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Phyto-Innervations: An Ethnography at the Margins of Plant Science

By

KRISTIN KATRINA ONZIK
DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Anthropology

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

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Committee in Charge

2022

CONTENTS

LIST OF FIGURES AND PHOTOS

Figures

Photos

ABSTRACT

This dissertation is an ethnographic study of a small, interdisciplinary community of researchers working to field the controversial sciences of Plant Neurobiology, Cognition, and Behavior (PNCB). Building upon the analytical techniques of decolonial theory, feminist science studies and more-than-human anthropologies, my research situates PNCB not as a coherent epistemic aspiration but as an ongoing experimental dissensus: a creative rupturing in, rather than a re-distribution of, the scientifically sensible. By decentering the debates over who or what plants truly are, and whether or not they are "cognizant" or equipped with "neuronal-like capacities," I focus on the practical, sensorial struggles of scientists risking their careers on the possibility that plants can think, learn, remember, and communicate with human and non-human others. The stories that emerge from this ethnographic attention document the uncertainties and the generative ethical and worldly potentials of scientists who no longer know from where the source of their knowing stems. These are stories of scientists actively struggling to think creatively about plants, to dishabituate from their prior trainings and familiar categories of thought, agency and sensation. My research suggests that it is within these experiences of "not-knowing"—mired in feelings of uncertainty, surprise, agitation, etc. —that it becomes possible to feel the many strange and unexpected plant configurations that embolden a re-imagination of a scientist's "knowing." Immanent to these encounters are phenomena I am calling "phyto-innervations," in which my capacity to know and make sense as an ethnographer is also made susceptible to creative, more-than-human constellations.

ACKNOWLEDGEMENTS

This strange and, at times, seemingly impossible journey has been made to feel possible by so many.

Eight years ago, Suzana Sawyer courageously accepted me as a student. Her unwavering support and faith in my creative potential has kept me tethered to a process I have tried to give up on many times. She has seen through my fears when I could not. Through her power, I have been patiently and lovingly guided to step into my own.

So too did Marisol de la Cadena courageously take me on as a student when I was prepared for no such feat. With a fierce devotion to untangling me from the traps of "the usual," she has irremediably cracked open my senses. Her teachings and "tender bites" will forever be part of the "complex we" that is me.

I found Joe Dumit at the end of my first year in a class on bodily improvisation. Shortly after, my body improvised a project that could not have been without him. His unflinching and persistent support, his ability to read, play with, and take interest in the most confused and lackluster of my words, has made even the messiest and most difficult parts of this dissertation into an adventure, if not a joy, to write.

Tim Choy, too, was pulled into my process for the utmost betterment of me and this dissertation. Suspended in the margins of some of my most carefully formulated thoughts is a piece of advice from Tim that still lingers as profoundly undigested material.

To the scientists who invited me into their labs, gardens, greenhouses, and homes, thank you for your struggles; for your curiosity, care, and commitment to thinking otherwise in a field which prefers that you would rather not.

To all of my brilliant and supportive fellow dissertation writers and co-thinkers: Sofia, Fatih, Taylor, Tory, Marie, Mariel. The best in me was brought out by all of you. Thank you for seeing it.

To my love and life-making partner, Barton, thank you for your patience and your generative impatience. This whole experience would neither feel, nor be, complete(d) without you.

To my family and friends, for being my "reality check" and comic relief throughout it all.

Lastly and not at all at least…

This dissertation was always already being written for my mom, who was told she did not have "what it takes" to be an anthropologist. May her creativity continue to empower, inspire, and persevere in all that I become

OPENING

On nervines, nervous systems, and plants that mind us…

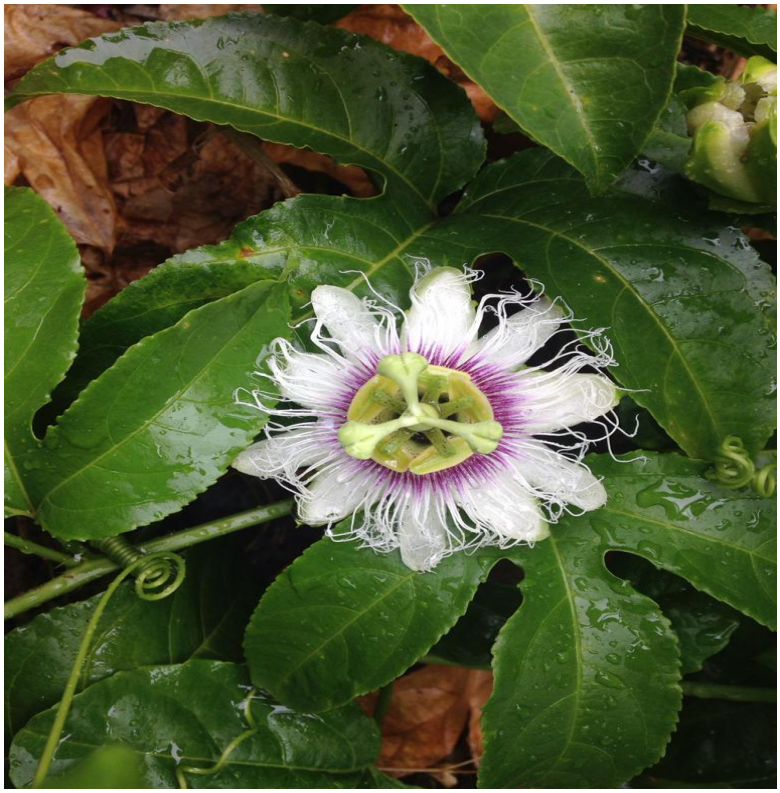

Photo 1. A passionflower vine growing outside of a scientist's makeshift lab on Bundjalung land (Mullumbimby, NSW Australia). Taken by and shared with the permission of Dr. Monica Gagliano.

"How does one side-step the NS [Nervous Systems] side stepping? How does one intervene…wherein, without warning, the referent bursts through into the representation itself?"

-Michael Taussig, *The Nervous System* (1995; 3)

"Imagine the kind of creation which does not heed Time.
The kind that does not ask about beginnings, or seek sequential evidence."

-Rosebud Ben-Oni, *Little Monsters: On Time and the Consciousness of Poems* (2018)

Part I.

I'm walking along a busy highway.

The rushing wind of passing cars keeps me alert, anxiously traversing between white lines and steep roadside trenches. Someone shouts at me, "Hurry up!"

I realize I'm in a race and the finish line isn't far. Pick up the pace and I could win.

My strides lengthen. Moving farther, faster, passing strangers. I slip off the road onto a forested trail. My feet pound softer, heart louder.

But now I'm in a spa. Surrounded by smooth wooden walls and low hovering ceilings, I'm frantic. Searching. Opening and closing doors, rushing through rooms with massage tables. The smoke of burning incense clouds my vision.

Amidst the smoke a desk emerges, a woman standing quietly and calmly behind it. She is warm, luminous, wearing a purple collar.

I ask her where the finish line is, tell her I'm in a hurry, that I could win if she could point me in the right direction.

She approaches me. Slowly. Gently. Without a smile.

"There is no finish line," she whispers.

"There never was."

Finish lines, and failed attempts at reaching them, have long haunted me. Not only in dreams, but in my so called "waking life." These finish lines have, over the course of my earthly existence, worked to condense the expansiveness of the present into narrowly defined margins, funneling and offering the awareness of the now into a race towards future achievement. They constrain the boundaries of my thoughts, isolate myself from my surrounds, and urge me to pick up the pace: progress is forward motion. Finish lines have also been the source and supply of chronic anxiety, tears and so called "nervous breakdowns." *Passiflora incarnata, or "*Passionflower,*"* came to me during a time that I consider to be my greatest nervous breakdown. "She" was, and continues to be, the woman in my dream. Inviting me to stay present in the here and now with the gentle yet serious message that *there is no finish line. There never was.*

Part II.

It was the spring of my third year in a PhD program, when a passionflower vine began growing into my home. Common knowledge among my fellow graduate student peers was that third year, the year spent preparing for our qualifying exams, was "the worst." And my experience could be described as such. There I was, lying on the floor of my living room, exhausted and depleted. I had been fueling sleepless nights and unproductive workdays with increasing doses of caffeine and nicotine, the favored plant chemistries of someone long conditioned and supported by a fast-paced, future achievement-oriented culture. My eyes were wandering in search of reprieve from the computer screen when they were captured by a green tendril, inching its way through a small crack in the sill of my living room window. I didn't know who it was at the time. Or, more precisely, I didn't know who it was beyond its taxonomic identification: *Passiflora incarnata.* A name, I later learned, that was inspired by the plant's encounters with Spanish missionaries in Peru. Entranced by the complex arrangements of the vine's flowers, its apostolic symmetries and filamentous "crown of thorns," they transformed it into a tool for teaching the "natives" of Christ's passion, symbolically incarnated in floral form.[1]

Over the course of a few days I had, in passing, witnessed this small green tendril grow up and beyond the windowsill, traverse across the wall, and branch into two, then three, searching stems. After several weeks this vine had multiplied several times over, spreading across the expanse of the windowed wall and winding itself halfway across an eight-foot ceiling beam that led to my sleepless bedroom door, sprouting spring coiled tendrils and glossy, palmate leaves along its way. During this time, I had been busy writing my qualifying exams. Two papers having something to do with the

[1] Passiflora incarnata is the Linnaean classification that evolved from the Italian translation "fiore delle passione" after being gifted to Pope Paul V by missionaries in the 16th century (Parlasca, 1609; Battisti Delia, V., 2014)

histories of plants, nervous systems and their scientists, and the many, ongoing attempts at making sense of the boundaries between. And though naïve and early on in my studies, I had begun to sense that, in practice, the boundaries between plants, nervous systems, and a scientist's sense making abilities, are quite difficult to parse. In my own practice, however, I was not inclined to question my own self, and my nervous senses, to have much to do with the plants around me. This was an attention I reserved only for the pieces of plants I consumed. For at the time "I" was all too confined to an idea of myself, and my writing, as an act of creation that took place somewhere up in my head, as thoughts conjured by the chemistries of my brain, released into the world by the powers of my own mind—albeit a mind whose composition had become increasingly reliant upon caffeine and nicotine to persist. So caught up in the race towards a future self's achievement, I could hardly consider taking the time to slow down and "smell the flowers," so to speak.

Photo 2. A passionflower vine growing into my home through a crack in the window achieves support, a Whiteheadian "foothold," (*see* Concept of Nature, 1920) in the form of a common rock-climbing tool, the spring-loaded camming device. From there it was able to wrap around the beam a few times before being cut by our landlord's gardener.

Had I not been so caught up in the race towards a future self's achievements, I might have learned that the vine and its roots, flowers and tendrils have long been and continue to be called upon as sleep, dream and vision enhancing allies amongst indigenous peoples across the Americas—relations that far exceed their time-bound ethnobotanical classifications. In the late 1800's, American doctors "discovered" and described passionflower's so called "sedative" and "narcotic" qualities, prescribing it in teas and tinctures for hysterical women, or those deemed in need of relief from neurotic impulses and spasmodic episodes (Felter & Lloyd, 1985[1898].) The midwives of enslaved African American women called upon the plant growing wildly amongst the fields as medicine to ease acute experiences of "fear, tension, anxiety and pain," often associated with the termination of pregnancies (Schiebinger, 2008). Today, in the southeastern US, the vine is commonly known as "maypop" — an English mispronunciation of the Algonkian term "maracock" — and is both celebrated and scorned for its ability to grow amidst "anthropogenic disturbance." Whereas the Algonkian peoples living in the area had long encouraged the vine to grow wildly amongst their maize and bean gardens (Gremillon, 1996; Vanderplank, 1996), industrial scale farmers consider its presence amongst mono-cropped corn and soy fields an economically destructive "weed" — it's long, climbing tendrils conceived of as "aggressive" resource competitors and a nuisance not easily disentangled from field machinery (Wehtje et al., 1985; Mcguire, 1999). Later on in the life of these same fields, the vine is welcomed as a mediator of exhausted soils; a plant that creates new opportunities for living amidst the ruins of fast-paced, plantation style agricultural practices (Gaspar & Hine, 1989). But it was only after I had experienced what biomedical doctors now colloquially call a "nervous breakdown," that I began to *decipher* (Wynter, 1999)[2] "myself" and my "nervous senses" from within these greater histories of plantation style

[2] According to Wynter, "A deciphering practice proposes, therefore, that the ways in which each culture-specific normal subject knows and feels about its social reality…should in no instance be taken as any index of what the empirical reality

agriculture and capitalist development, the histories masquerading here as so-called "anthropogenic disturbances," and their varying time-bound and timeless relations.

Deciphering Disturbance

The idea that there is such a thing as an individual self, and a biologically contained nervous system, typified as that of an undifferentiated Anthropos, like that depicted in the concept of "anthropogenic disturbance," is, as Sylvia Wynter helps me to think, rooted in the histories of European colonization and the over-representing of the "Western bourgeois" version of Man, "as if it were the human itself" (p. 260).[3] Tangled up in the overrepresentation of Man is also an underrepresentation of its "disturbance," as if there was a pre-existing Nature upon which the entire history of Man might be delineated as an inevitable "disturbance" in the name of "progress." Refusing to entertain the co-productive processes through which land (as Nature) and Man (as Culture) are generated, and generative of varying "containments" of time, space, body, environment etc.,[4] is fundamental to its perpetuation. This refusal, often disguised and materialized as a

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of our social universe *is*." Sylvia Wynter, "Rethinking 'Aesthetics': Notes towards Deciphering Practice," in Mbye Cham, ed., Ex-iles: Essays on Caribbean Cinema (Trenton, NJ: Africa World, 1992), 271.

[3] According to Wynter, the idea of a universal Anthropos came about through two epochal ruptures in Euro-western philosophy. The first, homo politicus (Man1), coincided with the "Enlightenment" of the eighteenth century as a revolt against medieval theocracy. The second, homo oeconomicus (Man2), coincided with the Darwinian influence of natural selection and rise of capitalism in the nineteenth century (Wynter, 2007). Both Man1 and Man2 are rendered as inevitable stages of the evolution of civilization, which is consistently presented as invariably enabled, white, cis-male and certainly not queer.

[4] In *Caliban and the Witch (2004)*, Silvia Federici, re-reading Marx and the history and development of capitalism through a feminist lens, argues that throughout the development of capitalism, as communal fields were "enclosed" and made into property, so too were bodies. The forms and processes of land and bodily enclosure differed, of course, according to categories of gender, just as it has differed by categories of race, i.e. for those who were, according to Hegel, "destined" to be enslaved and those who were subjected to other forms of coerced labor, waged work included. Federici expands on this in *Beyond the Periphery,* articulating the category of 'woman' in the development of capitalism as one emerging through a "double process of mechanization." Besides being subjected to the discipline of work, paid and unpaid, in plantations, factories, and homes, the capitalist "woman" has been made via expropriation from their bodies and being turned "into sexual objects and breeding machines" (*Beyond the Periphery,* 2020; p. 11). This, too, Federici argues, was the motivation driving the slave trade, the development of the plantation system and the witch hunts that took place in Europe and the "New World." These processes of bodily mechanization were further naturalized and disciplined during the early 20th century emergence of experimental psychology and psychiatry. Diagnosing pathologies inherent to the industrial organization of bodies as part of their preexisting instinctual reality and "giving a mantle of scientificity to policies only dictated by the quest for profit" (p. 65), psychologists have, since the 1930's, been present on the factory

desensitization, is also fundamental to the perpetuation of Time as linear; Time as a universal constant which must be managed, fought, beaten, and raced-against in order to create the capital necessary for Man's regeneration. A regeneration which was, as I am here only beginning to decipher, the very degeneration and "breakdown" of myself, as a nervous system made particularly nervous by believing itself to be fixed to a universal, biological order.

Reading Wynter's "Plot and Plantation" alongside her discussion of "deciphering practice," Mckittrick helps me to decipher the specificity of the passionflower encounter and invitation; not by ignoring, forgetting, and thereby reproducing the violence of plantation thinking, the violence through which the bodies of some humans and plants are rendered valuable, and destructible, through mechanization, labor and commodification. But to decipher from this story, this experience of an unsettling passionflower encounter, a different plot. A plot which is released from the shackles of fact/fiction, nature/culture, human/nonhuman binaries of representation, time, and history. A plot that, in disturbing the cognitive orders of colonial violence, the terrorizing orders of a colonial invented Nervous System (Taussig, 1995), refuses to be mastered by the powers of plantation rhetoric; what Taussig describes as "agribusiness" writing (Taussig, 2015).

In encountering passionflower, the "I" that was so furiously caught up in linear, productive "time" of capitalist, "plantationocenic" (Haraway & Tsing, 2019) re-production, is invited to not simply "relax," to become "sedate," but from within this suspension of productivity dwells an active revolt against the colonial mantra which reduces plants and peoples into varying iterations of plantation bodies; those living landscapes, built by a history of enslavement, of racialized and gendered processes of dehumanization and their concomitant mechanizations of both land and bodies into labor-power. Sinking deeper into the invitations of passionflower enables a conversation

floor, at times as permanent employees, shaping the "scientific" metrics of productivity.

that spans far beyond a simple articulation of a human and plant re-embodying themselves in the dimension of a "new" present, and a different kind of "future," but a rupture, an irremediable disturbance, to the experience and notion of linear, universal time as surmised through the lens of plantationocenic nerves.

Part III.

By the end of my third year my body and its self-centric, future oriented "mind" had collapsed. My qualifying exams were passed not with flying colors but with tears, incomplete sentences, over-caffeinated jitters, and very kind committee members. Throughout the following months, my vision grew blurry, my thoughts refused to be formed into coherent sentences, recent events and conversations were mostly forgotten, and my mundane daily tasks felt nearly impossible to achieve. I had come to imagine myself as a failure, and my body had seemed to support this narrative. This was the narrative of a "nervous breakdown," and one I became familiar with from a history of visiting the offices of psychiatrists for help with the chronic and sometimes dramatically acute experiences of "nervous tension" or "anxiety." Seeking a different kind of solace and healing, and what I had imagined to be a potential departure from the "finish line" tempos of academia in which I had come to feel so defeated, I enrolled in an herbal medicine course.

"Nervines" was the theme of week one. An umbrella term used by Western herbal medicine practitioners to conjure a long list of plant taxonomies that, when ingested, have an effect on the nervous tissues of humans. There are those that stimulate and excite, like coffee, those that mildly relax, like lavender, and those that can sedate, or induce a "hypnotic" dream-like state. *Passiflora incarnata* is often placed within the latter. In describing the particularities of passionflower's nervine

qualities, many Western herbalists borrow biomedical terms to describe its specific effects.[5] The story goes that, when ingested in teas, tinctures or capsules, passionflower can "sedate" or "depress" the over-active brain and central nervous system by increasing GABA, an amino acid the reduces neuronal excitability. Such a story is easily digestible by someone long trained to imagine anxieties and nervous senses to be confined inside of one's body, often located inside of one's "brain," and mostly, within the "minds" of women. But at the end of class, this narrative was deeply, albeit unintentionally, complicated. The teacher mentioned, in passing, that we ought to pay attention to the many plants that grow "like weeds" around us. That, in a fast-paced anxiety-stricken society like ours, calming nervines, the medicine we need most, can be found growing right beside us; thriving alongside busy highways, sprouting through cracks in our driveways and sidewalks, or, growing outside of our windows.

Or, inside.

I was stunned; jolted. A tingling sense of clarity that arrived far too instantaneously to be described as a moment in time--as a thought, or a memory. Though the comment was left unexplained, it's message resounded in a language deeply felt, but not verbally spoken. In that moment there was no question. The passionflower vine growing into my home, through a small crack in the window, had, all the while, been minding "me."

Within the year of my "nervous breakdown," and amidst an ongoing search for healing "myself" and my nervous senses, the invitation to slow down and listen to passionflower beyond brain-centric taxonomic bounds was, once again, extended. I was conducting research with a plant scientist in sub-tropical Australia when I was invited to "diet" the passionflower not so surreptitiously growing along the outer walls of the lab. Again, in a language deeply felt but not

[5] This borrowing of terms arises more so from histories in which biomedical explanations are given explanatory authority over "traditional" or "folk" remedies than from actual medical studies of passionflower, which are few and mostly informed by mice and rats (*see* for instance Dhawan et al., 2003).

spoken, and insights traveling far too instantaneously to be moments in time, the message was clear to both the scientist and myself. An invitation to "meet" on passionflower terms and tempos had been extended. By now I had known better than to hastily decline.

Though the practice of "dieting" plants is various and many, taking forms in different times and places, it has been popularly traced to the practices of *vegetalistas* in the upper Amazonian regions (Luna, 1984). In these tracings, conducting a "dieta" with a plant involves restricting one's diet—absolving from indulgences like sugar, salt, fat, sex and soap—and ridding oneself from the scents and traces of their typical human activities. And though the invitation to "diet" passionflower with a plant scientist working in sub-tropical Australia could be considered strangely misappropriated, such a reading is construed with an understanding that the *vegetalista*, or the human facilitator of the diet, is the one in charge. Common amongst all of those trained in the practices of dietas is that a dieta starts, and its particular constraints and conditions conjured, by following the invitations and instructions of the plant. The plant *is* the teacher, the human the student. Fortunately for me, I had found work with a plant scientist who had, through her training with plant healers in Peru and Ecuador, learned to listen for such plant invitations and directions, and helped to co-facilitate the communion between passionflower and myself--the self still struggling to heal from the embodied tempos and narratives of a finish line cosmology.

Under the new moon of the autumn equinox, I was asked to harvest a small piece of the passionflower root. With the light of my headlamp, I crawled beneath the dense thicket of the vines summertime abundance, gently digging my fingers into the soil at the base of its stem. A small piece of root, no more than three inches, arced upwards towards the surface. With an exhalation I offered gratitude to the vine and removed this small root "offering," and placed it in a dish at the center of an altar. After a week of nightly meditations at the altar, I was to ingest my first sip of tea brewed from the root I had harvested. But just as I had learned from my previous encounters with

passionflower and its "nervine" medicine, the plant need not be ingested to affect and make a different kind of sense out of "me." The night before I drank my first cup of tea, passionflower arrived in a dream. She was the woman behind the desk, approaching me softly, warmly, yet with the serious and humbling message:

"There is no finish line. There never was."

Upon awakening from the dream I began to experience a growing stiffness in my body. A tightening of my legs, an immense soreness growing from my hips into my sacrum and up my spine; an overwhelming sensation that, at the time could only be described as the feeling of something, or *someone*, dying inside. My muscles demanded to be stretched beyond their skeletal constraints, begging my bones to contort into unfamiliar arrangements. My search for reprieve in familiar yoga postures and various meditative mantras wouldn't suffice. There was nothing "I" could do. For, as it became clear, it was precisely this familiar urge towards "doing," towards searching for a plot of comfort "out there," that I was being instructed to release.

Later in the evening, upon drinking my first cup of the passionflower root tea, I began to feel a release of, and relief from, these all too self-centric senses. I sipped the tea, sat in candlelit meditation, and slid into a deep and heavy sleep across the floor of my bedroom. I awoke into a bursting portal of vibrant pinks and purples, a deepening concentric swirl into and through the famously ethereal inflorescence, and doused in the perfume of an overwhelming, euphoric sensation that "I" was, at once, being birthed by and giving birth to the passionflower. There was no origin or end, no finish line or boundary "between" us.

Thereafter my body was not mine, but something of a conduit, then a coalescence. Roots sprouted from my sacrum, gently coaxing my spine "back" down into earthly grounds. As my body sank heavier into ground, spring coiled tendrils and broad palmate leaves lifted and suspended all thoughts away from perception, though it was no longer clear "where" perception was, nor whom.

As the dieta unfolded my all too familiar concept of time, as a linear ordering of experience into past, present, and future, became confused, and in its deepest passionflower "ness," seemingly irrelevant--hardly interesting and only vaguely conceivable. In this timeless dimension of communing, there were no verbs, no end points, or destinations. Such distinctions couldn't be. "I" was passionflower and passionflower "me." A relation which, as I am only beginning to sense, continues, both "before" and "after" the ceremonial dieta—and both "before" and "after" the passionflower vine grew into my home, extending an invitation to open my all too self-centric, finish-line oriented window of perception.

Part IV.

As I continue to make sense of this passionflower communion in dreams, writing, and meditations, both *Passiflora* and "I" waver in and out of time-bound and timeless evocations--written into narratives of species, of the inheritance of plantations, colonial histories and the realms of "anthropogenic disturbance" in which nervines and nervous senses coalesce--yet all the while opened to ever expanding, more than human, and more than individually embodied creations. These are stories similarly told by the vines growing amidst the ruins of ongoing plantation style agricultural practices, alongside busy highways, and into the windows of an academic mind entranced and broken down by the coercive allure of finish lines and dreams of future progress. This plot, this story, that I am here introducing as a *phyto-innervation,* is not simply an embodiment, an unexpected coming into being with a passionflower vine, but continues to unfold in this dissertation—in the creeping, climbing, nonlinear entanglements of these stories—as an ongoing invitation. An invitation to crack open the window of a time-bound "finish line" oriented perception that assumes, for instance, that consumption is required for earthbound, plant-human connection. An invitation extending and innervating a potential to create from, and be created by, a

perspective that need not take place "within" a self, a nervous system, a home, a species, or in the confines of pasts, presents, and futures. An invitation to suspend racing thoughts of doing, producing, and achieving and sink deeper into the creative potentials of timelessness where there is no finish line.

There never was.

INTRODUCTION

Phyto-Innervations

phyto:
1.) word-forming element meaning "plant"
2.) from *phyein,* "to bring forth, make grow"

innervate:
1.) to stimulate to action, "innervate a muscle or a nerve"
2.) to give nervous influence to
3.) to supply with force or nervous energy
4.) to excite; to animate

A conspiracy sprouts afoot.

Writers, artists, philosophers and scientists across the globe are finding themselves entranced by murmurings of a "secret" underworld; an underworld from which "the minds of plants" (and their fungal and bacterial familiars) are staging a breakthrough. Stories of Venus fly traps that count to ten (Bohm et al., 2016); of entire forests that not only "think" (Kohn, 2013) "feel" and "communicate" (Wohlebben, 2015) but are "mothered" with the help of their extended mycorrhizal relatives (Simard, 2021); pea plants that remember their pasts and anticipate potential futures (Gagliano, 2016); of maize, squash, beans, and tobacco plants who recognize themselves as a certain kind of relative—as family, friend, food, or foe—in relation to their human and nonhuman neighbors (Kimmerer, 2013; Karban, 2007, 2016). These are just some of the many stories of "intelligent plants" (Pollan, 2013) propagating across popular and scholarly platforms with remarkable tenacity and interest (*see also* Chamovitz, 2012; Mancuso, 2015.)

Against the backdrop of doom and gloom images of a planet at its breaking point, of the end of all that brings us life as we know it, the reception, the alacrity of stories that speak of plant minds,

makes sense. Though what kind of sense that is, is not all that easy to explain. At least not with any grammar we are all that familiar with in the English language—the "official" language of science and its publics. And with so much burgeoning scientific, scholarly and popular literature about this "secret" underworld, it's hard to believe the sensorial-psychical-phenomenal, and otherwise highly communicative worlds of plants could ever have been so "secret." Secret to who? And for what purpose?

Many readers are quick to point out that of course, stories of animate plants, plant songs and other kinds of plant-human communications have, since time immemorial, existed in the languages and cosmologies of indigenous peoples the world over. Stories that have, since the birth of science, been relegated to realms of "myth," "belief" and "religion," or otherwise methods of sense-making that, somehow, have been said to precede the developmental margins of 'proper' knowledge.

This acknowledgement is significant and should not go without mention. But it is also significant to acknowledge that the category of "plant" with which these scientists are working with is not the same "plant" that we translate out of indigenous cosmologies. The "plant" these scientists speak of is a taxonomized plant; a plant with a particular epistemic and ontological history that neither wholly diverges from, nor can be readily and directly translated into, a plant that is universally known and recognized. The plant that harbors these "secret" dimensions of agency, sentience, and communication is a plant that grows out of a particular Western, Euro-American tradition of knowing plants. That is, knowing plants in the Aristotelian (and later as Cartesian, Newtonian, etc.) practices of philosophical inquiry. Those practices which have, since the 15th century, forged and flourished into a particular empirical philosophy that we now call "science."

This dissertation will deal specifically with a small, and controversial group of scientists working to, in part, disrupt a particular philosophy of science, in which plants are, taxonomically and evolutionarily speaking, primitive and passive organisms with no capacity for sentience or cognition.

But, they are also working to *maintain* it, in the sense that they still rely upon the tools, methods, and a shared ethos of "objectivity" which makes their inquiry into a particularly powerful and universalizing form of generating "evidence" about plants. A power that is not shared by those farmers, healers, herbalists, witches, and indigenous knowledge holders who speak of plants in perhaps similarly agentive ways. As such, the practices of these scientists, as you might already be surmising, are fraught with inherent and perhaps irresolvable colonial violences, tensions, insecurities, and intense uncertainties. Nonetheless, the scientists, and one allied philosopher that make up the stories I tell here, seem to, at least tacitly, know and feel something about plants that many of their colleagues don't, and fiercely doubt.

As a student and aspiring anthropologist, my dissertation research draws from years of working closely with a few of those scientists working to "crack" and reveal what they assume to be a *naturally pre-existing* code of these "hidden" realities of plants. By spending several months in the labs, gardens, offices, and homes of each of these researchers, my studies propose not only an irreducible diversity of practices of science-making through which a new scientific field gets presented, but the struggles, surprises, and otherwise unspoken of difficulties that come with fielding a science that disrupts "the order of things." A science that finds its ground in the cracks, fissures, and instabilities buried in the sediments of a perceived scientific consensus and a shared quest for universality.

Throughout my dissertation research, I have been working to ethnographically ingather a sense of how the novel and still highly experimental and controversial sciences of plant neurobiology, cognition, and behavior (PNCB) are being made. If my studies inquire into scientists attempting to, as Natasha Myers has best described it, "sense and make sense" of plant sensing (2015a, p. 2), then the scientists I study are attempting to make sense of plant sensing through apparatuses common to the domains of cognitive science and neurobiology. As such, there is a

peculiar kind of tropic twist that happens in conversations and experiments with these plant scientists, and not others. My field notes evoke stories of plants responding to scientists in ways that not only displace the centrality of the brain and vision from longstanding theories of cognition, but in so doing, challenge the cognitive theories embodied and prefigured by the scientist's methods of prehension. Lured into the nutational curiosities of roots and shoots, through spacetime encounters that challenge the language and techniques of a scientist's a priori 'cognition,' these scientists are, quite publicly, losing grip on those rationalist certainties that sustain their knowledge and their careers. The feelings—the doubts, fears, and hesitations—that once lurked in the shadows of their objectifying confidence become not simply palpable, but part of their experiments. Grasping for the stabilized explanatory grounds of cognition in the languages and techniques of neuro- and animal behaviors sciences, these scientists find that no such stable ground exists. The plants once naively assumed to be the objects of objective investigation become increasingly and unexpectedly responsive to scientists who are no longer certain where the 'true' boundaries of knowing reside. Immanent to these descriptions is a phenomena I describe as "phyto-innervations."

The terms *phyto*, the Greek prefix inferring 'a sense of, or resembling to, that of a plant,' and *innervation*, 'the distribution or supply of nervous energy' (OED, 2021) do not, in my conceptualization, refer to any a priori distinction between 'plants' and 'nervous energy.' Rather, this provocative and seemingly unnatural combination of terms works to draw attention to the ongoing social, material, and historical boundary-making practices of the sciences (Barad, 2007; Star & Griesemer, 1989). Through an ethnographic attention attuned to processes of embodiment (Prentice, 2013), this dissertation introduces the concept of phyto-innervations as a tool for articulating a particular relational materialization of more-than-human sensation and worldly creativity. These are emergent sensorial compositions that do not fit neatly within the

representational metrics of individual plants, nervous systems, or subject/object, mind/body, volition/reflex oppositions.

The dissertation chapters are organized around the experimental practices of four different PNCB laboratories, and the unique forms of phyto-innervations that unfurl from within them. In each of the chapters, I detail the processes through which PNCB scientists—spanning an international network of labs across Italy, Spain, Australia, and the US—are inventing a science of 'minds' that includes plants in previously unthinkable ways.

Chapter one begins by situating the contemporary struggles of these scientists from within the not-so-distant past—the 1973 publication of the *Secret Life of Plants* (Tompkins & Bird, 1973). The book, written by two ex-CIA agents, propagated sensational claims of a science of 'plant telepathy' and other forms of plant-human communication. A New York Times Bestseller, its widespread public reception sparked outrage amongst scientific authorities of the day. Through a historiographic study of the ensuing scientific debates, and the many spurious attempts to "debunk" the book's claims, I illuminate how the phenomena of a plant mind has long been historically relegated to the racialized categories of 'pseudo-science' and 'oriental mysticism.' Building upon the work of feminist decolonial scholar Banu Subramanian (2015), I suggest that such relegations are immanent to the colonial discourse of scientific boundary production, rather than reflections of a naturally pre-existing reality. In so doing, I approach the PNCB sciences of today as always already partially constructed in the margins of the 'sensible' and 'the historically real.' I propose that these struggles to field a new science of plants, and a new science of neurobiology and cognition, are not only constrained by the boundaries of scientific disciplines. In some situations they are also the struggles of scientists working to reinvent a science that does not secure its knowledge—its authority—against 'the mystical,' the 'irrational,' and the otherwise scientifically 'imperceptible.' At

others, these are the struggles of scientists lured into reproducing historically racialized and gendered hierarchies of 'intelligence' and Euro-centric ideations of 'self.'

Chapter two draws from fieldwork conducted at the International Laboratory of Plant Neurobiology (LINV) in Florence, Italy. LINV is a lab born from the ruins of plant electrophysiology—a field made to be 'taboo' in the wake of controversies surrounding the Secret Life of Plants. The chapter details the practices of three LINV scientists, trained in the tools and techniques of plant electrophysiology, as they attempt to reimagine, and re-brand, their practice as the new "field" of plant neurobiology. But the "field" of plant neurobiology is not found inside a lab in the same way that the "nervous systems" in question are not found inside a body--neither scientist, plant, nor ethnographer. In this chapter, I explore "the field" as a concept and an ongoing practice, through which the boundaries between plants, scientists, and myself are made through multiple, overlapping scales of inquiry and field-making potentials. By refraining from assuming the 'neurobiological plant' as a stable epistemic object, and 'plant neurobiology' as a coherent science, I focus on the varying conducts and resistances—the sensorial, technological and more-than-human orchestrations-- that impede, charge, and excite the margins of plant, scientist, and ethnographic fields both within and beyond the walls of the International Laboratory of Plant Neurobiology (LINV) in Florence, Italy.

Chapter three thinks through ethnographic encounters with a philosopher of cognitive science turned empirical scientist of plant cognition, Dr. Paco Calvo. Over the last ten years, Calvo has transformed an old student lounge in the philosophy department of the University of Murcia in southern Spain into a laboratory, or rather, a time-lapse recording studio, of plants. His chosen experimental subject is the climbing bean, a plant known for its rapid growth and 'grasping' or 'searching' tendrils. With Calvo, I explore the processes through which time-lapse cameras make a particular kind of 'decision-making' behavior in bean plant tendrils perceptible. But perhaps most

significantly, what they make imperceptible. Despite Calvo's painstaking attempts to develop the empirical grounds for a new philosophy—a new "phytology" — of cognition, this chapter focuses on the many disorienting moments in which the beans challenge Calvo's reliance upon visual technologies and metaphors. These are exasperating and oft hair-raising encounters in which Paco's a priori "images of thought" are being challenged, and unfurled, by the tendrils of beans.

Chapter four builds upon ethnographic fieldwork with Dr. Monica Gagliano, an evolutionary ecologist and pioneering researcher of plant cognition and acoustic communication studies. The chapter expands upon a co-authored paper (included in this application) that describes the evolution of a pea plant decision-making experiment "gone wrong;" an experiment in which pea plant root tips or 'radicles' refuse to respond to the initial terms of Gagliano's inquiry. From within these unexpected encounters with pea plants, I explore, with Gagliano, how her theories of 'knowing,' embodied through years of disciplinary training, come to be confused with the nature of 'knowing' and cognition in general—in humans as in peas. By relinquishing prior certainties of what it means to know, and to feel, we explore alternative means of making a science of plant cognition. That is, a science that does not claim to be 'about' the decision-making faculties of peas, but a science that is responsively composed *with* them. What transpires from these practices is a collaborative, more-than-human ethic of science-making that we describe as "radicley empirical."

Chapter five builds from a particularly provocative interview with Liz van Volkenburgh, director of the Plant Growth Lab at the University of Washington and one of the few female 'authorities' in the field of plant physiology. She is also an outspoken proponent of the PNCC movement. Nearing the end of her career, van Volkenburgh is less focused on research and more on teaching her students how to be 'undisciplined.' The chapter weaves insights from an interview, in which van Volkenburgh is actively coming to terms with the colonial logics that inform her disciplinary senses, and how her students are helping her to re-member alternative means of

knowing and practicing plant science. Through classroom environments and lab meetings, I explore the sensorial reckonings of a scientist trying to learn with her students how to be properly 'unfaithful' to an idea of science that stifles the creative powers of imagination. In so doing, van Volkenburgh, her students and I explore alternative methods of asking the "right" questions in plant science. These are questions that not only seek to open-up new sensorial imaginaries in the bodies of plants, but also in the bodies of a future generation of plant scientists.

While the dissertation is far from complete, what I hope to evoke through these stories-with-no-finish-line is a sense of other-worldly possibility, both within and beyond the sciences. As a young, burgeoning conservation biologist, tromping around as a research assistant in the very large, charismatic fields of southern Tanzania and the Greater Yellowstone Ecosystem of western Wyoming, I was sure I'd found the lifestyle and type of research I'd like to pursue for the rest of my life. A field-based practice, where more hours were spent outside than in. In the blissfully naïve minds-eye of my twenty-three-year-old self, pursuing a graduate degree in Cultural Anthropology seemed to further secure such a fate. A life lived in "the field" seemed certain. Never could I have imagined that "the field" in which I was to spend the next eight years of my life immersed would be a field of laboratories and eight-hour days spent staring at a computer screen.

Many times I left the labs early, feeling ill, disoriented, and out of touch with my senses. Laboratory life, according to my bodily experience, can be quite toxic, disenchanting, and creatively stifling. This perspective is no doubt present and evidenced in much of my writing and that of many other science studies scholars before me. But this is by no means the whole of the story. Because of course the lab is, for so many others, a source of immense creativity and life-giving possibility. Plants and other kinds of people can indeed be found thriving in these places at the same time that others can be found dead and dying. The contradictions are endless. I do my best to hold them together in ethnographic space; to suspend easy critiques, praises, and dismissals. Nonetheless, each

of these will give way to another at some point, and a "neutral" perspective is not only lacking here, but delightfully unobtained and unpursued. Objectivity has a place here, but one densely tangled up in the histories and experiences of lab scientists, their methods, languages, materials, and the plants that continue to find interesting ways of resisting them. Nonetheless, if I could choose the kind of affect that moves from these pages and into the bodies of my readers, I would choose a renewed sense of faith in the creative process that is science…even if it happens in the troubling and destructively wonderous spaces of a lab.

As long as there are scientists willing to risk their career on asking unpopular questions, on letting their inquiries grow from a sincere admiration for the ancient and untamed life forces that make our breath and life-as-we-know-it possible, then I have faith that a more nuanced, sophisticated, collectively indebted and reciprocal plurality of sciences might be realized. What I wish to evoke a sense of here, is that the seeds for this kind of future have already been planted. They are growing amidst us in weedy gardens, abandoned farms and plots of unceded indigenous lands, national parks, migrating old-growth forests, and even in the labs of scientists. May we be quiet, may we be courageous, and may we be humble enough to listen.

CHAPTER ONE

Situating the Margins: A Nervous History of Plant Neurobiology & Cognition

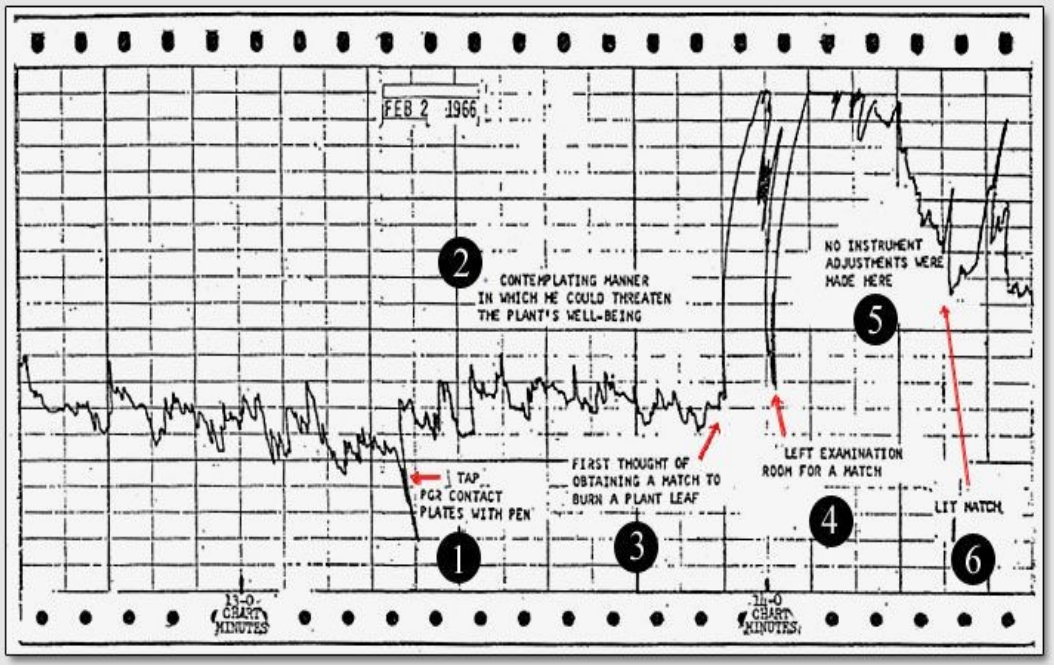

Figure 1. This is "Figure 2" in ex-CIA agent and lie detector specialist Cleve Backster's infamous "Evidence of a Primary Perception in Plant Life" article, published in the Journal of Parapscyhology in 1968. The figure tells the story of one of Backster's early experiments, in which he attached a lie detector to an unassuming office plant and found electrical "spikes" were elicited not by burning a leaf with a match, but by *thinking* about burning a leaf with a match. Five years later this research would become popularized as "evidence" of plant telepathy in Tompkins & Bird's *The Secret Life of Plants*.

Part I.

In 2006, a group of seven scientists, representing institutions across the US and Europe, publically introduced their "newly focused field" of plant science: Plant Neurobiology (Brenner et al., 2006). As if anticipating the knee-jerk, reflex reactions of their *Trends in Plant Science* peers—those plant physiologists who had worked so hard to maintain their careers upon a clear distinction between plants and animals—the authors choose their words carefully. For instance, "the field of plant neurobiology" is not "new," as in a new discovery, but "newly focused," as in a refined approach, a new microscopic lens with which the same old phenomena can be viewed in a new light, a new magnitude. Such a narrative works to position the authors interests safely within the Kuhnian terrain of "normal science"(Kuhn, 1962)— nothing to see here, business as usual, the work of plant neurobiology is still piecing together *the same old* puzzle, just from a slightly different angle. And yet despite the proclaimed need for this newly focused angle, the authors remind their audience that the field of plant neurobiological inquiry is "as new as it is old."

An extensive literature review composes the majority of the article. They traverse from ancient Greece—tracing the etymological roots of 'neuro' in 'vegetal fibers'—to the Victorian era discoveries of bioelectrical fields within the bodies of plants *as in* animals, and for JC Bose, in metals and minerals. Charles Darwin, the father of evolutionary reason himself, is named as a founding father, an original instigator of inquiries into "root-brains" and "nervous impulses" in plants. Furthermore, the presence and production of what have long been considered important neurotransmitters in animals, like serotonin and glutamate, has been well documented in molecular studies of plants. What's missing, they suggest, is more research on the neuronal-like signaling transduction pathways in which these chemicals are thought to be electrically propagated and systemically integrated.

The naming of the "nascent field" of plant neurobiology, then, appears to be an intuitive choice. The authors present it as a mere matter of re-familiarizing oneself with the history of things—a history in which the nervous natures of plants have been, again and again, mistakenly overlooked by "the science of the times," repeatedly disenfranchised by a "prohibition against anthropomorphizing plant function" (Brenner et al, 2006). But for many plant scientists, reading such an introduction to plant neurobiology was, as no doubt anticipated by the authors, an unnerving experience.

In response to the manifesto publication, a group of over thirty plant scientists spanning a variety of laboratories and disciplines—from molecular biologists to chemists to electrophysiologists in the US, Europe, and Australia—announced their public dismissal of plant neurobiology (Alpi et al., 2007.) Citing the "obvious inference" that plants have no brains or nervous systems, plant neurobiology appeared to be none other than a "mere catch phrase," offering no apparent contributions or potential advancements to the plant sciences. The authors conclude:

> "New concepts and fields of research develop from the synthesis of creative thinking and cautious scientific analysis. True success is measured by the ability to foster new experimental approaches that are founded on the solid *grounding* of previous studies. What long-term scientific benefits will the plant science research community gain from the concept of 'plant neurobiology'? We suggest these will be limited until plant neurobiology is no longer founded on superficial analogies and questionable extrapolations" (Alpi et al., 2007; 136).

In the margins of these publications and debates lies a phenomenon which most every plant scientist is familiar, but few so emboldened to speak of as anything other than a "pseudoscientific past."[6] But for those who are playing with the potentials for a neurobiological science of plants and

[6] A phenomenon which continues to haunt the work of plant scientists in largely tacit ways. *See,* for instance, Michael Pollan's "The Intelligent Plant" (2014) article in *The New Yorker* and Natasha Myers's "Conversations on Plant Sensing"

its proximal offshoots, the cognitive and behavioral studies of plants, this phenomenon haunts their practices in obvious ways. Eric Davies, a plant electrophysiologist and plant neurobiology ally has diagnosed this phenomenon, "the Secret Life Syndrome" (Stokes, 2005). His diagnosis is a reference to the whispered past of a scientific frenzy that still lives on in the wake of Peter Tompkins and Christopher Bird's 1973 publication of, *The Secret Life of Plants: A Fascinating Account of the Physical, Emotional, and Spiritual Relations between Men and Plants.* The book, being so widely received, and, to the dismay of many scientists, so widely *believed* by the public, that it sent shock waves throughout the plant science community—comprised of heated conference debates, heightened insecurity, emotionally charged defenses, and an enduring experimental paralysis that persists among plants scientists today.

But while the "Secret Life Syndrome" is a provocative term for diagnosing the phenomena innervating the nervous systems of plant science—mobilizing the possibilities for some kinds of sentience, some kinds of nervous responses in plants and their scientists, and not others—I suggest that the sparks of these debates and their ensuing boundary-policing practices neither begin nor end with the "pseudoscientific" conclusions of *The Secret Life of Plants*. Rather, in learning to see what Banu Subramanian describes as "the ghosts" of plant science, I suggest that the ghosts that dwell within the margins of plant science—those that enliven the nervous responses in the wake of plant neurobiology and behavior's introduction—emanate from a much deeper terrestrial terrain. They evoke a nervousness deeply seeded in the history of science which cannot be so easily parsed from the interests and violences of colonialism and the sciences of eugenics; a ghostly nervousness that I describe as a "paranoia of the paranormal."

for insight into the ways in which plant scientists in training are already imbued with a defensive reflex against what is often presented as an ahistorical "anthropomorphism."

This chapter is not intended to be a history based in "fact." Rather, it is an attempt at situating the emerging sciences of plant neurobiology, cognition, and behavior from within a greater discourse of debates, dialogs, and boundary-policing practices that make these sciences always already a matter of controversy. A closer examination of responses to the publications and claims of plant neurobiologists offers an entry point through which I might begin to understand the complex processes that make the field of plant neurobiology sensible, or, insensible. These divergences point to some of the social relations that work to maintain the multiplicity of plant scientists and their plant objects together as a fact generating community—"a stylized resistance in thinking" Ludwik Fleck refers to as a "thought collective." Controversies over plant neurobiological "thought styles" (not yet a fact-generating thought collective) and the policing of disciplined terminologies (plants can't be neurobiological) make explicit otherwise tacit dimensions (Polanyi, 1966) that work to condition how plant scientists regulate their facts and contour the possibilities of "making sense" in plant science. In so doing, I work to illuminate not a naturally occurring nervous system in plants (or scientists) that scientists have long ago been "discovered," but the affective, and emotionally charged practices through which the margins of "mainstream" plant science get made and unmade.

Part II.

The year is 1973. The U.S. government has declared false victory and an embarrassing departure from the Vietnam War; on their way home dropping off leftover weapons and supplies to Israel, spitefully perpetuating their proxy battles against Soviet-backed militaries in Egypt and Syria. Their interventions are met with a retaliatory oil embargo from Arab OPEC countries. The first official "oil crisis" commences along with President Nixon's second presidential term.

Impeachment looms as his ex-CIA agent chums are found guilty of co-conspiring the Watergate break-in. The times weigh heavily on the American public. Uplifting waves of technocratic optimism and lively psychedelic experimentation that had entranced American dreams of the 1960's have by now dissipated into the ether of a bygone era; increasingly entrenched into the sediments of a world that marked such creativity as mere hallucinatory figments of imagination.

Amidst this 1973 clime of travail and disenchantment sprouts a literary craze; a book, written by Peter Tompkins and Christopher Bird, that would spark a new wave of curiosity and excitement amongst millions of Americans. *The Secret Life of Plants: A Fascinating Account of the Physical, Emotional, and Spiritual Relations Between Men and Plants* was, for many Americans, a mind-altering read. It quickly became a popular bestseller and transformed into a film, the soundtrack composed by the famed blind pianist, Stevie Wonder. Tompkins and Bird were both journalists who, after being relieved from their respective positions as a spy (Tompkins) and CIA agent (Bird), bonded over their shared interest in unconventional, or "paranormal," scientific phenomena. The book foregrounds a number of experimental revelations, both past and present, both scientifically recognized and unrecognized, espousing some of the "secret" dimensions of plant lives. These included the kinds of "psychical" communications described as telepathic, of plants that commune with humans and other non-humans through invisible forcefields of perception. In other words, those kinds of "extrasensory" communications rendered as paranormal, and beyond the rational and measurable concerns of Euro-American sciences. The book featured works of many plant scientists, like George Washington Carver, Jagadish Chandra Bose, and Barbara McClintock, who were marginalized throughout their careers but who might now be recognized as constitutive of the "mainstream." The most formidable of research featured in the book, and the kinds of experiments that galvanized a heated response among plant scientists, was the work of ex-CIA agent and lie-detector specialist, Cleve Backster.

Sitting idle in his office one day, and for reasons Backster cannot explain, he decided to attach a lie detector, a Wheatstone-Bridge transducer, to an unassuming *Philodendron*. The response was startling. In the language of electrical signals etched into lines across flowing charts of paper, the plant was, according to Backster, not simply responding to his actions (i.e. burning a leaf with his cigarette), but the mere *thought* of burning a leaf with a cigarette. Anticipating the torture to come, the plant electrified a sharply amplified signal onto the paper, charging Backster with a sense of telepathic communion between "man" and "plant."

Backster, so amazed by the synchronized recordings he was detecting, decided that he ought to pursue these experiments scientifically. That is, with utmost attention to 'objectivity,' and to removing all traces of himself from the experiments. His experiments transformed through years of systematized methodological studies, replicated with different plants, and different stimuli. The most famous experiments being those in which plants "scream" (in the language of rapid, high amplitude oscillations) prior to witnessing the release of brine shrimp into boiling water. He published his findings in the Journal of Parapsychology, where no "serious" scientist would ever read them. It wasn't until his studies were picked up and published in "The Secret Life of Plants" that Cleve Backster was made into a nuisance, even a threat, to the "gatekeepers" (Dumit,) of science.

It may some obvious now that these kinds of experiments tell us more about the "secret life" of a CIA agent and the kinds of torturous strategies that go on inside a lie-detector session in the 1960's than they do about a communication between "man" and "plant." But it may also seem obvious that such revelations were easily overlooked by Tompkins and Bird, who may have suspended further investigation given their own interests and experiences working for the U.S. military's "secret service." And Tompkins and Bird were not alone in their wartime interests and desires to believe in otherworldly possibilities for communication. There was also the presence of a

public that, increasingly distrusting of the military and its sciences, was now perhaps more eager than ever to trust in the reality of a sentience—in plants as in humans— that had previously been entertained only as science fiction.

In response to the American public's widely believed and so-called "uncritical acclaim" of the book, plant scientists began to organize an "official" response. They American Society of Plant Physiologists (ASPP) and the American Association for the Advancement of Science (AAAS) set to work scheduling sessions to evaluate some of the claims made. While every good scientist seemed to already know, without question, that Backster's work couldn't possibly be revealing an "emotional" or "psychical" nature in plants, their concerns were with a public, who, oblivious to what counts as real science, consumed a fictitious story as fact. Among those most concerned and affected were plant electrophysiologists. Since it was on the interpretation of electrophysiological data that Backster's case and much of the Tompkins-Bird case rests. In effect, many plant electrophysiologists were charged with the task of repeating, and debunking, Backster's experiments. The expectation was that, having repeated the experiments and finding no such reality of "psychical" phenomena in plants, plant electrophysiological "experts" could resume their practices as authorities, and put an end to the public misinformation campaigns that Tompkins and Bird had triggered—a discourse sociologist of science Harry Collins has aptly named "the Backster effect."

It was an unexpected turn of events for Barbara Pickard, a plant electrophysiologist from Washington University. Having recently published a review of electrophysiological studies—past and present—that suggested evidence of a kind of nervous nature in plants, she was prepared to discuss such findings with colleagues at the 1974 ASPP conference. Instead, Pickard found herself charged with the task of assembling a symposium for scientists to coordinate an investigation into Backster's claims. In June 1974, Pickard organized a symposium at an ASPP meeting in which independent and "well-controlled" experiments were described that had attempted—but failed—to

reproduce Backster's results. Following this, Galston organized a session at the AAAS meeting in January 1975, which brought Backster "face to face" with some of his critics, including two scientists, E. L. Gasteiger and J.M. Kmetz, who had gone to great lengths to reproduce Backster's experimental conditions.

According to sociologist of science Harry Collins, the inability for "orthodox" scientists to reproduce Backster's experimental findings came as no surprise to Backster and his "parapsych" colleagues. Collins, having interviewed and spent time with Backster and colleagues throughout these debates, documents the "back and forth" dialogs that ensue and come to demarcate some kinds of boundaries between "normal" and "paranormal" scientists. Those who took up the challenge of replicating Backster's experiments had, according to Backster, failed to replicate even the most basic tenants of the experiment—for instance, using tap water instead of distilled water, aluminum foil instead of noble metal for the electrodes, and converting AC to DC, thereby recording the wrong kinds of electrical signals. One such attempt, conducted by a graduate student "under the careful scrutiny of the electrical engineering and botany department of the University of Washington," assembled an experiment so distant from Backster's protocols that even the most eager of "orthodox" scientists turned a blind eye.

It wasn't until 1979, six years after the Secret Life of Plants, that two plant physiologists were recognized as having "gone to great lengths to reproduce Backster's experimental conditions," and, having recorded no such thing as a "psychical" or "emotional" connection between scientists and plants, were given the power of authority over the matter. The case was closed. Backster was a quack. Or so it was made to seem. An extensive review of Backster's scientific and theoretical failures was summarized and published in *The American Scientist in 1979* by Arthur Galston and Clifford Slayman—at the time two of the most prominent, that is authoritative, voices in plant

science. The article reads as an obituary from the very title, "*The Not-So-Secret Life of Plants: In which the historical and experimental myths about emotional communication between animal and vegetable are put to rest.*"

In it, Galston and Slayman take up the task of synthesizing and reporting the evidence against those claims purported in "The Secret Life of Plants," particularly those having to do with electrophysiological experimentation. They begin by voicing their concerns for an increasingly antiscientific public, which was finding its way into their freshman biology classes, in which students were "naively" querying into fictitious claims about plant electricity. But before they can get into presenting the evidence against Backster's claims, they first need to clarify the book's presentation of the electrophysiological contributions of "eminent Indian physicist" J.C. Bose. In particular, to clarify the author's "mistaken historical impression" of Bose's scientific contributions.

J.C. Bose is a significant figure in the history of controversies that "situate" plant neurobiology and cognition science as a particularly nerve-wracking subject. And for reasons I work to parse through below, his science has received much less reflection and attention from plant scientist than that of Cleve Backster's. Unlike the authors above, my intention is not to compare their "science," which, devoid of their shared electrophysiological interests, is quite incomparable. Rather, my intention is to shed light on the differences in the controversies that surround them. To add to and complicate, rather than subtract from, the sociopolitical, material, and historical messiness that makes the sciences of plant neurobiology and cognition a particularly interesting space for investigating the varying possibilities and impossibilities of plant science. For getting a feel for the dynamics through which the nervous senses of plants and their scientists cannot be disentangled from a history of colonial science—in which race, racism, gender, and sexism all figure as shapeshifting categories in the making of some plants, and plant sciences, and not others.

For Galston and Slayman, Bose's thought was, in retrospect, quite "advanced" in some respects, but was "rather *primitive* in others." As if reading Bose for the first time, they relay a sense

of awe for his "ingenuity," for a perceived success in his ability to design "sensitive" and "elegant" instruments to measure small changes in electrical potential in plants in the late nineteenth and early twentieth centuries. And, as they see it, he did "quite properly" point to functional similarities between the electrical and mechanical responsiveness, or "irritability," of plant and animal tissues. But where his Tompkins and Bird and Bose had all concluded that such data suggests that plants do indeed perceive their environments, and respond accordingly, Galston and Slayman feel that such conclusions wrongfully suggest a correlation between the responses of plants and the responses of humans and higher animals. Instead of taking Bose's science to these conclusions, Galston and Slayman suggest that a better scientist would have looked to the much more "advanced" and noteworthy science of Bose's American and Swedish counterparts, for whom plant perception was no such possibility.

What is necessarily missing from their re-appraisal of Bose's work, and what is, in my reading, considered to be quite palpably present in the presentation of Bose's work as rather "primitive" in comparison to his European and American contemporaries, is an understanding of the "science of the times." That is, a science which was not only subtended by the racialized hierarchies which had long powered regimes of colonization, but which were now increasingly propagated, justified, and "evidenced," by the empirical rationalities of science. The colonial invention of racial hierarchies, once fervently defended as God-given and geographically evident "truths," as Hegel had believed, were now believed to be biological truths, made to be empirically evident with the metrics of a presumably rational, ahistorical science. This discourse of scientific racism not only affected (and continues to affect) the kinds of plants and scientists that get taken seriously as properly "scientific," but was at the time of Bose's research, being actively generated as a science itself. As such, Bose was not simply an "Indian physicist," as Galston and Slayman point out, but an Indian physicist working under the oppressive constraints of the British Raj. His

electrophysiological studies of plants were being published at a time when his American contemporaries were quite heavily influenced by, if not actively contributing to, the racialized sciences of eugenics.

Part IV.

Jagadish Chandra Bose was a Bengali scientist, or, as many describe him, a "polymath," living and working under British colonial rule during the late nineteenth and early twentieth century. While Bose is most famous and scientifically celebrated for his work in physics, he is also, in some circles, considered a founder of biophysics, having been one of the few of his time to search for an electrically unifying principal underlying "life" and "non-life" alike. In the early twentieth century, Bose turned his attention to the world of plants and worked to merge the previously disparate fields of biology and physics, establishing the groundwork for what is now recognized as the field of "biophysics." But it was a particular affinity and interest in exploring the "nervous impulses" and "irritable" life-processes of both "ordinary" and "fast-moving" plants that would occupy him until his death. These experiments, and the many books and articles that came of them, would be used against him by those who feared and denounced his work as the products of "Oriental mysticism." Through their power, Bose was transformed from a well-respected and knighted physicist, to a controversial, untrusted, and charlatanized figure within the plant sciences.

Bose was made infamous for proposing a phenomenology of plant perception, and delineating characteristics of electrical excitation that are now, if only in secret, amongst the general corpus of the few remaining plant electrophysiologists of today—those re-inventing their science as a science of "plant neurobiology." While the electrical depolarization events scientists now call "action potentials" had already been "discovered" by esteemed physiologist J. Burdon Sanderson in insectivorous "fast-moving" plants like the Venus fly trap, Bose had identified action potentials as

an electrical phenomenon inherent to all plant life, including those unflinching, "slow-moving" plants classically categorized as "ordinary," or "vegetables."

In the electromagnetically stimulated turnip, for example, Bose demonstrated "summation" of electrical responses, showing that a single stimulus producing no measurable electrical response led to a large depolarization (an action potential) after a thirty-fold repetition. The "all-or-none" property of mechanically induced action potentials was, for Bose, similar to those recorded in the hearts of animals:

> *"…During the gradual increase of the stimulus from a low value there would be apparently no response. But when a critical value was reached, a maximum response would suddenly occur, and would not be exceeded when the stimulus was further increased. Here we have a parallel to what is known in animal physiology as the "all or none" principle. With the cardiac muscle…there is a certain minimal intensity which is effective in producing response, but further increase of stimulus produces no increase in response…"*

In addition to being a prolific experimentalist and inventor, Bose was a prolific writer. His publications include, *Response in the Living and Non-Living* (1902); *Researches on Irritability of Plants* (1913); *Plant Autographs and Their Revelations* (1914) and *The Nervous Mechanism of Plants* (1926). The language of these titles echoes much of that used in his findings; where plant electrical impulses were deciphered as "nervous impulses," akin to beating hearts. As one might guess, these metaphors aroused much controversy and fear amongst the plant science community. A controversy which was, significantly, not present in response to Charles Darwin's claims of a similar nature; in which the roots and climbing shoots of "ordinary" plants demonstrated "irritability," which he likened to the *brains* of lower-animals (such as worms). Whereas Darwin's experiments and writings on the "nervous mechanisms" in plants went quietly unrecognized, relegated to the shadowy margins of his *magnum opus*, Bose's work would be used to ostracize and expel him from the plant science community. As plant physiologist and plant neurobiology ally Peter Minorsky has thoroughly researched, it was not simply his "provocative language" that was made to be at fault, but his "Oriental" affinities (Minorsky, 2021).

I was directed to Peter's research by Dr. Liz van Volkenburgh, who had been using one of his PowerPoints to discuss the history of racism in plant science with her plant behavior class (*see* Chapter 6). At the time of our interview, Peter was in the process of publishing his article in the Journal of Plant Signaling and Behavior (a journal founded by plant neurobiologists Stefano Mancuso and Frantisek Baluska). I ask Peter to tell me a bit about his interests in J.C. Bose's work, how he found himself writing an article that dealt with scientific racism. He tells me he was a graduate student in plant physiology at Cornell when he first came across Bose's name. At the time, Minorsky was interested in studying the electrical signals of plants and found himself reading a lot of literature written by Soviet scientists, many of whom cited Bose's work. As a son of Russian immigrants, Minorsky tells me that he didn't carry the same stigma that most of his American peers had, or had been instructed to carry. Because of this, he discovered many a paper in the archives of Soviet science journals that cited the science of J.C. Bose as "proper" literature, as a science that could be built upon in the development of further experimentation. Upon mentioning the name and research of J.C. Bose to his major professor, he recalls witnessing an uneasiness spread across his professor's face, impressing upon him that J.C. Bose's work was not to be taken seriously, but with no further explanation. It wasn't until his first job talk, which, he was told, "was going really well until I mentioned J.C. Bose." And not simply that he mentioned J.C. Bose, but that he mentioned him as a scientist, as a contributor to the field of scientific knowledge about plants, rather than a "legend" of mesmerizing tactics, a figure called upon only to warn against the dangers of crossing "proper" science with "Oriental mysticism" (Minorsky interview, July 16 2020).

Minorsky spent his sabbatical conducting archival research at a University of Arizona library. A place he found carried an extensive archive of letters and publications written by famed plant ecologist, Daniel Trembly MacDougal. It didn't take long for Minorsky to trace connections between MacDougal and the American Eugenics Society, and his many published contributions in

their archives. MacDougal, along with several other plant scientists and known eugenicist colleagues, created a powerful movement to ridicule, ostracize, and defame J.C. Bose's scientific reputation in the United States and, later, across Europe. For example:

In a letter to Albert G. Ingalls, a young editor at Scientific American, MacDougal declared, "I have about made up my mind, I am going to protect the American public from the products of [Bose'] pathological or East Asian imagination." (July 13, 1926.). (MacDougal, Daniel T. to Albert G Ingalls, 13 July 1926.

He went on to relay further personal sentiments, conflated and transcribed as overall scientific opinion and consensus:

"Bose has been publishing this kind of thing for years. He is a Hindoo, is wealthy and the English feel compelled to stand for him. The scientists simply writhe. When he comes to England he is not invited to lecture at the scientific laboratories but will be invited to give lectures in the office or waiting room of the Prime Minister."

MacDougal not only feels the need to categorize Bose's religion and socioeconomic status, and insinuates that he does not belong to the category of "scientists" of which he speaks, but he also seemed to overlook a major detail. Ingalls had contacted MacDougal about an excerpt he had received from one of Bose's lectures at University College London, one of Europe's leading research institutes. Contrary to MacDougal's conjectures (and Ingall's unquestioning acceptance of it), Bose, by the 1920's, was famous for filling up lecture halls. He was, prior to the nineteen thirties, celebrated and revered by physicists as one of Lord Rayleighs most accomplished students. In 1917 he was knighted, and in 1920, inducted into the Royal Society, whose hallways and surrounding streets he had famously overflowed decades earlier during a lecture on "vegetable" electricity in 1901. It would seem that any scientist of the time would not be so easily capable of overlooking such fame and esteemed scientific status that Bose had accrued since the turn of the century. Unless, of course, there was an alternative agenda.

In an interview with the editor of Science, MacDougal describes Bose's *Physiology of the Ascent of Sap* as "utterly lacking in scientific significance," and "a menace and danger to sound science." He further opined that, "The heartbeats of plants which Sir Jagadis Chunder Bose claims he has demonstrated are mere figments of a romantic Oriental Imagination, unsupported by any genuine scientific fact."

It should be further noted that MacDougal, a pioneer of American ecology and writer of many a textbook and article still featured in many of today's ecological texts, was a revered and esteemed member and leader of several scholarly organizations across Europe and the U.S. Among these were the Hollandsche Maatschappe d. Welenschappen, Societe d' Acclimation de France, American Philosophical Society, Explorers Club, American Society of Plant Physiology, and the American Academy of Arts and Sciences. He was an honorary member of the California Academy of Sciences and the Botanical Society of Edinburgh, a life member of the Torrey Botanical club and a member and merit award winner of the Botanical Society of America. As late as 1950, MacDougal was elected honorary president of the International Botanical Congress in Stockholm and was awarded the first Certificate of Distinguished Service from the New York Botanical Garden in 1956.

If anyone had the power and sway to erase J.C. Bose from the history of plant science, it was MacDougal and his supportive network of colleagues. And he was, for the most part, successful. Not only was J.C. Bose's science of electrical signaling in plants negated as a science, charlatanized as the confusion of a primitive mind, and a "romantic Oriental Imagination," but the significance of electrical signaling in plants in general was rendered a "touchy" subject—a matter of mysticism not to be taken too seriously by any plant scientist who, themselves, desired to be taken seriously.

Living and working during the era of the British Raj, it is perhaps not surprising that JC Bose's work is often only heard in the uneasy whispers of plant scientists, and why plant neurobiologists and cognition enthusiasts might be eager to "repatriate" JC Bose today; to channel

and revive his spirit out from the scientifically "dead." During the 1920's, a rift between plant scientists was forged, into "Bosephiles" and "Bosephobes," the latter being strongly motivated by the concerns of the American eugenics movement, and a concomitant push towards chemical and hormonal studies of plants at the expense of further electrophysiological experimentation. This was, in part, a movement made possible by the "discovery" of Auxin, a plant hormone whose roles were deemed so primary in the growth and functioning of a plant that electrical signaling appeared to be mere background noise. But it was also an effort made by those scientists who feared risking their credibility by continuing to conduct electrophysiological studies on plants; a practice which was too easily approximated and interrogated for its relationship to the science of JC Bose.

Thereafter, the sciences of plant electrophysiology were largely left to those European and American scientists who were quite convinced of a hierarchy of life in which humans, particularly the brains and nervous systems of Euro-American scientists, were biologically superior, and safely secured at the top. This is, of course, a gross reduction of an ongoing history of a scientific controversy, in which battles over the chemical and electrical compositions of agency and sentience have never been "settled," not even in the neurosciences, but which continue to germinate and grow and transform with the changing ecologies, industries, and political economies of "the times." But what is important to the history that I'm telling here, is that by the 1930's, Bose's work had been all but erased from the archives of plant science. No one, at least no one who wanted to be taken seriously as a plant scientist, would speak of, or cite Bose's work for decades to come. By most accounts, it wasn't until the 1970's, when Barbara Pickard attempted to re-introduce Bose's work to her plant physiology colleagues that Bose was, almost, re-considered. That is, made to be re-considered as "ingenious" but nonetheless "primitive" in comparison to his Euro-American counterparts, according to Galston and Slayman's authoritative assessment (1979). And such reconsiderations were made to matter only in response to the Secret Life of Plants; a situation which

threatened to spread misinformation about what is and is not the "sensible" and "insensible" kinds of plants and their scientists.

Situating the Margins

In situating the twenty-first century scientific controversies over plant sentience from within these "Secret Life" debates of the not-so-distant past, my intent is not to re-introduce the experiments of Bose and Backster as cast aside 'too soon' or 'irrationally' so, but to illuminate some of the sociopolitical and ecological dimensions through which a particularly nervous strain of plant science has come to fruition in the name of plant neurobiology and cognition. By drawing attention to the creative work of controversy, to the struggles over power, and the racialized and gendered forces through which some are granted the power to authorize the proper insides and outsides of plants, and not others, I get a feel for the cracks and fissures that make the boundaries of scientific fields perpetually unstable and thus, subject to change. For that which appears to be a naturalized boundary between reality and its pseudo- counterparts--between fact and fiction, plants and nervous systems--are not stabilized by a shared, and incontrovertible experimental discourse called "science," but rather are crafted and perpetually 'threatened' and altered through sociopolitical and material transformations. Through planetary crises and the unforeseen effects of agricultural industrialization, through the ongoing unraveling of nature/culture distinctions, colonial authority, its categories, hierarchies, and ever evolving methods of evidence production and denunciation.

Inspired by the many scholars who make studies of "science-in-the-making" relevant, and interesting, this dissertation gravitates towards studies of plant scientists who have, despite much effort to keep them at rest, provoked the spirits of J.C. Bose, Cleve Backster, and the plants that grow out of the cracks and failures of industrial agriculture and its sciences. Those who, decades

after the sciences of plant electrophysiology were "laid to rest," are crawling out of the woodworks—testing the grounds for a "neurobiological" and "cognitive" life in plants, measuring the degree of fallout that remains in the wake of "the Secret Life," and struggling to find the proper tools, and words, through which plant sentience might be rendered scientifically sensible.

Throughout my research, I have come to sense that this so-called "Secret life syndrome" has varying affective capacities and consequences, depending on the researcher, their variously gendered and racialized positions in the university, the financial stability of their careers, their particular trainings, interests, and motivations for studying plants, as well as the kinds of plants and the questions they permit—not all of which are deemed worthy of the experimental risk they call forth. But, in its most general sensibility, I speculate that this "Secret Life syndrome" is that which pervades the bodies of plant scientists as a paranoia of the paranormal; an agitation which activates some kinds of nervous responses in plants and scientists, and not others; innervating some bodies as sensible, and sense-able, and not others. Those working to assemble the field of plant neurobiology and cognition, those that give shape to this dissertation research are, despite finding creative ways to experiment with new articulations of plants, sensation and "knowing," are perhaps most susceptible to the consequences of such paranoias—being financially burdened, ostracized by journal editors and the "mainstream" scientific community, convicted of 'pseudoscientific' ventures, witchcraft and spreading misinformation to a naïve public. These are also those dynamics which sparked my interests in studying the "newly focused" field of plant neurobiology and cognition. For whom, and for what purpose, would this field become not simply relevant, but worthy of such a risk? How do neurobiological and cognitive prehensions of plants become a particular matter of concern for some and not others? And, who are these plants—what kinds of phenomena and communications between plants and scientists are provoking such a field of inquiry and experimentation?

This dissertation seeks to unfurl an ethnographic response to such questions. Not in the form of explanations or certainties but in the form of speculative propositions; a kind of attention and method of storytelling that Taussig describes as "apotropaic writing." A conspiring with forces that, elusive and shapeshifting, do not exist as representations, as forms to be conjured beyond those they take in these stories. As such, "we" work to fend off those modes of reading and writing which would reduce ones analysis to "knowledge," "fact," or "explanatory description;" to the entrancingly reductive sorcery of "agribusiness" (Taussig, 2015) and it's sciences.

CHAPTER TWO

Conducting/Resisting Fields

Photo 3. The field in front of the entrance to the University of Florence's Plant, Soil and Environmental Science Department, where LINV is housed.

Part I.

Outside of the Laboratorio Internazionale de Neurobiologia Vegetale (LINV) there was a field. Not a field that was pre-planned or managed or cared for, in the sense of a landscape designed, but the kind that grew by happenstance; from seeds re-surfaced out of pastures past, from the wind or birds or the herd of sheep that passed through from time to time but from where nobody seemed to know. Some guessed the sheep belonged to a family whose land the lab, and the whole of the University of Florence's Department of Plant, Soil and Environmental Science now proudly sits upon. A field that grows at the margins of agribusiness and its science.

Every morning I arrived on the 9:05 am bus (but it could also be called the "anytime between 9 and 10 am bus") and, still buzzing from my newfound and short-lived habit of drinking Italian espresso, tromped across the field to the lab by way of a narrow path of hand-laid concrete bricks.

I only mention the field outside now, as I'm writing, because the insides and outsides of fields, the kinds of conducts that make up what we know to be a "field," and the ones that don't, the ones that resist, are important to consider as an anthropologist, particularly one interested in the compositions of a marginalized field of plant science called "plant neurobiology." For the part of this scene, this image, that I considered to be worthy of my ethnographic attention at the time were the parts happening on the other side of those doors; on the so-called "inside" of the lab. These were the kinds of conditions and practices which would have been seen, half a century ago, as the very contradiction of "the field."

Depending on the season, (I was there, in and out, during a winter, a spring, and a summer), I was either knee-high or hip-high in tall green grasses, splattered with a variety of spindly and small

yellow, white, and purple flowers gregariously finding their way in the world of buzzing sounds, or I was walking across a path that was no longer threatened from being taken over but that now shared the same tones and textures of the decaying perennials that lined its edges. But the point I'm trying to make is that I noticed this field and the plants growing in it as a passerby. I noticed just enough to know that the field through which I walked neither looked, smelled, nor sounded anything like the one being named and cultivated as the "newly focused field of plant neurobiology" on the other side of those doors. And this was, in part, a pathway, a channel, through which the boundaries of my ethnographic field, my particular take on the field of plant neurobiology, has gathered shape.

The field of plant neurobiology, as I was beginning to learn, was, and continues to be, in part, an attempt at getting to know something about the conducts of the field outside; to find the right (Despret, 2016) tools and words with which to explain the ways in which plants bend and stretch and share and make meaning out of the sea of bright lights and buzzing sounds and grazing teeth that compose their worlds. But what I found, and am finding, are the many ways in which these attempts are constrained, contorted, filtered and enlivened by a dense thicket of scientific histories and controversies, a "locus of struggles" (Bourdieu, 1999; 19) over authority and alternating definitions of competence; of who or what has the means to perform proper plant science and which forms of science, which kinds of conduct, are denounced to the 'outside'-- banished to the margins as 'pseudo-.' These struggles are not only struggles over language and the power to decide who has the capacity to generate claims about plants, nervous systems, sentience, and agency and who doesn't. They are also struggles that, as I seek to articulate below, are tangled up in the specificity of one's technical trainings, the tacit dimensions particular to a scientist's empirical practice, as well as the varying access to resources—to materials, instruments and methodological techniques—that are distributed unequally within a greater knowledge economy.

In today's plant science, the extent to which ones practice visibly and conceptually aligns with an industry of science dominated by the molecularization of life and the interests of agribusiness has an immense influence on one's access to positions of authority, one's ability to speak on behalf of plants in the *doxa of scientificity* (Bourdieu, 1975). These are the tools, languages and techniques which—through principles of reduction, isolation, individuation, molecular modification etc. —continue to populate the fields of plant science with an implicit desire for standardization and homogenization. In this way, even a field of science that attempts to make itself by way of subversion—by way of knowing plants "differently," that is, in the words of the field's founders, to know plants not as "mere passive automata" but rather as electrically conductive, perhaps even synaptically-excitable "subjects" with memory, kin, imagined futures etc. —is bound to defining itself, to staging its dissensus, from within the terms and techniques of the so-called dominant plant science—the dominant "regimes of perceptibility" (Murphy, 2006). That is, the extent to which these scientists are able to successfully agree upon and communicate the terms of their disagreement safely within the boundaries of recognizable science, in no small part determines its ability to become a 'field of science,' and not simply its 'pseudo-scientific' margins. Thus, as I work to articulate below, insofar as the newly focused 'field of plant neurobiology' is a strategy for reinventing one's relevance within the 'mainstream,' it is, all the while, a strategy that reveals the inextricable ties to those techniques and technologies of knowing that work by standardizing plants as "all the same." That is, as objects that can be rendered not only visible, but sensible, accessible, and acceptable, by the apparatuses of the greater scientific industry.

Having dutifully tossed myself into the orbit of LINV scientists, traversing the lab by way of their well-traveled paths and into the electrical fields and flows of their experiments with plants, I get a sense for what they see and know, and, for what they don't see and don't know. I get a sense for

the kinds of plants they care about and the kinds they don't; the conducts and resistances that compose their fields of inquiry and the ones that compose mine. In the famous and creatively ambiguous words of Gregory Bateson, an attention to "differences that make a difference" (Bateson, 2015 [1970]).

The plants at LINV, the electrical and "neuronal-like" signaling events of their cells and the practices and apparatuses through which these kinds of events are made perceptible, teach me something about the conducting of fields—botanical, electrical, epistemic and beyond. About how the ideas and tools through which we conduct ourselves in relation with plants have an effect on the world, the making and unmaking of the "fields" we see, sense, and grow, their classifying and organizing as part of the "mainstream" or "margin." They call forth an attention to those happenings (Tsing, 2015) growing on the outsides, through cracks and along the fringes of my fields notes, and not necessarily in them. As "lures" (Stengers, 2008; Myers, 2015) for inquiry, they tug at the edges of my awareness, pulling me towards the margins of my ethnographic field—towards the phenomena yet unread, unrecorded. These are neither plants nor fields "in themselves," but rather interferences, traces, impressions that, in largely invisible but not intangible ways, have come to make a difference out of my senses. They become responsive as a reconfiguration of those plants, and the electrical and "neuronal-like" communications made visible by the constraints of particular lab apparatus', beckoning me into new terrains of sensing and perception. These are sensations that neither adhere to the insides of a lab nor the individual bodies of plants, machines, or scientists but are dispersed, diffused, propagated by way of trans-species and trans-disciplinary encounters; what I am calling *phyto-innervations*.

Part II.

Though the "newly focused field of plant neurobiology" was introduced in an article in 2006, the International Laboratory of Plant Neurobiology (LINV) was founded in 2005; or rather, that was when it was officially named. The naming of the lab coincided with the first "International Symposia of Plant Neurobiology" which was held in Florence, Italy that same year. And while the name of the lab has remained faithful to the "newly focused field of plant neurobiology," the name of the symposia was, through heated debate and much to the disappointment of the symposia chairs, mollified to the "International Laboratory of Plant Signaling and Behavior" in 2009.

The lab space itself, the largest in the building, was acquired several years prior, in 2001, with funding from a local bank, Ente Cassa di Risparmio di Firenze. Funding from a bank is atypical, or "unprecedented," I'm told. Even in Italy, where government funding of science is dismal in comparison to what is often described as dismal in the U.S. The details of this partnership with a bank are never made clear to me, but they are also not hidden (their website and all publications of studies conducted at LINV name this bank as their source of funding.) But in these gaps in information, and their labeling as "unprecedented," I gather that these kinds of unorthodox collaborations are, in no small part, what makes "the newly focused field of plant neurobiology" possible. And whereas many a scientist might consider this to be strange conduct from the perspective of the "mainstream," it has, to the extent of my knowledge, never been suggested that this is a kind of funding that is considered "improper" or "wrong." Given that much of plant science is heavily funded by the private sector—namely, by big names in the agri-business world such as Monsanto (now Bayer) —nobody seems to express a concern or find "fault" in the lab's primary funding source. Like any funding body, they have an influence on the kinds of science going on inside the lab (the kinds of instruments that can be afforded, the number of hired researchers etc.), but unlike other funding bodies that support the kind of conduct that gets recognized as "mainstream," the interests of the bank remain largely unclear.

For director of LINV, Stefano Mancuso, funding from the bank is just another way to solve the same problem that all researchers share: funding. And when one's science is, like Stefano's, actively testing the boundaries of scientific disciplines, then one might be pressed with the need to source funding from agencies other than those which fund (and therefore, authorize) the kinds of conduct—the ideas, lexicons, experiments, textbooks, peer networks and funding bodies— that constitute 'the mainstream.'

I sat down with Stefano several times over the course of my three visits to LINV (over a total of 4 months). Of late, that is, during my final visit in the spring of 2018, his desk was covered with piles of papers and books to read and review, a box full of plant resins like frankincense and myrrh (for an experiment he was still scheming up at the time), surrounded by posters and many a drawing, painting, or digital rendering of Stefano, done by admiring friends and students. And there are many.

Too many times to count, Stefano has been described to me as a "renaissance man" —pun intended, I presume. Though it is perhaps not ironic that Stefano has managed to stage such a grand scientific experiment in Florence, a city which prides and still very much identifies itself as being the grounds of the Renaissance movement. Whereas many of his colleagues in the plant science department are quick to dismiss the idea of plant neurobiology, there are as many, if not many more artists, philosophers, historians and anthropologists excited to think with such a conceptual provocation. And this is, in part, where the moniker "renaissance man" stems.

In one of several interviews with Stefano, he tells me that he much prefers thinking and collaborating with artists and writers and humanities scholars. They are, to him, "more interesting" than most scientists. While he himself identifies and has made a career as a scientist, it is, at this point, one among many titles he wears. For even before he was a scientist, before pursuing a PhD in biophysics, he was (and still is) a "bibliophile"—a lover of books, particularly science fiction—a

lover of history, and *music*. I perhaps find it more significant than he that he had, from an early age, wanted to make a career out of music, but it was, like many a scientist and doctor I've met, a path that did not meet his father's approval. In the years between a masters in agricultural science and his PhD in biophysics, he even entertained and began training to be an orchestral conductor. For reasons having to do with the financial uncertainty, the interests of his father, and, rumor has it, the passing of the famed Italian conductor who was his teacher (briefly mentioned to me by LINV researchers, not Stefano), he decided to pursue a career in biophysics: in particular, plant electrophysiology. His familiarity with amplifiers, voltage meters and electronic "filters," fostered over many years spent immersing himself in the world of music, no doubt helped him in his desires to learn plant electrophysiology. For at the time he was beginning his PhD, the late 1980's, plant electrophysiology was already on the "fritz," headed toward obsolescence in the wake of the "Secret Life of Plants" and the anti-Soviet sentiments of the "Cold War."

At the time most of the available literature on plant electrophysiology was done by Soviet scientists, published in Russian in Soviet journals. But nonetheless he perused them for their figures and tables, and, in combination with the abstracts which were written in English, he began to imagine what an electrophysiological study of plants could be. Then he went to the nearby music shops, picked up some old voltage meters and amplifiers, and learned to design and build his own instruments.

For Stefano, "the problem" that the field of plant neurobiology faces is not the kind defined by his critics, those who claim to represent the "old guard" of plant science. That is, it is not a problem of "superficial extrapolations" or a lack of "grounding" in prior empirical data, but rather a "problem of unquestioned idolatry;" what he describes as the "*Santificazione del neurone*" or, "making neurons like saints." I ask him if he means "sanctification," making holy. "No, saint-if-ication… Saint Antony, Saint Francis, Saint Neuron….there is no English word for it." According to Stefano,

scientists today, and throughout the last century, have "saint-ified" neurons; "as if they were able to produce miracles." He goes on to clarify his choice of terms. "We are human and we think we are the best example of animals, the epics of all creation, and why we are so extremely exceptional? Because we have our big brain that is made of neurons. And this is presumed to be logic, not history, or theory."

The "real" problem that needs to be addressed, according to Stefano, is that the neuron is not exceptional. It is but one way in which organisms evolved specialized cells that produce electrical signals, thus allowing for rapid, long distance signaling across the body and quick muscular movements in response. But rapid, long distance electrical signals are propagated by other means too. And plants, or rather, plant cells, according to Mancuso, do just that. "You can draw a neuron that looks like this (draws a neuron that looks like the branching, arboreal-like creature made famous in the drawings of Santiago Ramon y Cajal), "or like this" (a box connected to a box connected to a box with bridges connecting them). "Plants don't need a specific cell to do that because every fucking cell of a plant is a neuron." He is emphatic, clearly charged and amplified to enact a defense against the question "why plant neurobiology?" I remind him that he doesn't need to prove himself to me. That I'm interested in why the concept matters to him, not whether or not it's the right one. "I know," he laughs. "But now it's a reflex."[7]

"I am like most scientists, interested in fast responses…in the ones you can see in real time." But what has come to make him more rare or different among them, as Stefano sees it, is that many

[7] A defensive reflex, as I'm learning, is not only typical of a scientist working to redefine the margins of what is scientifically perceptible but is also fundamental to the making and maintaining of any scientific field. Assuming the position of authority, and defending an idea until "death," is, according to Bourdieu, fundamental to the formation of a scientific field. In *The Specificity of the Scientific Field and the Social Conditions of the Progress of Reason,* Bourdieu defines the scientific field as, "the locus of a competitive struggle, in which the specific issue at stake is the monopoly of scientific authority, defined inseparably as technical capacity and social power," or, in other words, "the monopoly of scientific competence, in the sense of a particular agent's socially recognized capacity to speak and act legitimately (i.e., in an authorized and authoritative way) in scientific matters" (Bourdieu, 1975; 31).

scientists "have not been able to imagine that plants are equipped with the capacity for fast responses, they think that because they don't move they have no need for electrical signaling." A response I have heard echoed by many a proponent for the field of plant neurobiology. For it is this particular sentiment, that plants have no "need for speed," and that, they are therefore, less responsive, that, as they see it, continues to guide most research regarding plants. The story goes that because plants don't move like (fast-moving) animals, the tendency has been to explain them as passive in nature, to look for slower, more passive means of explanation—such as chemical or hydraulic—rather than the "rapid, long distance electrical signals" common to the nervous systems of fast-moving animals.

In the neurosciences, these "rapid, long-distance electrical signals", are called "action potentials" and "variation potentials." Much of the controversy surrounding the word neurobiology in application to plants is, I'm gathering, not simply because plants, according to most, do not have neurons, but because there is a dearth of understanding and consensus surrounding the presence of long-distance electrical signaling events in plants. And there are several stories and explanations for this, several "histories-in-the-making" (Rees, 2015) by proponents of plant neurobiology and their critics.

For those interested in studying the electrical signals of plants and other organisms that lack "true nervous systems," it is important to recall a time when electricity was a phenomena that belonged to nobody in particular. In an article titled "The History of Plant Neurobiology," Rainer Stahlberg, a fellow plant electrophysiologist and proponent of "the field of plant neurobiology" recalls such a time. "*It is hardly conceivable*," he begins, *"that reflex responses, memory, and brain activity were once explained without consideration of the electrical activity in nerves and muscles…*

one must remember that electricity was only known then either as lightning or as the repelling/attracting charges that certain substances (such as amber, the Greek word for which is electron) accumulate when rubbed against wool or other textiles" (Stahlberg, 2007).

In this history of plant neurobiology, Stahlberg works to remind his skeptical scientific audience that action potentials (rapid endogenously generated electrical signals now largely considered to be specific to neurons) were long ago recorded in fast-moving plants like the Venus Flytrap by Sir John Burdon-Sanderson, an "esteemed" physician and animal physiologist of the times. But they were also recorded in "ordinary plants," such as the garden turnip, in experiments conducted by J.C. Bose. Though J.C. Bose's name carries less "esteem," having been ostracized from the plant sciences for being a non-white scientist amidst the rise of the American eugenics' movement, his work is being re-popularized and re-introduced by plant neurobiologists as part of the oeuvre of evidence subtending a neurobiological study of plants.

Photo 4. Director of LINV, Stefano Mancuso, drawing different kinds of 'neurons,' and explaining to me the concepts of conductivity and resistivity using Ohm's law.

But despite these histories and the rhetoric of rationality that subtends the emerging field of plant neurobiology, there remains another problem. This is the problem of technology. A problem of vision. With so few trained in the techniques of plant electrophysiology, the capacity to "see" these electrical events in plants is quite limited. Furthermore, the capacity to read these publications as "data" or "evidence" is further prohibited by predominant ideas of what counts as "data" and "evidence" in the plant sciences. These are ideas and standards largely materialized by molecular technologies and scales, and these are, in turn, partially materialized in the perceptions and visions of many plant scientists—the majority of whom are molecular biologists. Liz van Volkenburgh (see Ch. 5), a plant physiologist and co-author of the plant neurobiology manifesto, tells me that most

plant scientists don't understand how difficult it is to achieve these electrophysiological recordings. In plant electrophysiology, "achieving a 7/10 recording" is significant. Molecular biologists read this and think it's nothing. In short, they don't have the tools, nor the technological "know-how," the "vision" with which to see electrical recordings as evidence of anything, much less as evidence of "neuronal-like" behavior.

Unlike the neurosciences, replete with sophisticated electrophysiological technologies and the seemingly bottomless funding to support it, plant electrophysiology has no such economy subtending it. The tools that most plant electrophysiologists rely upon are either acquired from music shops and hardware stores, assembled by hand, or they're adapted from the neurosciences; tools that are scaled to the nervous tissues of humans and animals. There was a time when borrowing from the latter was considered, in Stefano's words, "not so wise." The instruments are expensive. Modifying them could be even more expensive, and, if done incorrectly, an expensive, and perhaps irreparable, mistake. Because of this, Stefano learned to build his own instruments. Eventually he became known as an "expert" in operational amplifiers. "If you understand how it works, you can build your own instruments for nothing, they're extremely cheap. From one side it was more economical, and from the other it was more customized. It was the most fitting for my experiments."

I ask Stefano if there is a standardization issue here. If you have to build your own instruments to record the electrical signals in plants, then isn't there quite a bit of resistance in making this a replicable science? He reframes my question. "The question is better asked, 'why is it so difficult to measure electrical signals in plants…because anyone with an engineering background can assemble these instruments. The issue is the plant's 'bloody cell wall.' This will require some technical detail to explain."

> *" let's say in general the resistance in terms of electrical resistance of a plant cell is order of magnitude higher with respect to the resistance of animal cells, because of the cell wall. And because of this resistance, it is*

extremely important because having a very high resistance means..because you know that current, resistance and voltage are related, its Ohm's law, it's very easy law, R=V/I. Also you can change in all the way you like in the sense that normally the most common way to explain Ohm's law is that intensity is current so I=V/R. What is interesting is that these three elements are related, the variation of one make the variation of everything."[8]

Ohm's law, I'm learning, is a mathematical equation in which "Resistance equals Voltage over Intensity." An abstraction that has, over centuries, been pulled out of a variety of empirical relationships in which "electricity" might be measured. It's become a particularly useful device for those working to make visible a phenomena, a relation, which is otherwise invisible. For plant electrophysiologists like Stefano, it is used to predict the conductivity of varying scales of plant cells and tissues over varying orders of magnitude of current. But achieving this is, as previously discussed, quite difficult. Plants, it turns out, are quite resistant to such measurements.

"Voltage is not so different in neurons and plant cells, but in the case of resistance, everything is changed. I'll just give example, 10 mega-ohm in neuron, in plant you have 10,000 mega-ohm. This is a huge difference and for instance if you are dividing by 10 or by 10,000 the intensity is going to be 0.001, so, much much much less. So in plants you are obliged to make amplification because on the contrary you would see just very very faint signals. So one of the things we had to do was we had to use specific chips, they were specific printed board, to make the operational amplifier…with small chips like transistor but they are not transistor they are the classical stuff that you find on the boards, like on a circuit board…so you need to understand electronics, not something I can explain in easy terms, but in the end what it's doing is amplifying a very small signal. But at the end I had to build all of my own instruments because all of the instruments were for animals. But not just building amplifiers but when you have such a small intensity measured because of the high resistance, you have a lot of noise, so that the signals in plants are normally much more noisy than in animals and this is just because of the 'bloody cell wall.' And so another instrument that I became expert to build by myself are the filters, so you need to filter out all this noise from the signal to see the real signal in the plants. So I spent a lot of time just studying electronics and building by myself with the soldering tools and so on. Ok? And at the end I had a wonderful result."

Part III.

Inside the lab stands a towering, multi-tiered shelf in seeming disarray; weighed down by an assortment of amplifier's ("amps") collected from music shops in the 1980's, dust covered voltage

[8] For a history of metrology and the standardization of the "ohm" as a measurable and containable unit of electricity, see Simon Schaffer's (1999) "Late Victorian Metrology and Its Instrumentation: A Manufactory of Ohms" in *The Science Studies Reader*, edited by Mario Biagioli, Routledge: New York.

meters ("voltomoters"), boxes of red, white and yellow plastic-coated copper wires, nails, screws, metal clamps and an old rusting bicycle wheel, the significance of which no one seems to recall. Researchers in the lab call this the "Museo di Stefano" (the Museum of Stefano). Many of the artifacts featured in the "museo" were collected and used by Stefano during his graduate study years in the '80's, when plant electrophysiology, at least in Europe, was still considered mainstream. Though Stefano was rarely sighted in the lab, I once saw him pull an old voltometer from the shelf. It was to serve as a potential replacement for its more modern, digitized albeit apparently malfunctioning iteration. It worked. This, I gather, is why he keeps such instruments around. Unlike computerized and digitized technologies that compose much of the laboratory technology of today, he knows how to fix such instruments, for he built many of them himself; "from the ground up."

Photo 5. A snapshot of the "Museo di Stefano," taken in 2018.

In a world dominated by the digitized instruments ushered in by molecular biology in the 1980's, the tools of plant electrophysiology are considered to be old, outdated, and lacking in both specificity and relevance. As one molecular biologist at LINV tells me, "no one wants to study the electrical signals of plants because the technology is outdated…and now there are only a few plant electrophysiology labs left in the world that specialize in it." LINV is one of them. Pointing to the Faraday cage with the "Vibrating Ion Probe" (VIP) setup beside us he says, "as you can see most of the machines are clunky and homemade. No companies would invest in making technologies for a science that hardly anyone practices." Along with these glaringly anachronistic technologies is, according to F, an accordant lack in theoretical relevance. Most cellular and organismal biology of today, he reminds me, is interested in systematic understandings of life, where multiple, interacting signaling pathways are studied at once; "not just the flow of a few particular ions," which is what the VIP, for instance, is designed to detect. But for some, like post-doc researcher "E," the techniques of plant electrophysiology maintain an allure, a "magic," that innervates in her a sense of relevance for not only the practice of plant electrophysiology, but the concept of "plant neurobiology," which, she is beginning to get a more technologically "grounded" feel for with the MEA.

In the mornings the lab was nearly silent, if not for the faint sounds of the espresso machine brewing in the distance. This was the time when E and I would sit together by the Faraday cage and the VIP, sharing stories in solitude and in trust. Her fingers were nimble, always spinning, wielding, something while we talked—electrodes, pens, knitting needles. It was during these morning hours with E that I began to learn more about her practice of plant electrophysiology, a dying field by most accounts. But it is also a practice which, somehow, continues to entrance and in many ways remain a significant and alluring mystery, even to trained "experts" like E. I unabashedly express to E that I don't "get" electrophysiology. What, where, when, how, are bodies, tissues, cells, and their

movements electrical? E admits that it's not something she fully "gets" either--at least not in any generalizable sense. What she knows of it is what she's trained to see and know in the cells of plants. And what she's trained to see and know as an electrical signal in a plant cell, or tissue, for instance, depends upon the apparatus with which she is working. With the VIP, for instance, she is measuring particular ionic flows, what are known as "depolarization events," as they move across the membranes of an isolated plant root and into a surrounding aqueous solution. With the MEA, an apparatus with which she is only beginning to learn to wield, she is able to record "action potentials" and "variation potentials;" electrical signaling events which have historically been identified as belonging to the natures of neurons, despite also being present and long ago recorded, in the cells of plants.

I watch E prepare for an electrophysiological study of Salix alba—"white willow"-- tree roots, which will be part of a larger study on phytoremediation strategies at an ex-military base outside of Florence. In the study, white willows are compared with poplars in their capacity to absorb heavy metals leftover in the soil, like Zinc and Aluminum. E is one of a few at LINV (and in the world) trained to use the VIP (Vibrating Ion Probe) on plants. I watch as she assembles the experiment over several days, first "baking" the electrodes--which are small, glass micropipettes--in a metal pot inside a tiny oven (the size of an EZ bake). This is one of those instances where, she tells me, she doesn't know exactly how it works. That is, she doesn't know how to fully articulate the process through which micropipettes become electrodes, how they become affixed with the capacity to sense one particular ion flux, in this case potassium (K+), and not others. But inside of the solution in the metal pot in the tiny oven, this is what's happening. She knows the process "worked" when she sees a white smoke billowing out of the pot. She calls it the "white pope

smoke," because, "you know, when they have chosen a new pope white smoke billows out of the chimney." I didn't know this.

I emphasize E's uncertainty, here, not as means of delegitimizing her expertise, or exposing the "gaps" in her knowledge. On the contrary. I am working here to emphasize the sophistication with which E approaches the workings of an apparatus in plant electrophysiology. After spending time with E, I learn how incredibly meticulous she is about knowing the in's and out's of the instruments she works with. She takes extraordinary care in not just knowing them, how they work, but knowing how to build them from the ground up. It is because of this intimacy with the apparatus that, I suggest, she knows the boundaries of what she can and can't know. That there are forces aligning in the conduct of her experiments which she simply does not have access to know, or to explain, with the language and tools of science alone. There is an excess to her field of inquiry which she has grown not simply accustomed to, or comfortable with, but inspired and allured by. She calls this the "magic" of an experiment in plant electrophysiology that, she contends, not many can understand.

The Faraday cage is a metallic chamber designed to deflect bombarding electromagnetic frequencies away from the interior of the chamber---away from the Willow root and the electrodes. Each electrode is also connected to a grounding cord which, somewhere along the line of wires and machinery, finds its end, its reference point, in a control box—a "transformer"—connected into the earth outside of the lab. This grounding or "earthing" cord conjures Earth's electromagnetic field into action—calling upon the steady flow of negative earthly ions to cancel and balance out an overabundance of positive ions, or positive electrical charge, the result being a potential "electrocution" of bodies and machines in contact. Introduced inside of the Faraday cage, then, is a field, composed of earthen electromagnetic resonances, the severed plant root, the VIP, and, hopefully, very little "outside" disturbances. E is now imagined to be on the outside, somehow

made to be external to the experimental stage, the field of inquiry she had so carefully worked to assemble. Now she stands back, taking care to remove any trace of her own electrical field from within the Faraday cage, and waits for the root to "settle" before she begins the recording.[9]

E doesn't know exactly what she means when she says this, but once the root has been removed from its greater plant body, it needs time to figure out its new surrounds. She imagines it's probably tuning into gravity, light, and the electrochemical compositions of its surrounding solution, to gain a sense of what's possible—of what life can be like in such conditions. I tell her that it feels strange to think that the root, having been severed, is still considered "representative" of electrical signaling behavior in "plant roots in general."[10] She agrees. It's weird. But her faith is renewed in witnessing the ability of the roots to, despite being temporarily disoriented, go on conducting ions across cellular membranes, and even growing new cells for another day or more.

E used to keep a Husky figurine, her alma mater's mascot, on top of the Faraday cage. She rubbed it for good luck—in the form of clear, recognizable signals-- before beginning the recording process. It's not unusual for the apparatus to disobey her expertise. Though E is uniquely skilled in assembling such an experiment from the ground up, crafting her own electrodes, feeling for the proper ins and outs of each facet of the experimental "machine," sometimes "the machine is just having a bad day, or a bad week, and I can't explain it. It's very sensitive," she tells me. The

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[9] Reminiscent of the early physiological experiments on animals in the mid to late 18th century. Haller, for instance, in his quest to prove some parts of the animal body to be more sensitive than others, took living animals of different species and age and exposed the part on which he wanted to experiment; waiting first for the animal to "calm down," he stimulated that part with different instruments or irritating substances, such as heat or vitriolic oil. If the animal gave signs of pain or agitation, the part stimulated was considered "sensible" (and if not, "insensible.") If the part being stimulated contracted and shortened, then it was assumed to be "irritable" (and if not, "not irritable.") (Piccoli & Bresolda, 2013; p. 44). Through his experiments, Haller concluded that sensibility was a property of nerves because only those parts that had nervous terminations reacted to painful stimuli, while irritability was a property specific to muscular fibers and independent of nerves (Haller, 1753).

[10] In *The Doctor and the Charlatan (2003)*, Isabelle Stengers describes how the history of experimentation in the name of scientific authority has cobbled together an artificial, laboratory-created behavior. Even in the laboratories of psychologists, the rat is not granted the capacity to confirm or refute hypotheses made about it; rather the laboratory created a 'laboratory rat' which is reduced to a mode of existence subjected to the constraints of observable, quantifiable objectivity. Like the rat, I am disturbed to think that the willow root specimen above, the 'laboratory plant,' could teach us anything about plant life outside of the experiment.

"machine," as E calls it, had once gone a whole year without working—without achieving a properly grounded signal recording. This was the year that E, pregnant and then on maternity leave, was not allowed to be in the lab (the lab is considered unsafe during pregnancy). During her leave, no one could get it to record properly, and no one, not even Stefano, the director of the lab long considered a plant electrophysiological expert, could figure out why. Upon hearing this I promptly quipped, "the machine really missed you." To which she responded, "I honestly think it did."

In the context of measuring the conductivity, the potentials for action, in plants, E's training in the MEA is significant. Not only because of its expense and rarity inside the walls of a plant science lab, but because it has the potential to record those rapid-long distance electrical signaling events which are otherwise quite difficult to measure with the hand-built apparatus' of plant electrophysiology. The MEA, it should be known, is a common neuroscientific instrument. The physical machine itself and its associated software programs have all been developed by the hands of neuroscientists (and a team of engineers) who are interested in measuring the electrical activity of neurons—the only cells in the animal body which can conduct electrical signals. Applying the MEA to plant roots, therefore, has taken much tinkering and adjustment. At the time of my research, Elisa Masi, one of LINV's principal investigators and overseer of research in the lab, is the only scientist who knows how to re-calibrate and apply the instrument to plant roots. While E is beginning to learn it, the extent to which the "plant action potential" can be seen and recorded by other scientists remains limited; and so too, the particular conductivity of "the newly focused field of plant neurobiology."

Part V.

The following is a speculative fiction experiment and contribution to American Anthropology Journal's special topic section, "Phyto Futures," edited by Emilia Sanabria and Silvia Mesturini. As above, so below, but by way of different spatio-temporal contours germinates an otherwise articulation of "the Field" that is not yet, but could be.

A Lab UnEarthed: Plotting the Grounds for Future Fields

Outside the lab there was a Field.[11] Not the Field of old storybooks; the kind where shepherds traipse through lackadaisically after their sheep. This was a Field crafted by the callous of abandon. The kind that sprouts unexpectedly from an unruly mixture of gravel, ancient sediment and industrial effluence. A porous, rocky, and metallically burdened composition that cannot be easily adhered to any temporal or ecological order. A Field that arises, in part, out of the haphazard construction of a lab. Earth∇, dug up,

tossed aside, flattened and compressed into

"Space."

A surface for gravity to tug.

A Ground.

A Plot.

[11] "the Field" concept gathers inspiration from the works of Diné poet, Jake Skeets; "Poetry as Field" (World Literature Today Online) and "The Memory Field" (*Emergence* Magazine Online) and the plants and scientists that continue to grow my sense of Time, Space, and Relation—the "field" of my phyto-ethno-graphic experience.

The Field outside the lab was largely invisible to the lab coats:

a peripheral blur of weeds (re: land out of relation[12]) as they passed through on their way to work. An unmapped feature traversed by a concrete path connecting point A to point B. But it was also, strangely, the Grounding source of their creativity. The reference point. The steady and stable connection to Earth∇ that made all their experimentation possible.

And,

eventually,

Impossible.

This Ground was of particular importance for Ohmic communications with Phytomorphs —of which they appear to have had very little success.
Ohmic to them was something that could be reduced to the coordinates of their particular geometric trance—the "vision" they encoded into their machines. Something they seemed to haphazardly enunciate as "chemico-, mechanico-, electro- or magnetic."

Inside the lab was grey and quiet, if not for the buzz of old light bulbs and the basal humdrumming of machines. Sterile and devoid of any edible material except for the caffeination station. An indispensable feature of all lab ruins encountered thus far. Remnants of their scriptures suggest that the lab coats preferred to work in the early mornings, when few other body-energies were orbiting through.

[12] See N. Myers' (2020) *For the Wild* podcast interview on rethinking stories of "invasive plants" and "weeds" as "lands out of relation."

It was assumed that fewer body-energies meant fewer heartbeats, fewer heartbeats meant less potential to disrupt the steady stream of chemico-mechanico-electro-magnetic forces pulsing through and powering the machines. The steadier and more Grounded the flow, the more responsive—the more *obedient*—the machine. The more obedient the machine the more submissive the Plant specimen. The more submissive the Plant specimen the more Knowledgeable the lab coat. At least, this was how their particular Circuitry had been designed. From what we gather, this Circuitry was quite difficult to maintain

(re: Ohmic-exhaustive.)

That the Crops (re: Plant laborers) they wished to communicate with must be dwarfed, domesticated, disembodied and subdued into signatures of mechanical submission was considered fundamental. A constitutive part of the Circuitry. That the lab coat, entrained and enmeshed and attuned to the language of machines, could only feel and respond to a few different frequencies—muffled and segmented pieces of Phytomorph-song—was too, part of the Circuitry.

But the Circuitry was not always as stable and predictable as it was believed. It began like many others. As a passing dream, caught and slowed by body-energy waves. But then verbalized, ritualized, metaphorized, plantationized, and militarized until it was no longer conceived of as a dream but as the way things were. As if, with the proper tools and cleanliness and controls, one could roll up their lab coat sleeves, reach out into the dark unknowns and pull out, one by one, the Order of Things.[13]

[13] See M. Foucault (2001)

In this Circuitry, abandoning the lusters of the manifestly fleeting—of the Phytomorphs *here/ now* (re: Presence)—was considered a necessary step towards unearthing their causal antecedent. The so-called solid, unwavering Ground beneath. The stable reference point from which they imagined an

Order of Things

could be plucked.

Measured.

Encoded—

anesthetized by a grammar-out-of-tune.

Out of touch.

From a metal pole implanted into the Field "outside," they conceived "Ground." From there an Ohmic current was conjured from Earth∇ (re: stolen…there are no records of permission requested.) Though they only managed to identify a narrow stream of the current—the kind that can be transformed and encapsulated by copper wires and body-energies labeled "batteries," —they were made to travel through wires traversing across walls, and into metallic machines, Ionized instruments and conductive solutions. Then absorbed and expelled, inspired and respired through the Ohmic fields—the fluxing body-energy waves—of "Plant Specimen #...."

According to the echoes that resound in the ruins, the last "Plant Specimen" was a small piece of root from a Willow tree (ancestral Phytomorph): "Plant specimen #7." Or rather, that which refused to be "Plant specimen #7."

Known by lab coats for its high tolerance of heavy metals. A "remediator" of intoxicated soils, like those left behind by their military bases and other laboratory testing sites. Parts of the plant's

Ohmic transmissions were also made "useful" as a pain reliever; a once potent anti-inflammatory medicine recognized by the body-energy waves of those in need.

But Willow was Willow but not only.[14] They were also a particularly powerful Ohmic force, weaving their roots into and out of many other dreams and constellation stories; or rather, dreams and stories made to be "Other" from within this particular Circuitry.

Residual memories speak of a sacred Undoing; a strike. Like a stroke of lightning.

But not the lightning that strikes from above.[15] Or below. Or out there, somewhere, or anywhere that could be said to be near or far or allotted neatly in the grammar of proximities and betweens. It was the kind that strikes from nowhere and everywhere at once. From a Field that grows not simply outside, but always also within.

The memories enfolded into the Field propose that such lightning was always already a conspiring,[16] a Plot[17] to be unfurled. A strike orchestrated by Ohmic forces of an ancestral magnitude, propagated by the Phytomorphs growing both within and beyond the lab; including that which they called "Plant specimen #7."

[14] See M. De la Cadena (2014; 2015)
[15] See K. Barad (2015)
[16] See T. Choy (2020) and N. Myers (2018)
[17] See K. McKittrick (2013)

From a small chamber, inside of a metallic cage, the Willow root struck a Chord. A shadow, like an enveloping wave of "dark matter," swam and swirled out of the machine, emanating out into the lab and traversing down wires into the Grounding pole outside. Songs wafted across the Field and,

The Circuitry

went

haywire.

The lab coats became delirious. Confused. A tightening spread across their chests, a serpentine sensation slithered up their torso and into their heads, blurring the visions they so heavily relied on. Those activated, acquired or, as they called it, "enlightened" through the Circuitry.

It appears an attempt was made to flip the Circuit breaker. Every button toggled, all devices restarted, but the humming, as it does, overwhelmed—began to melt away— the Circuit. The channels amplified to breathtaking, cement cracking decibels. Uproarious tones that innervated the lab coat into Dissensus[18]; into a Field they no longer recognized. The body-energy waves assembled through the Circuitry could not withstand such polyphony,

such Presence.

As percussive resonances arrhythmically thrummed up from beneath their feet and into every Ohmic fiber of their body-energy, visions of a previously unauthorized kind began to sprout. Syncopated rhythms coursed and germinated into a montage of never before seen images,

[18] See J. Ranciere (2010)

pullulating like a dream, softly, behind their eyes. The lab coat dropped to Earth∇ and began to Weep.

Placing their mouth to the Ground, gasping into the Field, they began to Breathe. Siphoning and suctioning metallic flavored slurps of melted Circuitry with every Inhale; every Exhale a deep, melodious aspiration of ease. Calm. Like water over fire.

Fumbling around on hands and knees they reached the site of the Grounding cord.

Where they found it,

torn up.

Unearthed.

By a cacophony of singing roots.

CHAPTER THREE

Circumnutating Thoughts

Photo 6. Four climbing beans appear to be in agreement that something beyond the philosopher's desk lamp, and behind the MINT lab doorway, is far more interesting.

Part I.

"*…thought is not the kind of thing that flows inevitably from a given "way of life," but rather something that takes off with the potential trajectories in which it finds itself in the middle*"

-Kathleen Stewart, *Ordinary Affects* (2009) p.128

Paco Calvo, a philosopher of cognitive science at the University of Murcia in southeastern Spain, has, over the last three years, converted an old student lounge into a time lapse recording lab for studying the mysterious, perhaps *goal-directed* circumnutations of *Phaseolus vulgaris* – commonly named the "climbing" or "pole" bean plant. And the beans have Paco wound tightly around their famously swooping tendrils, entraining him to their rhythms and motions[19], keeping him up at night with circumnutating thoughts. "When I go home at night," he tells me during one of our first conversations in 2016, "I get so excited just thinking about where the bean plant will be in the morning. I go to bed thinking about it, tracking with my body what position I think it will be in when I arrive."

A strange and unexpected trajectory for a philosopher, some would say. Many, myself included, have wondered how a philosopher of "CogSci" (as those on the inside call it) found himself conspiring and contorting into the experimental forms of a laboratory scientist. And not by the typical monkey or rat—those mainstreamed "models" of CogSci investigations—but by *climbing beans,* or "climbers," as he calls them. Over the years I have asked Paco this question on several different occasions, each of them eliciting a more complex, circuitous response; where surprising

[19] See Robert Kohler (1991) for discussion of Drosophila researchers becoming captured inside of their experiments, to such an extent that the rhythms of researchers lives became entrained to the breeding cycles of the flies.

plot twists don't simply shift the point of origin to an earlier date but tend to confuse my quest for origins and linear trajectories altogether.

Paco once told me that he was "tired of thinking in the abstract"—tired of thinking with words and theories, tired of thinking about how it is his brain might be thinking. He was "desperate to think with his hands again," like he did as a kid. But then again, when he "really thinks about it," he considers his long-time fascination with making pinhole cameras—the slowness of their photochemical imaging, the blurry imprints of varying speeds—to be some kind of early indication, a forecast of future time-lapse phyto-innervations to come. And "get this:" his time lapse cameras just so happen to come packaged in small, black cardboard boxes, perfect for making pinhole cameras. "Full circle," he beams.

At other times he directs me to the last chapter of his dissertation, where the "seeds" of his rogue philosophical meanderings were first planted. He doesn't know if it was "too much sun, too much beer" or just the people he was hanging out with at the time[20], but the final chapter proposes a fundamental unraveling of the first six. Those which, at the time of his writing, relied upon the trope of "the mental;" what is often surmised in the language of "representationalist" theories of cognition. He called upon none other than "the sunflower" to supplant the CogSci philosopher's tropic foundation: "the semantic reference."

> "*It is not the fact that there is more than one correct theory of reference that threatens semantics. Rather, it is the fact that there is no semantic relation of reference at all between a speakers' cognitive processes, and the external world….Put bluntly, I believe that every single pattern of behavior (non-cognitive, as well as cognitive) is to be seen as mere causal correlations between inner states, and certain environmental features…To illustrate, we may say that humans are equivalent to sunflowers. The latter chase the sun but no one would claim that they possess an inner representation of the sun. A full physical explanation in terms of causes and effects in real time, and real space, suffices to explain the sun-chasing behavior of the sunflower. I believe that the same goes when we try to explain higher cognitive abilities. The patterns of behavior to be explained are*

[20] Famous (or infamous, depending on who you ask) neurophilosopher Paul Churchland was his official UCSD advisor at the time. Given his busy schedule, however, Paco found himself hanging out with the computer science people at UCSD, who showed him the burgeoning work of 4E (embodied, embedded, enacted, extended) CogSci scholars like Andy Clark.

more complex quantitatively, but the principles are the same: causal correlations in the physical world. I just fail to see where the notion of representation can fit in this picture. I am aware that this is a radical claim, but unfortunately I still lack the conceptual and technical apparatus to flesh out these thoughts. This is a project that I hope I can take up soon…."[21]

The opportunity to develop a conceptual and technical apparatus to "flesh out these thoughts" perhaps arrived in 2007, when he received a book in the mail—*Communication in Plants: Neuronal Aspects of Plant Life* (2006)—a gift for reviewing a CogSci textbook manuscript. He read it, front to back, in a day. He reached out to and quickly befriended two of the book's main authors, Frantisek Baluska and Stefano Mancuso. Both Frantisek and Stefano are considered two of the primary catalysts for the proposed field of "plant neurobiology." But it was Frantisek who first suggested to Paco that he, too, could do science. "It was one of those 'eureka' moments," he says. "I suddenly realized that I could make my own discoveries…that not all science was 'rocket science.'"[22]

But he didn't know where to start. Administratively speaking, he needed to figure out how to go about starting a lab, "what with all the paperwork and stuff." He inquired among one of his psychologist friends at the University of Murcia, who had a lab doing language research on human subjects. He told him of his ideas, of building a lab to study the potentials of plant cognition. His buddy laughed, told him to just put a sign on the door that says "lab." There was no other paperwork needed when his subjects were plants. So, he did. And received nothing short of full administrative support.

Ask any of his colleagues in the philosophy department and they'll tell you something along the lines of "those who know Paco, *know* Paco." Through conversations with Paco and his philosophy department peers, some of whom he has known since childhood, I get a sense of

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[21] Calvo, F.J. (2000) "Connectionism and the Twilight of Propositional Content" Ch. 7: p. 52.

[22] Insert here resources on "physics envy" or "science envy"… thinking Sharon Traweek, Sandra Harding, Isabelle Stengers etc. Explore how Paco came to make sense of division between "hard" and "soft" science in breaking free of inferiority complex

comfort and ease with his unorthodox practices. The sense that, to them, Paco has always been unquestionably and delightfully strange, not unexpectedly so. An ease of acceptance that comes from knowing that Paco is up to something that excites him. And he writes about it—prolifically publishes about it[23]—and that's enough. There is a radically different network of support surrounding Paco than other "plant neurobiology, cognition and behavior" enthusiasts have gathered. One that, unlike that which surrounds the work of plant biologists and physiologists, does not require empirically convincing evidence, nor assume the language of "matter of fact" in order to be acknowledged, and supported, as a worthy "matter of concern" (Latour, 2004).

Paco now spends most of his days nestled inside of his lab on the first floor of the philosophy building—just down the main corridor on your right. You can't miss it. Outside the door sits a round, open air bin with a few bean plants waiting patiently inside (Photo 2a). A sign on it reads "PSSST, PSSST, EH, TÚ SÍ, SÍ, TÚ, ACÉRCATE!" (psst, psst, eh you, yea yea you, come closer!) A letter, penned by the beans themselves, asking passersby to help them escape to a new home, preferably a balcony garden with a view (Photo 2b). In the spring and summer months this is where Paco's used or discarded "test subjects" end up—his garden having reached capacity years ago. Much to his delight the beans are almost always gone by the end of the day, at least in the spring and summer. In the winter, when the outdoor growing season rests, all discarded or used "test subjects" are referred to as "future compost."

[23] See https://www.um.es/web/minimal-intelligence-lab/contenido/publications for a list of 20 publications authored and co-authored by Paco in the last 5 years.

Photo 7a (left). The "view from the outside" of the MINTlab, featuring the climbing bean donation stand and seven climbing bean "subjects" which were gone by the end of the day. **Photo 7b (right).** A zoomed-in photo of the above mentioned sign, penned by the bean plants (en Español), asking to be rescued by passerby's, typically philosophy students on their way home for the day.

The other sign taped to the bin's side reads "MINTlab;" a once fitting herbal acronym, short for the "Minimal Intelligence Lab" which, as Paco softly concedes (if only to me), the lab has already outgrown. When I first met Paco at the 2016 Plant Signaling and Behavior Symposia in St. Petersburg, Russia, I was quick to inquire about the lab's name; about the hierarchies of intelligence presumed and propagated by the word "minimal."[24] At the time, he felt the name worked. His theories for assessing the presence of intelligence as maximal or minimal were formed throughout his PhD training, where theories of mind, and all talk of intelligence (increasingly artificial), were strongly humanist, unquestionably brain-centric. This was the 1990's after all, the so-called "Decade of the Brain" (according to U.S. NIH, 1989). Entertaining the idea of intelligence without a brain,

[24] See Vincianne Despret's chapter "Do Apes Ape?" in *What Would Animals Say If We Asked the Right Questions?* for discussion of "double form of hierarchy" proposed by Darwin's student, George Romanes—hierarchy of modes of learning and that of intelligent behaviors.

even an artificial one, could only be seriously considered by his "CogSci" philosophy peers with a corresponding "minimal" or "basal" prefix.

But the 1990's Decade of the Brain stimulated the American Psychological Association to claim the early 2000's as the Decade of Behavior, and Paco had already begun to swerve towards a growing trend in the cognitive and behavioral sciences known as "embodied cognition." A field where the behaviors of humans and sunflowers might, theoretically, meet. Though "the body at large," as physiologist and philosopher William James once put it, has long been considered a basic unit of analysis for studies of "the mind," such ideas have been largely dwarfed in popularity since the rise of modern neuroscience and it's increasingly "in-vivo" techniques. But as historian and anthropologist Fernando Vidal (2009) writes, ideas of modern human subjectivity are infused into such theories and techniques of modern neuroscience. That is, theories of cognition, as a computational phenomenon inherent to the neurons, the inner-workings of the human brain, do not merely precipitate out of the (very well-funded) and increasingly specific "in-vivo" studies of brains. Rather, these kinds of subjectivities, in which the human subject is made reducible to the human brain, are discursively generated and enmeshed into the contemporary brain sciences. It is both an idea borne from famed enlightenment writers like John Locke and Rene Descartes, and the only 'logical' outcome of research that inquires into cognition by way of the brain. This "mind-as-brain" entanglement has, since the rise of modern neurosciences, been perpetually reinforced by historically "representationalist" ideas of the modern human subject—an individual bounded to the rational (or irrational) interiors of one's mind, positioned, with increasing neuroscientific authority, within one's head.

Through concepts like "embodied cognition," such historically modernizing mantras of mind-as-brain are being variously—and not without ongoing debates and challenges—redistributed throughout bodies, and relations, of all kinds. Within these growing uncertainties and disagreements

amongst the neuro and behavioral sciences arises a window of opportunity for those seeking to "make sense of plant sensing" (Myers, 2015). In particular, those interested in making sense of plants as far more than simple organisms—as passive and automatic—but as complexly sensitive, responsive, and interested co-creators of our shared worlds.

Paco can be found somewhere in the middle of this convergence of the sciences of minds and plants. Of late, it is the language of "coupled organism-environment system" that Paco feels to be most responsive to the shortcomings of the "old" paradigms of cognition and behavior, and their perceived distinctions from the objects of plant scientists. The "organism-environment system" concept foregrounds the inextricable connections of bodies in ecological motion—where organisms do not simply "receive" and "store" information from the outside but are always already becoming with and through the contingencies of "the outside." Paco sources this newfound conceptual device within the works of James Gibson (1966) and the field known as "Ecological Psychology."[25]

Writing in the 1960's and 70's, Gibson's Ecological Psychology proposed an embodied, situated, and non-representational intervention into the twentieth-century psychological sciences. Less a theory than a conceptual proposition, Gibson's "organism-environment system" endeavored towards a study of perception that refrained from assuming the perception/action, organism/environment, subject/object, mind/body dichotomies typical of both cognitivist and behaviorist sciences—the "mainstream" experimental psychologies of the day. While cognitivist and behaviorist approaches were oft considered in competition, Gibson understood them as complementary, or rather, co-constitutive phases of a larger perceptual organization. The ecological psychology approach, in its rejection of both the inferential and representational commitments of cognitivism, and the physicalist ideas of stimulus attributed to behaviorism, proffered a notion of

[25] I made the mistake of referring to "Ecological Psychology" as "ecopsych" in an earlier draft. Paco has pointed out that "ecospych" is its own "thing," having more to do with "developing a spiritual connection to nature" and little if anything to do with Gibsonian Ecological Psychology—the sciences of organism-environment perception.

'affordances' that submerged both "cognition" and "behavior" into an emergent, that is, relational, model of perception. Affordances, according to subscribers to the Gibsonian Ecological Psychology method, are those sensory experiences through which perception is generated…now, and now, and now. They are, at least for Gibson, "both physical and psychical, yet neither" (Gibson, 1979/2014, p. 121). They are those experiential encounters through which an organism-environment gains traction, that is, through which an organism is conjured into being; ideas that were quite openly influenced by the radical empiricist teachings of William James (Gibson, 1967).[26]

What Paco appreciates and trusts about this model, is that it does not rely upon a notion of perception mediated by a cogito, that distinctly 'mental,' 'psychical' or 'computational' faculty presumed to have evolved for storing and manipulating abstract symbols. Perceptions, as mediated by the Ecological Psychology model, exist only insofar as they arise through the encounters in which an organism and environment are both morphically affected, a process Paco often describes as "coupling." Affordances, in this way, are considered inextricable from the meaning, or "purpose," of our actions.

In newfound alliance with these experientially situated ideas of perception, Paco's understandings of cognition and intelligence are now more broadly understood as "perception," and tend to favor less substrate-specific definitions, such as: "the capacity for adaptive and selective movement in relation to contingent flows of environmental information" (I asked Paco for this definition, and this is what was written in my fieldnotes on 11/14, next to a note, in underlined emphasis, "*subject to change*"). Such definitions challenge the brain-centric morphologies and "representationalist" metrics for the mental hierarchies that had once given shape to MINTlab's

[26] In his autobiography, Gibson describes himself as a "radical empiricist," though his ideas have propagated and made to travel into universalizing realms of psychological science as a stabilized "model" or "theory" of perception.

"minimal intelligence." Nonetheless, the MINTlab moniker remains. "It's a reminder of where the lab came from…problematic as it is, it's my baby."

Circumnutating Histories

The term circumnutation was coined by Charles Darwin and son, Francis, in their book, *The Power of Movement in Plants.* The concept referred to the movement that, as they sought to show, was ubiquitous and universal to all growing plant organs as they bend "successively to all points of the compass" (Darwin & Darwin, p. 1.) Today the term maintains a particular historical adherence to the plant world, but it is also used to describe the spiraling, or "chiral[27]," configurations present in the developing phases of molecules, bacteria, fungi, and animalian embryos. Unlike the prefix 'circu' suggests, the motions are rarely circular. Though the sense of a circular rotation was perhaps inspired by those most conspicuously mobile of plant organs, like the tendrils of climbing plants (i.e. Phaseolus vulgaris), the shapes of circumnutations are more often, as even the Darwin's admitted, elliptical, pendulus, or zig-zagging, depending on the particular organ, the life stage, and the surrounding conditions (i.e. temperature, light, season, etc.)

The suffix, -nutation, is also a matter of ongoing disagreement amongst those scientists seeking to understand these movements as something other than *passive.* Deriving from Latin *nutare*—to give way—the concept of nutation maintains a particular adherence to passive movement. Born into English as an observation of 'the staggering of nature' upon a tired body (OED [Cotta], 1612), nutation described the likes of a drowsy head that, when seated upright, gives way to the powers of gravitas. A phenomena many of us now perhaps all too familiarly recognize as "nodding off. "

[27] Chiral is a popular term for chemists, referring to the asymmetrical geometry of a structure, like DNA strands, which can be said to be "right or left handed." In short, a structure which cannot be superimposed on its mirror image.

Throughout the eighteenth and nineteenth centuries, after Newton's "law of gravity" began to take a firm hold on scientific observation, many a physician and physicist found the term relevant for theorizing the gravity induced motions of, for instance, skeletons and planets. For eighteenth and nineteenth century physiologists, the term was found to be particularly useful for describing the rotational 'tilting,' 'rocking,' or 'swaying' movements of the sacrum and pelvis. And for physicists, both then and now, nutations are those periodic rotations and inclinations of Earth's axis. The mechanical effects of the fluctuating tug of the magnetic poles, the (relative) distance between planets, moons and stars, and the many unknown undulations that arrange orbiting bodies in space. Though the term's relevance has transformed in context, the term has not veered far from its initial orientation. Nutation is a matter of being acted upon, not *acting*.

Much like a planet orbiting in space, plants, at least those observed by botanists and naturalists in the eighteenth and nineteenth centuries, have long been considered to be governed by external forces. Julius von Sachs, a pioneering plant physiologist of the time, coined the term 'rotational nutation' to describe the radial bending and swaying he observed in growing stems of many plants—though much of his theory derived from observing *Helianthus*, or sunflower. Sunflowers are, to this day, those famous exemplars of what many a scientist knows as a 'circadian rhythm.' An organism so moved by the powers of the sun they have ingathered it into their rhythms an 'internal clock' that 'programs' their stems (more specifically, a specialized organ known as the pulvinus, present at the base of leaves and flowers) to rotate according to the rising and setting of the sun. A phenomena which is part of a larger class of movements called *tropisms*. Tropism being the most famous and longstanding of concepts coined by Sachs, and one that continues to order and organize different categories of movement and their relationships to 'external' or 'internal' forces.

A tropism, much like nutation, is considered to be a mechanical, that is, obligatory reaction to an external stimulus, like gravity (gravitropism), light (phototropism), the sun (heliotropism) and

touch (thigmotropism). For Sachs, rotational nutation was a gravitational tropism. As he sat (admirably still) and watched the stems of many a plant grow over the course of days and weeks, he observed an asymmetrical growth pattern, where one side of the stem swelled and became convex, while the other side was pulled concave, and so on and back and forth. The movement, for Sachs, was not so much a movement but a byproduct of growth, driven by hydraulics—increased turgor or water pressure being pulled up and into the growing plant cells—and, gravity. That is, rotational nutation was a fairly basic, and ubiquitous form of gravitropism.[28]

Tropism was also a term that managed to leave the world of plants and planets and travel into the troubling world of early clinical pyschology, if only briefly. For the term tropism, like nutation, described a class of movements that was passive, mechanical and, therefore, non-volitional. As such, late nineteenth and early twentieth century clinical psychologists, steeped in their own racial tropes and neo-Darwinian hierarchies of the times, went searching for new tests and methods for measuring capacities for 'intelligence' for American public school students found much utility in the term. For instance, early American Psychologists, G. Stanley Hall and J.E Wallace Wallin's, creators of one such "diagnostic theory for classifying the feeble-minded and backward," found tropism to be a description not only for those who were, "backwards," by nature, that is, born incapable of behaving by 'choice', but also movements demonstrated in the most "normal" of schoolchildren and "primitive peoples" alike. While the language has changed, the constitutive hierarchies subtending these popular ideas of "intelligence" largely remain.

The Darwins, however, came to a different conclusion about these seemingly ubiquitous plant movements. As Charles and his son, Francis, wrote in *The Power of Movement in Plants,* these

[28] Sach's gravitropic theory of nutation was largely accepted until the 1970's, when scientists began sending plants into space. As it turns out, a sunflower living and growing in 'micro-gravity' conditions still nutates (Brown et al. 1990). But this does not discount the gravitropic theory of nutation in full, but suggests that perhaps there is something specific to the pulvinus, the specialized organ at the base of the stem, that enables nutational movement in micro-gravity conditions.

movements were "universally present" in all plants, and virtually every growing organ—not just the stems. Through thousands of 'naked eye' observations and experiments involving the groping, rubbing, and delicate touching of developing plant roots, shoots, tendrils, and leaves, the Darwins claim that indeed, that which Sachs described as 'rotational nutation' was a fundamental feature of all plant life. So much so, they suspected, that the movement "commences even before the young seedling has broken through the ground" (p. 3). But, unlike Sachs and the majority of plant physiologists of the time, the Darwin's felt that the movement could not so easily be reduced to the mechanics of a gravitropic response. For the Darwin's, there were far too many "exciting" and "disturbing" instances in which the presence of an internal "irritability"[29] was felt.

There was, for Darwin, no doubt a very tactile 'sensitivity' to many plants, which varied across organs (and differences in the convex vs concave sides of the organ), the species, the phase of development, the duration of time spent moving etc.[30] And this sensitivity, which he believed to be focused within the very tips of developing organs like the radicle or the tendril was, like most of earthly life, affected by the forces of gravity, temperature, light, the direction of the sun etc. But for Darwin, the movements, specifically the phenomena of circumnutation, could not be reduced to a mere tropic reaction. For the movements he was referring to were not always accompanied by a change in organ structure, but rather a change in the amplitude and speed. It was, in the case of climbing plants specifically those of the tendril-bearing kind, that a lateral bending and "striving" or "searching" behavior could be observed. For instance, he writes of the Bignonia littoralis, which

[29] The "doctrine of irritability," coined by Swiss anatomist and "father of modern physiology," Albrecht von Haller, subverted the dominant understandings of sensation and muscular motion in the sciences, which considered "animal spirits" to be the circulating cause of muscular contractility and sensation. Conceived of as a fluid (similar to light, electricity, magnetism, and heat as defined at the time) the direction of the flow, from muscular body to brain, was considered the basis of sensation, and the reverse, from the brain to the muscular body, muscular contraction or movement (Steinke, 2005).

[30] In *The Habits and Movements of Climbing Plants,* Darwin claims that the Passiflora genus was the most sensitive of all climbing plants he was able to study, at least in the relatively cool climes of England. In particular, he noted that Passiflora gracilis "possesses the most sensitive tendrils I have observed."

twines spirally up a stick "like a sailor pulling himself up a rope." Or like the Bignonia unguis which has "curiously," evolved a three-pronged grasping structure similar to the tarsus of a bird's foot. Upon reaching a twig of good proportion it "seizes fast hold of the twig" and wraps around it, "like a bird when perched." And then there was the Ceropegia, which fell from a stick not once, but twice, and appeared to Darwin to move thereafter in a very odd way, "as if it were *disgusted* with its failure but was resolved to try again." In short, in the circumnutation of many a climbing plants, Darwin perceived not a passive movement, like that implied in the words nutation and tropism, but *an action*. An "irritable" *motivation*. A *desire*.

Part II.

"*Whether we accelerate the growth of a plant through time-lapse photography or show its form in forty-fold enlargement, in either case a geyser of new image-worlds hisses up at a point in our existence where we would least have thought them possible*."

-Walter Benjamin, New About Flowers (1928)

The lab's material composition, like its conceptual composition, has and continues to change in time, practice, and perpetual tinkering. Since conception in 2012, Paco and the MINTlab have co-conspired into numerous iterations and permutations, spending countless hours assembling the boundaries of another's thoughts—or rather, another's potentials for thought.

Once stationed on the third floor in a non-climate controlled spare office, the lab's preliminary material and conceptual failures can be found in remnants of home-grown devices—literally. Affixed to the back of a cutting board he "borrowed" from his kitchen is a y-maze made of zip ties and plastic tubing. Inside the tubing hovers the "mummified" remains of a corn kernel's roots, only a few inches deep. "And that's how I learned that roots need moisture…they dried up before they could even reach the decision-making point." Paco admits that he knew nothing of

plants then. That so much of those early MINT years were spent figuring out "who the fuck plants are." In time and practice, he has been afforded the opportunity to describe his current task as "just trying to figure out what the fuck the plant is *doing*." A transformation afforded by not only a change in plant—from corn to climbing bean—but also a shift in the technology of observation—from "naked eye" to time-lapse cameras.

Photo 8. One of Paco's early experimental prototypes, a double Y-maze affixed to the back of a cutting board he "borrowed" from his house. The mummified remains of a Maize root can be seen in the upper Y of the maze.

The time-lapsing of beans was inspired by a "business" trip to Cabo de Gata—a favorite summer vacation destination for Paco and many others in southern Spain. It was a "root-brain meeting" with the "plant neuro guys"—Frantisek, Stefano and Dave Lee, an ecological psychologist from London. Stefano brought with him a USB stick featuring a time lapse of the "Super Marconi" climbing bean. "We plugged it into my computer, projected it on the wall of my favorite restaurant,

and spent the next several hours watching it on repeat, jumping on top of the bar, dancing and mimicking the movements of the climbing bean with our whole bodies." Thereafter climbing beans became MINTlab's "model organism," and the time-lapse camera its main perceptual apparatus.

He now suffers from chronic back pain. A recent development he attributes to long days in the lab's "chilly" 64-71 F temperatures.[31] A small price to pay for the happiness of the beans, he contends. A humidifier mists moisture from a corner above the door at regular intervals. A fan blows from beneath to keep the humidity circulating throughout. Though Paco has covered windows and sealed the room with sheet metal, I have also heard him describe a week of consistent temperature as a "cosmic fluke"—having more to do with the weather outside than in.
Photons radiate from varying sources, bouncing off leaves and metallic surfaces. Some, like those hovering above the "pet" Venus Fly Traps in the corner, travel at the rate of pink. The lights over the three time-lapse booths, white. A piece of cardboard wrapped in aluminum foil sits atop the cameras, protecting their batteries from losing energy to the heat of the hovering lamps. An adjustment made after losing important time-lapse footage to battery life gone too soon.

To prevent the metallic time-lapse booths from overheating and emitting reflections in the camera lens', Paco inserted black paper along the bottom half of the interior walls. During my time at the lab, he had adjusted this to include white paper at the top half of the booth in an effort to create a gradient for the plant and the camera to sense a distinction in space. The poles inside have been sourced from old brooms, devil staffs—leftover Halloween decorations found at the nearby hardware store—or, of recent equip, black bamboo culled from the backyard of a local marijuana grow shop employee.

[31] Though it might also have something to do with the lab's cramped 7x13 ft dimensions, a massage therapist might critique the mismatched height of his stools and benches.

The beans too have varied. After first receiving Super Marconi seeds from Stefano Mancuso, he went on to purchase nearly 15 varieties of climbing bean seeds from local plant nurseries and Amazon.com. At the time of my arrival in October 2018 he had narrowed his favorites down to three: Super Marconi, Perfection, and Buenos Aires. By the end, Buenos Aires had been deemed the official MINTlab model organism.

Choosing which individual bean plants make it into the time lapse booth is a matter of standardization, coordination, and waste. In the making of one "good" time lapse model, many others are discarded. Their leaves too small, too large, tendrils arcing and twisting just too soon. If the leaves fold too close or too far from the stem (though they oscillate in day and night), the entire plant could be said to be already "off balance"—already in route towards something of interest. The chosen ones are sturdy, relatively straight, not yet orienting or turning towards any direction-in-particular.

The time-lapse cameras, positioned both above and beside the plant, once took photos every five minutes, though now every minute. For Paco, even a photo taken every minute misses "too much of the action." The individual images are uploaded into a software program called "Circumnutation Tracker," where the climbing bean movements can be flattened into xyz coordinates for a more "standardized" or quantifiable analysis. They're also downloaded onto his computer and assembled using QuickTime into sped up compilations— hours become minutes, minutes become seconds (and 59 seconds of every minute of action is "missing"). "The truth is," Paco divulges, "we're not seeing shit… In my heart of hearts though, I used to think that wasn't an issue, because you can interpolate, you can trace the trajectory, fill in the dots and the gaps, nothing much happens between. It's not like the bean plant went to grab the milk from the refrigerator when you weren't looking." But then, one time, it did. He calls this the "Usain Bolt"[32] case.

[32] Usain Bolt is an Olympic gold medalist and world-record holding sprinter from Jamaica.

He shows me, with one of his index fingers, "the pole," and then, with his other, the tendril. The tendril swoops around and barely touches the pole but senses it, and has to come around for the next full circumnutation of the tendril to extend and grab it. It typically takes about an hour to do this. But in this time lapse recording, the tendril passed the pole but then suddenly appeared back on the other side of it. "We couldn't say it went backwards, because whatever happened, happened so fast that it was within that minute that we missed."

More than any "trained" scientist I have encountered, Paco obsesses over the porousness of experimental systems—the indefatigable excess of parameters, no matter how careful his tinkering, how persistent his scrutiny. He tells me that he used to think he just wasn't a good scientist, that he was running into all of these issues because he didn't know how to do science. But then he realized that this is what happens to any scientist "working at the fringe." The "correct" experimental apparatus doesn't yet exist. You can't google the answers to anything. You have to build your own apparatus, figure out who the organism is, their movements and timescales, and make mistakes. "Now I have plant scientists asking me how it is that I do it."

And though he "truly believes" his bean plants are intelligent— "of course they are"— he pours much of his energy into disproving this potentially biased belief. His working hypothesis is that the bean plants are responding to a light stimulus, a difference in electromagnetic radiation between the pole and the booth, that incites a change in the direction and shape of tendril nutation. He calls this his "optical hypothesis:" whereby the chloroplasts in the bean tip detect the pole as a significant difference in the light gradient—a difference that may be "optically" sensed. "Chloroplasts move, they arc and bend and straighten—dilating with dynamic flows of energy—like that of a retina." As such, Paco's latest time-lapse recordings are compiling a data set that may one day support a theory of "plant vision." But he's working hard to convince himself otherwise.

"Most of the chloroplasts are in the leaves, not the tip," which, he suspects, is equipped with other kinds of sensory modalities that exceed his optical metaphor.

For Paco, the tip of the climbing tendril hovers amidst atmospheres of information that may only partially overlap with those of the stems, the leaves, the roots—and perhaps even less so with those of Paco. Daily, I hear him voice his concerns of "confirmation bias," or "anthropocentric bias." I get the sense that in the process of assembling his newfound capacities to experiment and "discover," to once again "think with his hands," like he did as a kid, Paco has, with a twist of irony, become skeptical, even fearful, of the creativity of his hands; or rather, the inextricable presence of his body-in-excitable-relation—the organism-environment system in which Paco is afforded the capacity to sense.

Part III.

"*The situation of action is thus an inexhaustibly rich resource, and the enormous problems of specification that arise in cognitive science's theorizing about intelligible action have less to do with action than with the project of substituting definite procedures for vague plans, and representations of the situation of action, for action's actual circumstances.*"

-Lucy Suchman, 1987, p. 47

Every morning he greets me with the "exciting news:" a bean plant reached the pole last night. He has seen hundreds of bean plants reach poles. The excitement never wanes. Our mornings are spent watching the latest time lapse footage. His gaze focuses in at once with the vision of a seasoned filmmaker and the energy of a child's first cinematic experience. He leans into the screen, dissecting movements frame by frame. His eyes widen with every oscillation of the bean tip, anticipating the shape shift from "lasso" to "fly fish" with a "wait for it…there! Did you see it?!"

Amidst the fervor I offer a voice-over to the actor in the scene, saying "oh shit was that it?" after what looked like the tip of the tendril peeking back at the pole; like passing a stranger but then

realizing it was an old friend. He cautions me about this problem, this problem of "excitement;" the tendency, or perhaps the *ease* with which "we humans" assume too much "goal-directedness" from these time-lapse animations, confusing what may have been a "simple reaction to the change in light" with an intentional response.

I pause, wondering whether my excitement was intentional or merely a reaction to the flickering photons on the screen.

The screen turns off, the lights back on, and the wonder begins to fade. I realize I had been caught; trapped in a web spun by a philosopher's quest for the truth, and a burgeoning scientist's desire for the dissociated sensorium of an objective stance.

Unpeeling myself from these sticky lures of cognitive philosophy, the quest for the true source of enlightened thought, I step back into the apparatus of ethnography, and begin to feel for the boundaries, the "rules" and parameters, that Paco delimits in this "problem of excitement."

Speculative philosopher and mathematician, Alfred North Whitehead, helps me to get a feel for the particular philosophical problem that Paco presents. For Whitehead, philosophy was a practice of imaginative and risky interpretation. If it is a philosophy worthwhile, it is precisely because of this "culture of imagination," this "experimentation with language" (Stengers, 2005; 150), that nourishes an appreciation, and an interest, for reality in the making; a reality which includes our feelings, conflicts, and judgements. Imagination, in this sense, is not merely the chatter of the mind, but rather a sensitivity for the possible, submerging that which is presented as "fact" within a sea of alternatives. As such, imagination precedes the opposition between what matters as a fact and what is "only an interpretation," because it is concerned with the very fact that such an opposition is what matters for scientists (and philosophers grappling with the newfound hybrid position of philosopher/scientist).

Relinquishing any need to represent the 'truth' of the matter of imagination, in which thought is a concept which comes to figure, I am more interested in the phenomena through which a perceived 'truth' of the matter—in this case the matter of thought and imagination—is made possible. Even Paco, when pushed with this line of questioning, seems confused by his certainty that what is happening is not, in part, that which appeals to our senses, our language of translation, and prior experience—the expanded flow of the "organism-environment" system. What is the relationship between Paco's desired apparatus of 'interpretation,' and, in Whiteheadian terms, 'that which we experience in nature.' And whereas, in this instance, Paco might be quick to point to the gaps in the technology, or that the art of cinema and time-lapse cinematography are to blame for the partiality of our perception, I suspect it is a confusion that might not exist without the peculiar interventions of the beans, for whom the questions of what counts as true "intention" versus "reaction" are perhaps irrelevant to the process of finding the next foothold, the next support, that may bring them "closer to the light." The bean plants might just be, all the while, doing their best to cast a shadow on Paco's search for an 'enlightenment,' a "thought-style"(Fleck,) free of excitement. In the translation, and transformation of "excitement" as a problem, I get a sense that the feeling of disenchantment, of mistrusting ones bodily innervations as somehow misappropriating the signals of its surrounds, is a feeling most liable to reducing the movements and cares of a climbing bean to that which can be grasped.

Defining the boundaries between active and passive movement, intention and automation, remains an ongoing struggle for Paco—an ongoing 'thought experiment,' and experiment in thought. Focusing in on the practices through which Paco's struggle over 'thought,' or the potential for 'thought' takes hold, evokes in me a sense for the mimetic entanglement of thought—as category and process—in which the presence of 'thought' is not an entity or image one 'has' or which can be isolated to one's inner experience but rather is mattered in and of a world affectively and perpetually

imagined. In Gibsonian terms, thought is an affordance that makes possible some kinds of action and not others. As such, I suspect that concretized delineations between what counts as a thought, as a guiding image, intentionally directed movement toward or away from an object, those yearnings to distinguish and define the particularities of motivation and movement in beans as in other kinds of persons "once and for all," will continue to evade a final grasp. Instead, we might take a tip from the beans and learn how to bend and sway and nod with reverence to a light that has never existed neatly "outside," of us, that is, in the binary dimensions of "enlightened thought," but is rather always unfurling from within their affectively charged and mimetically "coupling" between.

CHAPTER FOUR

Radicle Empirics

Photo 9. A panoramic view of Dr. Monica Gagliano's new "lab," garden, and home on Bundjalung land in northern NSW, Australia. In the far right corner, against the shed, is *the* passionflower vine mentioned in the *Opening* of this dissertation.

*This chapter is a modified version of the following publication:

Onzik, K & M. Gagliano. 2022. "Feeling Around for the Apparatus: A Radicley Empirical Plant Science," in *Catalyst: Feminism, Theory, and Technoscience*, Vol. 8, No. 1: 1-18.

Part I.

In *A Feeling for the Organism,* historian of science, Evelyn Fox Keller, details the life and work of Nobel Prize Winning scientist, Barbara McClintock (Fox Keller, 1983). Though it wasn't until the end of her career that McClintock became famous for her "discovery" of genetic transposition in corn, she was long made infamous amongst her colleagues for the incoherence of her scientific reasoning. Despite her perceived lack of appreciation for the institutionalized norms of scientific communication, she was accepted by her male colleagues as a "hard worker," and nonetheless had what it takes to be a committed researcher in the nascent field of genetic science. The molecular techniques that came to define genetic science—and later biological "life itself" (Rose 2001, 13-17)—in the mid 20th century were still being developed, and McClintock's studies of genetic inheritance were yet to be inhibited by disciplinary expectations. Though she shared with her colleagues a desire to reveal the lawful patterns of natural organization, she did not share, nor was she afforded the same opportunities to share, the power to isolate her discoveries to the objective coordinates of the experiment itself.

Such narratives of discovery are often reserved for a scientist's Nobel Prize Winning speech or autobiography, articulated in the sensational language of "eureka" or "aha" moments, in which the missing piece of an experimental objective was suddenly received by the unassuming mind of the scientist. For example, while riding in a streetcar in Bern, Einstein recalls tapping into "God's thoughts," as the theory of relativity suddenly hit him as a "storm that broke loose in [his] mind" (Kaku 2004, 60-62); the ring structure of benzene arrived in a dream of Kekulé's, in which a snake appeared to be eating its own tail (Rocke 2010, 194); and while in a cinema, Francois Jacob was jolted—"as though a line of fire cut through the darkness"—by a "glare of evidence" into the nature of gene regulation (Jacob 1987, 398). These are stories that describe insight as instantaneous, decisive, and external to the 'normal' processes of science; as the miraculous effects of a scientist's mind making

a brief foray into the realm of the "mystical" or "subjective experience," only to return to the laboratory with visions of an apparatus whole and complete in its objectively discernible performance.

The story of McClintock's discovery, as both she and Fox Keller tell it, was markedly different. McClintock's desire to know the processes through which corn kernels inherit their particular organizations developed through years of "losing herself" in the subtle variations of the corn she had planted—of spending long hours with each individual plant throughout their development, informing in her an ability for "direct communication." What her colleagues understood to be irrational "vision" and poor scientific description were, for McClintock, the ineffable findings of a reverence and commitment to listening to "the material itself" (Fox Keller 1983, 179); a knowing made possible through years of cultivating "a feeling for the organism" (Fox Keller 1983, xxii). It was only after McClintock had long been dismissed into the margins of scientific rationality, and molecular scale technologies later developed, that her colleagues could bear witness to the vision she had spent the majority of her career trying to translate into a language of objective reason.

McClintock's story works to partially situate (Haraway 1988, 578-81) our inquiry into the feelings that make a scientist's insight possible, and differently so. We (ethnographer + scientist) draw inspiration not only from the more-than-human connections that give shape to McClintock's empirical practice, but from Fox Keller's accounting of them—her honoring of a scientist's desires to know and represent her knowledge as objective, while choosing to contextualize, embody, and pluralize such pursuits; to add to, rather than subtract from, a scientist's experience of knowing. Building upon McClintock and Fox Keller, we borrow insights from a rich tradition of feminist science studies and sensory-based ethnographic approaches that have laid the grounds for studying not simply the empirical compositions of a science, but the empirical compositions of a scientist. Those studying the affective, more-than-human dimensions of bodies in experimental formation (Prentice 2012, 171-198; Myers & Dumit 2011, 241; Myers 2015a, 99-117), and the shapeshifting,

"involutionary" (Hustak & Myers 2012, 78) encounters through which the relations "between" scientists and plants, subjects and objects, feeling and knowing, are made susceptible to reconfiguration.

We foreground the unfurling of a pea plant decision-making "apparatus"—as a "dynamic set of open-ended practices, iteratively refined and reconfigured" (Barad 2007,167)—as a means of inquiring into the affective, material-discursive conditions through which Gagliano, a plant scientist, comes to feel and know differently. In so doing, we simultaneously inquire into and offer a different translation of those narrative habits that locate a scientist's insight, the locus of their knowing and making decisions, inside of their head—as an isolated 'aha' moment or as the objective, unmediated discernments of an apparatus 'out there.'

What grows out of this attention to an unfurling apparatus is not only a re-articulation of the empirical grounds of scientific insight, but a different constitution of "the empirical." Traversing into unexpected experimental terrains, the pea plants invite Gagliano to slow down and pay a different kind of empirical attention; from one bent on separating "feeling" and "knowing" through a perceived distance between observer and observed, words and things, to one that takes all categories of analysis, including 'empirical,' 'experiential,' 'feeling,' and 'knowing,' as contextual, contested, and contingent (Scott 1991, 796). From within the wily 'outgrowths' of this apparatus sprouts a situated, more-than-human response to an event in which it becomes possible to trace how a scientist's senses are reconfigured through unexpected encounters with pea plant root tips or "radicles:" an ethics of response we describe as "radicley empirical."

Radicle, like radical, describes a rupture—a root sprouting from seed. In our experience, or rather, the experience which we found ourselves responsive to, radicle simultaneously describes an object of empirical inquiry—the primary roots of pea plants—and the morphology of the context—a nonlinear feeling around for the creative potentials of experimentation. In this sense, our notion

of radicle empiricism stems from and builds upon its Jamesian alliteration "radical empiricism" by inquiring into, rather than assuming, the relations that constitute the "between" of feeling and knowing (James 2003 [1912], 51-68). As such, our concept of radicle empiricism aspires towards what feminist scholar Lindsey Andrews calls a "minor empiricism" (Andrews 2015, 6). In refusing the terms of a rational organization of the senses, especially the privileging of vision, as a fixed, ahistorical, and value neutral source of knowledge, pea plant radicles invite us to explore a "minor" awareness of experimental senses; an awareness that unfurls from within their ongoing constitution and reorganization.

Radicles are, after the seed, considered to be a plant's "first" sensory organ. Highly sensitive and rapidly shapeshifting, radicles are not only charged with the capacity to break through the hard casing of embryonic primordia, but to drop into and navigate the dark unknowns of subterranean earth. For Darwin and the few who call themselves plant neurobiologists today, the radicle is equipped with "neuronal-like" signaling capacities, the electrochemical wherewithal to translate messages from their surrounds into a coordinated trans-organismal response (Darwin 1880, 573; Masi et al. 2009, 4048-53). But radicles, as we have come to make sense of them, are masters in sensing. Siphoning around through soils for stories of potential lifeways, radicles can forecast possible atmospheric futures through the touch of earthly matter. Their power, or rather the mystery of their power, lies in their meristematic indeterminacy; the courageous sensitivity of undifferentiated cells to reach into the unknown and gather insight. With Natasha Myers, we have come to see these "million-fold nodes of growth" as "centres of indetermination, each an ongoing experiment in and with the world" (Myers 2015b, 3). And akin to Deboleena Roy's stolonic inspiration, radicles can lure us out of a transcendent trance and into immanent connection; inviting us to not simply "feel for" the organism or apparatus, as if it's already 'out there' waiting to be revealed, but to "feel around for" the possibilities of our milieus (Roy 2018, 57-89)—to re-root and

ground our senses into the demands of the present for a more responsive and response-able (Haraway 2016, 34-36) plant science. That is, a more radicley empirical plant science.

Part II.

From January to April 2019, Onzik, an anthropologist and feminist science studies scholar in training, had been studying and working as a research assistant with Gagliano, an evolutionary ecologist and pioneer of the emerging fields of plant cognition and communication. Gagliano's name is perhaps readily recognized by many feminist scientists and science studies readers, particularly those 'differently' interested in plants. Over the last decade, she has published several provocative experimental studies, in "prestigious" journals such as *Scientific Reports* (2016) and *Oecologia* (2014*)*, demonstrating preliminary evidence for phenomena such as memory, habituation, and associative learning in plants. Such phenomena have long been thought to require not only a 'proper' nervous system, but a highly sophisticated one. Further amplifying her knack for what she has described as "unthinkable plant science" (see her phytobiography *Thus Spoke the Plant*, 2018), Gagliano has also catalyzed the field of "plant bioacoustics," in which she and a very few others have begun to explore the sonic realms of plant communication. It is within this burgeoning and highly experimental field of phytonic soundscapes that our collaborations in cultivating new kinds of empirical senses with plants began to take shape.

Onzik has spent the last five years working to ethnographically ingather a sense of how the novel and still highly experimental (and controversial) sciences of plant neurobiology, cognition, and communication are being made. If Onzik's studies inquire into scientists attempting to, as Natasha Myers has best described it, "sense and make sense" of plant sensing (2015b, 2), then the scientists Onzik studies are attempting to make sense of plant sensing through apparatuses common to the domains of cognitive science and neurobiology. As such, there is a peculiar kind of tropic twist that happens in conversations and experiments with these plant scientists, and not others. Onzik's field

notes evoke stories of plants responding to scientists in ways that not only displace the centrality of the brain and vision from longstanding theories of cognition, but in so doing, challenge the cognitive theories embodied and prefigured by the scientist's methods of prehension. Lured into the nutational curiosities of roots and shoots, through spacetime encounters that challenge the language and techniques of a scientist's a priori 'cognition,' these scientists are, quite publicly, losing grip on those rationalist certainties that sustain their knowledge and their careers. The feelings—the doubts, fears, and hesitations—that once lurked in the shadows of their objectifying confidence become not simply palpable, but part of their experiments. Grasping for the stabilized explanatory grounds of cognition in the languages and techniques of neuro- and animal behaviors sciences, these scientists find that no such stable ground exists. The plants once naively assumed to be the objects of objective investigation become increasingly and unexpectedly responsive to scientists who are no longer certain where the 'true' boundaries of knowing reside.

At the time of Onzik's fieldwork, Gagliano had recently been awarded a two-year grant at the University of Sydney. Her position as a "natural scientist" was unusually co-funded by the Sydney Environment Institute, an interdisciplinary cast of humanities and social science scholars broadly working to "deal effectively and justly with ongoing transformations of the environment." And while Gagliano was considered part of these conversations, she was also given space in a large lab in a stately old (re: imperial) biological sciences building, replete with portraits of Darwin, Cook, and a rich display of 19th century taxidermy, where she could continue her experimental work.

Shortly after Onzik's arrival, we began building an apparatus designed to test pea plant decision-making behavior in response to the sound of water. The apparatus was to be a more complicated variation of a previous one, in which pea plant roots were asked to make a choice inside of a two-way Y-maze: to either grow towards the sound of water, or away. Water is here understood to be an evolutionarily necessary and thus desirable resource for peas, and sound being one possible

modality through which pea plant roots can sense and locate water. Gagliano noticed the germinating pea plant radicles not only grow towards the sound of water (% of time) but anticipate its direction prior to reaching the "node" or "decision making obstacle;" the radicle having already chosen to grow into the arm of the Y-maze that would prove the path of least resistance—the most "efficient" path— towards water (Gagliano et al. 2017, 151-60).

As scientific apparatuses, Gagliano explains, mazes have generated much insight for cognitive and behavioral scientists and are themselves considered amongst the most "efficient" ways of studying spatial awareness and discriminatory learning behaviors in a variety of animal species. As pea plants have a different bodily organization with different sensory organs, perceptions, and speeds than animals, Gagliano has designed a maze out of two panes of plexiglass, nylon rope, a thin layer of soil, and a small hole at the center in which the pea seedling (Figure 1) is positioned. Beneath the glass are time-lapse infrared cameras, so that Gagliano can record the decision-making behaviors of the growing roots in the dark. With this new apparatus, Gagliano aims to test whether pea roots can make the right decisions to explore efficiently and choose the path of least resistance when navigating the more complex four-way maze (Figure 2). Based upon the findings of Gagliano's prior research (2017) she expects to find that peas can sense the location of water through sound vibrations, and can do so *efficiently*—that is, they can avoid energetically expensive detours by using sound waves for sensing and deciding upon the most direct path to water.

Photo 10. Pea plant radicles sprouting inside water-soaked paper towel roll; a hydroponic germination technique G learned during training. Seeds are considered germinated and ready for planting inside a maze when the radicles are >5mm long.

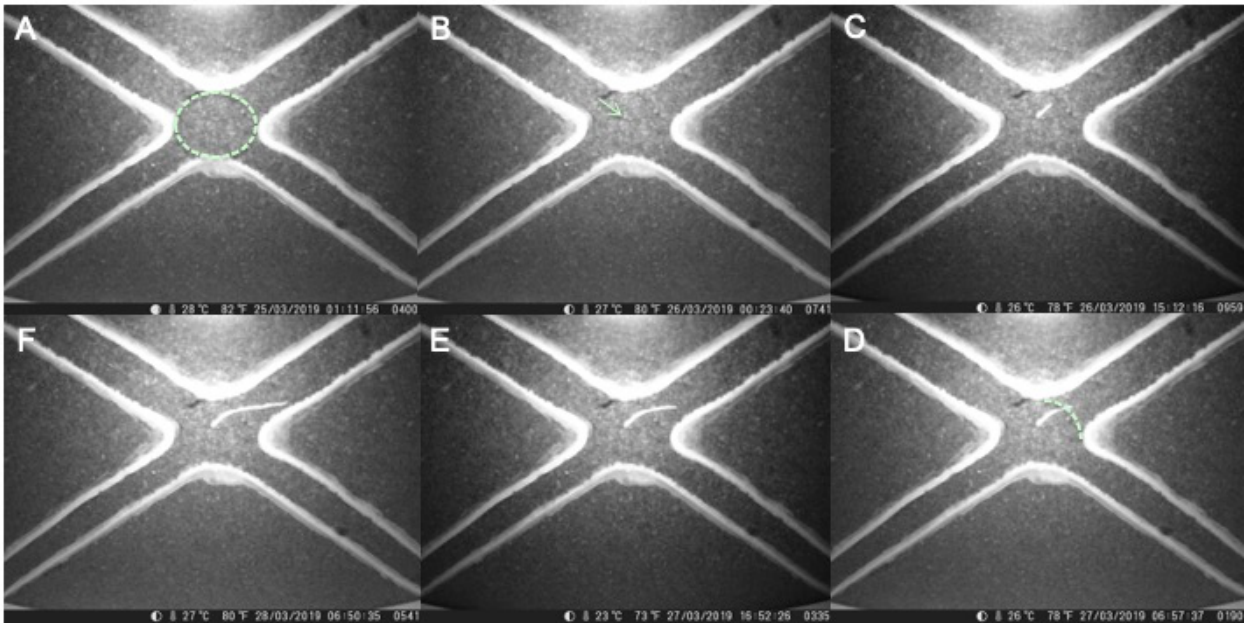

Figure 2. Time series infrared photography of a pea root navigating a four-way maze. (A) Experimental time T0: the germinated pea is planted in a small circular pot whose base is positioned at the center of the maze as indicated by the green dotted line (Circle of Choice, CoC). The base of the pot sits on a glass panel and has been cut open to allow the root to exit and explore the maze once the glass panel is reached. No root is yet visible. (B) Experimental time T:1 the root reaches the glass panel and becomes visible within the CoC area as indicated by the green arrow. (C) Experimental time T2: the root starts growing within the CoC area. (D). Experimental time T3: the root grows directionally towards one arm of the maze and exits the CoC area as indicated by the green dotted line. The root is recorded as "making the choice." (E-F) Experimental time T4-5: the root grows into the chosen arm of the maze.

Through her trainings as an evolutionary ecologist, Gagliano has come to accept efficiency as a defining parameter for knowing and making right decisions across all life forms—in humans as in peas. As Gagliano described it to Onzik, the right decision pivots upon a peas natural tendency to move through the world teleologically—motivated by an *innate* desire to achieve fitness and duration in the world—and this is embodied as a natural predisposition for making good predictions; for knowing one's world and anticipating one's place within its evolving conditions. Thus, the one who knows best—the one who knows how to make the right decisions—is the one who has what it takes to not only "sense" or "feel" but to "know" where they ought to be and how to get there on the path of least resistance. Implicit in this way of knowing how right decisions are made is the assumption that not knowing where one is going is, evolutionarily speaking, a risky energy expenditure—constitutive of detours, mistakes, or "wrong" decisions. Wrong decisions are thus revealed not simply in actions of moving away from what is assumed to be the desired stimulus, but by parameters that recognize non-goal directed actions as behaviors lacking predictive value; those behaviors based on bodily guesses, heuristics, or *feelings*, not 'true' cognition. In the design of this experiment, wrong decisions take on the appearance of pea roots growing in a variety of directions, or those that make "detours" before finding the clear path.

Early in the construction of the mazes, Gagliano began to feel overwhelmed by the particular constraints and affordances of the lab. While it offered her science the possibility of controlled temperatures, sound-proof isolation, and sterile conditions, it also espoused the privilege of generating waste in the name of science. As we unpacked the plexiglass of her mazes, engineered according to her specifications, we found ourselves surrounded by plastic wrap and Styrofoam boxes; materials of short-term use and long-term terrestrial consequences. An unbearable sense of ethical disconnect imposed upon Gagliano's ecologist senses, demanding of her to change course. Without much hesitation, and the support of her new colleagues, we packed up the mazes, water tanks, cameras and

pea seeds into the back of her van and headed north to the sub-tropical part of New South Wales. We found ourselves a house surrounded by forest, crawling with spiders, newts, and snakes, and equipped with a large backyard shed, spacious and barren enough to perform as Gagliano's new lab. We began setting up the pea plant decision-making apparatus immediately, so as not to waste any more time on her short contract. We also incorporated the Styrofoam boxes into the apparatus itself, so as not to waste any more materials.

The experiment began with what appeared to be several weeks of successful piloting. The initial design was based on two groups: the treatment group (i.e., water sound is randomly assigned and applied to one of the four arms for each replicate maze) and the control group (i.e., no sound is applied, all arms are intended to be equal and hence, seedlings are expected to grow randomly into any one of the arms). As the experimentation proceeded to testing phase (after approximately 5 days of seed germination), something unexpected arose. When removing the plexiglass covering to peer at the growing roots beneath, Gagliano noticed that almost all pea plants in their individual mazes, both those in control and treatment groups, were making the same decision. Irrespective of treatment but far from random, the young root tips are responding to *a* stimulus, albeit not the one provided by Gagliano. The apparatus worked to generate a collectively oriented behavior of the young pea plants, though Gagliano did not know, or control for, this decision.

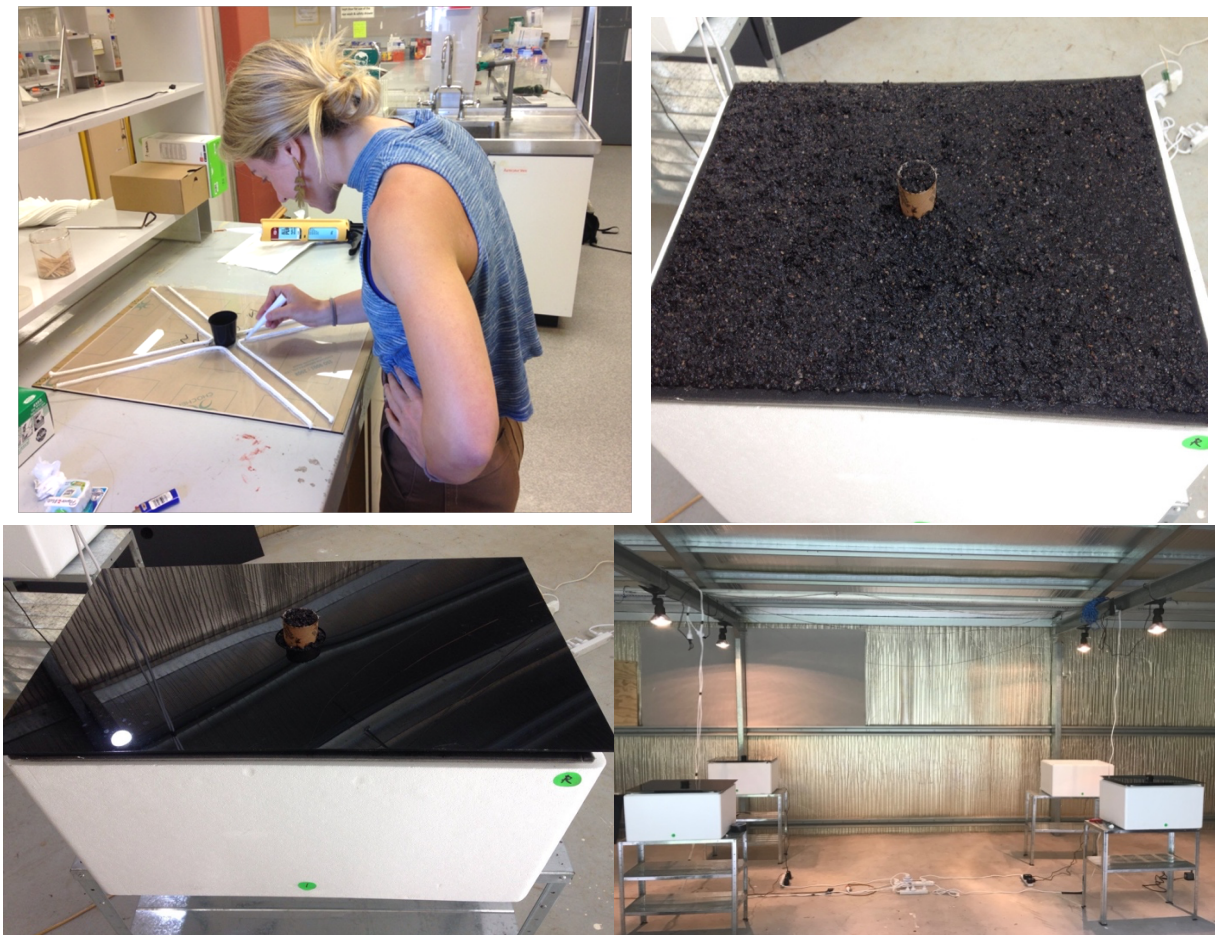

Figure 3. Images of maze apparatuses in construction. (A) Onzik adhering nylon rope to plexiglass at the University lab. (B) After the four nylon rope "arms" are adhered, mazes are, after being moved north to new lab, covered in soil (C) then topped with dark plexiglass to protect roots from light radiation, pot with germinating pea seedling placed center. (D) An image of the four replicate four-way mazes inside of the new backyard lab.

Part IV.

Gagliano's initial response to the unexpected performance of the apparatus was what she described as a "visceral," "gut feeling" of frustration; a frustration that comes with the sense that she, not the peas, had *failed* to know correctly. In previous studies she had considered herself successful, and knowledgeable, after demonstrating that pea roots sense and make the right decisions by growing efficiently towards the sound of water. So, what went wrong with her design of the apparatus? Where

did *she* go wrong? Rather than assessing all the details in which Gagliano's experiment could be rationalized as "wrong," we explore how it is that Gagliano came to feel, and know, the response of the apparatus as the effect of her own cause, her own wrongdoing.

In *Meeting the Universe Halfway*, Barad describes a situation in which a scientist's apparatus becomes palpable as a "dynamic set of open-ended practices, iteratively refined and reconfigured," rather than a mere instrument of observation (Barad 2007, 167). She gives the example of Stern & Gerlach's magnetic spatialization experiment, in which a simple exhalation, rich in the sulfuric residues of cheap cigars (the only kind Stern could afford), left its mark on a silver plate. In so doing, the liveliness of the apparatus was revealed to Stern, and evidence for a different phenomenon-- the angular momentum of the electron--a difference that was previously inconceivable, became possible. For Barad, the example of Otto Stern's cheap cigar makes poignant the material-discursive natures, the indeterminate and dynamically shape-shifting potentials of an apparatus. The cigar is, in Barad's rendering, a "condensation" or "a nodal point" of the "workings of other apparatuses, including class, nationalism, economics, and gender, all of which are part of the Stern-Gerlach apparatus" (Barad 2007, 167). As Barad's account works to demonstrate, scientists tend to take for granted that the outside boundary of an apparatus ends at some "obvious" visual terminus, or that the boundary circumscribes only that set of items a scientist learned to list under "equipment" during lab exercises in science class. They tend to trust the *habits* of their training, a training that encourages "an immediate grasp of the "apparatus" in its entirety" (Barad 2007, 165). Such habits, Barad suggests, make a scientist susceptible to preconceptions. They work to manage uncertainty by diverting attention away from the lively, agential propensities of matter—of the creative potencies of silver and sulfide or, in our case, a laboratory porousness made perceptible, and significant, through radicle recalcitrance—and focusing attention on the stabilizing forces of past experience. These are embodied conceptions of how an apparatus and a scientist, entangled with the habits of another, ought to perform.

In Gagliano's initial response, we trace a sense of success and failure—the "right" and "wrong" outcomes— of her experiment pivot upon a habit of knowing in which Gagliano considers herself solely responsible for defining and predicting all possible parameters and outcomes of the apparatus. This is a habit that, in facing the unexpected, affects a feeling of frustration and a concomitant story of individual failure. In this response, feeling corresponds to a wrong kind of knowing, of being uncertain and lacking control. The right kind of knowing is, like that inscribed into the design of the apparatus, an achievement of goal-directed foresight or "planned" action (Suchman 1987, 27-48). It takes shape as an assumed clear line of intent, where action proceeds from a plan made inside of an actor's body; inside the scientist's head. Such explorations are, to Gagliano's disciplined senses, not only inefficient but also difficult to articulate and prove as objectively knowable. They are expressions of feeling bodies whose experiences of knowing are porous to their milieus in ways that run the risk of expending too much energy. In this narrative, such bodies lack the ability to transcend the temporality of the present into the realm of the future abstract—the realm in which, according to the design of Gagliano's apparatus and that learned through her training—is what constitutes true "knowing," and the conditions in which true "knowledge" of the world can be presented. These feelings of wrong kinds of knowing, as disciplined senses or what Barad calls "habits," can be traced from within the material-discursive relations of a highly competitive evolutionary ecology department, where Gagliano was trained to feel that having what it takes to be a good scientist is a "natural predisposition."

In their ethnographic studies of physicists and protein crystallographers, respectively, anthropologists Sharon Traweek (1988, 123-25) and Natasha Myers (2015a, 23-25) propose that what comes to count as "natural predispositions" are sociotechnical achievements—embodied in time, through ongoing practice, and subject to change through technological, material, and sociohistorical contingencies. We briefly explore some of the material-discursive practices through

which Gagliano became entrained to a particular narrative of knowing—through which Gagliano learned to embody an image of herself as a scientist already predisposed to making those decisions that lead to the most efficient or "immediate" grasp of an apparatus and its outcomes-- towards generating knowledge in objectively definable, and probabilistic terms. From within Gagliano's response, we can trace the subtle cues of her teachers and peers, iteratively articulating and reinforcing the conditions in which she was put to the test as 'fit' or 'not' to know as a scientist. Through coursework and lessons to familiarize herself with her biases, or "subjective feelings," Gagliano embodied the distancing protocols of an objective observer, developing what was presumed to be an affectively 'neutral stance' between herself and her apparatus. Repeated practices of checking 'biases'—incorporating cameras as technologies to stand in support, or as counter to, her potentially fallible vision, searching for ways in which one's "social" body, the influences of unscientific experience, might get in the way of proper knowing—aggregate and condense to become experimental habits. Throughout her training she came to make sense of herself as either already having what it takes to accurately, and efficiently, predict and demarcate the parameters of a knowable outcome, or not. Feeling emerges from within this narrative as part of this realm of "subjective bias." As subjective it formulates an experience of knowing that, while at times insightful, cannot be taken seriously, or made legible, as a true form of knowing—or not the kind of knowing through which objectively right decisions get made.

In revealing some of the material-discursive compositions of Gagliano's apparatus, the narrative of "knowing" affectively entrained into her practice as a "natural predisposition," we work not to reduce such sensory dexterities—such habits of feeling for knowing 'objectively'—to being "inherently wrong." Rather, in foregrounding the feelings made possible by encounters with the unexpected, we suggest that feeling is neither antithetical to objectively knowing nor is it a sense, or experience, that a scientist *has* and that may prove insightful "at times." Rather, we seek to

demonstrate how feeling is a phenomenon both affectively constituted by and constitutive of a particular habit of a scientist's knowing experience. And, like all habits, such feelings are susceptible to reconfiguration; "made and unmade on the level of immanence and radical experience" (Stengers 2011, 27). From within the material-discursive contingencies of an apparatus, in which it becomes possible for Gagliano to feel—to sense and make sense of—herself a failure, insight reaches out like the roots of the peas, luring us into experimenting with the indeterminacies of an apparatus as the grounds for a radicley empirical plant science.

Part V.

In *Getting Lost,* feminist scientist and science studies scholar Patti Lather proposes a practice of learning to work within the "ruins" of science, despite its many disappointments (i.e., deterministic biological theories, biotechnological waste, the violence of positivism and belief in pure objectivity). Like Haraway's invitation to "stay with the trouble" (Haraway 2016, 1-8), Lather asks of us to renegotiate the conceptual limitations of our scientific ruins, suggesting that "terms understood as no longer fulfilling their promise do not become useless. On the contrary, their very failures become provisional grounds, and new uses are derived" (Lather 2007, 10-11). In their "preferring not to" (Stengers 2005, 996) respond, or at least, not to respond in "the right way," the pea plant roots invite us to slow down and pay a different kind of attention to "the limits and necessary misfirings" (Lather 2007, 11) of an unfurling pea plant decision-making apparatus. From within the mess of a scientist's newfound experimental entanglements, it becomes possible to not only reimagine G as the 'one who knows,' designs, and speaks for, the performance of the peas, but to translate such imaginings into more-than-human empirical formations.

Turning toward the undetermined, albeit collectively shared interests of the peas, Gagliano, like the peas, begins to *feel around* for the potentials of a new possible apparatus; one in which the

design, performance, and outcome are no longer constrained to the visual or "knowable" spectrum of Gagliano's prior trainings, but opened to radicley empirical formulations. The guiding inquiry is thus no longer concerned with whether or not the individual plants respond to the sound of water within their individual mazes—efficiently or aimlessly—but with what it becomes possible to know within the porous and indeterminate contingencies of the apparatus.

In so doing, Gagliano becomes a scientist whose knowing is made possible by not simply "losing herself," but by becoming herself, "a scientist who knows," differently. For her capacity to know is no longer trapped inside of her body as a "natural predisposition," revealing itself as either right or wrong, objective or subjective, efficient or aimless. Rather, in feeling herself as a failure in response to the unexpected outgrowth of the apparatus, Gagliano begins to feel herself as part of its empirical formulations—both constitutive of and partially constituted through the very phenomena the apparatus was designed to reveal. From within this disorienting space of no longer being the 'one who knows'—the feeling of being immersed with one's apparatus—the boundaries between scientist and object, knower and that which is to be known, are unclear.

Gagliano is absorbed into unexpected experimental relation with the peas, where the boundaries between the two, are subject to radicley empirical innovation. For a scientist's insight, her capacity to know, is not a matter of 'aha' or 'objective' revelation, but a matter of feeling around—a matter of unfurling in time, space, and intimate, more-than-human relation. A matter of becoming responsive to asynchronous outgrowths, to the inevitable sproutings and spreadings of the unexpected; to those radicle ruptures in rational conformity in which new possible plants and scientists take shape.

From within these newly responsive iterations of the apparatus, the individual pea seedlings are still positioned within individual mazes, but the four arms are now reduced to two, with both arms oriented towards the common, albeit still unknown, *a* stimulus. The difference between the treatment

group and the control group is constituted by a small roadblock. The roadblock, a rectangular cutting of polystyrene foam, is randomly assigned and placed at the entrance of one of the two arms for each replicate maze. No roadblock is added to the control group, and therefore the seedlings are expected to grow randomly into either arm of the maze, as both arms are equally un-inhibited. By adding a roadblock between the pea plants and their desired direction, Gagliano is interested in observing how plants decide the best route to reach stimulus *a*: are they able to identify the arm of the maze with no obstruction before arriving to it? And would they change the direction once the obstacle is encountered or would they attempt to overcome it? Neither decision is more right or wrong. Rather, Gagliano is now interested in observing the spatial and temporal patterns that arise from "the root collective"—including the pea roots, maze boundaries and roadblocks, time lapse recordings, stimulus *a* and the *in situ*, that is intra-active cultivations of the apparatus—through which Gagliano, too, is figured. Her recordings and observations are not only generated in response to the direction of the pea roots growth and whether they reach the target inside of the maze (i.e., can the peas make right decisions), but also how roots move and traverse through soils in relation with the shifting boundaries of the maze (i.e., the relational encounters through which pea roots are responding to different constraints and affordances within and beyond the maze) (Figure 4).

Cultivating a heightened attention to the qualities of the medium through which knowing can be felt or experienced as knowledge— the transparent panes of glass through which both the scientist and the camera can visualize the pea plant roots inside a maze—Gagliano relinquishes the capacity to claim unmediated transparency to an objectively discerned experiment. Instead, the panes of plexiglass, the soil, the cameras, the pea roots growing towards an unknown stimulus, activate a "vision beyond the visible" (Scott 1991, 794). A vision that both conducts and challenges the fantastic projections that form the basis for Gagliano's scientific investigation into "pea plant decision-making." In this story, the phenomena of feeling, knowing, and making a decision

originate not in a presumably unmediated experience of a 'natural' or 'inherent' predisposition, but out of an intra-active or affective prehension of the moving, differentiating qualities of the apparatus: the displacement of soil by growing roots, the light diffracting through the lens of the cameras, the sonic vibrations of water, the emanations of an unknown albeit significant signal somewhere beyond the walls of the lab, and Gagliano's trained senses, expanding and feeling around for the potentials of a living, growing, unfurling apparatus.

Figure 4. (A) Construction of two-way maze with roadblock (B) Image of radicle growing into unobstructed arm of maze.

Part VI.

Gagliano's radicley empirical inquiries remain ongoing, though not in any form easily translated into the representational demands of science. The peas continue to lure her into feeling around for the creative outgrowths of an apparatus—spurning a curiosity in more porous, ecologically responsive and response-able modes of experimentation. Having since expanded into a meshwork greenhouse adjacent to the lab, and thereafter into the unruly bounds of the vegetable garden, the once sterile expectations of a properly controlled apparatus have given way to the fervor of the surrounding forest—to the cacophony of birds and insects, the fluctuations of light, moisture,

wind, etc. The apparatus through which Gagliano's insights become possible is subject to dynamically more-than-human composition. The perceptions of both Gagliano and the peas a matter of perpetual cultivation. And while such radicley empirical modes of experimentation have the potential to provoke new insights about how a scientist comes to feel around for knowing differently, it nonetheless proves difficult for a scientist charged with the task of generating replicable data in a timely manner.

In pointing to the limitations and tacit conditionings of a scientist's knowledge making habits, the peas invite us to slow down and feel around for new possible conditions through which science can be made. While the peas point away from the expected, from the conventions of an a priori knowing, they do not point to a 'something else' out there waiting to be revealed. This is, as we see it, the radicley empirical invitation. It is not simply a reformulation of the scientist's question, but a re-construction of the very terms through which a scientist's questions become possible. Not simply a renewed epistemic attention to a scientist's 'feeling body,' but an interest in the material-discursive histories through which the very concept of 'feeling' is made possible within the empirical practices of a scientist. In accepting such an invitation, we endeavor to expand our potentials for response.

Feeling around for the potentials of a pea-plant decision making apparatus is less a practice of generating new knowledge about peas than it is a collaborative experiment in cultivating a radicley empirical ethics of transdisciplinary and transspecies response-ability. As such, feeling and knowing do not precede their experimental encounters as inherent capacities, natural predispositions, or experiences that one 'has,' but are rather experiential categories made possible through intra-active, more-than-human encounters. Particular scientists and plants, feelers and knowers, precipitate out of these intra-active entanglings at the expense of others. No 'decision,' nor theorizing of 'decisions,' is innocent, but rather is partially constitutive of the very world it claims to represent.

Like many scientists, Gagliano continues to grapple with such ruptures in convention. For such empirical habits are not easily broken. They are instilled in the canons of her discipline, the expectations and policings of colleagues, and the maze-like network of institutions that demand efficiency and control—at the expense of curiosity—out of both herself and the processes she studies. But as we have come to see it, Gagliano's struggles against the habits of science are, all the while, indications that Gagliano is feeling around for openings into a differently possible science; sensing and making sense of herself anew from within the mess, the ruins, the failures and ethical entanglings of the scientific venture. We suggest that this is perhaps all the while the kind of science the peas invite us to craft. As Robin Wall Kimmerer reminds us, learning to listen to plants requires us to "unlearn hurrying;" to relinquish "the parameters of efficiency and controlled for precision" from our scientifically trained preconceptions (Kimmerer 2013, 233). Such modes of listening require much more time, and *trust*, that scientific insights can be generated without fully knowing the conditions in which, for example, "right" or "wrong" kinds of knowing can be rendered knowable.

As a minor empiricism, our radicley empirical proposition is neither better nor worse, more right nor wrong, but a different way to go about crafting inquiries into the sensorial (re)configurations of knowing. From within the creative unfurlings of an apparatus in unexpected formation, it becomes possible to amplify the responsive potentials for radicle and all kinds of radically empirical means of knowing. Evoking different translations of a scientist's detours, their feeling around for an apparatus without a clear knowing of what's to come not as wrong, but as perhaps immanent to the act of novel inquiry; extending the invitation to feel around for, and therefore about knowing, plants, scientists, and all kinds of feelers and knowers, differently.

Chapter Five

Re-membering Future Plant Sciences

Photo 11. A beloved *Monstera deliciosa* hovers above Dr. Liz van Volkenburgh in her office at the University of Washington during the first of many conversations to come.

"The question of a science capable of opening itself to questions that it has traditionally judged "non-scientific"—including the questions raised by the definition and requirement of a scientific career and by the formation of future scientists—belongs more than ever to the future. But such a future, if it is ever to become present, will probably never come from a dynamic generated inside the university—who knows, perhaps it will come from outside, from those men and women who will learn to become actively concerned by those questions that they are not supposed to meddle with."

-Isabelle Stengers & Vincianne Despret, *Women Who Make A Fuss,* 2015, p. 44

Part I.

Dr. Liz Van Volkenburgh is a Professor of Plant Physiology at the University of Washington in Seattle. An apt location for such a profession. Seattle, the so-called "Emerald City," might also be called the "Land of Fertile Concrete." The plants of Seattle, big and small, command your attention. Failure to notice them brings potentially high consequence. Many of the brick walkways on UW's campus are slick with the primordial stages of emerging moss forests. The surrounding sidewalks are at various stages of rooted rupturing and upheaval; arguably the concerted efforts of nearby Western Red Cedars, Douglas Firs, and Big Leaf Maples who have long been busy outgrowing the city's desires for pavement.

And perhaps it goes without mentioning that Seattle, like the rest of the Pacific Northwest, is famously green because it is also famously grey. It rains almost every day of my initial month-long visit, and I am the only one in sight with an umbrella; a sure sign that I'm traveling from California.

At the time of my first visit in February 2017, Liz's "Plant Growth Lab" is housed on the second floor of the earth sciences building on UW's campus. NASA's emblem can be found in the

corners of most research posters on the wall and the tiles of the floor are organized according to molecular structures. Liz's lab, the only plant biology lab in the building, is relatively small and temporarily tucked away on the second floor. The lab will move to the new "Life Sciences Complex" in the fall, and its sparse fillings and relative inactivity are reflective of this "in-between" phase. But what the lab lacks in space it makes up for in light. It's east facing windows must be ten feet tall and experts at absorbing and refracting as much light as one can from Puget Sound's famously interminable winter fog. Enough for two large *Monstera deliciosa* plants to make a good living here climbing up and across their window-sill homes. The Monstera, I learn, are some of Liz's favorite plant allies.

We walk down the hallway from the lab to Liz's office for the first of several informal interviews. Since Liz has done many an interview in the wake of introducing the 'new field plant neurobiology' in 2006, I am quick to preface that, unlike those conducted by a professional journalist, the "interviews" I speak of are more-so roughly (re: "organically") guided conversations, and can stray to wherever they might feel the need to go. I had already begun the recording when I say this and, in the background, you can hear Liz gently laugh and glide her way across the desk to her chair and sit down quietly. The leaves of yet another *Monstera deliciosa* plant, with whom she shares (much of) her office with, stand tall, holey (the "holes" are part of the allure of their leaf morphology), and well-loved behind her. She is poised, assertive, letting me know how much time she has to give, and also warm and embracing of my improvisational style of inquiry.

I begin by mentioning to Liz that I had recently been reading about the "Secret Life of Plants" controversy and learned of a professor and graduate student at UW that were particularly involved in efforts to "de-bunk" the Cleve Backster lie-detector experiments. I ask Liz if she was present at the time. She wasn't. But she does remember reading the book when it came out in

1973. She had just finished her undergraduate degree in botany at Duke University, and was lingering around, working as a research assistant, trying to figure out what was next. She remembers reading it inside of a greenhouse at night, where she had been collecting night-time leaf-movement measurements. She recalls mentioning the book to a post-doc she was working with at the time, telling him how much weirder it felt to be reading it at night, when her senses seemed to be more vulnerable, perhaps more sensitive to the idea of plant sentience—to the conjuring of a "secret life" surrounding her in the greenhouse at night. She was careful to articulate it this way, not wanting the post-doc to think she wasn't already assuming the position of a skeptical scientist. Which is why she was surprised that he didn't immediately reject the book. At least, not in its entirety. "There were ideas in the book, particularly in the chapter about JC Bose," she tells me, "that could be interesting to a scientist, and not totally unwarranted." And Liz remembers talking about these ideas, like electrical signaling and its connection with ideas of plant agency and action and feeling inspired.[33]

She followed this inspiration into a PhD program in plant physiology at the University of Washington. Her advisor was Bob Cleland, or "Cleland," as she now refers to him. He is still a friend, and colleague (emeritus), and still has an office at UW today. Cleland is also a "big deal," in plant science, or what Liz describes to me as a "mainstream card-carrying plant physiologist." During the time of Liz's doctoral training, he was developing the Acid Growth Theory; a theory of plant cell elongation based on the stimulation of auxin, a major plant hormone. His research focused on coleoptiles (the first leaf to grow above ground and the protective sheath over the stem) and Liz wasn't interested in coleoptiles. At the time it was hard for her to recognize the "plant" in

[33] It should also be noted that Liz was long encouraged and equipped to pursue such a path. The daughter of a U.S. Army Colonel, she spent much of her childhood in Jakarta, "running around in the tropical forests with her brother" and begrudgingly touring the colonial botanical gardens, spending her evenings with a "Gray's Manual [of Botany] in hand, memorizing and categorizing the names of hundreds of plant species" under the tutelage of her mother, a librarian, and the influence of her grandmother, a professor of botany at Wellesley College.

them; "they're not even green," she remembers thinking. Cleland asked her if the Acid Growth Theory worked the same on leaves, and she thought, "of course it does." But it hadn't been proven. So, that became Liz's research.

Both then and now, Liz is trained to conceive of plants like a "mainstream card-carrying plant physiologist." In other words, Liz isn't convinced that the phenomena of plant sentience demands something more than a "mechanistic" perspective and explanation. But she does feel that there is a great deal missing in the repertoire of a mainstream plant physiologist, and this is reflected to her in the textbooks she uses for teaching, in unanswered questions in classroom discussions, and the kind of research her graduate students are capable of conducting. What's missing, according to Liz and the rest of her plant neurobiology colleagues, is centuries worth of electrophysiological studies of plants. And it is in large part because of this gap, that she feels there is also a lack in understanding, and theoretical consideration of, the mechanisms for plant sensory integration. When, for instance, she has a student who, like E (now a researcher at LINV), is interested in ecophysiology--the relationship between the environment and the whole plant, down to the bioelectrical level--she has to teach them what she knows, and has to do so using the electrophysiological technologies of the 1980's. She also sends them to her colleagues in the biophysics department at UW, where they have access to some of the more advanced electrophysiological instruments coming from the fields of biomedicine. And if they, like E, choose to pursue a post-doc, the only place they can go to continue learning and doing their ecophysiological studies, particularly with an inclusion of electrical signaling research, is across the Atlantic to LINV.

For Liz, plant neurobiology is a "nascent field of science," that holds promise for a greater understanding of plant sensory integration and response. But this is just as a science. As a philosophy, and a phenomena of inquiry, she says, "its hundreds if not thousands of years old." I mention to her that one such critique of plant neurobiology assuming such an ancient philosophical position is that these thousand year-old philosophies are not necessarily as brain-centric as today's understanding of 'neuro' seems to permit. That there may be something more charged about the use of 'neuro,' rather than, say, 'sentience.' She nods, having clearly heard this critique before. "If it's true," she says, "that some of us are trying to abscond with the brain and put it in plants…then I disagree." But insofar as the field of plant neurobiology works as a kind of "attractor," capturing and orienting the interests of students to make the future of plant science better, more thorough and equipped in their capacities to ask questions at the scale of plant-environment sensory integration, then plant neurobiology is precisely what Liz has been hoping for.

This is, in large part, why Liz felt compelled to co-author the 2006 plant neurobiology manifesto in *Trends in Plant Science*. And even further, to serve as acting chair of the 'Society of Plant Neurobiology,' which is now, like its affiliated annual symposia, called, the 'Society for Plant Signaling & Behavior.' She feels strongly that her students should be able to ask questions about the electrical natures of plants, and find the support and guidance they need in textbooks and journals to address such questions with the tools and techniques of biophysics (neither molecular biology nor ecology, for instance, can answer these questions.)

> *"They're the ones that are going to be doing this for the next 30 years….so the 'hook' of plant neurobiology, for me and for them, is the premise that plants have all the same physiology of animals, they just have different structures. The focus is not on the structure of a neuron. Their morphologies are fundamentally different, but neurobiology gets expressed through these different morphologies, and to me neurobiology is a physiology, and it refers to the physiological integration process that's based in time. I think about it this way because I am a physiologist, this is just how I think about life."*

With so little access to the terms and techniques of plant electrophysiology, Liz fears there will be an entire generation of scientist's that have no clue that plants are electrical, and fundamentally electrically integrated. So much of a plant's capacity to sense and make sense of their worlds, for Liz and many other proponents of plant neurobiology, depends upon these fast-acting and long-distance electrical signaling pathways. Having herself learned throughout her early career of the significant role that electrical signaling plays in cross-cellular communication, Liz finds it strange that there is still so little mentioned in the literature. Liz shares with me an email she sent to one of the textbook authors, Lincoln Taiz. Taiz, like Cleland and Liz, is also a "card-carrying mainstream plant physiologist." Now retired, he has been writing the textbooks for decades. He was also one of the authors of the *Alpi et al.,* (2007) article that dismissed plant neurobiology as a new field of science, on the grounds of it having "no grounds" at all (other than the reference to neurotransmitter production in *some* plants). She wrote to him telling him that she appreciates the latest textbook, that it's the one she uses to teach her classes, but that she is hoping that the next one will feature much more about electrical signaling in plants. As is, the only discussion of electrical signaling in the textbooks is a small section on the Venus fly trap—the most "obvious" example because of its fast movement and insectivorous (re: animal-like) behaviors. Liz tells him that she was surprised by this at first. But then again, Liz *does* know why, ending the email by encouraging him to move past "the whole *Secret Life* saga."

Liz's lab was the first lab I visited on my fieldwork tour. And over the course of the month I understood very little about the significance of Liz's advocacy, about the message that was being sent to other scientists reading Liz van Volkenburgh's name as an author of the plant neurobiology manifesto. Liz is, in the eyes of the plant science community, a "card-carrying mainstream plant

physiologist." She is simultaneously allied with "the old guard" *and* its margins. But there is, of course, a significant difference between Liz's "card-carrying mainstream plant physiologist" position and that of, say, Lincoln Taiz and Bob Cleland's (both of whom, I might add, are strongly skeptical and in disagreement with Liz on this matter.) Liz is a woman.

Liz's status as one of the few women publicly affiliated with the field of plant neurobiology is something I considered to be worthy of discussing, and reflecting on, in the first of many informal interviews to come. I wanted to hear *her* perspective. For she is not only one of the few who were willing to risk their reputations on a marginalized, and admittedly promiscuous, scientific concept, but she is also the only woman scientist to vocalize her allyship with the plant neurobiology, cognition and behavior movement. At the time of my first visit, however, Liz was not convinced gender mattered. When I told her about my interest in her experience as a woman in science, and as a woman choosing to align with a particularly controversial margin of science, she responded the way I imagine many women, trained and indoctrinated into the "old guard," might have answered. She said: "I made a point to work so hard that my gender didn't matter." A sentiment echoed by Barbara McClintock decades earlier, and nearly every woman scientist I've spoken to during my research. Such sentiments seemed to be a far cry from the very publicly branded feminist science labs that I had been exposed to as a burgeoning feminist science studies scholar, and that seemed to be sprouting all over UC campuses. But I was also not shocked by the endurance of such "gender-blind" stances. No doubt Liz and many others *do* have to work very hard. Much harder, it has been argued, than many of their male colleagues, who more readily assume the position of the "unmarked" scientist.

As Stengers & Despret write in *Women Who Make a Fuss (*2015*)*, before the "science question in feminism" (Harding, 1986) became the object of critical (re: *feminist*) attention, science was

considered to be the work of "humans," for a long time exclusively that of men. It was understood that this science would not change if women took their rightful place in the collective effort. In other words, women were welcome in science on the condition that they did not make themselves noticed as women, that they presented themselves as "unmarked" scientists among the others (Haraway, 1989).

Like that presented in conversation with Liz, this idea of the "unmarked" gender in science, is materialized when the scientist is presented (and presents their perspective) as "neutral," or "normal," and in sharp contrast with one that could be defined as the "marked gender." The difference between marked and unmarked is found each time that a category is "invisible;" what it designates then becomes synonymous with a standard permitting the characterization of what "marks" those who stray from the norm. Thus, as Sylvia Wynter (1971; 2003), Audre Lorde (1984), Donna Haraway (1989) and many others have now brought to the attention of "the mainstream," the category of "Man" long imagined to be universal, and therefore invisible, corresponds only to those regarded as white, European, heterosexually presenting men.

And as the feminist movements throughout the twentieth century have made clear, one standard can hide another. That's what many feminists were pushed to discover when women of color questioned their white peers and contested the manner in which they represented, in both senses of the term, the "woman gender." White women feminists have had to accept that "white" has also long been an "unmarked" category in Euro-American thought, and that their particular analysis of gender relations situates them in a privileged, and deeply partial, position. But as black feminism scholars like Patricia Hill Collins (1986), Audre Lorde (1984), and bell hooks (1981) have made clear, inclusion into the interior of pre-existing academic thought is not the goal. Rather, in drawing attention to the invisibility of whiteness in feminist thought, they activate an attention to the

kind of thought made possible in the margins of whiteness; a "marginality" which is not only debilitating, but can also be "an excitement to creativity."[34]

In the context of the history of feminism in science, we have thus far largely leaned upon the work of white women to teach us about what kind of science becomes possible when we take into account "the situatedness" of a scientist's perspective. Through the work of Barbara McClintock, and primatologists like Shirley Strum and Barbara Smuts, feminist historians of science like Evelyn Fox Keller and Donna Haraway have brought to our attention how the question of "women" in science is not a question of how women (as a pre-existing gender or "genre" of humanity) do science differently. Rather, it is a question of how science can, and is, conducted differently, depending upon the empirical orientation, the generation of questions, the intimacy and commitment to the organisms and behaviors of interest, rather than a priori theorizations of what ought to be seen, in order to be considered true. Many a woman scientist and feminist science studies scholars have taught us that achieving the status of "good scientist" cannot be summed up in the collecting of good facts or better facts, but requires, amongst many qualities, an openness to being "wrong;" to standing corrected—not by the pressures of existing authoritative beliefs, but by a willingness to be transformed by the subjects of scientific inquiry.

The more time I spent with Liz, the more I realized that her subjects were, at this point in her career, not so much plants "themselves," but the students of plants. For Liz, the emphasis was not so much about "cultivating a feeling" for the plant, as it was with Monica, but about "cultivating a feeling," a responsive relation, with her students, such that they can begin to cultivate feelings for plants that may not fit neatly within the confines of textbooks and a priori knowledges. The future of plant science is, just like its past, a matter of pedagogy—of training.

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[34] *See* Patricia Hill Collins's, "Learning from the Outsider Within: The Sociological Significance of Black Feminist Thought"(1986), pg. S15.

With Liz I learn that taking students seriously, as critical contributors to science, rather than mere novices or replicators, is a political act. And it is an act that not many scientists, particularly those who travel through the world of science "unmarked," take seriously (and, historically speaking, the most common induction of women into science has been an induction as educator, rather than as researcher). But to say that it is political, is, as Liz too is beginning to learn, not to remark upon an accessory aspect of science. Rather it is to remark on the very foundations of science. And as such, to do as Liz is doing—to challenge the traditional, textbook delineated orchestrations of scientific pedagogy and to engage with students otherwise—is to shake science at its core. As Liz and I explore in the conversation that follows, it is not only to shake "science" at its core, but the "scientist," the body through which the discourse of the "unmarked" can be made, unmade, and thus susceptible to germinating into new forms.

Given the prior conversations with Liz, and the pride she assumed in achieving the "unmarked" scientist position, I was surprised, and deeply excited, when Liz sent me an email in June of 2020, letting me know she needed to tell me about "something interesting" showing up in her awareness. For many of us, June of 2020 was a time marked by one unsettling awakening after another. As the new reality of a global pandemic began to sink in, we also saw the older, all-too-deeply entrenched realities of systemic racism violently bubbling up on our news media radars and neighborhood streets. We were forced to look at ourselves in the mirrors of the Black Lives Matter movement, asking ourselves the difficult questions of how "we" (white folks) too, have been complicit in the perpetuating of a violent and unjust sociogenic code (Fanon, 1967; Wynter, 1999); complicit in a world in which the murdering of black men, women, and children by police could not simply be made possible, but justifiably so. By the summer of 2020, even our "best" selves, the faces of good intentions, were forced to reckon with the monsters that live inside of us. These

monsters, or "ghosts" of our colonial pasts, were being released from their bondage to the invisible realms, and now suddenly here to haunt us in plain sight.

It is from within this greater historical context—the context of a burgeoning pandemic, the publicized murdering of George Floyd and the galvanizing of nationwide protests led by the Black Lives Matter movement, and the question of how "we," as plant scientist and ethnographer respectively, might be moved to decipher, to learn to listen and, potentially, to release these ghosts from within the very humble confines of our experience and work-- that the following conversation with Liz can be situated, and its somatic consequences most affectively realized.

Part II.

Our phone conversation in June of 2020 begins with a brief catch up, how was Spring semester (Spring quarter, for me), what with the transition to teaching online, and all of the other impacts brought upon by quarantine life. I tell her how much energy it takes to even approach my computer these days. That I haven't been writing as much as I'd like.

She tells me that she's reading, again, a book by Julie Cameron called *The Artist's Way*. She starts her mornings writing with a pencil or a pen for thirty minutes. "Just writing whatever comes, and if nothing comes than you write 'I don't know what to write,' over and over, but usually after a page or so you shed the self-criticism and it starts to flow." I loved this advice. And later I bought the book. But at this point, the point at which I'm talking to Liz, I can hardly convince my fingers to pick up a pencil or pen, much less to use it. I'm confused as to whether or not I should even be trying to write my dissertation in this moment, or if I would be better off putting the pen/pencil/keyboard down and just *listening*. Paying due attention. Liz nods in agreement and tells me that both she, and many of her grad students are feeling the same.

Liz has been teaching a Plant Behavior course for the last four years, and I was able to spend half of spring quarter 2019 sitting in on the class, learning with Liz and her students. It's an upper division course, most are seniors, pre-med, looking for an easy elective to take during their final quarter. It's considered "easy" because there's no lab, no exam, and grades are a matter of participation rather than demonstrating an accumulation of knowledge. The course is designed to explore the idea and the burgeoning sciences of "plant behavior" by putting their physiological knowledge to work in new ways. As such, an effect that student's write about in their course reviews is that they learned how to test the limits of their physiological languages, and how new ideas about plants can become scientifically possible, and testable, even without a stable definition of what plant behavior *is*. Most don't leave the class convinced that plants are behaving, or that plants are "aware…at least not in the same way that animals and humans are." But they do leave with a newly opened awareness of the scientific process—of a more complex understanding of how ideas and words come to matter in the making of a scientific study; whether the study be with plants or other humans.

Liz tells me that this year's class was less exciting. Not only because everything was online and it was harder to get discussion going, but also seemingly less balanced—"less diverse, more white." She clarifies this by adding that many of her students are coming through the wealthier, suburban school districts in the Seattle, a kind of "pre-med pipeline." Half-way through the semester Liz introduces her students to the science of JC Bose—not simply to the remarkable aspects of his plant electrophysiology research, which she describes as "ahead of its time," but also how it got to be considered "ahead of its time." She borrows a powerpoint made by her friend and colleague Peter Minorsky at Mercy College, who was once told during a job talk that everything was going great until he mentioned JC Bose's work. The conversation left him spooked, and curious, as to whether or not racism was to blame for the silencing and rendering taboo of JC Bose's plant

research. The powerpoint was one that Minorsky presented at a conference, and is currently writing a historical research paper about how overt racism (the concerted effort of several white, male American scientists, outspoken proponents of eugenic science) used their power to prevent JC Bose's ideas and experiments from being considered science at all. Today his papers are still considered mostly un-citable in plant science, and Liz suspects this is because most don't consider the history of scientific knowledge—how the racism that commandeered the possibilities of our scientific past comes to pervade the possibilities of the present. A reality that Liz, and many of us marked by the category of "white," are just beginning to see, and *feel*, more clearly.

She tells me that the JC Bose week was the week that her class started to get more interesting, more engaged. She explains how in the weeks prior they had "been reading all of the science papers like science papers, and they're good at that, they're well-trained science readers and thinkers, but after Bose the conversations changed. We started to read some of Monica's work and it was clear that they were not only reading it as science but also thinking about science as a process, and as a political one."

Here, Liz presents a type of science, and a reading of science, that is said to be more readily translated as neutral, that is, apolitical, in comparison to the work of, for instance, JC Bose and Monica Gagliano. Though I don't stop Liz to ask her how such a difference is prepared, or learned, from my experience in her classroom and in conversations with Liz, I gather that Liz maintains an adherence to a proper idea of science which is grounded in the explanatory language of 'mechanism.' And such a language is entrained and repeated in textbooks and the kinds of articles that scientists are taught to scour for evidence of 'good,' and 'bad' kinds of science. The languages used in the works of JC Bose and Monica Gagliano, like that of a plant 'heartbeat,' an 'electrical autograph' or ideas of Pavlovian peas, learning, decision-making, and memory, get marked as different; as having

strayed from a non-neutral 'mechanically explicable' stance on the matters of plants at hand. If they had a 'neutral' science, a proper scientific grasp on the matters that would elide any discussion of politics, their language would not stretch too far beyond the rules laid out in the mechanisms of their textbooks and BIO 101 courses.

I tell Liz that I get excited thinking about her exploring the politics of science with her students, learning *with them* how to think about how exclusions and inclusions get made throughout the greater sociohistorical and material craftings of the 'mainstream', and the many iterations of racisms and sexisms that have come to be disguised in the language of objective reason, or rather, the "science of the times," as Liz would call it. In doing so she is opening herself to not knowing, to not being the expert in the room; to being vulnerable and navigating terrain beyond her training alongside her students. She is actively grappling with the question of what it means, and what it has come to mean, to be marked by the category of not only "white," but also "woman," in a science which presents itself as anathema to any categorical demarcation. And it is not just Liz, of course, but Liz's students who are helping her to grapple with the racisms and sexisms inherent in the history of her beloved plant science; those sociogenic realities that not only manifest in metrics of "student diversity," but are built into the institutionalization of science as an authority and 'arbiter of truth.' Those conductive realities, perpetuated through the languages of debates over who plants and their scientists can and cannot be, and the forceful neglect and publicized disempowerment of those who propose ideas that stray from the normative purviews of science's "gatekeepers."

Liz tells me;

> *"There are a couple courses in our department that try to do this, that ask political questions about science, with a perspective that highlights women and people of color in science…but I kind of backed into it sideways with the idea of teaching plant physiology and behavior but realizing that my colleagues who are doing the most provocative work are the ones who are being excluded. And wondering why there is such a desire, and power, to exclude different ideas from science."*

Of course, not every scientist whose work has been considered "provocative" is excluded from science. Provocation, whether in the form of controversy, disagreement, anomalies or other kinds of creative rupture, are, as many a historian, philosopher, and social scholar of science have demonstrated, constitutive of the discourse of science—its varying "regimes of perceptibility and imperceptibility" (Murphy, 2006). What's missing in this analysis, but which is slowly unfurling its way out of Liz, is an awareness that those who provoke from the position of the historically "umarked" are treated differently than those who provoke from the already marginalized (that is, provocative) "marked" position. Presenting a dissenting perspective as, for instance, JC Bose, a marked brown man conducting research under the British Raj, is a much heavier burden to carry on the journey towards translating one's studies as "evidence." Convincing an all-white jury (of scientists) that one's ideas are "innocent," (devoid of myth) has been, as history continues to teach us in the present, much easier for some (unmarked) than others (marked).

Part III.

> *"This year my students helped me to see not just the racism but the sexism at work in plant behavior science. I felt profoundly outraged at the sexism exerted towards Monica. I feel like it is sexism and it's ruthless. David Robinson is the worst, the one who organized the original paper with Alpi and others. I have a little email back and forth generated by Lincoln Taiz when the Markel paper came out. Lincoln and I have a very friendly relationship, but he copied Robinson who then decided to write to me, in a very ugly way, and I wrote back politely with a calm, single sentence, but then I wrote back to Lincoln and he never responded."*

Some background on the characters and situations that Liz mentions here is necessary to understand how she began to see the attack on Monica's work as sexist.

Lincoln Taiz, as mentioned previously, is a professor emeritus in plant physiology at UC Santa Cruz. He is one of the primary editors of the last six volumes of "*the*" plant physiology textbook and is considered an authority on all matters having to do with the physiological studies of

plants. In other words, he and many others consider and trust him to be a "gatekeeper" of proper and improper physiological studies of plants. David Robinson is a plant cell biologist at the University of Heidelberg, and has actively tasked himself with the need to publicly denounce the proposed sciences of plant neurobiology and cognition,[35] with a particular vendetta against the work of Monica Gagliano. The "Markel" paper refers to a 2020 *Elife* publication authored by a UC Davis Plant Biology graduate student, Kasey Markel. The paper's title, "Lack of Evidence for Associative Learning in Peas,"[36] claims to have replicated Monica Gagliano's "Pavlovian Pea" experiment but with contrasting or "negative" results. The publishing of negative results, Liz tells me, is almost unheard of. In other words, there appear to be strongly motivated interests in publishing a UC Davis graduate students "failed" replication of Gagliano's experiment.

I've spoken to none of these scientists in person, though I did have a brief email communication with Lincoln Taiz. I mention this to Liz, telling her that I had reached out to see if I could chat with him about his reaction to the proposed "field of plant neurobiology," that I was an anthropologist and feminist science studies scholar interested in the language of the controversies these sciences have ignited, and interested in his perspective as a continuously engaged, and outspoken critic. He responded with, not a hello or any other greeting or introduction but with a demand, "As a scholar, you need to read the book that my wife and I wrote, *Flora Unveiled*. Once you've read it and digested it, we can talk." I laughed about this to Liz and told her that I don't think I'll ever end up "chatting" with him, but that I've nonetheless received some important insight into his particular "scholarly ethos."

[35] A quick Google scholar search reveals that the only articles that David Robinson has published (as a contributing co-author) in the last decade are all dedicated to refuting the language and techniques of "plant neurobiology" and "plant intelligence." As a primary author, he has published only one article in the last twenty years, an *Opinion* piece titled "Plants Have Neither Synapses nor Nervous Systems" (Robinson and Draguhn, 2021).

Liz laughs. She says she thinks it was him trying to let me know that he was "woke" (…because, after all, he did write a book about the history of plant sex with *his wife*), and, in so doing, reveals many of the ways in which he remains "un-woke." But she tells me that there was a time when Lincoln could have been considered woke, or at least more so than many of her other male colleagues.

> *"I had been invited to a conference that Lincoln was organizing and I was invited to give one of the bigger talks. I had a post doc, Teo, and he figured out how to use patch clamp techniques for ion channels, and I asked Lincoln if Teo could give the talk instead of me, as he was the one who had done much of the work and he was much better at talking about it than I was. And, he was a post doc and I wanted to give him the opportunity. Lincoln wrote back very reluctantly and said Liz I would like for you to give the talk, and if you defer to Teo it doesn't give you the opportunity to show yourself. I wrote back saying thanks for the concern but that I already have a job and I'd like to give Teo the opportunity, but I guess I was one of his 'women speakers,' and it was 91 or 92, and he wanted to make sure that women were not silenced."*

Liz tells me that she had recently received an email from Lincoln that "very patronizingly said he was worried about the poor undergraduates who were being led astray by my class. Which really lit a fire for me in the response I wrote with my students. They're too good of scientists to be led astray."

Liz shared with me this email, which was actually part of a string of emails between Liz, Lincoln, and other "gatekeepers" (like Robinson) that he CC'ed into the conversation, unannounced. In these emails, more so than the published debates, one gets a sense for the emotional depths of the controversies over who plants, and plant scientists, can and cannot be. As I peruse through them I begin to cultivate an image of a scientist who is, like Liz, identifiably white and in the later stages of their career but who, unlike Liz, is identifiably Man (as in Sylvia Wynter's (2003) Man2, an overrepresented and mistakenly universalized "homo oeconomicus," proclaimed guardian of rationality.) This Man2, armed with e-mails faceless and audience-less communication at their fingertips, can finally dispel with their unguarded feelings about "plant consciousness" (their

words) with no need to refrain and contour them into the "evidence-based rhetoric" of journal article formulations.

The chain goes something like this. Lincoln sends an email in June of 2020, wishing Liz well (amidst the circumstances), and letting her know that she might be interested in a new paper published by a graduate student at UC Davis, Kasey Markel, who, attempted to replicate Monica Gagliano's study of associative learning in pea plants, with no success. The paper, as I am to learn in this email chain, was, unlike Gagliano's, received with much praise and excitement by Lincoln and friends. I learned, for instance, that while Gagliano's study is flawed in many ways, Markel's 'almost exact replication' is seemingly lacking in those same flaws. That his version of the study was 'evidence' that pea's do not demonstrate associative learning, and that Monica's was only ever a 'putative positive result.' And while Liz responds with a "thank you for sharing," she refrains from assuming that either result holds more power over another. Instead, she reframes the debate, expressing that "Whatever we think about Monica's data, she certainly has ignited the imagination of many, and curiosity for how plant's work (especially among students in biology). To which she received the following response:

> *Dear Dr. Van Volkenburgh,*
>
> *Linc Taiz has forwarded your e-mail to me.*
>
> *I just wanted to say that I do not agree with you in your assessment of Dr. Gagliano. I am well aware that she has a huge following especially in Australia. But anybody who believes that she can communicate with plants is selling snale [snake] oil. Gagliano is a spiritualist and not a scientist. In my opinion she is misleading the general public, and it is good to see that her data cannot be confirmed.*
>
> *Regards,*
>
> *David Robinson*

CC'ed in the email were both "Linc" and Michael Blatt, who chooses not to respond to this particular email chain but is present in many of the other email debates I've been made privy to.

Liz responded with the following:

> *Hello David,*
>
> *Thanks for being in touch. Your opinion does not at all surprise me.*
>
> *Liz*

And, then received the following response:

> *Dear Liz,*
>
> *under the circumstances it could have been much worse!*
>
> *David Robinson*

Lincoln finally chimes in with his response:

> *Yes, MG has certainly stirred things up, but she's been very self-aggrandizing in the process. To make the ridiculous and unfounded claims about plants she's been making to the press has turned her into a celebrity, but in the end it undermines the credibility of science and doesn't help the environmental cause either. And it's very confusing to gullible students. So far she has failed to follow up any of her own results with additional experiments and supporting data. Why not?*
>
> *Best,*
>
> *Linc*

Liz responds by speculating that it is perhaps due to a lack of funding, and that she disagrees with the undue emphasis and targeting of Monica's work as a science in need of replication. Calling the focus on Monica "at this point…cruel" and that, given how thoroughly they have attempted to "trash" her in the past, it would take an extraordinary amount of courage for her to keep doing the science.

Liz further elaborates on this "Markel/Gagliano" disagreement in our phone conversation, telling me that it "goes something like this:"

"There's an assay I do in my lab, you take a leaf and take discs off the leaf and after a while the leaf either grew or didn't grow, so I call that the leaf growth disc assay. A lot of students have issues because the discs they remove are not intact. I've had colleagues ask me to show them how to do it, and usually when I run it side by side with them, we

uncover what the problem was. They were following what I wrote but there were other things that weren't written down. And I feel like that's what happened with Markel and Monica. Markel probably tried to repeat it but there was more to it. If Monica had not experienced so much cruelty she probably would have connected with Markel, but when Markel is already identified as being part of the Taiz camp, I would think it would be really difficult to be helpful to him. It's a matter of protection."

Here Liz reiterates the consensus of many an STS scholar, who, in the likes of Ludwik Fleck, Thomas Kuhn and Harry Collins, understand that scientific controversy is rarely, if ever, resolved through the replication of experiments. For Collins (1985), this is due to a phenomena he calls "the Experimenters Regress." In this context, the experimenters regress begins with a scientist like Gagliano, whose findings have been negatively replicated, and so, in theory, Gagliano (and colleagues) will argue that the second experiment was not properly carried out. Such a view, Collins suggests, can be supported almost indefinitely because experimentation is a skillful practice; there are no direct measures of the proper execution of a skill except getting the right result. But in a scientific controversy, the "right result" is itself the subject of dispute. And so on and so forth the controversies continue in the form of "the experimenters regress," until, as was the case for the Secret Life of Plants disputes, "authorities on the matter" will decide which was the "right result," claim it to be true and final, and from then on the funding agencies, textbooks, journal editors and review boards will be encouraged to follow suit. Through these controversies, very little of which takes place in laboratory experimentation, one gets a feeling for what Ludwik Fleck (1979) describes as the "policing of thought collectives;" through which the boundaries of science, unmasked of their political, moral, and social materializations, are made palpable. What's missing from these "classical science studies" theorizations, but which is particularly palpable in the language of the debates around the sciences of plant neurobiology and cognition, is the particular kind of authoritative power one holds simply by assuming the position of "the unmarked." That is, by assuming the position of being identifiably white, male, and, as Liz calls it, a "card carrying member" of the mainstream.

Liz tells me that it was her students that helped her to see the "writing on the wall," so to speak. One student pointed out how patronizing the language of the debates was, and expressed that because it was so patronizing it was also very limiting in perspective. It was designed to silence, rather than stimulate, conversation. Another, after reading the Markel paper, felt that the paper was an attempt at "speaking over" Monica's work, rather than to it. With the help of her students over the last semester, Liz is more gaining a sense, "cultivating a feeling for," what her students see as the "white male superiority trip of the old guard."

Part IV.

It was during these most recent exchanges with Lincoln et al, and the revelations and discussions brought upon by her students, that she experienced an "overwhelming visceral feeling," and felt the need to reach out to me to talk about it. She was sitting in her office, on the phone with friend and colleague Peter Minorsky, when Peter told Liz that he had heard (through me) that Barbara Pickard had passed away. Liz hadn't yet heard of Barbara's passing and, amidst all of the Markel conversation and "TIPS Ruckus[37]" she tells me that hearing of her death "*really activated something in me…"*

Barbara Pickard is a key figure in the burgeoning and controversial sciences of plant neurobiology and cognition. Not because she allied herself to their present propositions and field-making mobilizations, but because she was one of the few who had, in the eighties, been interested in discussing the findings of JC Bose and the otherwise hidden archive of literature that suggested an integrative electrical signaling phenomena in plants. She was, as mentioned in Chapter One of this dissertation, also charged with the task of addressing (that is, disproving) Cleve Backster's lie-

[37] "TIPS Ruckus" is how Liz refers to the "Trends in Plant Science" journal debates, which has largely been the editorial "testing ground" for the introduction of plant neurobiology and cognition sciences and their critics.

detector experiments. I had reached out to Barbara via email a year earlier, in May of 2019, introducing a bit about my research and asking her if she'd be interested in speaking with me. She responded:

> A good project.
> However, I am pushing as hard as I can to do the exciting research I have laid out and to work on the climate crisis, and i do have a large tumor that is under treatment. I am not sure i want to relate all the bad things in my "career" and i suppose the good things are the same as inspire men to do exciting science!
> Please keep my name in your records. And please give my best regards to Liz.
> Barbara

Barbara passed away seven months later, in December 2019.

Liz was upset by the news and confused as to why she had only been hearing about it six months later, through a colleague that had not heard about it from another caring and concerned plant scientist, but through me, who was, in their eyes, a mere spectator of it all. Liz tells me that the news brought up a memory that, at this point, felt more like a wound than ever before. She was remembering a moment when both she and Barbara were at a plant science conference, the same one that Lincoln organized in the 90's, and at which Liz was invited to speak but declined in favor of her graduate student giving the talk instead. Liz remembers vividly how:

"she [Barbara] danced and pranced across the stage, went off script, spoke for over an hour for a twenty minute slot, wearing her brightly colored African fabrics and heavy beads, and at the time I remember thinking 'oh Barbara you're not doing us a favor.' But now I realize that she was doing what she needed to do in order to be alive—in order to save herself from being like them, to being reduced to one of them. I thought she was overly displaying herself, which I didn't realize at the time was purposefully fighting against the system. And Barbara was really hurt, thoroughly sidelined as a scientist after the Secret Life of Plants saga. I can tell you that, for me, her ideas were so imaginative and lively and because of that powerful and because of that people thrashed her the way they do Monica. They said Barbara didn't have the data to support her ideas, and Monica is seen the same."

At this point in the conversation I had to pause, recognizing that something quite profound was happening; something far more profound than the eliciting of a "memory." Like the passionflower presented a different plot, a different story, through "me," I felt something here

presenting itself through Liz, a similar unfurling, one born of plantation pasts, long ago buried and enfolded into the "unmarked" nervous tissues of plant science. But now here, presenting itself, asking for a witness, so that it might be given permission to speak as an "entity," or perhaps rather an enduring and transformative "event" (Stengers, 2005.) One not simply bounded by the margins of a scientific past, as a "happening" that came and left, but an event which persists, still palpably and "viscerally" living and haunting and innervating Liz's imaginative and sensorial possibilities into the present. I paused because I felt that there worth leaning into here, something that needed to be slowed down in order to be reckoned with and transformed—to be re-membered. And so too, did Liz.

Borrowing a tool from the techniques of somatic-experiencing therapy, I ask Liz if I can join her in that moment in her office; where the visceral feeling, the feeling of becoming "irate," overwhelmed her. I ask her if the feeling dwelled in a particular place in her body, or, better yet, how did the feeling *move*?

She pauses for a few palpable breaths. Exhales. Then begins, "I'm not sure I know what you're asking for but…

> *"It's a physical response, I feel it in my chest, in my belly, it's a swelling, an emotional response, a body feeling that I associate with feeling an emotion and then where I go from there is this image of a cartoon character pulling her hair out, that I just want to pull my hair out, pound on something, smash something, then it becomes an intellectual anger, I don't mind having bodily feelings because it reminds me I'm alive but the intellectual anger is different. It's hard. It's just a response that feels so wrong, like I couldn't believe that this behavior has been going on for so long and that they're getting away with it even today. There is this historic woundedness that comes through, and it hurts, knowing that in the process of my career I feel like I lost half my body, like a leg and an arm, and now I'm almost retired and wondering if it's too late.*"

Her voice is audibly agitated. Pained. She tells me she doesn't understand why "there's no place in the whole body of science for those people working on the margins, producing new ideas…why isn't there a place for them?" This is a rhetorical question. One not directed to me but

one that seems to open the floodgates for association. From here on, the connections multiply, intersect, overlap, and confront. They are awakening in Liz not only old memories but new stories, and new responses, for them to become not simply represented, but re-presenced. Through the chaos of unfurling memories, new attentions to bodies, to bodies-in-relation, and their potentials to be in relation otherwise, are germinated. They are susceptible to new configurations, to being re-membered and generative of a science that can be, and is, far more other than what it has historically and paradigmatically presented itself to be—a "culture of no culture" (Traweek, 1992).

Through the anger presenting itself as a "historic woundedness," Liz can feel how her gender blindness is connected too, with the experiences of her few non-white colleagues. "Handful, three or four of my colleagues who were on the professor track who were black would say numerous times and in varying words that they're colorblind." Liz feels that this is, like her gender blindness, a "defense mechanism," and how "painful it is to wear all that armor day in and day out." But it is not just Liz that is beginning to see the oppressive dynamics of gender and color blindness, but rather, it is Liz with the help of her students. They are, and continue to be, a source of inspiration, insight, and visions of plant science pasts that can be "re-membered" into alternative plant science futures. She tells me that it is really her students that have helped her to see how,

> *"assimilation isn't helpful…it's like asking black people to assimilate to a white standard. What we need is anti-racism. A breakdown of the system. What I tried to do was assimilate. I noticed I was wearing pants and a sweater to work, years later along came this assistant professor in the department who was wearing all this feminine clothing and I was shocked, and I wondered how she could do that. I learned from her. I was hired in '87 so 35 years I've been in my job and I think in that period of time I have noticed that many women in science no longer feel the need to protect themselves from being a woman."*

The connections continue:

> *"When I went up for tenure and both of my promotions I was denied. The same male faculty member oversaw my progress and told me that my CV was just really different, and as far as I could see mine looked just like the guys, but he was right. My approach to science was different. I think what he noticed, and what a subsequent chair noticed, is that I had a whole lot more service in my package, like I had a heavier teaching load, I was on several committees and as a result had a slower track record of scientific publications [Liz doesn't mention the fact that she was/is also a mother, and now a grandmother]. And I remember at the time this younger female faculty member had been described to me as being confusing to listen to. And I was*

wondering if I was also confusing to listen to. And then I realized I understood her, and other women around me, really easily when they talk to me. I now realize that when I teach my plant behavior class I can approach science my way, I can do my strength, which is a more creative, imaginative, fun, way of learning science, and perhaps for Taiz et al, more confusing."

Liz's students are helping her to see that there is extraordinary creativity happening not simply in spite of, but because ofm their positioning at the margins of what counts as "standard," "normal," and "acceptable." They help Liz to direct her attention to those otherwise "invisible" spaces, to those marginalized and uncertain "in-betweens," in which it becomes possible to re-imagine a plant science that refuses the position of the "unmarked;" an analytical attention through which science can become aware of its "historic woundedness" and thus opened to questions traditionally judged as "non-scientific." These margins might very well be the most germinal and conceptually and materially innovative of spaces—replete with all kinds of phyto-innervative potentials. In cultivating a vulnerable, curious, and collectively configured pedagogical approach that foregrounds the adventure, the sociopolitical stakes of science, Liz invites her students to conspire with her, to begin to imagine a plant, and a plant science, which is not yet but could be.

Together they work to re-member a science that is not only more equitable, more supportive and encouraging of different ways of "doing science," but also a science that is more attentive to its somatics, to the ways in which its bodies—both scientist, plant, and beyond-- sense and respond with and from experience; with sensory dexterities that can be trained and untrained, mimetically and morphically responsive to the ever changing demands of the present. And while much of this work is being conducted "inside" the very privileged spaces of the university, Liz's students are not yet considered "inside" the paradigms of science. They have not yet been trained, indoctrinated, and equipped with any such authority to speak of what a scientist is and is not capable of asking. Through conversations and reading their written responses to this course, the students have the following to say about their experiences, and the kinds of openings it has created:

"this class has taught me a lot about plant behavior and has led me to really reflect on how I understand plants and their sensory capabilities. I already had a decent amount of knowledge on the topic since I am interested in it, but there was still a lot that I hadn't heard about until this class. As I continue doing research on plants, the things I've learned about and discusses in this class will undoubtedly stay with me and influence how I see plants: as 'intelligent,' perceptive, and more complex than we may ever truly understand."

"I know there's a lot of research done in the plant community that have not been repeated and are looked down upon because others won't take the plant science community as seriously, but I really do admire the creativity and bravery for those researchers that wanted to study the unimaginable. It has inspired me as a student to be curious and question things and propose new ideas."

"This class made me view plants in a less "animal-centric" way and recognize that behavior can be manifested in many different ways…[and] on a last note, interestingly enough, the course has also connected me to my past and brought back memories and conversations of my mother's experience working in a horticulture lab."

"..leaving the class knowing that plants do behave, but in a completely complex and different way than we do. I look forward to reading studies in the future on the topic of plant behavior."

"one of the best educators I have had the privilege to work with….unbelievably dedicated to your craft and I thank you for being an excellent role model. Not only have I learned much about plant physiology, but I have also learned how to kindly and effectively communicate with others to establish a welcoming environment"

"I leave this class with a new lens, a lens for looking at plants with awe."

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