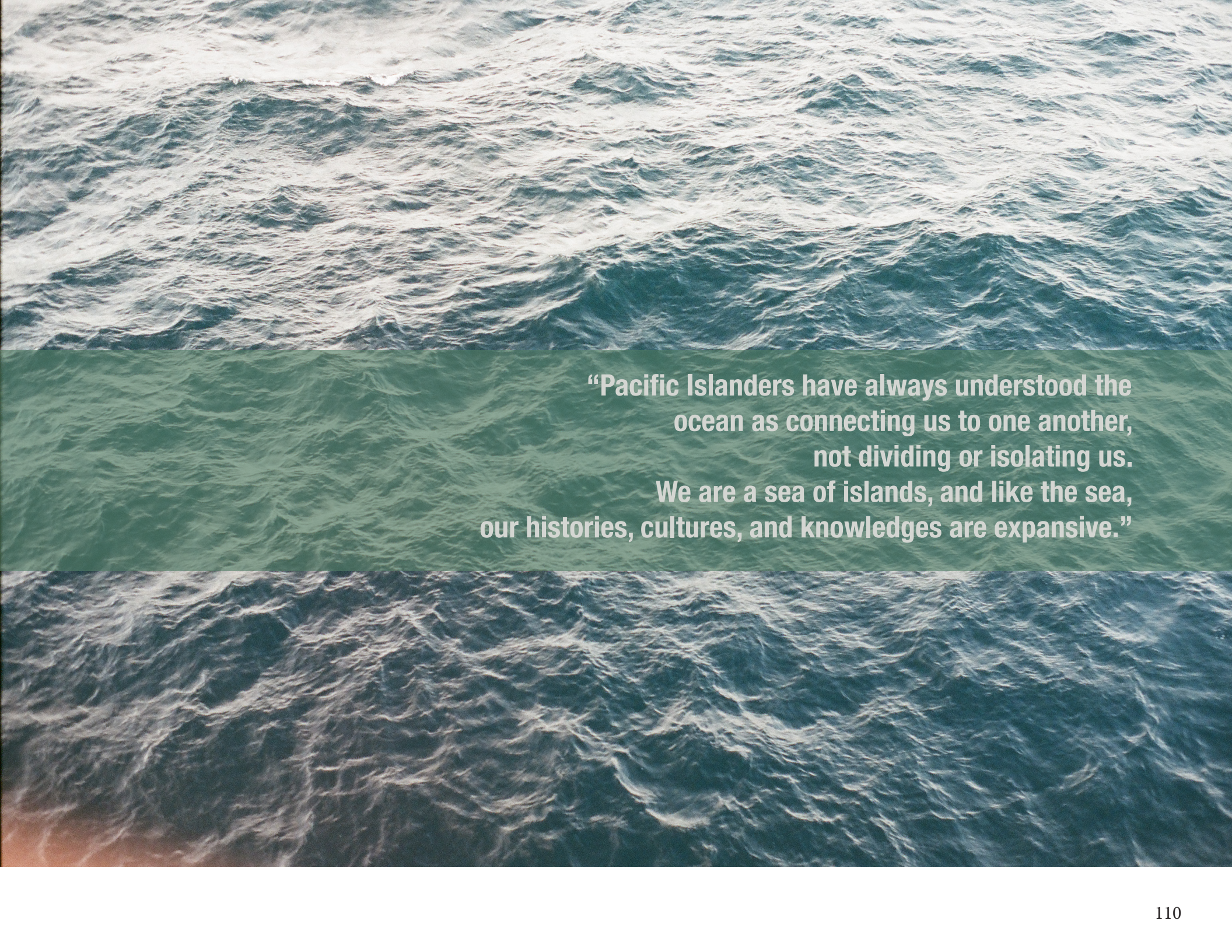
architecting action

chapter four :: chapter four :: chapter four

When attending the 2020 SING Indigenous Genomics Conference, I met Dr. Riley Taitingfong, who was a PhD student in Communications at UC San Diego at the time. I saw her talk, titled “Islands as Laboratories: Indigenous Knowledge and Gene Drives in the Pacific,” which explores how emerging gene drive biotechnologies are situated within the histories and ongoing realities of colonialism and militarism in the Pacific Islands. At the time, I had also been reflecting upon the ways in which gene editing more broadly (specifically agricultural editing and ecological editing) intersected with colonialism, imperialism, neoliberalism, and techno-capitalism in the Global South (mostly Asia and Africa at the time; see chapter 2), and was inspired by Riley’s approach to producing and sharing knowledge about this complex reality.

I noticed that when I drew from the fields of critical studies or science, technology, and society studies to inform my work, I felt a heaviness in my body. I felt the weight of these top-down global infrastructures constraining my mind, my breath, my body, and would at times feel suffocated, hopeless when reminded of the generations of trauma that the world’s people have experienced by design of these socio-political infrastructures. But when I experienced Riley’s talk, I felt something different. I felt hope, I felt inspiration, I felt power, and I felt my body, heart, and mind transcend into an orientation of expansion, imagination, connection, care.



An aerial photograph of the ocean, showing a vast expanse of water with varying shades of blue and green. The water is textured with small waves and ripples. A horizontal band of a solid, medium-green color runs across the middle of the image, containing a quote in white text.

“Pacific Islanders have always understood the ocean as connecting us to one another, not dividing or isolating us. We are a sea of islands, and like the sea, our histories, cultures, and knowledges are expansive.”



This is how Riley began her talk. And throughout her presentation, she spoke with authenticity, with the power of her own responsibility to share essential perspectives on how this biotechnology may impact the people and places that she is tied to. With grace and conviction.

It is hard to share knowledge about the histories and contemporary realities of trauma. It is even harder to talk about these experiences with just the right balance of emotional investment and objective detachment, so that people can feel you and feel what needs to be expressed, but also see the facts, the truth. And it is hardest to do all of these things, while leaving those we seek to educate with hope in their bodies instead of despair.

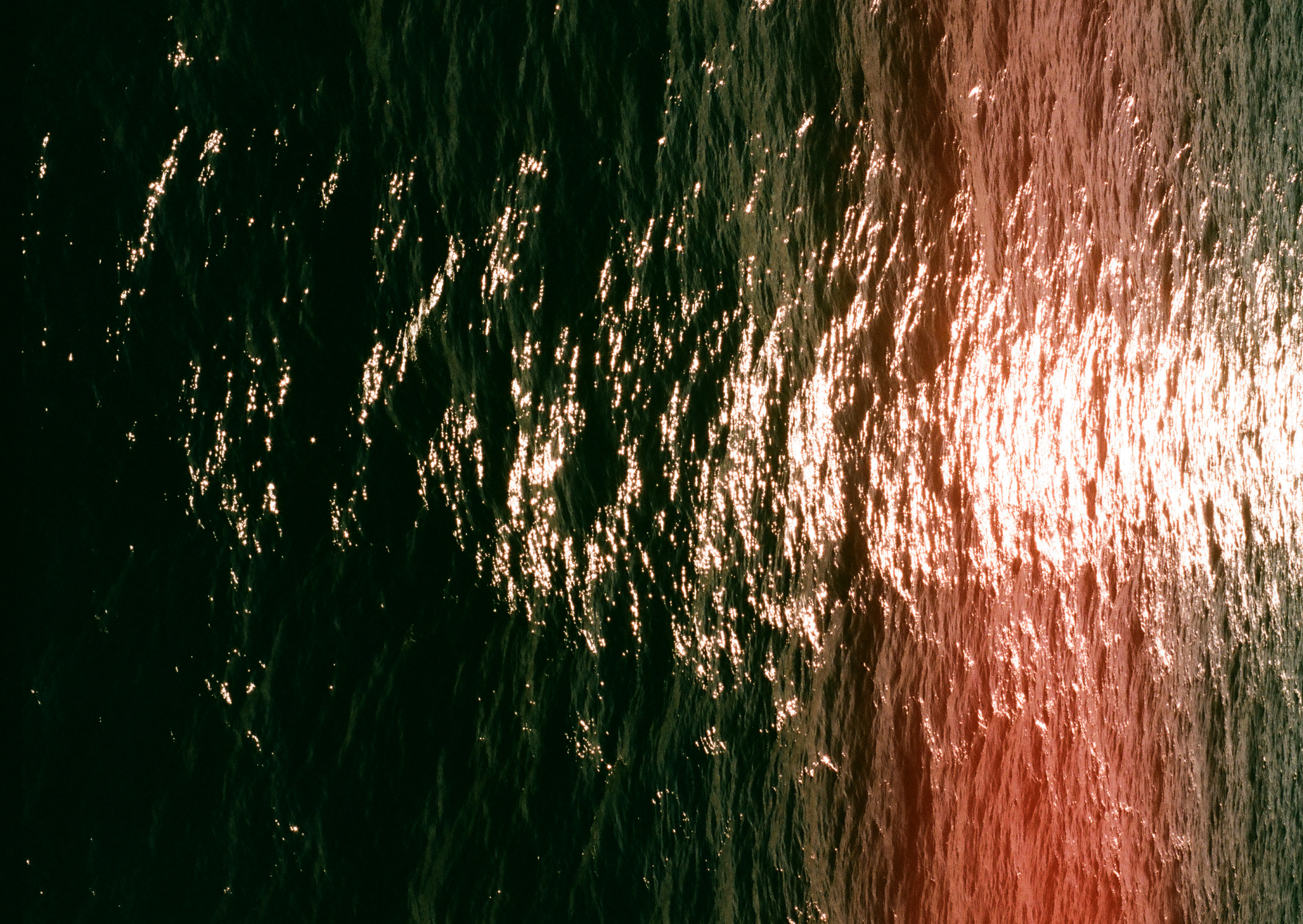
Yet Riley did all of this and more.

And so this is the beginning of my relationship with Riley. After her talk, we made time to connect and unearthed several serendipitous connections between us. I had also studied communications at UC San Diego during my undergraduate studies there, and so we connected over shared professors, academic interests, friendships, and memories of the sea.

Over the months following our meeting, we became friends and collaborators. And at many points, Riley was my mentor. She guided much of my academic thinking, in addition to helping me process several difficult personal challenges that arose during the pandemic. She offered unwavering emotional support in individual reckonings with reconnecting to my own Indigenous heritage, and even opened her home to me at a point when I had been drifting with no place to go. And so I speak of Riley with the utmost love, respect, and admiration.

Below are two works that Riley and I have collectively created together, with additional input, contributions, and guidance by friends, mentors, and colleagues in our shared academic and personal communities. Though the following constitutes just a select portion of the collective creations by our minds, I am inspired by the potential of our relationship to evolve through life-long friendship, alliance, and care.







**“HOW CAN WE BEGIN TO MOVE FORWARD TOWARDS
ECOLOGICAL AND CULTURAL SUSTAINABILITY
IF WE CAN NOT EVEN IMAGINE WHAT THAT PATH FEELS LIKE?”**

ROBIN WALL KIMMERER, BRAIDING SWEETGRASS

speculative imagineries

How does your body feel when you engage in acts of imagination?

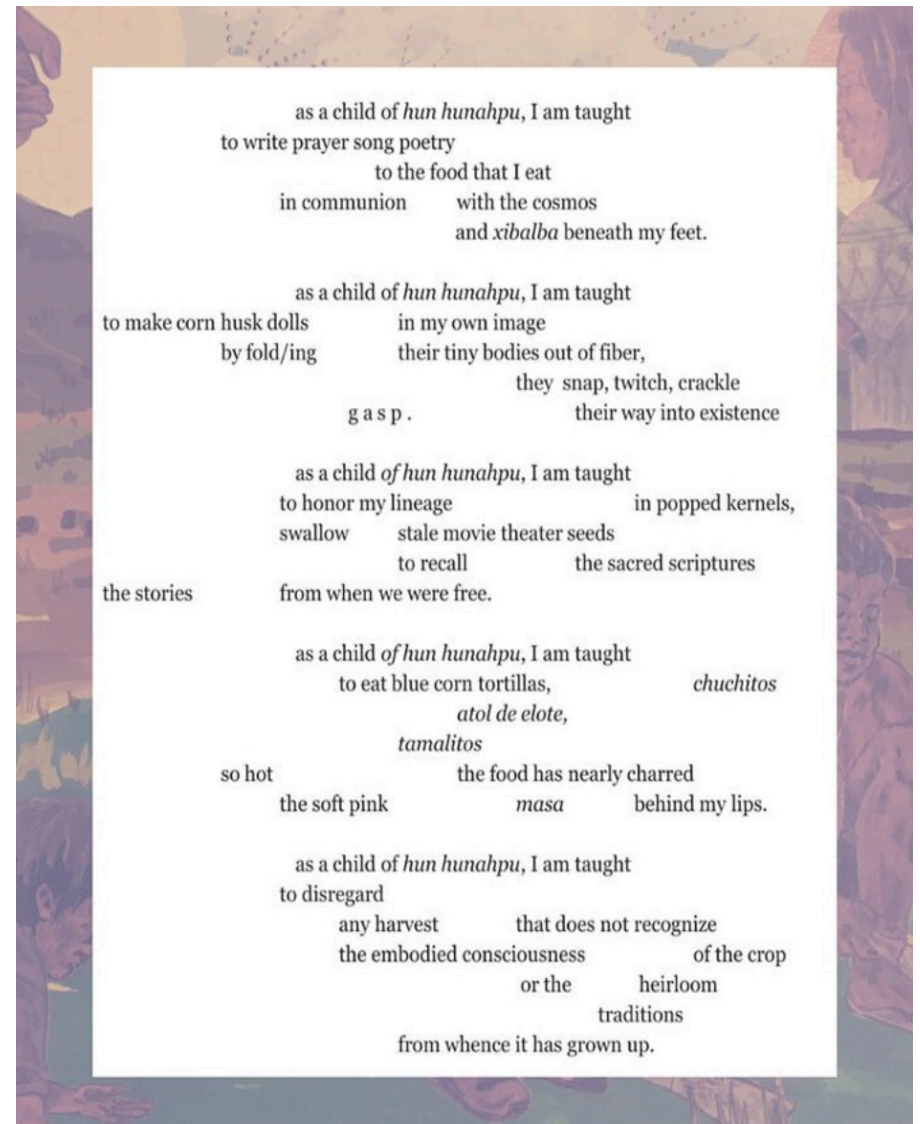
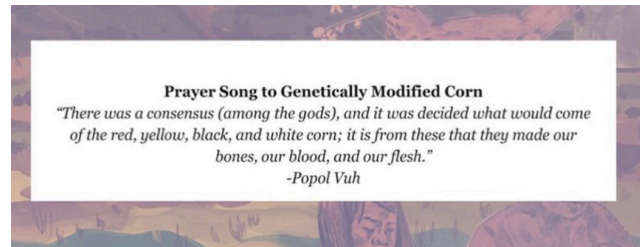
When I imagine, I feel light. Open. My body becomes a vessel, my thoughts diffuse into the spaciousness of another world. A world not subjected to language, time, or the weight of gravity at 9.807 m/s^2 . Blood memories surface and disappear like water on stone. Everything leaves a trace, yet nothing is concrete. Sometimes a rhythm emerges, I feel it build within me, the beat transforms into the tempo of my mitral valves opening, closing, opening, closing, I surpass a threshold, I enter a new realm, stumble into a frequency that resonates resonates resonates so I start dancing, I dance and I dance until my eyes are drawn to the sky and my mind merges with the clouds. Sometimes thoughts drift here to there, punctuated by staccatos of silence. Sometimes imagination is pure silence. No words, no thoughts, just a sense of space, hints of emotions in a place. And then I am looking down with the ancient red sun, eyes tracing the shadow of my white wings cutting through the desert plains, I am here and there, underneath and above, breathing, witnessing, being, in continuities, existing, amorphously.

I wanted to imagine, with people I trust and am inspired by, what a beautiful future for biotechnology could look like.

I met Berkeley, CA based artist and community organizer Rene Revolorio Keith after stumbling upon an excerpt of a poem titled “Prayer Song to Genetically Modified Corn.” (See right).

Perhaps it was the algorithm, perhaps it was destiny, but when we connected the subtle strings tying our existences together surfaced.

In the following months, Riley, Rene, and I began to meet virtually to share dialogue and imagination about what it could look like to deglobalize, decolonize, localize biotechnologies from our lived experiences and distinct cultural perspectives. The following is an exercise in speculative imagination by Riley, Rene, and I. Collectively, we created The Decolonial Biotech Network, a statement, short film, and imagined set of relations to transform our shared biotechnological futures.



watch the decolonial biotech network short film [here](#).



DECOLONIAL BIOTECH NETWORK STATEMENT

The institution of science is rooted in colonial ideology and praxis. Emerging ecological biotechnologies, such as genetically modified golden rice to alleviate hunger or genetically engineered mosquitoes to curtail malaria, reinscribe hegemonic power relations by disregarding local knowledge and treating native and Global South communities as sites of experimentation and extraction. From genetic engineering to bioprospecting and the mining of personal health data, the vast majority of scientists, nonprofit organizations, and companies spearheading biotechnology projects are in the Global North, while piloting on-the-ground implementation in the Global South. Consequently, the design and ethical assessments of biotechnologies are largely decontextualized from the place-based experiences of the communities they intend to benefit.

To subvert these asymmetrical relations, we will create The Decolonial Biotech Network, a decentralized and transnational collective of Indigenous peoples, musicians, artists, scientists, academics, farmer unions, and advocacy groups. We will co-develop media that (re)centers community, traditional, and Indigenous knowledges through diverse modes of participatory media production (e.g., virtual reality filmmaking, storytelling, oral histories), to communicate place-based experiences of life and sovereignty. Rather than representing native and Global South regions via the problems biotechnology promises to solve, our media will express the rich ancestral knowledges and futurities sustained in these communities.

The Decolonial Biotech Network reframes revolution from the emergence of new biotechnologies, to the emergence of new relations and institutional practices that allow for the flourishing of Indigenous lifeways. We will begin building these relations by confronting creators of top-down biotechnologies with the media created by communities who carry their own visions of the future and the role of technology within it.

Phase 1: Build community networks; participatory media workshops; media curation; map global biotech stakeholders; identify fertile sites for reform. Phase 2: Pilot online platform; spearhead strategic dialogues with global biotech stakeholders; upload media; community feedback.

preventing harm

Riley and I wrote the following paper, titled *Empowering Indigenous Knowledge in Deliberations on Gene Editing in the Wild*, as a contribution to the 2021 Hastings Center Report special issue on public deliberation of gene editing in the wild [paper under final review, intended for publication by end of 2021].

In the words of Dr. Gregory Kaebnic and Dr. Michael Gusmano, the principle investigators of this National Science Foundation funded project:

“This project is examining the rationale and the challenges of broad public deliberation on the use of genetic editing technologies to modify populations of wild organisms in the shared environment. The objective is to address two overarching questions: For what kinds of proposals to modify populations of wild organisms should public deliberation be conducted, and how should it be conducted? The methodology consists in case-based analysis by an interdisciplinary work group and synthesis of the group’s findings and of relevant literature. The project will advance the study of public deliberation and generate and disseminate recommendations about public deliberation to audiences in academia, science research, policy-making, and education.”

As part of the aforementioned interdisciplinary work group, Riley and I decided to focus our contributions on offering concepts and practical guidelines for engaging Indigenous peoples in deliberations about ecological editing. Much of our writing was shaped by our experiences working collaboratively with diverse Indigenous peoples and our respective areas of graduate research.

Empowering Indigenous Knowledge in Deliberations on Gene Editing in the Wild

by Riley Taitingfong (1) and Anika Ullah (2)

(Both authors contributed equally)

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2 MIT Media Lab, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

Abstract

Proposals to release genetically engineered organisms in the wild raise complex ethical issues related to their safe and equitable implementation. While there is broad agreement that community and public engagement is vital to decision-making in this context, more discussion is needed about who should be engaged in such activities, and in what ways. This article identifies Indigenous Peoples as key stakeholders in decisions about gene-editing in the wild and argues that engagement activities need not only include Indigenous Peoples, but be designed, conducted, and analyzed in ways that confront longstanding power imbalances that dismiss Indigenous expertise. We offer specific recommendations to guide deliberative activities to not only be inclusive of Indigenous Peoples but empower their diverse, situated knowledges. We call on those committed to the inclusive design of broad public deliberation to pursue strategies that shift dominant power dynamics to include Indigenous communities in more meaningful ways.

Introduction

The advent of genome editing tools such as CRISPR/Cas9 (clustered regularly interspaced short palindromic repeats/associated protein Cas 9) are enabling new possibilities in the genetic modification of insects and other wild organisms. While genetic engineering techniques have been used to suppress populations of disease-vectoring insects like mosquitoes for over a decade (e.g., Oxitec's *Aedes aegypti* technology), emerging genetic engineering technologies make it possible to do so more rapidly than ever before¹. Scientists can now theoretically push genetic modifications that cause population decline or crash (e.g., via infertility or biased sex-ratios²) through entire populations of organisms with unprecedented speed and efficacy. As such, genetic engineering may provide a powerful strategy to intervene in a number of challenges including vector-borne disease (e.g., malaria, Zika, chikungunya, Lyme) and invasive species or pest control (e.g., management of rodents or insects threatening ecological biodiversity or crop health).

However, proposals to introduce genetically engineered organisms into the wild raise complex considerations about the processes that should guide their safe and ethical use. It is impossible to know for sure how technologies not yet tested outside the laboratory will affect natural ecosystems. How should risk assessment be performed given this high degree of uncertainty? Whose notions of risk and benefit shape these processes? Some genetic engineering technologies have the potential to significantly and irreversibly impact shared environments. Who should ultimately decide whether they are released in the wild? Decisions about the development and deployment of these technologies are invariably complex and value laden.

Given these vexing ethical issues, there is broad agreement that some form of community and public engagement will be necessary to guide decisions about the release of genetically engineered organisms in the wild. Some recommendations call for the engagement of local community stakeholders who would be directly impacted by the use of a given genetic engineering technology (e.g., residents of geographic regions where a genetically engineered organism is proposed for release), while others suggest that broader publics ought to be engaged, given the high stakes associated with technologies that may forever change our shared environment^{1,3}. While there has been some acknowledgment that it is important to engage groups historically excluded from decision-making about research and technology-development that has impacted them^{4,5}, more discussion is needed about specific ways to pursue the meaningful inclusion of such groups.

This article argues that Indigenous Peoples should be involved as key stakeholders in decisions to release genetically engineered organisms in the wild. We add to a growing conversation {Convention on Biological Diversity, 2017 #77}^{1,4,6-11} about the importance of engaging Indigenous Peoples in this context, and argue that engagement must go beyond the mere inclusion of Indigenous Peoples to ensure that the design, conduct, and analysis of those activities actively confronts and subverts power imbalances that marginalize Indigenous ways of knowing. After introducing power as a generative framework for the design and conduct of deliberative activities related to gene editing in the wild, we discuss why Indigenous Peoples represent vital stakeholders in those activities. Finally, we offer specific recommendations to guide deliberative activities to not only be inclusive of Indigenous Peoples but empower their diverse, situated knowledges. While our discussion focuses specifically on Indigenous Peoples, our recommendations may have broader relevance to other key stakeholder groups who have historically been excluded from conventional deliberation processes for gene editing in the wild, such as marginalized communities in the Global South.

Power as a framework for deliberative design

In its 2016 consensus report on an emerging genetic engineering technology known as gene drive, the National Academies of Science, Engineering, and Medicine (NASEM) defines engagement as: “Seeking and facilitating the sharing and exchange of knowledge, perspectives, and preferences between or among groups who often have differences in expertise, power, and values¹” (emphasis added). The report offers ample discussion about the importance of engaging multiple forms of expertise and values. It notes that community insight and knowledge may contribute pragmatically to more robust approaches to gene drive development and governance, or ensure that tasks such as risk assessment adequately account for community or culturally specific perspectives on what constitutes a risk or benefit. However, there is limited discussion devoted to the power imbalances that emerge among stakeholders in the conduct of genetic engineering research, development, and deployment, such as power differentials inherent to the institution of science, perpetuated across geopolitical divisions, or constraining marginalized communities’ capacity to inform decision-making.

For instance, scientists working to develop genetic engineering technologies commonly express positive intentions to leverage their work to help people in the Global South (formerly known as the ‘developing world’) or island nations, as these geographic regions experience disproportionate impacts of several issues that genetic engineering technologies seek to address, such as vector-borne disease, climate change linked issues with invasive species or pest control, and food security¹². However, the vast majority of scientists, ethicists, and philanthropic or corporate funders central to the development of genetic engineering technologies are in the Global North, aiming to trial and eventually implement these technologies in the Global South.

Thus, when deliberative activities seek to include Indigenous or Global South communities, they must be conscious of the power differentials undergirding those relations and how they might influence the dynamics of a deliberative activity. In the broadest sense, this necessitates cognizance of global histories of imperialism, including the role that science has played in facilitating the various forms of colonialism that have emerged from imperialism, and their negative impacts on Indigenous Peoples and local communities¹³. Another facet of power imbalance to consider is that of a scientist or other stakeholder backed by a relative wealth of monetary resources and institutional support approaching a smaller, historically marginalized community that may live under a dominant settler colonial structure, and how this affects their power to directly impact decision-making.

Such local and global power imbalances (as well as heterogeneity of different community stakeholder groups) also influence how different groups of people understand and experience harm, making it critical to engage Indigenous Peoples in a way that empowers them to define what is deemed risk, benefit, and harm through their local epistemologies and lifeways. It is imperative for Western-trained scientists and ethicists to reflect upon the presumptions underlying their own perceptions of risk and benefit: for instance, the reliance on definitions of harm that manifest in physical and measurable ways on human and ecological health. In seeking to minimize the continued perpetuation of harm across historic and ongoing power differentials, we suggest that researchers adopt a more holistic and inclusive conceptualization of harm that includes cultural, emotional, psychological, and socioeconomic aspects. Acknowledging the inseparability of Indigenous wellbeing from ecological health and stewardship practices, it is evident that the loss of land, knowledge, and traditional practice represent significant forms of harm to these communities.

Indigenous Peoples as key stakeholders in decisions to genetically engineer the wild

There are at least 476 million people who identify as Indigenous around the world¹⁴. While Indigenous Peoples comprise around 6% of the global population, it is estimated that their ancestral lands encompass more than one-quarter of Earth's surface¹⁵, and as much as 80% of Earth's remaining biodiversity¹⁶. Having stewarded this biodiversity for millennia, Indigenous Peoples around the world have cultivated sophisticated knowledge systems spanning agriculture, aquaculture, forestry, celestial navigation, and much more. Sustained over many generations through a variety of oral traditions and ceremonial practices, these knowledge systems are distinct from Western perspectives as they draw on embodied, experiential knowledge derived in close relation to the natural world¹⁷.

Indigenous knowledges are as diverse and heterogeneous as the communities who steward them, and live not only in the written word but in embodied forms like speech, storytelling, songs, and chants. Diné scholars Tsosie and Claw aptly describe Indigenous ways of knowing as knowledge that endures, affirming the empirical quality of knowledge created and continuously substantiated through countless trials over time¹⁸. Indeed, Indigenous Peoples and knowledge have also endured generations of suppression by colonial and settler colonial structures seeking to disconnect them from their lands and ways of relating to them.

Western science is a significant site of this suppression. In spite of the fact that many basic Western technologies and medicines are sourced from Indigenous cultures and traditions throughout history¹⁹, Indigenous expertise is often minimized and dismissed by Western science. Given that Indigenous knowledge does not follow Western conventions of separating the empirical and objective from the sacred, intuitive, or spiritual, it is often perceived as incompatible with Western conceptions of rationality, earning derision from those who perceive tradition as outdated, unscientific, or primitive²⁰.

However, there is growing recognition of the degree to which this dismissal of Indigenous knowledge has had deleterious effects not only for Indigenous communities, but for the ecological health of our planet at large. For instance, to manage rampant wildfires in California, government officials are partnering with tribes to revitalize cultural burning practices previously outlawed under state and federal policy -- the banning of which has contributed to the unprecedented size of today's fires to begin with²¹.

All around the world, biologists, conservationists, ecologists, and government officials are partnering with Indigenous Peoples to provide insights into the intractable issues of climate change, deforestation, species extinction, and ecosystem degradation²². As we look to technological solutions like genetic engineering to aid in the management of issues that will intensify on a warming planet (e.g., neglected tropical disease, ecological degradation), we must actively support Indigenous and Global South communities to guide technology-development and look critically at the degree to which dismissal of Indigenous knowledge has created these issues in the first place. While Western science offers valuable knowledge about navigating these issues, we would be remiss to not consider the robust knowledge cultivated in Indigenous and Global South communities.

Indigenous self-determination

As long as there is intention to release genetically engineered organisms directly onto Indigenous territories, or there is risk that those organisms may spread into those territories and affect ecologies they steward, Indigenous Peoples must be involved in the oversight and decision-making regarding genetic engineering technologies. Because considerable uncertainty remains about how gene editing technologies might impact wild ecosystems, and whether those impacts will be reversible or truly confinable to a given geographic space, we argue that any decision to gene edit the wild poses risk to Indigenous lands and thus necessitates inclusion of Indigenous stakeholders. Excluding this key stakeholder group from these processes would not only decrease the likelihood of authorization or acceptance of the technology by these communities-- it would represent a violation of Indigenous rights to determine the use of their lands.

The inherent rights of Indigenous Peoples to self-determination are communicated in several pieces of international law and policy, such as the International Labour Organization Conventions 107²³ and 169²⁴, and the United Nations Declaration on the Rights of Indigenous Peoples²⁵{United Nations General Assembly, 2007 #212}. UNDRIP affirms that “Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources ...” and that “States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources...”. The United Nations (UN) has also discussed the potential application of free, prior and informed consent (FPIC) specifically to genetic engineering⁶, and scholars have explored the possibility of extending the ethical principles of FPIC to ecological editing in order to respect Indigenous rights to autonomy and self-determination⁷. However, in the absence of clear guidelines or policy to ensure that Indigenous self-determination is respected, the onus is on researchers and the institutions with which they are affiliated to commit to practices that do not intentionally or unintentionally exclude Indigenous stakeholders.

Engagement activities that support Indigenous self-determination will go beyond ensuring that Indigenous Peoples or communities are merely present or equally represented to identify whether the qualities of the engagement are truly inclusive of Indigenous expertise, values, and perspectives. In the realm of deliberation, scholars have noted that deliberative activities including Indigenous and settler participants may surface culturally distinct or even incommensurate viewpoints given differing empirical beliefs, norms, or epistemic procedures among these groups ²⁶. Inclusion of diverse cultural perspectives in a deliberation may serve as a valuable resource for reflexive thinking and collective problem-solving^{27,28}. However, the hegemony of certain cultural perspectives may foreclose the meaningful inclusion of non-dominant knowledge or expertise.

A deliberative activity that does not allow Indigenous Peoples to express their situated expertise, or that devalues those inputs, will amount to exclusion regardless of their presence. While we believe there are opportunities at every stage of a deliberative activity (i.e., design, recruitment, conduct, analysis of outputs) to meaningfully include Indigenous Peoples and knowledges, we argue this cannot be done without a direct confrontation of the historic and ongoing power imbalances that are relevant to genetic engineering, and how those may be reified in deliberative spaces. Put another way, without critical reflection on the broader social, political, and economic contexts in which genetic engineering technologies would be deployed, deliberative activities may reify the very inequities they are meant to overturn.

Recommendations for Facilitating Empowering Deliberation with Indigenous Peoples

How might Indigenous ways of knowing be similar and different to the epistemology of a western scientific framework? How do we design specific deliberative processes that facilitate mutual understanding with Indigenous Peoples and subvert the traditional power differentials underlying normative deliberation spaces? These are core questions to consider when seeking to facilitate empowering deliberation on gene editing in the wild with Indigenous peoples. The meaningful engagement of Indigenous Peoples in these processes is vital to respecting Indigenous self-determination, and, when treated as an opportunity for mutual dialogue and relationship-building, deliberation may also help to align scientific research and development to Indigenous priorities. Drawing upon our personal experiences working with Indigenous Peoples and cross-disciplinary ideas participatory design, psychology, education, development, global public health, performance studies, and cultural anthropology, we offer the following recommendations to foster a deliberation process that longitudinally recognizes and cultivates Indigenous ways of knowing²⁹⁻³⁶. While we have derived these recommendations specifically to address the inclusion of Indigenous communities, we invite readers to consider how certain recommendations may have import for the inclusion of other key stakeholder groups whose knowledge and lifeways may be excluded under dominant or normative modes of deliberation.

Establishing Relations and Recruitment

Deliberative activities encompass important recruitment questions, such as who to involve and how to ensure the equal representation of diverse groups. Organizers may seek ways to boost the attendance of typically underrepresented groups so they are equally represented, or perhaps even overrepresented, in a given deliberative activity. However, we recognize that representation alone cannot ensure the meaningful engagement of underrepresented groups including Indigenous Peoples. We invite an approach that seeks to establish relations with local Indigenous communities, and defers to community preferences in navigating questions related to recruitment (see Table 1).

To begin discussion of establishing relations with Indigenous Peoples, we would like to build upon the concept of “reflexivity,” which the 2016 NASEM gene drive report defines as “creating opportunities for reflexive thinking to clarify one’s beliefs and understandings, reflect upon and revise one’s opinions, and gain insight into how different interests and values are situated in conversations about how to proceed”¹. In relation to the recommendations we offer below, each stage of the deliberation process must be grounded in reflexivity of the researcher. At the stage of establishing relations, engaging in reflexivity could take the form of the researchers making time to learn about the historical and current sociopolitical issues occurring in the community they would like to work with, asking communities if there are certain shared values that can be met through a partnership, and understanding that actively inviting Indigenous Peoples to deliberate on environmental gene editing technologies may not yield specific outputs that can be easily translated into the framework of Western science (see Box 1 for examples of reflexive questions to guide gene editing research). Furthermore, it will be helpful for researchers to learn more about how Indigenous Peoples have been historically harmed or exploited through certain scientific research projects^{37,38}, and how these negative experiences necessitate creating a non-confrontational space for Indigenous communities to refuse engaging in deliberation activities if they believe a partnership could impose harm or constrain limited time and resources.

With these important considerations in mind, there are still many Indigenous Peoples who will likely be interested in sharing their perspectives to guide environmental gene editing technologies. When establishing relations with Indigenous collaborators, practitioners will ideally find community leaders or representatives to work closely with and cultivate opportunities for co-design and collaborative decision-making about what the relationship will look like, such as by establishing shared expectations surrounding time, labor, compensation, and potential outputs. We recommend deference to collaborator input on established, culturally-variant processes for deliberation, such as decisions on who to include in deliberative activities and how to conduct them. Finally, practitioners should aim to build enduring relationships with Indigenous communities that are not contingent upon successful future development or deployment of the technologies deliberated upon.

Design of deliberation

The design of deliberative activities involves questions about what the deliberation will look like, includes a location for deliberation, and materials needed to conduct the deliberative activity. We emphasize the need to consider the power dynamics associated with particular places and suggest a partnership approach to identify strategies that will increase access to Indigenous participants. We also recommend a holistic approach to background materials that will be presented to deliberation. In particular, we call for materials to situate the genetic engineering technology(ies) of interest within the broader social, political, and economic contexts that they would be deployed (see Table 2).

In acknowledgement of the diversity of Indigenous Peoples and their cultures, practitioners should draw upon a strengths-based approach to participatory action research³², and pursue place-based³⁹ and collaborative design of deliberation process rather than a standardized approach across different communities of Indigenous Peoples. Practitioners should invite Indigenous collaborators to lead decision-making on where to conduct a deliberative activity and the logistical concerns surrounding accessibility of such activities. Although it may be more convenient for researchers to hold deliberation activities on university campuses, researchers should take time to learn about the historical trauma that may be associated with certain places like universities, as some of these sites may

be associated with harm through their association with historical mistreatment of Indigenous Peoples or unethical treatment of ancestral remains. Some communities may prefer or be willing to host deliberative activities in their own spaces, and it would be helpful for researchers to support such activities through additional resources, time, and research personnel.

In publicizing the deliberative activities, researchers should work with Indigenous collaborators to co-design materials for presentation to the broader Indigenous community in a way that situates the technology into local contexts: this could include mention of specific aspects of local culture and history that are relevant to deliberation about gene-editing. Beyond asking questions about how to best to communicate facts about the technology, it is imperative to consider questions like: What information should deliberants have access to so they can understand the broader contexts in which the proposed gene-editing technologies would be deployed? What forms of knowledge are deliberants likely to draw upon during these deliberations (i.e., cultural narrative, song, spiritual, personal experience), and what specific strategies can be incorporated into design of activities ensure that diverse forms of knowledge are accounted for in the deliberative space? How can we create a culture of collaborative problem solving early in the deliberation process so that Indigenous Peoples feel respected and supported in sharing context for existing health and environmental issues that the technology seeks to contend with? How do we create equal time and space to center existing Indigenous technologies and approaches that may already contend with issue at hand and continue viewing these approaches as plausible options in addition to the technology being deliberated?

Facilitation of deliberation

Facilitation involves the conduct of the deliberation. This raises questions about how the deliberative activity will open and sustain discussion and how participants will be asked to engage with materials and with each other. We recommend a participatory orientation to deliberation that values collective learning and co-design of outputs, and we call for an approach to facilitation grounded in reflexivity, empathy, and active listening (see Table 3).

Following the previous discussion of fostering a culture of collaborative problem solving, practitioners should consider providing equal time and space for scientists and community members during the beginning of deliberation activities to share important information about the collaboration and issue at hand. Such information could include overviews of each stakeholder involved in the collaboration, the origins of the specific environmental or public health issue the technology seeks to address, and existing or emerging technological and non-technological approaches to mitigating these issues through broader stewardship of the local environment. For instance, Indigenous community partners may wish to discuss their kinship relations or guardianship responsibilities to particular ecosystems or species, factors threatening those relationships, and the types of interventions most appropriate to explore in various contexts.

During the deliberation activity, it is crucial to cultivate an environment built on listening and sharing instead of one-way dissemination or the use of persuasion and urgency narratives. Framing dialogue around Indigenous wellbeing rather than pure deliberation of the technology at hand could be a helpful strategy for surfacing how potential technology development and deployment may interact with wellbeing in nuanced and culturally specific ways. Examples include consideration of the material conditions under which the technology will potentially be produced and tested, the history and significance of the land such technologies will potentially be trialed on, and culturally diverse perspectives on how gene editing in the wild could yield particular risk, benefit, and harm in a specific regional context. Collectively producing a dynamic document detailing the dialogue arising from activities aimed at surfacing Indigenous concepts of harm, risk, benefit can offer a productive strategy of deliberation for both community members and practitioners.

Output and Analysis

Outputs refer to the documents, texts, or other materials generated from the deliberative activity. Conventional outputs may include meeting notes or reports that distill key insights from the deliberation, and they may be public-facing and/or disseminated to specific stakeholder groups involved in decision-making about gene-editing such as regulators, risk assessors, or policymakers. We invite an approach to outputs grounded in participatory design and epistemic flexibility. Deliberants should not only inform what information is represented in outputs, but also the form those outputs take. We call on organizers of deliberative activities to consider how outputs might take diverse, multimodal forms beyond conventional written reports. Finally, we call on those charged with analyzing and distilling information from deliberation into an output to practice reflexivity, remaining mindful of the ways in which their own cultural biases or interpretive frames may impact their participation in this task (see Table 4).

Practitioners can ask their collaborators what forms of outputs would be most accessible to the community at large and representative of the dialogues that took place. Researchers can consider including visual metaphors or diagrams that document collective understandings from deliberative activities, such as by using a red/green/yellow light system to categorize the status of consensus on different viewpoints arising from deliberation activities. Other avenues to explore include the use of social media to share updates and open space for additional dialogue, jargon-free language, audiovisual recordings of both the deliberative activity and future decision-making activities in which the outputs of the deliberative activity with Indigenous Peoples were consulted (i.e., policymaker meetings, internal lab meetings, institutional meetings in regards to the gene editing in the wild), physically or digitally accessible materials, and providing outputs in the local language or with closed captioning. Beyond simply sharing outputs with involved communities, practitioners may also consider creative approaches to facilitating ongoing deliberation in ways that are synergistic with the values and objectives of involved communities. For example, this could involve working with Indigenous youth interested in the sciences to conduct audio interviews with elders in their community on cultural perspectives regarding the environmental or public

health issue the technology seeks to address or potential use of environmental gene editing technologies. Practitioners could also explore funding a local Indigenous performing arts group to create a participatory public skit on a nuanced cultural viewpoint unearthed during the deliberation process. Outputs can also offer provide future remote opportunities for Indigenous Peoples to continue engaging with deliberations between in-person deliberation activities, such as through online or social-media based forums, online multimedia storytelling projects, voicemail, or leaving questions and notes at a collaborative public installation commissioned specifically to foster dialogue in relation to salient themes discussed during deliberative activities.

Practitioners should focus on creating deliberation outputs with communities rather than for them. Practitioners should identify ways to involve community partners to iteratively refine of outputs and inform the processes and avenues through which such deliberations are incorporated into decision-making. Before sharing any outputs publicly or with policymakers, it is important to iteratively seek feedback and approval from deliberants and collaborators. By creating open channels of communication to keep communities in the loop on post-deliberation activities, offering opportunities to provide more input, and sharing updates about how deliberation is shaping the decision-making process, practitioners can remain accountable to their community partners.

Conclusion

Significant and unprecedented advancements in gene editing technologies are well underway. If the potential benefits of these technologies are to be realized, scientists, researchers, regulators, and ethicists must first grapple with ethical and political stakes of their implementation in the wild. While many recognize the necessity of community and public engagement to the collective navigation and deliberation of these ethical issues, more discussion is needed on the ways to engage specific stakeholder groups. In this article, we argued that Indigenous Peoples must be involved as key stakeholders in gene drive research given their inherent rights to self-determination, and offered a set recommendations to guide broad public deliberation involving Indigenous communities. While the recommendations offered are neither comprehensive nor universal, they invite continued consideration of how deliberative activities can be designed to empower the dynamic, historied, place-based knowledges of Indigenous Peoples. We call on those committed to the inclusive design of broad public deliberation about

genetically engineering the wild to critically reflect on the normative orientation of deliberative activities, and pursue strategies that de-center dominant Western approaches to deliberation. Given the complexity of genetic engineering technologies (and the problems they seek to address), we believe the most generative and just outcomes will arise from those activities that exercise epistemic humility and invite the meaningful engagement of Indigenous knowledges.

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