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Celestial Ecology: Multiple Ontologies of Plant Breeding

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Abstract

This study investigates the role that concepts of nature play in contemporary plant breeding practices, primarily in the Wageningen University plant breeding department but also among biodynamic breeders and breeders working for private companies. A Grounded Theory approach seeks first to understand and typify the diverse ways that breeders conceptualize the ontological relationship between humans and plants, and then to relate these concepts to breeding practices and to larger structures of power. Findings reveal that concepts of nature influence practice in explicit and implicit ways.

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We used to think our fate was in the stars. Now we know, in large measure, our fate is in our genes

James Watson

Just as each herb or plant is a terrestrial star looking up at the sky, so also each star is a celestial plant in spiritual form, which differs from the terrestrial plants in matter alone

Crollius

Introduction

The practice of plant breeding, like most scientific and productive practices, is underlain with particular concepts. Some of these are "textbook" concepts, presented as evidence-based, objective and value-neutral: inheritance, backcrossing, heterosis, etc. Such concepts are learned, discussed and employed by any formal student or practitioner of plant breeding. At the same time, another set of concepts also has bearing on the way that plant breeding is practiced, and how it interfaces with larger agroecological and social systems. These concepts - which are rarely called into question - could be called *ontological*, because they deal with the nature of *being*. What does it mean for something to be natural? What is a plant? What is a human? What are we to make of this activity called "breeding" that relates the two?

Some might argue that such inquiries are best left for philosophers, that they are too abstract and removed from the concrete concerns of developing sustainable and just food systems. My research, however, is not a philosophical quest for metaphysical truth - for the "correct" concepts, but a social exploration of the multifarious ways that plant breeders think and practice naturalness. As I observed, ontological concepts about nature are not separate or detached from reality; they have material, social and political effects on the way that food is produced and on the lives of food producers and consumers. Furthermore, the presence and promulgation of these concepts often correlates to patterns of the distribution of power in global food systems. Companies like Monsanto which have consolidated power over the seed industry not only promote a particular model of plant breeding, but also a particular ontological conception of it. As corporate capital continues to gain footholds in university breeding departments, so too do the conceptions of plant breeding and nature that it espouses - a phenomenon I noticed in my interviews with university breeders. On the other hand, plant breeders working outside of the mainstream often exhibited alternative or oppositional conceptualizations of nature.

This thesis revolves around the question of how plant breeders conceive of naturalness, and how these concepts interact with their breeding practices. Because concepts of nature and the natural cover so much territory, I have focused here on the most relevant aspects: plants, humans and the relationship that obtain between the two. Is plant breeding inherently unnatural? Does human interference automatically confer unnaturalness? If not, at what point does plant breeding transition from a natural to unnatural practice? With scientific breeding? With genetic engineering? If breeding techniques are unnatural, does that make them undesirable? Do plants play an active or passive role in the breeding process? The multiplicity of ways that breeders answer these questions influence breeding decisions and the production of new crop varieties.

While such investigations of underlying ontological concepts are likely to be relevant in many areas of agroecology, I chose to focus on plant breeding for two main reasons. First, although agriculture in general might be described as an assemblage of human-nonhuman relationships, it reaches a certain intensity and conceptual richness in the activity of breeding. Where cultivation involves the production of plant products, breeding involves the production of plant *properties*. The complexity and tenor of the societal and scientific debates around genetic modification (compared to pesticide use, for example) bears witness to this intensity. Secondly, the problem situation at hand with regard to plant breeding is not just about an asymmetry in power relations - it also has a particularly ontological inflection. In fact, at least in Europe, regulation of GM crops is an area in which civil society has actually managed to resist the influence of capital to some degree. However, debate between those for and against genetic engineering has been fraught with miscommunication and lack of understanding; one of the breeders I interviewed described it as "World War I style trench warfare". Partly this failure to find common ground is due to different ways of "framing" the

issue, but it also results from incommensurate conceptions of how to define plant breeding techniques as natural or unnatural, and what the implications of these categories are. I hoped that research into these concepts of nature amongst plant breeders might reveal new openings in a long deadlocked conversation.

Deep Stories

If concepts of nature are rarely expressed or considered explicitly by plant breeders, operating instead on the level of implicit assumptions, then what is the appropriate method of researching them? In a few cases of particularly reflective or philosophically inclined interviewees, direct questioning was effective, but most breeders had little to say about their own ideas of nature. Sometimes, these ideas were seen as something that *others* held, an *ideology*, and that they interfered with the scientific objectivity of breeding work. However, I came to notice that the way in which interviewees put together narratives - both on the *longue durée* of plant breeding history and stories from their own professional experience - were often quite revealing about the underlying ontological assumptions of the breeders. Having done previous research on mythology, it was not surprising to me that people's basic concepts about nature might be coded into narrative forms rather than in discrete, encyclopedic explanations. For example, whether one tells the story of Neolithic plant domestication as an "invention" of early "genetic engineers", as an unconscious process resulting from climatic change, or as a cooperative project of particular plants and humans is quite revealing about how one views the relative agency of plants and humans, and what sort of breeding techniques might be considered natural or unnatural.

After sociologist Arlie Russell Hochschils (2016) I have approached them as alternative *deep stories* of nature. Hochschils, a liberal social scientist from Berkeley, uses deep stories in her fieldwork with Tea Party conservatives in rural Louisiana, whose political views initially appear to her as utterly irrational.

> *"A deep story is a feels-as-if story—it's the story feelings tell, in the language of symbols. It removes judgment. It removes fact. It tells us how things feel. Such a story permits those on both sides of the political spectrum to stand back and explore the subjective prism through which the party on the other side sees the world. And I don't believe we understand anyone's politics, right or left, without it"*

The trench warfare of the GMO debates struck me as remarkably similar to the lack of empathic communication between liberals and conservatives in the United States, another reason it seemed like Hochschils deep narrative approach would be appropriate. The plant breeders I interviewed and worked with - mostly conventional breeders at the university, but also organic, biodynamic and company breeders - told deep stories about the history of breeding, the current state of world agriculture and their roles within them. These narratives hinted at certain conceptions of nature, conceptions that are implicated not only in the construction of plant breeding narratives, but also of breeding decisions and practices. Lastly, they also map onto a topology of power, domination and suffering that structure contemporary breeding and agrobiodiversity regimes. This topology has been described with respect to consolidation and monopoly (Howard 2009), neoliberalization of the university and loss of public funding (Welsh et al 2008), bioprospecting of indigenous cultivars (Van Dooren 2008), and biohegemony - the collusion of state and corporate biotech interests (Newell 2009). While the effects and machinations of these power structures have been well documented by the aforementioned authors and many others, there has been a need for research on the ontological concepts that both support and resist them. Additionally, plant breeders as a

group have received relatively little scholarly attention compared to peasant farmers and multinational corporations. My research has sought to begin exploring these research gaps by investigating the role of concepts of nature among plant breeders.

Research Question

How do multiple and contested concepts of naturalness play a role in plant breeding?

My research looks at plant breeding as not just an unfolding of objective science (see: Kuhn 2015), or as determined by relationships of power (Kloppenburg 2005), but as a process also driven by particular ontological concepts. Specifically, concepts of naturalness. These concepts are ontological in that they conceptualize ways of *being* in reality: naturally, unnaturally, culturally, artificially. By interviewing and observing plant breeders working in a wide range of contexts (university, breeding companies, conventional, organic, biodynamic), I investigated the concepts of naturalness they expressed and how these concepts influenced and were influenced by their work. While I did look for general patterns among different segments of breeders, I also made an effort to stay attuned to differences within groups, or even within individual breeders.

By *multiple*, I refer to the evidence (see Descola 1996, Van Dooren 2008) that concepts of nature are culturally and historically specific. I am not looking to describe the one conceptualization that characterizes contemporary plant breeding, but to explore a multitude of concepts united by a single suite of subjects: the naturalness of human-plant interactions. By *contested*, I mean that these different conceptions are often contradictory or even diametrically opposed to each other. Appeals to nature lend "ontological weight" (Harvey 2106) to strongly antagonized positions. Progressive farming advocates call for an agriculture more "like nature". Opponents decry such arguments as romantic (ie based on *culture* rather than *nature*), and in turn locate industrialization in a *natural* path of human progress. Within Dutch plant breeding, fundamental disagreements about the *naturalness* of certain techniques seems to lie at the heart of divisions between organic, biodynamic and conventional breeding.

This contested field of multiplicities is what I intended to open up, without making recourse to simple generalizations - industrial vs organic, science vs the public. At the same time, I was very much interested in finding generalizable and meaningful patterns. While not all biodynamic breeders shared precisely the same concepts about nature, there was indeed a certain family resemblance when contrasted with university breeders, or with social activists. My challenge was to remain attentive to both the individual and the general, and then to examine how these more general patterns at the conceptual, ontological level interfaced with the broader context of plant breeding practices and structures.

Two subquestions further focus the inquiry:

(1) What are these multiple natures and what are their significant properties? What are their points of overlap and disjuncture?

As the conceptual field is particularly nebulous and abstract compared to more concrete subjects of analysis, one way of focusing my inquiry was by generating a conceptual typology. This was especially necessary when using breeders' narratives as an indirect proxy for their concepts. Such a typology was intended to organize and direct the analysis: firstly by showing what concepts were present, then by providing a framework for exploring their properties and associations in more detail, and lastly by facilitating an analysis of how particular concepts related to each other. Because these concepts were generally presented in some sort of narrative form, the typology here is also made up mostly of narrative fragments, pieces of stories that recurred in multiple interviews and speak to the nature of plants and human interaction.

Thinkers in fields such as bioethics have developed schemata for categorizing people's attitudes towards nature, from domination to despot, steward, participant and mystical union. However, most individuals do not have a comprehensive, internally consistent conception of what nature is and isn't. It is important to reiterate that the subject matter are not *theories* of nature of the sort that a philosopher might present. In analyzing the data, my strategy was then to generate codes for patterns of thought that might be called proto-concepts - for example the idea that nature is defined in some relation to the human. Then, after establishing these category codes, to richly explore what Grounded Theory would call the *properties* of the category (Strauss and Corbin 1967).

In addition to fleshing out the understanding of particular proto-concepts I also wanted to explore relationships of both continuity and disjuncture between them. In particular I was looking for the unexpected - occasions when ideas that are often radically opposed might have hidden layers of continuity or vice versa. In them I hoped to find possibilities for opening up societal debate about biotechnology in new directions.

(2) How are plant-human ontological interactions expressed and performed in plant breeding?

This second subquestion also serves to focus the scope of the main question. Out of the broad range of subjects included under concepts of nature, I am mostly interested those concepts related to plant-human interaction. From the complex ways that these concepts play a role in breeding, I have focused on two aspects: how they are expressed (in narrative) and how they are performed (in practice).

Why does this relationship of concept and practice matter? There has been some general recognition that human interactions with non-human beings in general, and anthropogenic environmental crises in particular are tightly bound with individual and cultural variability in ideas about nature. However earlier arguments like Lynn White's (1967) famous assertion - that the contemporary ecological crisis was a result of Christian concepts of dominion over nature - have been shown to be overreaching (Moncrief 1970). Yet if not a simple causal relationship, what are its characteristics? Concepts encompass practices, just as practices contain concepts. The relation is complex and recursive. My aims in the research were not to arrive at schematic, causal relationships between nature concepts and plant breeding practices as two separate variables - that

for instance people who view non-human nature as inert are less likely to have qualms with transgenic techniques. For one, they are not separate variables, but deeply entangled. My method has been to follow those very tangled threads in all their multiple valences, strange loops and split ends, leaning towards thick description (Geertz 1973) of the relationship over distillation of general statements.

Literature Review

GMOs, Plant Breeding, Seeds

In 1988 when Jack Kloppenburg wrote his influential political economy of plant breeding, *First the Seed*, he was still able to point towards a "paucity of critical analysis devoted to plant breeding" that reflected a perception that it was "one of the most unambiguously beneficial of scientific endeavors". Perhaps due to developments in both the social sciences and agricultural biotechnology, today there is no shortage of such critical analysis. This scholarship covers a wide range of subjects and theoretical perspectives. Cleveland (2001) examines the practices of plant breeders through a constructionist lens, exploring "unexamined assumptions" especially around considerations of yield stability. Cleveland, Kloppenburg (2005), Wallace and Yan (1998) and others provide alternative histories of plant breeding, that counter "objectivist" histories (e.g. Stakman et al 1967; Streeter 1969), where "[p]lant breeding as a whole is often seen as responsive to a social demand for improved crop production to counter hunger" (Cleveland 2001).

Scott (1998), Van Der Ploeg (1993), and Tsing (2012) have all, from various angles, criticized the notion of "ideal plant type" that is central to the production of modern crop varieties. Agroecological environments are then coerced into meeting the demands of these ideal types, displacing a land race process of co-evolution. The ethnobotanical work of Stephen Brush (2008) has demonstrated that the ideal plant type is a fundamentally different understanding to that of the traditional Peruvian potato systems he studies, where "diversity within a single crop and field is a logical corollary of the variety of the world around them".

> *"The question ''Why do you grow so many types of potatoes?'' is silly and nonsensical to Andean farmers. Informants were surprised and baffled when asked. From their point of view, diversity is natural and a given of the Andean kaleidoscope rather than something strange or unusual to be explained" (Brush 2008)*

Coomes (2015) and Da Via (2012) have both written about networks of seed and variety exchange outside the formal sector, De Via in the context of re-peasantization (Van Der Ploeg 2009) in Europe and Coomes about farmer seed networks more generally. What some call "informal" seed networks are often portrayed by development agencies as an obstacle for the penetration of modern plant breeding into developing world agriculture. Maredia and Howard (1998) describe how they are portrayed as an "evolutionary stage" on the path towards formal seed systems based on market logic and improved varieties. However, numerous studies (Cleveland and Murray 1997; Coomes and Ban 2004; Rana et al 2007; McGuire 2008) demonstrate that

exchange of seeds in farmer networks is often not “free” - rather it is constrained by local social and power dynamics and in some cases can even limit varietal diversity instead of encouraging it (Kawa et al 2013).

There is also an extensive literature focusing specifically on genetic modification of crop plants. Pechlaner and Otero (2008, 2010) analyze it through the lens of McMichael’s “food regimes” (2009), arguing that GM biotechnology is part of what constitutes the corporate food regime. Wynne (2001) and van den Daele (2007) have criticized the creation of a discourse centered around risk and innovation, respectively, that have shaped the limits of discussion in the public sphere. Sheila Jasanoff (2005) compares the “risk cultures” of the United States versus Europe and its impact on the reception of GM crops. Welsh et al (2008) have coined the term “academic capitalism” to describe neoliberalization of universities and how market fundamentalism has driven research of agricultural biotechnology in particular directions. In an attempt to explain why Argentina has embraced GM crops so readily when other nearby countries exhibit such strong resistance, Newell (2009) uses the term bio-hegemony to describe how “material, institutional and discursive power” align to create a consensus in support of a particular agricultural system. Schnurr (2013) has also found a similar coalition of corporate and state interests with the entrance of GM technology into Uganda, one that notably excluded the interests of farmers. A widely cited study by Howard (2009) shows the process of consolidation in the global seed industry. Sustained ethnographic studies of GM crops and their effect on farming communities have been somewhat lacking, with the notable exception of Glenn Stone. Stone’s account of Bt cotton adoption in the Warangal District of Andhra Pradesh (Stone 2011) is more nuanced than narratives that are entirely positive or negative. Stone also widens the frame to changes that occurred in the decade prior to the introduction of Bt cotton, particularly the use of hybrid varieties of cotton that impacted farmers’ lives more than GM cotton would.

Naturalness

Cultural theorist Raymond Williams was probably the individual most responsible for introducing the study of ideas about nature.

> *"What matters in them is not the proper meaning but the history and complexity of meanings: the conscious changes, or consciously different uses: and just as often those changes and differences which, masked by a nominal continuity, come to express radically different and often at first unnoticed changes in experience and history" (Williams 1972)*

Williams followed the changing ways that nature was represented, from the Romans’ *natura rerum* (describing the quality of a thing) to a singular entity that expressed cooperation, competition, wildness, conscious force or inert mechanism, representations that were closely linked to a particular “agenda or view of society”. In recent years, Sullivan (2009; 2010; 2013) has focused on representation of nature as a

financiable commodity, one that asserts that market valorization of the environment (including agrobiodiversity) is not only the most effective means of preserving that environment, but also a “natural” product of human progress.

Plumwood (2002) and Merchant (1981) have since tied together such studies of nature ideas with threads of feminist thought. Haila (1999) has reflexively built upon their work, “decomposing” the nature-culture dualism into a more complex relationship. Studies in cultural history from Richard Tarnas (1991), Clarence Glacken (1967) and Arthur Lovejoy (2001) have since traced the development of nature concepts from classical Greece to the modern era, while abundant ethnographic evidence from anthropologists has relativized these Western notions. Ingold (2000), Descola (1996) and Viverios de Castro (1998), drawing on fieldwork in the Amazon basin and the circumpolar north, are the most prominent contemporary anthropologists whose research projects seek to compare indigenous and Western ways of demarcating the world into domains of nature and culture. In philosophy, Donna Haraway’s *naturecultures* (Haraway 2003) and Timothy Morton’s *ecology without nature* (Morton 2007) are representative of attempts to rework ways of thinking about non-human beings that might facilitate more ecological practices. Psychologists Tam et al (2013) have found that anthropomorphism of nature (a crude correlate to animism in indigenous societies) is predictive of what they call “conservation behavior”.

Other scholars have since studied ideas of naturalness in the realm of biotechnology. Hansen (2006) focuses on the role of metaphor, noting that they are,

> *"deliberately chosen with a view to facilitating not just ‘understanding’, but with a view to framing what are often contentious and controversial issues in such a way as to promote and strengthen particular arguments and discourses" (Hansen 2006)*

He uses Roland Barthes’ idea of *inoculation* (Barthes 1972) to show how uses of the word natural “immunize against further questioning”. Sutton (1999) reports on the deployment of nature and naturalness in anti-GMO food campaigns. Anthropologist Thom van Dooren (2008, 2009) looks at the “multiple natures” in the field of agrobiodiversity, demonstrating how traditional land races are categorized as products of nature (and therefore the free, common heritage of all humankind) while modern varieties are seen as inventions of culture (and therefore proprietary technology that can be patented and sold), such that the multi-generational labor of traditional farmer-breeders is devalued and hidden. Van Haperen et al (2012) provide a useful overview of the various debates about the naturalness of transgenic breeding techniques, along with their ethical and ecological consequences.

Multispecies Turn

The precursor to the multispecies and ontological “turns” in social science and philosophy over the past two decades was the ethnographic work of Irving Hallowell among the Ojibwa in the mid 20th century. Rather than describing their social structure or subsistence patterns, Hallowell (1960) focused on how the Ojibwa

construed their ecological reality. Animals, plants and even stones and weather phenomena were perceived and engaged with as “non-human persons”, in contrast to a dominant Western ontology that since Descartes has taken nonhuman nature to consist of unthinking, automatic machines.

This underlying critique of the Western tradition in regards to nonhumans is also prominent in more recent iterations of “ontological” social science and philosophy, and has also led to such work being deeply intertwined with that aforementioned scholarship of “naturalness”. These projects all converge in what Arturo Escobar (1999) calls “anti-essentialist neorealism”. Multispecies ethnography responds to the challenge of how to conduct non-anthropocentric social science by opening up the field to various nonhuman actors and agents, with work by Anna Tsing (2015) on matsutake fungi and Eduardo Kohn (2013) on the Amazon rainforest ecosystem being particularly influential. As Elizabeth Povinelli (2016) notes, this type of scholarship is not emerging at this time by virtue of its own internal logic, but rather as response to global ecological crises that force shifts in perspective.

Though the multispecies turn has moved beyond the human, the plant kingdom has been somewhat underrepresented. Both anthropologists (van Dooren, Viveiros de Castro, Willerslev, Raffles) and philosophers (Gray, Haraway, Tyler and Rossini, Marks) have focused on animal life, though also on microbes (Kirksey; Paxson) and even mountains (de la Cadena). There is some extant multispecies ethnography of plants, like Rival (2001) on manioc, Hartigan (2015) on botanical gardens, Hitchings (2003) on home gardens in England, Archambualt (2016) on gardens in Mozambique, Lewis-Jones (2016) on the Millennium Seed Bank and Head and Atchinson (2016) on wheat, but in comparison to animals, fungi and microbes it is sparse. According to Jones and Cloke (2002), flora remains a “ghost-like presence in contemporary theoretical approaches” compared to animals.

Methodological Considerations

In the past few decades, plant breeding and the associated seed industries have been subject to intense levels of scrutiny from activists, academic and the general public. They have focused on intellectual property rights (Blakeney 2009), political economy (Kloppenburg 2005), bio-hegemony (Newell 2009), academic capitalism (Welsh et al 2008), social construction (Cleveland 2001), science and technology studies (van Zwanenberg and Arza 2013), multiple natures (van Dooren 2008) and peasant studies (Heller 2013) among others. Despite this wealth of research perspectives, ethnographic studies are still somewhat lacking. Of the ones that do exist, they focus primarily on the lives of peasant farmers (Stone 2011; Fitting 2011; Lapegna 2014) who are responding ‘from below’ to the actions of development agencies, agribusiness and plant breeders.

Partly in heed with Laura Nader’s injunction to ethnographers to ‘study up’ (1972), instead of focusing on oppressed and excluded segments of society, I have chosen to engage with the lives and practices of professional plant breeders. Studying up is, of course, a relative matter. Even university plant breeders are operating within strict structural constraints, especially when beholden to agrochemical companies for

research funding. I focused on plant breeders not only because of their positioning within power relations, but because their everyday practices are in some way continuous with the lifeworlds of the plants themselves. Incorporating a theoretical framework of multispecies ethnography (Kirksey 2014) allowed for a non-anthropocentric approach that placed a spotlight on the plants in addition to the human managers of breeding programs. If anything, the research subject might be called the *breeding nexus*, that zone of practical engagement between humans and plants along with the patterns of ideas and institutions that run through and around breeding practices.

It is this breeding nexus that is often most opaque in studies of modern plant breeding and seed systems, obscured by a focus on polarizing issues of patent rights, legality of genetic modification, corporate maneuvering and privatization of breeding research. These studies cast university plant breeders as impersonal elements in an industrial genetic factory, and cast farmer breeders/seed savers as either political heroes or romantic idealists. My hope is that a focus on practices - in their complexities and contradictions - will open new avenues for dialogue in a debate where the sides have become entrenched.

The research question asks how multiple and contested concepts of nature play a role in plant breeding. What ontologies of plant-human interaction are inhabited and performed by breeders? This sort of question has often been approached through ethnographic methods that afford opportunities for participant observation and thick description. Because of constraints of time and access, I was only able to incorporate ethnographic methods to a limited degree, and relied primarily on interviews. As ontological concepts of nature are not always consciously theorized by individuals, close readings of the interview transcripts aided in developing an understanding of their dynamics.

Grounded Theory

My research methodology has drawn heavily on the Grounded Theory of Glaser and Strauss (1967). To avoid any confusion arising from the ambiguous use of the term “Grounded Theory” in the research vernacular (Gibson and Brown 2009), it is perhaps best to simply state that there is a significant “bottom-up” component of *theory generation* in contrast to “top-down” *theory verification*. As such, I did not engage in data collection aiming at proving a particular hypothesis about concepts of nature among plant breeders. Rather, I began with a more general field of inquiry, and allowed the research questions to narrow in specificity based on the data.

Though I adopt Glaser and Strauss’ techniques of memo writing, theoretical sampling, coding of categories and reflexive reiteration of the research questions, my approach differs somewhat in that I began engaging with existing literature at an early stage. According to Gibson and Brown, such modifications of the original Grounded Theory are common, given the demands of research proposals early on in the research process. Furthermore, in agreement with critique by Charmaz (2006) and Clarke (2005) of a positivist epistemology of the original method, I have adopted their constructionist variations of Grounded Theory. Although Mills et al

(2006) ascertain a constructivist element in the work of Glaser and Strauss, these developments are not really particular important here. What does matter is a recognition that both breeders' concepts of nature and my own interpretations of those concepts are generated through a constructive process, rather than being objective representations of ontological or social reality. This is not merely a philosophical stance on the nature of reality, it also directs the research process - by focusing attention towards the processes through which those ideas are constructed.

Other Methodologies

Because of a background in anthropology and experience with ethnographic methods, I have tried to maximize participant-observation techniques when possible, supplemented by interviews for more focused inquiry or when access was limited. Ethnographic methods were favored not simply for providing insight into the emic, "insider's view" (Emerson 1983) of meaning creation, but also in generating a thick description (Geertz 1973) of what I've been calling the breeding nexus. Participant-observation is contrasted with sociological techniques in which the researcher remains objectivity and epistemologically outside the field of study. Instead, by participating in breeding activities alongside professional plant breeders I sought to understand these breeding activities as they unfolded in practice, in addition to as recounted in interviews.

The thesis research has also been influenced by Science and Technology Studies and the environmental humanities, less in terms of specific techniques than in cultivation of particular sensitivities. Science and Technology Studies (STS) emerged from the ethnographic work of Bruno Latour (1987) on laboratory practices, and has since examined the practices of scientists in many contexts (e.g. Puig de la Bellacasa 2011). Much of this work is critical of "technoscience", and demonstrates how the everyday practice of science often runs counter to objective, apolitical narratives of scientific endeavors. My alignment with STS lies less in this critical stance, and more in the way that STS scholars have opened up the constructedness of scientific knowledge as a valid concern for social scientists.

The environmental humanities is a much newer field, and has largely featured the work of philosophically inclined anthropologists who see a need for uniting the methodologies of social science, natural science and the humanities towards contemporary environmental crises. Their work is ethnographically grounded but engages with questions that have traditionally been the purview of philosophy and cultural theory. A major theme has been the ontology of nature/culture distinctions, and how these have functioned cross-culturally and throughout history.

> *"The environmental humanities positions us as participants in lively ecologies of meaning and value, entangled within rich patterns of cultural and historical diversity that shape who we are and the ways in which we are able to 'become with' others" (Rose et al 2012)*

STS and environmental humanities have been less influential in terms of adopting concrete methods, and more in developing particular sensitivities and attunements - towards the constructedness of scientific knowledge and the dynamics of nature ontologies.

Ontology

My use of the word *ontology* is intended to situate this work within the broader ontological turn in the social sciences that has been so prevalent in the last decade or more. The diverse works that fall under this theoretical movement are notoriously difficult to characterize in a concise way. As Eduardo Kohn writes, the movement "cannot be circumscribed by any single intellectual or social context" (Kohn 2015). Kohn notes that some work in the ontological turn is *metaphysical*; that is, concerned with concepts - "identifiable styles or forms of thought that change our ideas about the nature of reality", while others are *ontological*, in that they make specific claims about reality itself. Many are both. Both speak to the fact that the ontological turn has been in many ways a reaction to social constructionism. According to Kuhn's schema, my research has been for the most part metaphysical. Especially in the data analysis section, it is concerned with ontological concepts about plants and nature, and not with making general claims about plants or breeding activities themselves. However, parts of the interpretation section do occasionally touch on issues that are ontological rather than metaphysical, and here I have been guided by scholarship in the tradition of ontological anthropology. Indeed, Morton Pedersen (2012) argues that the movement between metaphysical, ethnographic descriptions of others' ontologies on the one hand and scholars' own expositions of the world on the other is one of the key contributions of the ontological turn.

Thomas Kuhn prefigured the ontological turn in important ways when he wrote that scientists working within separate paradigms did not hold different representations of a single material reality, but that for all intents and purposes, they actually inhabited and behaved in different worlds. Both Kuhn (and myself) would hesitate before making the ontological claim that these different worlds *actually exist*, without certain qualifiers. As far as my own research is concerned, the methodological significance is that scientists (and everyone else) acts as if it is true. As diverse as the ontological turn is in terms of theory, it is generally opposed to what Pickering (2017) calls the *representational idiom* - the idea that culture, beliefs, etc are simply representations of a single material reality. Scholars in the ontological turn often speak of "taking seriously" the ontology of others (de la Cadena 2015). This seriousness is a methodological approach, not a judgment on the reality or unreality of another's lifeworld. The representational idiom collapses the ontology of the other, focusing on its context and social construction, while the ontological turn seeks to explore the richness of that ontology and how it informs a whole way of being (or an activity like plant breeding).

I have tried to incorporate the insights from the ontological turn not as a replacement for social constructionist theory, but as a way of tempering its excesses. In the present research, that has meant attending both to breeders' ontologies of plants and nature in a rich and serious way, and to the processes whereby they are constructed.

Additional Considerations

Reflexivity - Reflexivity on the research's subjective role in knowledge creation has long been central to ethnography. Here it was especially important to consider my own biases, due to my own previous involvement and alignment with groups and organizations that are highly critical of modern agriculture.

Social science has a legacy of portraying the practices of technoscience in a negative light - most notably during the “Science Wars” of the 1990s. Thought it helped that I myself had some background in the physical sciences, I still made an effort to engage in interviews with all the empathy and humanity I could muster. Furthermore, the fact that genetic engineering is the subject of heightened controversy meant that I needed to proceed with extra sensitivity while interviewing university breeders who have been subjected to abuse and attacks by activist groups.

Limitations - Most of the research limitations were due to lack of time, logistical complications and simple lack of foresight on my part. Due to previous experience doing ethnographic research with the university department of Terrestrial Ecology, I had assumed that I would be able to accompany university breeders in laboratory work and field trials. However, more stringent security measures were in place in the plant breeding department, and so I had to settle for conducting interviews. Thus there is a source of bias in that fieldwork with farmer-breeders consisted of both interviews and participant-observation while with university breeders it was limited to interviews alone. I have tried to remain cognizant of this through the process of data analysis.

Methods

Data Collection

The primary method of data collection was through semi-structured interviews, supplemented by participant-observation. I would have preferred a more predominantly ethnographic approach - because of my experience and confidence in such methods - but was limited by time and access to university breeding projects. In the end, the data collection included 13 formal interviews of 1-2 hours, a number of shorter, informal interviews, and a two-week period of participant-observation at a biodynamic vegetable breeding farm.

Interviewees: Most (9/13) of the formal interviews were with breeders from the planet breeding department at Wageningen University, and they have been the focus of my study. This was partly determined by access (as I was living near campus), but also of design - I wanted to focus on one segment of breeders more deeply, while also taking a sampling of breeders operating in different contexts. University breeders proved easier to contact and meet, as well as being more open to interviews than breeders at private companies. Even within the group of university breeders there was significant diversity. Some had backgrounds in weed science, biology or ecology. One was head of a small organic breeding department. Some did conventional breeding, some used trans- or cisgenic techniques, and one worked with new gene editing technologies. Of the non-university breeders, two were breeders for private companies: one that bred varieties for organic farmers and one that was focused solely on producing hybrid varieties of potato. One breeder worked at a private research institute which had originally been associated with biodynamics but now worked with organic agriculture more generally. Another had been working mainly with development agencies in Africa. I also interviewed a philosophy professor who has worked extensively with the plant breeding department. Despite

the broad range of contexts in which these breeders worked, in terms of demographics as a group they were quite homogeneous. All but two were male (the two females were both organic breeders). All were white (two from Germany, the rest from the Netherlands). All but one were at least middle-aged. This predominance of older, white males in my interview subjects is also reflected in the Wageningen plant breeding department itself, and was something I failed to account for in the research design. Recommendations for further research would include greater demographic breadth in sampling.

Interview Strategies: Interviews lasted about 90 minutes on average, and most were within the range of one to two hours. With one exception they were conducted face-to-face, usually in the office of the interviewee or in common areas of the plant breeding department. The one exception was conducted via Skype. All interviews were done individually, rather than in groups, though especially with the university breeders they were aware of who else I had been interviewing, and often made reference to the work or ideas of others in the department. Most interviews were recorded and transcribed with the permission of the interviewee, although technical trouble with the recording device forced me to rely on handwritten notes in a few cases. All interviewees understood that they would remain anonymous. This was especially important due to the sensitivity of topics relating to genetically modified crops. I did not use a structured set of questions, though I did have a set of topics that I guided conversations towards. This conversational style seemed to help develop rapport, as did demonstrating that I had a certain technical understanding of modern breeding techniques. University breeders tended to associate antagonism towards genetic modification with a lack of scientific knowledge by "the public", and so proving some degree of scientific and genetic literacy helped to allay suspicions that I was ideologically anti-GMO. Interviews were guided towards the following topics:

> characterizing the history of plant breeding

> the significance of farmer breeding today

> what distinguishes the different approaches to breeding

> non-technical dilemmas faced in their breeding work

> vision of what direction breeding will go, and what direction it should go

> how new technologies affect the experience of breeding

> whether certain breeding techniques are more natural than others

I also found the semi-structured format helpful in that it allowed space for interviewees to speak on issues that they felt were important. Often these were emotionally charged issues, which was significant in that ontology is composed of affect as much as language.

All recorded interviews were transcribed using transcription software (InqScribe).

Participant-observation: Participant-observation occurred primarily over the course of two weeks, during which I worked as a volunteer with a biodynamic farmer-breeder. I also made shorter visits to the fields of other farmer-breeders, as well as to the headquarters of the biodynamic breeding association that they

belonged to, located in central Germany. While working at the farm I also lived and ate with the family, allowing not until abundant opportunities for questioning but also a chance to observe how the breeding work interfaced with the domestic sphere. The farm was also involved with a project sponsored by a Dutch chain of grocery stores, aimed at increasing consumer awareness of different vegetable varieties. At one point the company's board visited the farm to see the breeding operation and conduct a taste test of bean varieties, during which I was able to speak with some of the company executives. There was also a collaborative project with a breeder from an organic research institute who came to check on trials several times during my stay. The presence of individuals from so many different contexts interacting with the same field allowed me to observe a great deal of variety in how they related to it.

Data Analysis

The purpose of the data analysis has been to discover meaningful patterns in the way that concepts of nature play a role in plant breeding. These patterns have been explored on three levels, as distinguished in the research question and subquestions: the composition and properties of the concepts themselves, their relationships with each other (continuities and disjunctures), and in their relationship to practice.

The process of analysis has consisted of (1) generating categories by coding interview transcriptions and fieldnotes (2) fleshing out the characteristics of each category, what Glaser and Strauss (1967) call a category's "properties", and (3) exploring relationships between categories, specifically what I call Continuities and Disjunctures. Codes were extracted from the interview transcripts and fieldnotes, rather than being formed a priori. This process involved reading carefully through the transcripts and fieldnotes, generating a numerical list of categories that spoke to the ontology of human, plant and nature, and marking specific quotes and fieldnotes according to the coding system. One challenge was deciding on using fewer, but more general categories, or to use a greater number of more specific ones. Eventually I settled on a system that seemed well-balanced. In some cases I included numerous variations on a theme under a single heading. These categories were further divided into narrative (termed *narrative fragments*) and non-narrative (termed *themes*). Narrative fragments were those categories with a subject-preposition form. For example, Mendel's discovery of inheritance laws fundamentally changing plant breeding was a recurring category, with a narrative structure. On the other hand, the idea that the naturalness of a crop variety is determined more by it's physical form than by the process through which it was formed constituted a non-narrative theme. The initial categorization and further distinction between themes and narrative fragments could certainly have been done differently; my decisions were based on what seemed most conducive for analysis. After generating this list of themes and narrative fragments I returned to the transcripts and fieldnotes to analyze how each fit within a context of practices and of other themes.

Narrative "fragments" were defined as such because they only constitute pieces of stories, rather than entire narratives. Different breeders arranged these fragments together in different ways to form deep stories of plant breeding. Following the analysis of the themes and fragments, I show how they might fit together to form such deep stories, stories that hold particular implications for the way that breeding should be done in the present. The construction of these deep stories is based on the earlier analysis of continuities and discontinuities between the different narrative fragments.

Data Analysis

My analysis of the research data is divided into several components, and is built primarily out the process of coding interview transcriptions and field notes. It begins with (1) the exposition of several non-narrative themes that recurred throughout the fieldwork. Though I have oriented the analysis around accessing breeders' conceptual architecture through narrative fragments, these themes were coded categories that, while not conforming to a narrative structure, seemed too important to leave out because of their bearing on relevant ontological questions. Secondly I attend to the (2) narrative fragments themselves. This mode of analysis was inspired by sociologist Arlie Hochschils' (2016) attempt to bridge the "empathy gap" between liberals and conservatives in the United States by constructing the *deep story* of each group. Throughout the fieldwork I noticed striking resemblances to the debates over transgenic plant breeding, where individuals occupying opposing positions also seemed to inhabit different deep stories. Collecting narrative fragments has been the first step in understanding *plant breeding deep stories*. Following Gell (1998), I take a narrative fragment to consist of an agent-action-patient relationship. Furthermore, the choice of subjects to be taken as "agents" is not to be seen as a proposition concerning their capacity for intentionality and affect (in the case of "inanimate" objects/ideas), but is rather about their being *experienced* as agentive - for example with markets, corporations, technology, etc. In the exposition of both themes and narrative fragments, I focus my analysis on their *properties* and *continuities* and *disjunctures* with other categories.

Themes

Product/Process

> *"So you can, in a very artificial matter, you can get very close then to a product that looks like a natural product. Then you get this product/process" (university breeder, gene editing)*

"This product/process" distinction arose, unprompted, in nearly every interview. It also clued me in to the possibility that even for those who claim that questions of naturalness are outside the purview of scientific breeding, such questions can emerge in other forms. The distinction is essentially one of identity - if two plants are identical in form but have emerged from radically different processes, are they equivalent? Can a plant variety still be "natural" if it was developed with the use of "unnatural" techniques? Sometimes the distinction was deployed as a polite dismissal, as a simple way to explain the disjuncture between the approach of the organic breeding minority and the rest of the department,

> *"We have a very small group of organic plant breeding. They don't want certain techniques to be used because then it's not organic anymore and it's not natural anymore so to say, so they use natural processes. And so its not looked at from a product point of view but a process point of view" (university breeder, conventional breeding)*

I interpreted this as a strategy to remain respectful to the organic breeders without deeply engaging with the quality of the difference. Those who placed importance on process were also described as following a "values-based" ethics that was beyond reach of rational debate, in contrast to the utilitarian or consequentialist ethics that the other university breeders espoused.

The description of a minority of organic breeders as "process" oriented implied a self-identification as "product" oriented. Indeed, among the majority of university breeders the question of naturalness seemed most relevant when discussing varieties developed by various plant transformation techniques (transgenics, gene editing, etc), and their equivalence to so-called "products of nature". As such, arguments by activists that transgenic techniques are unnatural were seen as easily countered by the example of *Agrobacterium* genes discovered in non-GMO sweet potato (Kyndt et al 2015), proving that transgenic processes also occur "in nature", even in major crops. Thus, the discovery of an equivalent *product* "in nature" was taken as a sufficient counter-argument, despite the fact that vastly different *processes* had contributed to each.

It was in relation to new breeding technologies - cisgenesis and CRISPR-Cas - that product/process thinking emerged most forcefully. Cisgenesis uses transgenic methods, but does not cross any reproductive barriers. More specifically, it uses *Agrobacterium* but only to introgress genes from plants that could theoretically have been crossed. A number of breeders I spoke to at the university had just completed a 10-year project using cisgenesis to insert multiple late-blight R (resistance) genes into potato.

> *"What we've developed here in Wageningen is cisgenesis, trying to make that pretty much free of any agrobacterium vector sequences and sequences which don't belong there, and using genes which are not so synthetic and actually come from other potato cultivars, lets say wild types" (university breeder, gene editing)*

Why are the products of cisgenesis techniques seen as more natural? Certainly the process itself very closely resembles that of transgenic methods. Rather, because the product could theoretically have occurred using classical breeding techniques, it is perceived and presented as more natural (even though the speakers elsewhere describe classical breeding as fundamentally unnatural). It is not even necessary to dwell theoretically on that possibility, because an organic plant breeding group is in fact developing a variety using the exact same resistance genes. They, however, see the cisgenesis *process* as still unnatural and are using classical methods of backcrossing. Nevertheless, the organic group makes welcome use of genetic markers developing in the cisgenesis project, markers developing using techniques they reject as unnatural. Thus, they are in a situation of overlooking the *process* used to generate the markers in favor of their usefulness as *products*.

The latest gene editing techniques like CRISPR-Cas go even farther, because its products are completely indistinguishable from "naturally" induced mutations (whereas transgenesis and even cisgenesis still leave some vector traces of the process)

> *"There's a lot of technology used, but the product is not really special. It could have - through a single sunbeam - could have created the same mutation. So how alien is a CRISPR product?" (development agency breeder)*

With gene editing, the contradiction between product and process was forced to the surface and could not be glossed over. The plants developed using CRISPR embody this contradiction.

> *"You can put in the same genes as in the plant in the agrobacterium, and the only difference then is that the gene is put at a random site in the genome. There comes the technology again, if you have these targeted mutagenesis systems, you can put in the cisgene in a place where another resistance gene. You exchange cisgenes so you can - in a very artificial matter - you can get very close then to a product that looks like a natural product" (university breeder, gene editing)*
>
> *"It's beautiful genetic engineering. It's wonderfully, you know, it's very elegant in it's approach, but it's far from being natural. The product in the end is fairly natural, because it could have also presumably occurred in nature. It would be silly to try and say that somehow this is a really natural way of doing things. No it's not, it's not at all. It's highly engineered and elaborate and sophisticated. But the product in the end is closer to natural than anything else we've done up till now" (ibid)*

These are also questions that are tightly entangled with frameworks of food safety and intellectual property protection. A genetically engineered product may be equivalent biologically, but because of the machinations of capital that propelled the process, it may *behave* economically, socially and legally in an entirely different way. Here the commodity form comes to transcend the product/process dualism. The regulatory frameworks in the United Sates, with their doctrine of *substantial equivalence*, are relatively product-oriented compared to Europe where more varieties are allowed to be cultivated depending on the processes by which they were developed.

Plant Boundaries

If a breeder were to do something “unnatural” to a plant or plant part, is that an ethical wrong? Certainly all of the discussion around plant breeding and naturalness would indicate at least the possibility, or it wouldn’t be worth debating. But who exactly is being wronged? The individual plant? The species? Nature as such? I noticed at least four distinct ways of drawing boundaries - both ontological and ethical - around plants.

Encompassed - This is the view corresponding to the Western materialist tradition, whereby plants do not constitute ethical subjects at all. In a sense they are “encompassed” (Dumont 1980) by the human domain. This was also the view that most mainstream plant breeders seemed to adhere to, as well as some in the organic field. Even when these breeders spoke in favor of restraint or precaution regarding breeding techniques, it was because of human or ecosystem health factors, power issues or social considerations. “Harm” to individual plants was not a factor, and it would be questionable whether such an idea holds any purchase at all. Thus, while the material boundaries of plants are clearly defined (one might say hyperdefined), their ontological and ethical boundaries are encompassed by the human sphere.

Species Level - This is the position held by various anti-GMO activists as well as conservative Christian groups in the Netherlands, who hold boundaries between species to be sacred. In fact, transgression of the species barrier by transgenic techniques constituted the primary reason for the Dutch Christian Reform Party’s opposition to genetic engineering. One of the university breeders working with cisgenesis told me that the

Reform Party had just announced that they accepted cisgenic products because the introgressed genes came from within the species barrier.

> *"This person…said if…God has created the world and he has decided to have different species, [a] human being is not able to mix these species. So if we have genes from wild potato species and these wild potato species are able to cross with the potato we are eating, then cisgenesis - you can do the same in the laboratory with genetic modification, then it's better acceptable than if it's a gene from a jellyfish" (development agency breeder)*

In this case perhaps the ethical boundary is not only between species and taxonomic groups, but between humans and God, or humans and Nature. Also there is some ambiguity here about whether it is a boundary between species in the taxonomic sense or a reproductive boundary.

Cellular Level - Organic plant breeding in the Netherlands has very well defined ideas concerning what they call Plant Integrity. These emerged out of a series of meetings held to arrive at a consensus on a specifically organic way of doing plant breeding. They indeed take reproductive barriers to be more meaningful than species barriers.

> *"Plants are more fluid in crossing barriers between species - where in the animal it's much more strict…so there the borders are a bit more fluid - so we then use the not the species borders as criteria but the reproductive barriers should be respected so you adjust" (university breeder, organic)*

Besides these *horizontal boundaries*, the organic rules also recognize what might be termed a *scalar boundary*, at the level of cell membrane. Techniques which operate at the cellular scale and pierce the cell membrane are not allowed, which prohibits not only transgenics, cisgenesis and gene editing but also cytoplasmic male sterility techniques.

They also make it clear that these prohibitions rest upon intrinsic values of recognizing the plant as fully Other, in the way that encompassing ontologies and ethics do not.

> *"Each individual deserves respects because of his otherness, his autonomy…so the integrity is the wholeness, the otherness" (ibid)*

The biodynamic ontology of plants shares some of the qualities of the previous ones. Crop plants are in some sense encompassed in the human sphere because they are part of Culture, rather than Nature. Nevertheless they remain fully Other, whole and deserving of ethical consideration. Those I spoke to generally agreed with the organic ethics, as well as the prohibitions against particular techniques. CRISPR-Cas was often in the news during the time of my fieldwork, and biodynamic breeders were especially vehemently outspoken against it.

They also saw an additional boundary, one that defines the farm as an individual entity. Hybrid seeds transgressed this boundary because they forced the farm entity to rely on yearly import of seed from outside the farm. For this reason, biodynamic breeders only worked with open-pollinated varieties.

The opposite of nature (relative vs absolute)

> *"…and when you say what do we consider natural, is unnatural, by definition, wrong?" (development agency breeder)*

What is the opposite of nature, and what is the relation between the two? With the exception of the biodynamic breeders, nearly everyone I spoke to used the word “unnatural” to describe processes or products that were “not natural”. I found this somewhat surprising, because in anthropology we are accustomed to arguments that oppose nature and culture. So why the prevalence of the word *unnatural*, emphatically defined in the negative, against nature?

In the case of activist rhetoric, it is quite understandable. Here the word is deployed with its strongly judgmental connotation. In this sense, unnatural things are those that do not belong, that offend simply by virtue of their existence.

There is another sense of the unnatural, one used by some of the scientific breeders who called agricultural in general unnatural. Here Nature is the supremely conservative space - natural processes are law-bound (to the Laws of Nature) and predictable. By contrast, Unnature becomes defined as a zone of freedom, where truly novel events can occur as a result of human intervention.

> *"Agriculture is not natural - nature would never put 160,000 bean plants in one hectare - even if you have intercropping, five or six in Africa, 10 crops in one field - that is not similar at all to a natural ecosystem" (ibid)*

On a few occasions, I noticed use of the term *artificial* as the opposite of natural.

> *"Well at least in the Netherlands much of the nature in the Netherlands is also artificial" (university breeder, conventional)*

> *"So you can - in a very artificial matter - you can get very close then to a product that looks like a natural product" (university breeder, gene editing)*

In contrast to unnatural, the negation of natural, *artificial* is positively defined. It is also a quite different word than *culture*. Culture is a domain, within which multiple actors engage and transform themselves and each other. *Artifice* implies a single act and a single actor - a single event of invention. It also connotes that artificial takes nature as its model, and is therefore in a hierarchical relationship of representation to it.

Culture, at least as used by the biodynamic breeders, is not really an opposite to Nature so much as its interdependent complement. It is a separate sphere of activity, one that is profoundly anthropocentric (in the sense of being organized around human activity). Nonhuman beings in the cultural sphere derive their meaning and utility via their relationship to the human order. A biodynamic breeder in Germany distanced the group from anti-GMO activists, by emphasizing the importance of not only protesting but also being *"for something"*.

As for the relationship between Nature and its opposite, this was expressed in either absolute or relative terms, and in several cases I noticed the speaker switching between absolute and relative oppositions during a single interview.

> *"Well you can say that everything that humans have done since the start of agriculture is unnatural - or you see the human as part of nature" (development agency breeder)*

> *"Making a cross between two plants, which is the start. Or even before that, just selecting, well maybe* more natural" *(my emphasis) (ibid)*

Boundaries of breeding

University breeders often appeared internally conflicted about whether breeding work could be considered independently of its political, social and economic context.

> *"There will be the Monsantos and the other who will do it of course for profit - but that's something independent of genetic engineering - there's always this mix in my mind of this corporate colonialism to try and you know conquer the world, which is a bit irksome and probably something that you can criticize - but separately there's the question of the technology you use to make something better, and that should be seen separate, although of course it can't be because the large companies are gonna be the ones who are gonna be implementing" (university breeder, gene editing)*

"..that should be seen separate, although of course it can't be" perfectly encapsulates this contradiction. Why insist so strongly on the independence of science and then immediately give evidence against it? Another university breeder remarked that he and many others in the department wanted to breed for mixed cropping systems, but that the private companies they were dependent on for funding weren't interested in those traits. Later he said that private industry didn't have undue influence over the university, only that he was worried they were getting too large. This happened during other interviews as well.

Challenges to the objective authority of science were met with surprise,

> *"Greenpeace was very critical about our report, Monsanto was very critical about our report, and at that time I thought 'oh what's happening!' And I needed some time together with colleagues to realize that if Greenpeace is against, if Monsanto is against - if Monsanto is critical. Being a scientist you need to be independent of all those views - you need to do your own job" (university breeder, cisgenesis)*

On the other hand, the same breeders expressed convictions that they as scientists should be very much concerned with the ramifications of their work,

> *"We really need to think about it - what should be good - and not always thinking what is possible should be ok. We should think about you know, is this what the world, society benefits from or not. And if so, then we should explain it also to the people who eventually will be buying the foods and the plants that was produced in that way" (university breeder, conventional)*

This is not an accusation that breeders are hypocritical in any sense, but rather that there exists some kind of tension between breeding as an activity and the way that it interfaces with broader contexts, and that this tension is something that is consciously acknowledged by breeders themselves. How do breeders negotiate - mentally and in practice - the boundaries of breeding work?

In the biodynamic group of breeders, one approach was that of *insulation*. Starting from the assumption that market demands have an influence on the breeding process, breeders are paid a flat rate by the organization, rather than depending on royalties, which might orient their breeding towards what sells well, rather than what is (defined as) *good*. Nevertheless, farmers' needs are still considered important, and the central organization becomes a mediator between this kind of information, market pressures, and the breeders. On the other end, the farmer-breeder who with I did my fieldwork was also working closely with supermarkets to encourage awareness of varietal diversity in shoppers.

Another boundary issue was whether breeders saw questions of naturalness as being relevant to their work. Among university breeders, the general consensus was that no, it did not - *"they don't think it's a topic"* - at least until they were forced to confront it by "external" forces.

> *"Most plant breeders don't worry about it [naturalness] - until they are confronted by for example the organic movement that says GM is a no…[because of syngenesis] suddenly normal plant breeders are confronted with these kind of questions" (development agency breeder)*

There was however, one example of a case where a Dutch breeding company that decided not to use CMS technology, not because of any regulatory pressure but because of an internal decision.

"I wanted to say that they don't really think about this, plant breeders…some person came up with CMS - and they said, we don't want to use that - because either because we think it's not natural, or maybe also because they may have thought there will be some opposition against using this at some stage and then we lose our business…all the other competitors moved to CMS and they didn't - it was more expensive to develop good hybrids using the old methods - but they consciously did not start that work - because they considered it more - a bit GM like and they didn't want to use it and they still don't" (ibid)

Intimacy of Food

"People are afraid of eating genes!" (all university breeders)

A final theme is that of the apparently inexplicable, irrational relationship people have to the food they eat. Most of the university breeders I spoke to brought up a recent report that found many Dutch people were "afraid of eating genes", which was seen as evidence for either ignorance or ideology - in any case *not science*.

"Youngsters who are really focusing on 'I want to eat very healthy' … but it is losing any relevance any more - or it's going crazy - there is no real scientific fundament for it - it's a sort of almost religion" (university breeder, cisgenesis)

In many cases it was opposed to the medical use of either transgenics (e.g. in producing insulin) or CRISPR-Cas (to eliminate point mutation genetic disorders).

"Even if you ask people if your child is very ill and it can be treated with for example CRISPR-Cas what would you feel about it - I haven't met a parent that will say no - if you ask such a people in the market would you like to eat a tomato with a controlled mutation technique, now it might depend - so there is something special with food" (ibid)

"Why do we not care to put it into our body and we do care put it into our mouth?" (development agency breeder)

One proposed explanation was that food is deeply entangled with identity.

"It's more even than lifestyle - it's a sort of identity" (university breeder, cisgenesis)

"Food - how do people view food - because that's much more than the jeans you wear - a plant product - so it's something you internally put into your mouth and you eat - so this view of food as something that's very intimate in terms of your contact with it - it becomes you" (university breeder, gene editing)

Narrative Fragments

Neolithic humans - genetically engineered - plants

"Plant breeding starting 10,000 years ago - farmers selecting, etc- that's how we got our crops - which are different from the natural species - if you ever saw a wild tomato plant you would not recognize it as a tomato, with tiny little berries" (philosopher)

Although it appears to be a single fragment of narrative, this single activity implies an entire story. I first heard this idea while visiting the Monsanto offices, saw it again in their published history of plant breeding, and came to find that in the university all the breeders were familiar with and accepted it.

"I agree with Monsanto that people are manipulating the cropping and the genetics of the plant themselves already for a very long time - and this is a - yeah lets say the classical way is even more black box than what they can do nowadays with GMO now they can kind of trace exactly this part has changed - and so in fact yeah I actually agree with them - yeah I think that's a good way of putting it and I think agriculture in itself is not nature - it's against nature in many many aspects" (plant breeder, conventional)

The telling of how Neolithic humans genetically engineered crop plants is generally accompanied by the dramatic juxtaposition of wild relatives with the domestic forms we are familiar with. Usually this is either maize compared to teosinte or tomato compared to wild *Lycopersicum*. The effect of this is multiple. First, it shows that pre-modern humans had dramatically altered the form of certain plants, implying that modern techniques of genetic engineering are not particularly exceptional. Secondly, it posits the “break” from a state of nature 10,000 years ago, and so because plant domestication is *already* unnatural, arguments that modern genetic engineering are unnatural are baseless.

What follows logically from this narrative element is that subsequent developments in plant breeding do not change the activity or relationship between human and plant in any fundamental way, but are simply adding

new tools to make the process more efficient, precise or “scientific”.

> *"I see both genetic modification and transgenesis but also the new plant breeding technologies as just a new step in filling the toolbox for breeders - like genomics - so there is not for me a principle difference" (university breeder, cisgenesis)*

Variation I

An extension or variation of the narrative fragment is that because the development of modern breeding was a quantitative change towards more precision and scientific understanding rather than a qualitative shift, it accentuates the unscientificness and imprecision of pre-modern breeding. Because modern genetic engineering is presented as safe because of its precision and depth of scientific understanding, pre-modern breeding takes on a quality of danger.

> *"I believe that the whole trial and error process of 10,000 years is more dangerous than whatever Monsanto does - in the sense of really dangerous because what happens a lot was that - on a chromosome there are different traits - and we are interested in only one thing - so we enhance it - but at the same time - not knowingly we also enhance other traits that are not so favorable for us" (philosopher)*

Variation II

A second variation portrays initial domestication and pre-modern breeding as less anthropocentric and also less focused on conscious manipulation. This is a view espoused by many recent discussions of domestication in the literature (source), but also presented by some breeders. Here there is some agency both for the plants and for the unconscious.

> *"Consciously probably, they selected for bigger seeds - that's probably has been from the very start conscious selection - there's both - and then of course at the same time natural selection pressures were on the same plants - and probably by putting more of the same plants together, even natural selection worked to create more resistant plants - because the less resistant individuals died or did not produce offspring - like in nature - so all these different pressures come together - conscious unintentional and natural selection" (development agency breeder)*

The biodynamic concept is an extended version of this, because instead of plants possessing a rudimentary or metonymic agency, their agency is considered equivalent (if radically other) to human agency. This concept has significant implications, one being that a plant breeder is obliged to open him or herself to perceiving the plants’ “desire to become”.

Humans - made themselves - (agri)cultural

This second narrative fragment is quite similar to the first, though more abstract and expressed with less rhetorical flourish. Indeed it might be considered a subtext of the Neolithic genetic engineer narrative. Here the subject is humans in general rather than pre-modern plant breeders, and instead of making domestic crops they are making themselves and their zone of activities into something that is not nature. As such, not only plant breeding but all agricultural activity belongs to a realm defined as either cultural or unnatural.

> *"I think agriculture in itself is not nature - it's against nature in many many aspects - you clear away all the others and you force the plant to grow there - the plant that you want to produce and this plant is unnatural because you know it puts way too much effort in this harvested product - and by the end of the growing season it's probably exhausted and etc - so it's a very unnatural system - and I'm not saying that modern varieties are weak - but they are not nature" (development agency breeder)*

> *"Is plant breeding natural? - it's a question that I find challenging - and my conclusion in a one-liner is that plant breeding is as natural as agriculture itself - because agriculture is not natural - nature would never put 160,000 bean plants in one hectare - even if you have intercropping, five or six in Africa, 10 crops in one field - that is not similar at all to a natural ecosystem" (ibid)*

Culture in general and agriculture in particular is taken as the product of uniquely human traits like rationality and invention. The biodynamic concept is quite similar, except that intuition also comes to play a role, still as a uniquely human capacity.

The expansion of this sphere reaches a point where Nature is considered not in terms of the broader context for human action, nor even as a complementary sphere to Culture, but as something reserved (in the sense of a nature reserve) and objectified (as an object of study) in enclaves that are both cognitive and geographical. This statement about how nature is made small is not particularly original, but it does hold relevance for thinking about plant breeding because it becomes easy to define a small, simple object in small, simple terms. The natural then, becomes defined not by biological processes or ecological relationships, but simply by the absence of human intervention.

> *"Basically all wheat varieties even up to today have the blood of that cross that was made 200 years ago between French wheat and Ukrainian wheat - is it natural to cross those two plants? - in nature those plants would never meet - because there's 3,000 kilometers - 2,000 kilometers in between - no it is people that brought the plants together…you open the flower and then, that is not natural, doing that - conventional breeding based on crossing and selection - it's man-made - it could happen in nature, one in a hundred million times - but we aid that" (ibid)*

Variation I

The variation - that humans live in and as nature - is actually the inversion of the initial narrative element. That is, it takes the very terms of the original and produces their opposite.

> *"Humans are not very different from...other natural organisms - we create an environment that suits us - we build a house - we build a roof over our head, that is not natural - is it then unnatural to do that? - no it's pretty logical to do that - agriculture you till the soil, you weed between the plants that you find useful - is that natural?" (ibid)*

Ideology - constrains - sustainable technology and practices

Most university breeders depicted their central aim as trying to make farming more sustainable, and their central dilemma as being constrained by reactionary, ideological and anti-scientific ideas. The word "religious" was often used as a pejorative to criticize positions that were not evidence-based.

> *"I want to use the best technology to make farming as sustainable as possible - and so that's mostly in conflict [with organic breeding]" (university breeder, cisgenesis)*

> *"For a long time I've also liked the idea of organic farming I still do - but at this point it's more like a religion than a technical solution" (private company breeder, hybrid potato)*

> *"I don't care so much about organic farming or type of farming - I think about sustainability - and if you can do it with GMO you should do GMO - if you can do it with organic farming - do organic farming - but sustainability that's the main issue - and that's why I call it religious" (ibid)*

The restriction on genetically modified crops in the EU was seen as the result of unscientific, populist sentiment, and as hindering sustainable farming practices in Europe.

> *"So this is really an example of that the EU is allowing a political situation in which new technology is restricted, frustrated, and that the results of this ten year program are at this point used the in US in several projects and that Dutch farmers are not able to get" (university breeder, cisgenesis)*

In fact, the EU regulations were noted to be “backfiring” on activists because they result in a situation where a great deal of capital is needed to pursue breeding and therefore drive consolidation of the industry.

Greenpeace and other similar organizations were seen as taking unscientific positions against genetic engineering, and that their influence was constraining progress towards sustainable breeding.

> *"When I talk with Greenpeace I always ask what kind of ethics are we following - is it this belief which I respect - or is it pros and cons - he always says no not belief it is pros and cons and we can - but then you are able to talk in this way and then the position of Greenpeace is from a scientific point of view difficult to confirm to base to support" (ibid)*

> *"We said Greenpeace you are neglecting scientific developments and there are sustainability costs linked to that - and so there is you see that there is more people starting to get critical opinions if there is an NGO which simply takes populistic [stances]" (ibid)*

The breeder working with gene editing related how he used to be heavily involved with the Green Party and started working with transgenics in the early 1980s because he saw it as the best way to reduce herbicide spraying. He described feeling *“seriously pissed off”* and leaving the Party after they wrote a manifesto against genetic engineering.

I found the emotional intensity with which the breeders expressed these experiences interesting and important, especially because they often told how other sustainability goals not connected to genetic engineering (breeding for mixed cropping systems, or for mycorrhizal associations) were also being hindered by lack of corporate support. Why did the anti-GMO arguments trigger such responses when more structural constrains did not? My guess is that this is partly due to the “naturalization” of capitalist processes, partly due to “religious” thought providing an easy foil to the objective, rational self-image of science, but mostly because the accusatory tenor of the anti-GMO movement provokes a defensive stance in the breeders.

<u>Variation I</u>

The public is against genetic engineering not out of ideology, but of ignorance.

> *"As soon as you involve the general public then it's really a different story you have to go very basic" (university breeder, conventional)*

> *"Scientists are very very - they get carried away sometimes on the subject and they talk about metabolomics and genomics and these are all words that the general public cannot grasp - they are afraid of eating genes!" (ibid)*

"I also had people that were in fact crying - it shouldn't be allowed - I said what's the problem can you explain - people were really afraid of being poisoned or so or being changed from within by eating these crops - we have to start explaining from scratch you know" (university breeder, cisgenesis)

Variation II

This is actually the exact same narrative fragment as the original, but leveled in the opposite direction. Anti-GMO activists accuse the whole industrial-breeding complex (mostly companies but also universities) of contributing to ecological crisis and "ecocide" by following a neoliberal ideology that sees both plants and people as exploitable commodities.

Markets and anti-markets - exert selection pressure - on crops

This narrative fragment was touched on earlier in the theme on the boundaries of the breeding activity. Contrary to an "internalist" account of plant breeding, which sees development as the independent unfolding of the scientific method, it is seen as subject to social, political and economic influences. This point has long been argued by critical scholars and activists, but even mainstream plant breeders at the university expressed worry about consolidation in the industry.

"These breeding companies they take over each other - we now have only a few really that are very large worldwide - and that's not a good situation yeah - that's really a bad situation - but it's maybe an unstoppable trend… it's something that we do not feel comfortable about, also not in the department of plant breeding" (university breeder, conventional)

"If there is a trend to monopolies - for example in telecommunication in ict - there is even at the highest level of the European Union there is a secretary who takes care that there is still balance in competition - I think that's its effective in Europe - as far as I know, I'm a biologist - but what I already say for several years - we need such a person at this highest European level for food - for food production - because this is at this moment so important topic" (university breeder, cisgenesis)

There was concern that reduced public funding was increasing the influence of private corporations over breeding goals

"That's a general trend that the government the central funding goes less and less - and there should be more and more - at least 50/50 or 80/20 a combination of private funding - but you see sometimes mistakes are being made that cannot be or aren't reversed" (university breeder, conventional)

This breeder also said himself and others in the department thought that agriculture should move towards mixed cropping, and if there was funding for such breeding programs, that *"everyone would be willing to do that"*. However, none of the major breeding companies were interested in breeding for mixed cropping systems, and so breeding objectives were oriented towards traits like disease resistance in monocultures.

Regulation of genetically modified crops was seen as misguided, and that breeding companies should be regulated instead

"I often think it's much more about regulating the companies that essentially have a profit based motive rather than a societal motive in producing plants, that's what you've got to regulate" (university breeder, gene editing)

There was also the sentiment that market pressures could be used positively, with the example of stimulating food production after World War I.

"Then of course the products of plant breeding can be reproduced very easily - of normal plants, lets not talk about hybrids- because even a plant copies itself, you don't even need a copying machine…here in - well everywhere in the world - how can we stimulate plant breeding? - so what I have found, say just after the First World War - a movement came up - hey we need patents, we need protection - and the only protection that was there, from 1883 onwards is patents…in the late 1800s there was hunger in Europe - after the first world war there was no food - we had stimulate food production - and plant breeding was considered a very important way to stimulate food production - there was not much discussion about that at that time" (development agency breeder)

Technology is outpacing society

During multiple interviews, university breeders took out their cell phones and said that we should be worrying about them instead of genetic engineering. Though at first it seemed tangential, after a few times I began to think more deeply. Eventually it struck me that while they dismiss public fear about genetic engineering as irrational and misguided, they express the same feelings about other technology that they do not understand.

"My wife and I drive a car that is 23, 24 years old, without electronics - but I've been told that if you buy a new car at this moment there are all kind of sensors - and that might follow your life and you do not know - you have no idea what's going - and if your telephone - and I'm totally - very stupid in these things- but I've skipped all the connections and still I get a message that you need to leave - going to Utrecht - and it knows - it's very strange indeed" (university breeder, cisgenesis)

"I think in 1989 there was an American naturalist in Scientific American in such a journal - there was some special on GM - at that moment we were told be the lecturers this is a new technology and it will change the world and everybody was telling it - I think that expectations of new technology were a little bit too high - I think these telephones, they have changed the world - I don't think that for breeding we will get such - it's just a step in a continuation" (ibid)

Mendel initiates real/scientific breeding

The modern practice of plant breeding was sometimes presented as having a sort of double origin mythology. One was that of the aforementioned "neolithic genetic engineer". The other was the beginning of what was variously called 'true', 'real' or 'scientific' breeding - that is, the rediscovery of Mendel's work on inheritance around the turn of the century.

"Plant breeding has always been intuitive - but from Mendel onwards plant breeding became a science - and that's only from 1900 onwards - because Mendel's laws even though they existed already 35 years - they only became known in the scientific world in 1900" (development agency breeder)

Plant breeding was characterized as becoming more "conscious"

"Then we have 1860 Mendel - so he found out that you can predict to some extent the offspring of a cross - and then slowly slowly plant breeding started to be more conscious" (university breeder, gene editing)

Along with this was the idea that the first 9,900 years of plant breeding were "static", and after Mendel entered a phase of rapid "progress" linked to increasing intentionality,

"Now we are much more intentional because we know much more - we know about heredity, we know about plant physiology - we know agriculture is more focused on what we want to do - we plant plants in rows and not like that anymore, sowing - so we more consciously select for the cropping system that we want to develop the seeds for" (development agency breeder)

True breeding was characterized as the dual process of generating variation and subsequent selection, and so pre-Mendelian practices were thus not “real” breeding,

> *"So it wasn't real breeding it was just selection - and I think that was largely - well I think it was conscious but it wasn't with any knowledge of soil, day length - it was just a conscious selection of yes let's take ones that seem to yield a lot, which are nice big potatoes not millions of little tiny ones" (university breeder, gene editing)*

> *"Nearly all of the crop plants have undergone a domestication process where traits have been selected out initially just by selection and later on by crossing, which is then the true breeding process - so yeah so then that now goes into the really modern era where we have knowledge of the genes and how the crosses actually function" (ibid)*

This story is somewhat at odds with the Neolithic genetic engineer narrative, which emphasizes the intentionality and consciousness of pre-modern breeding. If there is no fundamental difference between the practices used to domesticate maize, to develop hybrid varieties and to edit genomes, then there can be no radical breaks such as that posited between a pseudo pre-breeding and real, scientific breeding.

Modern breeding - _____ - developing world agriculture

Breeders had many different notions regarding modern breeding in relation to agriculture in the developing world and Africa in particular. The conceptualization of this relationship is significant because the historical opposition of pre-modern and modern breeding is often transposed geographically onto the opposition of developed and developing world. That is, Africa today is often understood to remain in an older, more primitive “phase” of breeding (and development more generally). Because of this, narratives about the history of plant breeding are tightly linked to narratives about contemporary agricultural development through breeding.

Notably, breeders at private companies seemed to adhere to this idea most strongly.

> *"So then from a social point of view say we have to maintain this culture - but it's a very very poor way of living - so I think from a humanitarian point of view you can better just try to produce them in a way that is from an economic as well as from an ecology standpoint it's much more efficient" (private company breeder, hybrid potato)*

> *"I think this kind of farming might have been feasible 1000 or 2000 years ago when there was a very low density but still then I don't think these people were very happy in the way they were producing their food" (ibid)*

A breeder for a company producing hybrid potato seeds said that developing countries really needed these kind of high-yielding varieties, but that the “informality” of the current management of agrobiodiversity was a barrier

> *"These countries they have maybe 95% informal and you can only do this if you have a formal system - so there has to be a lot of changes in these countries" (ibid)*

Another breeder, who had worked for many years in Africa, saw things differently. We were mainly discussing the AGRA initiatives to bring modern varieties to Africa.

> *"This AGRA program is basically saying how can we make the formal sector work? - and they do it mainly by supporting local investments in seed production - so they even say - the Monsantos and the Pioneers, that is not the way to go, which I appreciate - say can we support local initiatives in the formal seed production sector, and by doing that they will disregard these farmer group ideas - they will disregard the informal one…it's a typical program with a way too stringent this is the solution this is what we're going to do" (development agency breeder)*

> *"It's naive - they have no clue about - they still don't have a clue about the diversity that is there in reality - all blueprint solutions in a complex thing like agriculture are stupid" (ibid)*

His proposal was for an “integrated seed sector” that included many systems, both formal, informal and somewhere in between. He was also very attracted to the use of local land races, but said that in the past few years climate change has been moving too rapidly for land races’ rate of adaptation.

> *"You need breeders - or farmers whose scope is wider than their own village, because they can't find the diversity within their own village, in such climate change" (ibid)*

A breeder from the university saw a socioeconomic benefit of transgenic varieties in Argentina was that farmers would have extra time to work another job.

> *"From an economical analysis you learn that if farmers use transgenic herbicide resistant crops they were able to save time so they could do another job - combine it, which is from an economical point of view very helpful of course" (university breeder, cisgenesis)*

Another was highly critical of arguments that terminator gene technology was a useful way to create a formal seed sector in Africa, just as patents and breeder’s rights had been proposed to stimulate plant breeding in Europe and North America

"People saying oh this [terminator technology] is beautiful - because there's no plant breeding in Africa - and because there's no protection on plant breeders rights etc, so who is going to fund plant breeding - of course the global community is doing that with the big plant breeding institutes, national institutes, etc - but it doesn't reach most of the farmers, etc- but this way you can create a business out of plant breeding and seed production - and then we said, this is not the way to do that" (development agency breeder)

Others saw participatory plant breeding as a solution,

"A way to improve their yields would be to say participatory plant breeding approach and I don't know so much about it but that would be a very nice thing to do because that would be another path let's say" (university breeder, conventional)

Laboratory work - _____ - classical breeding

This narrative fragment, closely related to the theme of product versus process, concerns the extent to which plant breeding is uniquely transformed by the "laboratory step". The very fact that certain varieties are referred to as GMO or transgenic indicates that the laboratory step dominates the identity of the final product, such that they give the impression of being fabricated entirely in the lab. University breeders were insistent on the point that the laboratory step is *"a minor addition to that system [of classical breeding]"*, although they also indicated trends towards a higher ratio of lab to field work.

"This combination of looking at detail measuring measuring and molecular work on the one hand and looking at the crop in the environment and saying this is good and that is - and plant breeding needs both - or needs both needs anyway that field step - because you're looking at something in an ecological environment - so you cannot do breeding only in the lab whatever they think, these gene jockeys" (development agency breeder)

As mentioned earlier, breeders said that classical breeding techniques will always be important in the development of new varieties, and that to some extent it depending on the breeding goals.

"If you have cisgenesis and the way the resistant genes were brought into the genome you have always still have variation and you always need to do your selections - in fact the same as with crossing - so the breeding work - what the person is doing in his field trials is exactly the same - only the variation is more focused but in fact its the same work - so I think that there is not really a difference" (university breeder, cisgenesis)

"Always breeders will need their intuition and creativity - and there will be many many breeding targets that will be better reached with classical breeding than with GM or site specific mutation - but there are I think some targets that you really get easier your result with genetic modification" (ibid)

Others also pointed towards the tension between the persistence of classical techniques and the trend towards increasing lab-based techniques, including the automation of phenotyping.

"Well you still need craftsmanship to perform these sort of experiments I think - but on the hand you can make your changes more precise so it becomes more technological - that's clear - but again the final making of new variety is a more holistic thing - you have to take into account all sorts of characteristics so that will still remain - well of course what I said that everything is becoming more technological nowadays" (university breeder, gene editing)

On the other hand, during one interview it was pointed out that in a legal sense pertaining to EU regulation, the laboratory step does come to define the entire product.

"Somewhere in the preparation was this GM element, so the whole thing is now GM - so that's our ideas about identity - and about the ontological status of a plant" (philosopher)

Gene editors - ____ - plants

During the period of my fieldwork, new gene editing techniques like CRISPR-Cas were the subject of both numerous scientific publications and reports in the popular media. Although only one of the breeders I interviewed was working extensively with the new systems, the topic arose many times throughout the fieldwork. Opinions about the technology were strongly polarized. At the Monsanto Tribunal there was a workshop to explain gene editing to the participants. It focused heavily on the “gene drive” being used in gene editing of mosquitoes to rapidly spread the edited gene throughout a population. Gene editing was perceived as a tool for the breeding-industrial complex to assume far greater biopower (power over life) than before. It not only presented a threat to the integrity of plants, but to that of whole populations and ecosystem. This was an opinion shared by some of the biodynamic breeders. They also expressed the fear that because gene editing was being presented as novel and different from transgenics, that organic breeders might not be resistant to it in the same way as earlier genetic engineering techniques. To these critics, gene editing was a kind of *intensified* genetic engineering, that also intensified an undesirable relationship between plant breeder and plant.

The breeder who was actually working with CRISPR-Cas shared the opinion that gene editing is still genetic modification and should be considered as such.

> *"CRISPR-Cas is just the next generation of genetic modification - and they are GMOs, everyone has to be quite clear they are genetically modified organisms, using CRISPR-Cas but they are highly specifically edited and changed" (university breeder, gene editing)*

However, he saw gene editing not as an intensification of transgenics, but as a refinement that ameliorated some its negative aspects - in particular its clumsiness and limitation in types of traits.

> *"Everybody talks about this big paradigm shift, CRISPR-Cas is gonna change the world - well it probably is - but it is part of this gradual development between you know old fashioned traditional breeding which was just to make a cross between two genotypes which you like the look of and then selecting out in the progeny something which you feel is good and can pursue - up to modern marker precision based marker breeding and the much shorter time than the old fashioned whacking in just a gene with a 35s promoter and trying to express it - the herbicide resistance and the things which are out there right now are very primitive in terms of what we can now do" (ibid)*

Although the typical traits of transgenic varieties - like herbicide resistance and Bt - align with the profit motives of major seed companies, he had been involved in the earliest work on genetic plant transformation and insisted the prevalence of these traits was due to lack of knowledge and limitations of the technique. His current work was on improving mycorrhizal associations of potato roots, precisely the sort of symbiosis that the paradigm of genetic engineering is often held in contrast to.

> *"I'm now involved in a project in potato to look at mycorrhizal associations with potato and if you can enhance nutrient use efficiency and water use efficiency by making these mycorrhizal associations better and selecting for those advantageous interactions, then I think that's a very natural way of doing things - and so what I'm saying is that having this extra string to your bow will allow us to make better healthier more environmentally friendly plants" (ibid)*
>
> *"I think it's what is the impact of the product on the environment and on human beings in general - and there of course there's a big choice you can say - ok you can make an even better herbicide tolerant plant, or you can say let's make a plant where we no longer have to spray anything - and so make it environmentally much better - and I think that's the key, what is the impact of the product that you produce from this sophisticated technology" (ibid)*

Deep Stories

In this section I attempt to piece together the “narrative fragments” from the previous analysis into more cohesive narratives, or *deep stories*. These deep stories are driven by particular protagonists (science, nature) and antagonists (technology, modernization, ideology, global capitalism, tradition) and call for particular stances and responses. First I address a number of critical points in the history of plant breeding, whose historicity is acknowledged by all the breeders I met. However the signification attributed to these points varies greatly, and as such the deep stories “hinge” on them differentially. Often they mark temporal boundaries between expressions of naturalness and unnaturalness. After this follows an exploration of the stories themselves, though it should be stated that these formulations are speculative and not meant to be conclusive in any sense of the term. A more extensive study would follow-up by presenting the stories to the breeders and taking their feedback into account.

Hinges

For the most part, all the breeders agreed as to the historical existence of these critical points. At the same time, they disagreed as to their ‘criticality’. Therefore I have focused my analysis around these five points as a way to foreground both the continuities and disjunctures between deep stories.

Neolithic Revolution - The approximately simultaneous initial domestication of food crops in multiple regions around the world, about 10,000 years ago.

Rediscovery of Mendel - The introduction of Mendel’s principles of inheritance to the scientific community around the turn of the century, and their subsequent incorporation into breeding practices.

Hybrid Breeding - The development of F1 hybrids, first in the 1920s with maize and soon followed by other crops.

Old Genetics (genetic markers, transgenics, CMS) - The adoption of a variety of techniques to interact with plants on a molecular level. This is actually more a cluster than a single point, as some breeders and groups make important distinctions within it - for example the acceptance of genetic markers but not of transgenics or CMS by Dutch organic breeding regulations.

New Genetics (cisgenesis, gene editing) - The recent development of new molecular techniques, which have not yet led to commercially available cultivars.

Stories

Science/progress (Critical Points: Neolithic Revolution, Rediscovery of Mendel) - *10,000 years ago, humans in their ingenuity domesticated the first crops. They didn't understand what they were doing, but through the accumulation of trial and error they dramatically increased the form and usefulness of these plants. Before, these plants belonged to nature, but now they became attached to human progress. Such land races were nice, but could only sustain a low standard of living. This process continued, mostly unchanged, until the 19th century when Gregor Mendel discovered the principles of heredity and plant breeding. From this point on breeding became scientific, and could really start to progress rapidly. Over the next century scientists learned more about genetics, and with this knowledge developed modern cultivars that made agriculture more productive. Today, this continually increasing knowledge is being directed towards making agriculture more sustainable.*

This story mostly turns on the initial domestication of crops - everything before is natural, everything after is not. Agriculture and plant breeding are therefore governed not by laws of nature, but by the laws of progress, and scientific progress in particular. Because the true revolution already happened in the Neolithic, none of the later developments has constituted a really fundamental shift. From within this story it is very difficult to mount any critique on the role of capital in breeding priorities, because science is seen to be driven forward by internal engines of human curiosity and ingenuity rather than outside interests. Scientific progress thus has a direct, unmediated connection to societal development in general. Opposition to this scientific progress is understood as 'religious' or 'romantic'.

Breeding as culture and care (Critical Points: Neolithic Revolution, Rediscovery of Mendel) - *10,000 years ago, humans domesticated the first crops, and the realm of culture was formed. This realm is ordered according to human principle, but plants (and animals) participate as independent beings and retain a semi-autonomy. Humans and plants have mutual obligations of care towards each other, and develop together. Like in the above story, history is moving forward in a progressive way. This progress, however is not a result of reductive science, but from developing the human self as an instrument of perception. Mendel's insights aid in this, but the molecular methods of the second half of the 20th century misdirect our perceptions and disrespect the plant as autonomous whole.*

This story, characteristic of the biodynamic end of the organic spectrum, resembles the science-as-progress narrative in some surprising ways. There is a fundamental break at the Neolithic Revolution, and a progressive teleology. However the signification of the break and the qualities of the teleology are quite different. The realm of 'culture' is explicitly and positively defined, and the path of modern breeding towards reductive analysis is seen as a divergence. Methods that break up the plant into pieces are not unnatural, but 'uncultural'. Mainstream breeding is seen as misguided at best and violent at its worst.

Means of production (Critical Point: Hybrid Breeding) - *Farmers have always been saving seeds; that's just the natural way of things. It means that farmers always have some degree of independence and control over their lives and livelihoods. Also, mass selection meant that the plants would adapt to the specific agroecosystem of the farm. In the early 20th century, breeding companies figured out they could force all the farmers to buy seeds every year by focusing their breeding on F1 hybrids that were 'economically sterile'. All the developments in mainstream breeding since then have basically been a continuation of this trend, giving more and more power agribusiness capita.*

While hybrid varieties were once seen as an affront to nature (Kloppenberg 2005), today this view is uncommon. However from this story, hybrids are the 'original sin' that wrested power over the means of production from farmers and handed it to agribusiness. This is perhaps the inverse of the first story; where that one is blind to power, this sees nothing else. Both old and new genetics are interpreted as an intensification of the hybrid power dynamic.

Capitalism vs nature (Critical Point: Old Genetics) - *People used to live together close to nature, and lived in a more natural way. But because of capitalism, human greed now just sees nature as a way to make money. It doesn't respect either people or nature as sacred, and will stop at nothing to accumulate more power and wealth. Scientists in laboratories are violating plants by manipulating their essence in their DNA, and creating monstrous 'Frankenfoods'.*

This story is characteristic of some segments of anti-GMO activism, but also visible among some hobby breeders. 'Traditional' methods are strongly associated with the natural and positive, and 'modern' methods with the unnatural and negative. Breeding in the old ways becomes an act of resistance. Here the critical point is the introduction of transgenic varieties.

Discussion

Research Question

Returning to the original research question - *how do multiple and contested concepts of naturalness play a role in plant breeding?* - the findings reveal that ontological concepts are at play in many ways. Sometimes these are made explicit, as in the case of the rules on organic breeding in the Netherlands, which are based on a particular ontological concept of plant (namely that it has integrity). This recognition of plant integrity has consequences for which breeding techniques are used. The group of biodynamic breeders choose not to

develop hybrid varieties. This decision was not based on the way hybrid seeds alter power relations between farmers and companies, but out of an ontological concept of farms and crop plants as an organic whole - crop populations must retain the capacity to adapt and change with the farm, and this requires breeding of open-pollinated varieties. In the university plant breeding department, concepts of nature were more implicit. Most university breeders saw agriculture and breeding in general as unnatural. One major effect of this was to frame breeding dilemmas in terms of utility or risk; there is no ethical concern for the plant in itself. At the same time, naturalness reappears in other guises. The risk presented by genetically engineered crops is determined in large part by their degree of resemblence to "natural" crops. In the United States this is the principle of substantial equivalence. In Europe, cisgenesis has been promoted mainly because it is "more natural" than transgenesis, as no reproductive barriers have been crossed. Both rely on a kind of naturalness that inheres in the *product* rather than the *process*.

To respond more generally, it seems that ontological concepts of nature are rarely singly determinate factors in shaping the plant breeding process. Breeding decisions take into account a multitude of factors, some conscious and some unconscious. Perhaps the best way to characterize the role of ontology is that it shapes the terrain in which questions about the the direction of breeding are asked. If one does not consider plants worthy of autonomous moral consideration, then breeding decisions will be made in an anthropomorphic context. Whether one sees breeding in the realm of the natural, the unnatural, the artificial or the cultural will likewise determine the topography within which breeding proceeds.

Literature

The findings engage with existing literature in a number of ways. First, it contributes to recent scholarship on how the processes of breeding and domestication are to be understood, for example in Cassidy and Mullin (2007). Anthropologists have been moving away from seeing breeding (of both plants and animals) as a distinctly human project, and towards a co-evolutionary model. My findings contribute to this discussion by demonstrating how some contemporary plant breeders understand and practice this interaction. I have also sought to begin the work of filling certain research gaps in the study of agricultural biotechnology. It's political economy is well-studied (Kloppenberg 2005; Howard 2009; Newell 2009); it's conceptual economy far less so. My findings show that concepts of nature are far from independent of these relations of power and capital. Indeed biotech corporations and advocacy groups have promoted a particular ontological conception of plant breeding, as embodied in the narrative of the "primitive genetic engineer". Furthermore, these dominant conceptions have rarely been contrasted with alternative ontologies of nature that are still European and modernist (ie biodynamics), rather than the indigenous (e.g. Descola 2013). Lastly, the findings shine some light on plant breeders themselves, a group which has received little attention as scholars focus on the transnational corporations, policy and peasants. Studies of university biotech have generally been critical (e.g. Welsh et al 2008). My findings, I believe, have been sympathetic to the breeders as complex individual people, while not taking a blind eye to institutions which have earned their criticism.

Issues of Validity and Further Research

How generalizable are these findings? The study has been limited both in terms of breadth and depth, due to a lack of time for fieldwork, access to research subjects, and the improvised nature of employing a methodology like Grounded Theory. My aims have been to conduct a preliminary exploration of the ways in which concepts of nature play a role in plant breeding practices, rather than to make any authoritive statements on contemporary plant breeding in general. Still, my research would have been improved by a more diverse group of subjects, both in terms of demographics and in social/professional context. I only had opportunity to study a small number of breeders working for private companies, or in biodynamics. With the university breeders, ethnographic methods such as observing and participating in field and laboratory work would have been preferable to relying on interviews. Also, considering the often indirect methods I used in analyzing breeders' concepts of nature, there is concern that I have made errors in interpretation. An improvement in the research design could have included a second meeting with the breeders to see their reactions to my interpretations.

Concepts of nature in biodynamic plant breeding certainly deserves a study of its own, especially as it contrasts in particularly interesting ways with dominant ontologies. The same holds true for plant breeding by indigenous and peasant farmers. In general, I believe that plant breeding provides an especially revealing lens into the way that people construe and practice their relationships to plant and other non-human nature.

Conclusion: Genetic Driftwood

> *"Any object that one encounters in the world invites the question 'how did this thing get to be here?" - Alfred Gell*

Raymond Williams once wrote that "the idea of nature contains, though often unnoticed, an extraordinary amount of human history" and that the differences in these ideas are "almost invariably connected to a certain agenda or view of society". My aim in this thesis has been to explore how what holds for human society and history in general also holds - in particular and significant ways - for the breeding of agricultural crops. Such an investigation is derived from my belief that agroecosystems consist not only of seeds and farmers and tractors and consumers, but also of ideas. That is, ideas are not *reflective* of these systems, operating on some separate plane or superstructure, but *participate* in them, promiscuously. For instance, the CSA model has become popular not simply because it distributes economic risk, but also because of historically determined ideas about how a farm should be in community, and these ideas participate in actuating this mode of being in reality.

Williams not only asserts the material efficacy of ideas in the world, but also presents guidelines for the general materialist approach to the study of 'culture' - that is, meaning and value. Because most breeders are

not philosophers, what I have been referring to as “ideas” and “concepts” of nature are not rigorous and systematized doctrines. They correspond, more or less, to what Williams calls *structures of feeling* - assemblages of meaning and value that are “in solution”. That is, they have not “precipitated” into formal ideologies or institutions. Like other cultural entities, structures of feeling in any given society are found in a tripartite structure: (1) the dominant, (2) the oppositional and (3) the alternative. I have found Williams’ framework serves as an effective way of summarizing my research findings on the mental and material dynamics of ideas of nature in plant breeding. It should be emphasized again that these represent pattens of thought rather than categories of persons.

Dominant - The dominant assemblages of concepts does not necessarily encourage the “domination” of nature in the aggressive, Baconian sense. Rather, it indicates a participation in hegemonic modes of economic, social and human-nonhuman relations. Characteristic of the dominant mode is that agriculture in general and plant breeding in particular are defined as *unnatural* or *artificial* - both of which are tied into the origin mythology of the Neolithic genetic engineer story. The *unnaturalness* of plant breeding implies that its processes and ethics are governed by anthropocentric ideals (whether of capital accumulation or the sustainability of human life). It’s *artificiality* implies that the products of plant breeding are considered as artifacts, rather than natural beings. In other words, an *inventive* mode of production rather than an *evolutionary* one. Within this mode nature is defined negatively - as the absence of human intervention - and as such is ontologically *encompassed* by the human domain. Unnatural and natural are thus defined against each other (a radical opposition), with the unnatural/human as the dominant pole. Within this schematic, the meaning of nonhuman beings is generally derived from their utility for humans, even if that utility is purely recreational or aesthetic.

Just as capitalism as an economic system embodies certain contradictions, so too do the concepts of nature that are tied into it. One of these is the idea of science as a neutral enterprise, operating independently from markets and power, juxtaposed with the conspicuous role of corporate influence into both basic and applied research. A second is contained with the particular history of plant breeding promulgated by seed companies and internalized by plant breeders, where premodern farmers are depicted as “Neolithic genetic engineers”, and at the same time “real breeding” is considered to have only begun in the end of the 19th century.

Oppositional - Another assemblage of concepts is organized around a resistance to dominant relations and ideas. Here the demarcation between natural and unnatural is usually located at the initial use of transgenic techniques, and there is a strong positive valuation of the natural and a negative valuation of the unnatural. The opposition of natural and unnatural is made far more explicit than in the dominant mode. The oppositional mode in its strongest expression is found in anti-GMO activism and certain segments of the organic farming spectrum. In contrast to the *product orientation* of the dominant mode, it is *process oriented*. For the dominant mode, cultivars are natural in the positive sense if they resemble the “products of nature”; their identity is derived from their stable physical qualities. However an organic food item or cultivar is identified as such because of the processes that brought it about, regardless of the resultant material properties of the product. The *oppositional* character of these concepts are recognizable in the organic regulations, both for farming and breeding. For the most part these regulations are negative: no pesticides, no synthetic fertilizer, no transgenic techniques, no transgression of the cell membrane or reproductive boundaries.

Alternative - A third set of concepts is not oppositional to the hegemony but constitutes a semi-autonomous alternative. The biodynamic end of the organic spectrum in the Netherlands expresses such alternative ideas and practices, though it also has many oppositional tendencies as well. At the same time, non-biodynamic organic farmers and breeders may also display positive alternative as well. Biodynamic breeding is constituted not only by a rejection of hybrid, genotype-oriented techniques, but also by their own set of perceptive and selective practices, similar to how biodynamic farming is identified not only by the absence of chemical inputs but also the presence of biodynamic preparations. One biodynamic breeder emphasized the importance for them of being "for" something instead of only "against". Like the dominant mode, agriculture and plant breeding are seen as outside the realm of nature, but are defined positively, as *culture*, instead of negatively, as the *unnatural*.

Genetic Driftwood

The original introductory passage to this thesis referenced the Norse story of doomsday - Ragnarøkkr. It also seemed especially fitting that the complementary story of creation be invoked in closing. The Norse cosmogony is almost the inverse of *ex nihilo* creation myths. Instead of being formed out of nothing, the cosmos already exist, waiting to be revealed. Audhumbla, the cosmic cow, uncovers the forms of the gods by licking away the ice that encases them. Ask and Embla, the first two humans, are carved out of pieces of driftwood.

The driftwood model is a vision of creation in which the material itself participates actively in its own crafting. How do plants participate in plant breeding? As raw materials or as active co-creators? Driftwood contrasts with the *hylomorphic model* - that creation happens first in the imagination of the human mind, which is then imposed on the inert, material substrate. By foregrounding the "moment of invention" (Van Dooren 2008), hylomorphism "denies the seed's embeddedness in broader webs of meaning and life". It posits creation as a single, heroic act - a heroism that ought to be rewarded by intellectual property rights. Take, for instance a recent headline (that is also dubious for other reasons):

> *"China Invents Rice That Can Grow in Salt Water, Can Feed Over 200 Million People" (Samson 2017)*

Hylomorphism is not merely a fiction of the intellectual property regime - though its most significant effect now may be the way IP regimes draw a line between the patentable products of modern breeding and the freely available "common heritage of mankind" products of farmer breeding. However, today not only the legal representations of breeding but breeding practices themselves are becoming increasingly hylomorphic - moving towards an approach of innovation and invention.

The driftwood model recognizes the liveliness of plants as they participate in breeding projects, that plants not only perceive and behave (Baluska 2006) but do so out of an unknowable depth that is not

fundamentally present and available to our scientific apparatuses. It seems as if the traditional “objects” of agroecology - seeds, plants, farmers, breeders, varieties, technology - are more complex and “withdrawn” (Harman 2011) than our bourgeois ideas about them. Graham Harman’s radicalization of Heidegger posits an ontology of such withdrawn objects, and says that even though things are fundamentally unknowable in their completeness, we can nevertheless make more or less truthful hints and speculations as to their hidden facets. I see this as the task for ontological agroecology, and this thesis in some sense has been a grounded speculation into the hermetics of plant breeding.

What will be after heaven and earth and the whole world are burned? All the gods will be dead, together with the Einherjar and the whole of mankind. Didn't you say earlier that each person will live in some world throughout all ages?

Hárr answered: "In that time the earth shall emerge out of the sea, and shall then be green and fair; then shall the fruits of it be brought forth unsown…

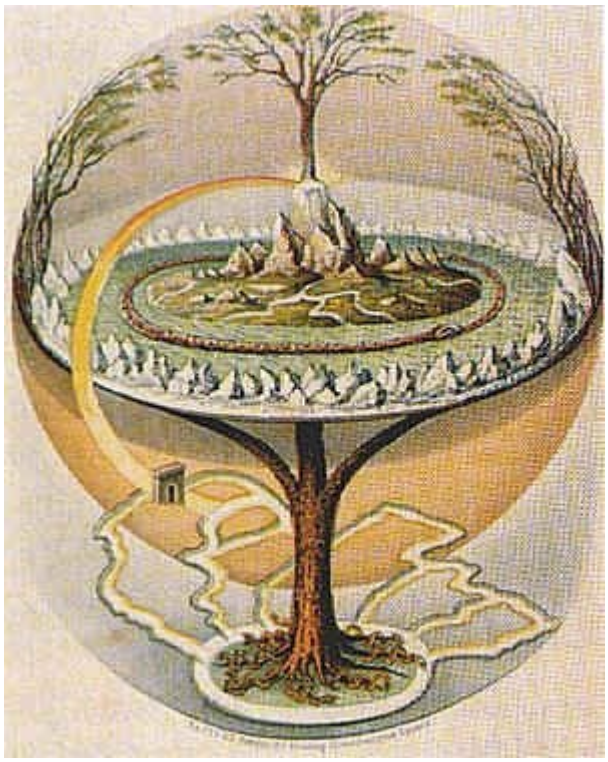
In the place called Hoddmímir's Holt there shall lie hidden during the Fire of Surtr two of mankind, who are called thus: Líf and Lífthrasir, and for food they shall have the morning-dews. From these folk shall come so numerous an offspring that all the world shall be peopled, even as is said here:

Líf and Lífthrasir, | these shall lurk hidden

In the Holt of Hoddmímir;

The morning dews | their meat shall be;

Thence are gendered the generations.



Questions about plant breeding are ultimately questions about change and becoming: the human and nonhuman selection pressures that steer plant evolution, who exerts these pressures, and on which principles. What is the end of plant breeding? In one sense - what is its purpose? Who is it for? In another sense - where does it terminate? Within what vanishing point? Apocalypse or technological rapture? Breeding occurs. A plant changes. Towards what end is this change directed? These are big questions. Too big, in fact, for this thesis to address in any meaningful way. Yet my own research questions are nested inside these inquires into the being and becoming of plants.

Unlike the cyclical pattern of the Norse apocalypse mythology, plant breeders' narratives of their own discipline tended to be linear - a series of developments, a theory of change as the continual unfolding of a progress narrative, both on the level of plant and technology. Within this theory of change, is anything truly new? Can we call gene editing new if it was already contained in humankind's destiny as a species of progress? If teosinte was destined to become maize? Unexpectedly, we need to look to cyclical time for the authentically novel - for each circle is never complete. Every repetition is distorted, Líf and Lífthrasir are not Ask and Embla. There is, in other words, a mutation. Is this not the process of natural selection, and by extension plant breeding? Some might see the death-throes of Jörmungandr the world-serpent in the expanding violence of global industrial agriculture, but perhaps Doomsday is actually to be found in the life and death of every plant.

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Data Interpretation

I have generally followed Wolcott's (1994) demarcation of what is conventionally termed data analysis into fields of Analysis and Interpretation as opposite poles of a "see-saw" with Description as the fulcrum. *Analysis* "refers quite specifically and narrowly to systematic procedures followed in order to identify essential features and relationships", while *interpretation* gives "sense to the data by creatively producing insights about it" (Gibson and Brown 2009). In contrast to the systematic procedures of the analysis, the following interpretation sections discuss the data in terms of a wide range of theoretical perspectives, looking for broad and unexpected connections between phenomena. As a more creative process, the methodology has been less systematic, emerging out of reflection and free writing. Where the analysis is a metaphysical focus on concepts, the interpretation is at times properly ontological - questioning not only the concepts of breeders but the process of plant breeding itself. This section is thus intended to situate the data and research questions within broader academic trends and agrecological concerns.

One: Breeding in the Image of Nature

The Engineering of Naturalness

Is the genetic engineering of crops natural?

It's not exactly a robust question. Indeed, it falls to pieces with the slightest prodding. None of its constituent elements (genes, engineering, crops, and especially 'naturalness') have much of a defensible claim on being universal kinds. The concept of genes was constructed through ideas from early computing and Cold War cryptography (Doyle 1997); engineering through analogy to a particular relationship between builder and invention (Ingold 2000); crops and naturalness through a provincial dichotomy between human and nonhuman domains (de Castro 1998). The usefulness of such a question lies not in its potential to disappear into an answer, but rather in the loudness and productivity of its deconstruction. Take, for instance, the

concept of the 'natural'. What does it mean to make a claim of unnaturalness?

From both my own personal involvement in farming activism and more focused ethnography conducted during the fieldwork period (for instance at the Monsanto Tribunal in The Hague), I was quite familiar with the argument that GMOs are unnatural. Having been exposed to enough scholarly work on the contingency and constructedness of concepts of nature (e.g. Williams; Glacken), I had approached these arguments as suspect. However after conducting interviews with the authors of articles commenting on both sides of the naturalness debate (Gremmen 2005, van Bueren 2003) and talking to activists at the Monsanto Tribunal, it seemed necessary to revisit the claims that transgenic crops (and the processes leading to their development) are unnatural.

Transgenic crops were not the first technology to trigger such responses; cloning and nuclear power have been subject to similar scrutiny (Weart 2009). Even more relevant were charges of unnaturalness leveled against the first hybrid seeds in the early 20th century, which were seen by many as abominations against nature in much the same way transgenics are today (Kloppenberg 2005). These days criticism of hybrids are mostly limited to their political economy - that they make it more difficult for farmers to save their own seed. Though a vocal minority remains, few still argue that hybrids are unnatural. What does this mean, that the boundary of the natural and unnatural is mobile? Studies by Mitman (2012) and Wall (1999) demonstrate the extent to which social constructions of nature can shift in only half a century. If concepts of nature are socially constructed, does this imply we ought to dismiss the unnatural argument's claim to truth?

Perhaps the first misunderstanding is in classifying it as an 'argument' in the first place. Taken as an argument of classical logic, it is quite easily parried. Indeed the appeal to nature is often listed as a 'logical fallacy'. Yet based on interviews and conversations with those who invoke naturalness in their resistance to transgenic crops, it would be a mistake to reduce such sentiments and inclinations to their logical skeletons. In many of these cases, the appeals to nature may not have been rational, yet neither were they necessarily *irrational*. Indeed they had little to do with rationality at all. The mistaking of *affect* for flawed logic seems quite common, as does a more general dismissal of fears considered outside the purview of risk discourse's sacred objects: environmental and human health (Wynne 2001).

David Harvey writes that "[t]he advantage in seeing values as residing in nature is that it provides an immediate sense of ontological security and permanence" (Harvey 2016), but it does not necessarily follow that we ought to respond with critical demystification, to demonstrate that these arguments are logically bankrupt. An alternate approach would be to question *why* exactly so many people are feeling ontologically insecure when presented with transgenic foods. What is it about genetic engineering that would generate anxiety about the nature of being? One university plant breeder mentioned having gone to the local market recently with a colleague to see what lay people (non-scientists, non-activists) had to say about genetic modification. They were surprised to find that many people were more likely to support gene editing on their own children (to prevent a serious congenital disease) than engineering of crop genomes. How could food be more sacred and intimate one's own child?

In one sense, the comparison is unfair; I would venture that if the hypothetical had been posed as a life or death scenario, the majority of people would have agreed to eat the GMO tomato. At the same time, it demonstrates that foodways are wound deeply into identity, and that simplistic formulae of risk and reward are incommensurate with the genuine concerns of the eating public. Appeals to nature, it appears, are generally not born of scientific illiteracy or indiscriminate technophobia, and rationalizing them as such reveals a fundamental misinterpretation.

Nevertheless, concerns over naturalness are not entirely dismissed by the mainstream plant breeding establishment. Many of the university plant breeders I talked to were involved in a project called DuRPh (Durable Resistance against Phytophthora). DuRPh was introgressing *Phytophthora* resistance genes from wild relatives of potato in domestic varieties. Though they used the same *Agrobacterium* process as transgenesis, it was considered *cisgenesis* because it did not transgress the species barrier. Unlike transgenics (like Bt-cotton), such a cross could theoretically occur 'in nature' a fact repeatedly emphasized by the research group.

While the concept of naturalness (and indeed that of species) may be somewhat arbitrary, the realities it amplifies certainly are not. It has steered research agendas and Dutch organic farming regulations (Verhoog 2003). Some Christian groups in the Netherlands approve of cisgenesis despite being firmly opposed to transgenesis. For many breeders, domestication has brought crops out of the domain of nature entirely. *Genetic engineering is as natural as plant breeding*, said one. Already unnatural, there are no further boundaries to cross. As Mary Douglas (2003) once noted, sensations of unnaturalness are intimately tied up with perceived transgression of boundaries. These breeders based their research ethics mostly on (health/environmental) risk and the imagined public good of research products.

Because defining naturalness is not an appropriate 'scientific' question, university plant scientists generally resorted to folk distinctions of culture and nature. Anthroposophic thought, on the other hand, has traditionally held a more well-defined doctrine. Like many from the university, biodynamic breeders maintained that domesticated crops were no longer natural. Unlike them, the ontological alternative to the natural was not the unnatural, but the cultural. Perhaps it would be more accurate to say that they considered crops natural and cultural. This implied different affordances - breeders assumed a position of control relative to the plants, but only a limited degree of agency. For them, the 'naturalness' that persisted in domestic crops meant that they retained some of their own integrity, some element of individual destiny. Genetic engineering was considered anathema not simply for the transgression of species boundaries, but more importantly because it violated the integrity of plant beings.

An ontological approach explores naturalness as an overlapping of partial connections, an equivocation (Viveiros de Castro 2004), rather than a defining property of entities or practices. Not only are there multiplicities abounding within nature, but nature herself is multiple. Maneuvering, palpating among the multiple natures of scientific, biodynamic and indigenous breeding, ontological agroecology attunes to lines of disjuncture and areas of overlap. Naturalness may not be a universal category, to which certain products

and practices do or do not belong, yet it is still very much a *category*, one that heavily shapes plant breeding concepts and realities.

The Naturalness of Engineering

"The "plant manipulation as progress" narrative is standard in histories of biotechnology from corporate media departments, showing a natural progression from grain domestication to genetic modification" - Glenn Stone

It doesn't take long in the trenches of the GMO debate before one becomes quite familiar with variations on one particular narrative - the story wherein humans have been 'genetically engineering' plants since the Neolithic Revolution - the implication being that modern transgenic techniques incorporating *Agrobacterium* do not differ fundamentally from the previous 10,000 years of plant domestication and breeding (see Monsanto history of breeding). Such a narrative is vulnerable to the standard critiques of attempts to 'naturalize' the products and methods of technoscience - that it seeks to establish transgenic crops as the inevitable and natural result of progress in plant breeding, rather than contingent on particular asymmetrical relations of power and historical happenstance. Like other 'internalist' histories of the sciences (Puig de la Bellacasa 2011), it presents the history of plant breeding as a succession of discoveries by individual geniuses: Mendel, Darwin, Jones, Borlaug.

This recent promulgation of the 'primitive genetic engineer' narrative is easily read as a response to the arguments highlighted above that genetic engineering is unnatural, and it hinges on the shared belief that the practices and products of premodern people belong to the realm of nature. If premodern breeding practices were natural, and the activity of modern breeders is not fundamentally different, than modern breeding practices must be natural as well. As Krupenikov (1993) has written of soil science, the paradox of plant breeding is the "brevity of its history and the length of its prehistory". A standard demystification account would show the contingent facts of modern plant breeding progress - how the agency of individual geniuses was shaped and directed by structural formations - but it has little to say about the border between prehistory and history.

Checking in with the mother question of whether genetic engineering could be considered natural, another line of inquiry emerges. What exactly does it mean to *engineer* something? What distinguishes it from other modes and styles of production? What are the consequences when the only language we have to discuss human/crop co-evolution is that of engineering?

The etymology of engineering originated with the construction of war machines in ancient Rome, *siege engines* like battering rams and trebuchets. Today, the main approaches to genetic engineering share a similar brute force approach - the primary method of introducing foreign genes into monocots is actually referred to as *particle bombardment*. Of course engineering as a discipline has largely outgrown its martial origins and is now associated with the design and production of things in a much more general way. Still, there remains some quality of the battering ram in the process of engineering an object. Siege engines are notoriously lacking in sensitivity. That is, they are indiscriminate and forceful in their interactions, which are generally unidirectional.

Engineering is likewise generally defined as the application of abstract, general, knowledge and technical systems (Merriam-Webster.com 2017) - systems that are external and ultimately incidental to the project at hand. The product comes into being first in the mind of the engineer, then in their schematics, before finally assuming material form. As for the original material itself, it remains inert as the besieged city's walls, passively awaiting transformation. Think *social engineering*. Certainly not a collaborative endeavor or a process of consensus, but arising out of the designs and machinations of an exclusive group of individuals.

Engineering then, or least this caricature of it, is the ideal that informs Marx's conception of production. *What distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality* (Marx 2015). Production and engineering are then purely human endeavors. Tim Ingold has criticized this way of thinking about production for falsely dichotomizing human and nonhuman creative practices. He argues that production should be treated as an intransitive verb (to roam, to grow, to play) rather than as transitive (to commute, to upgrade, to bring):

> *"It does not start with an image and finish with an object but carries on through, without beginning or end, punctuated – rather than initiated or terminated – by the forms, whether mental or ideal, that it sequentially brings into being" (Ingold 2000)*

Within the many modes of production, engineering stands out as particularly transitive. Grammatically, transitive verbs take on a direct object, or rather whichever noun follows a transitive verb assumes the form of an object. In other words, the materials appropriated into projects of engineering are *objectified*. Contrast this with sculpture, where the material exerts what is experienced by the craftsman as a kind of agency, some kind of say in the final product. This is what many call 'truth to materials'. The material never becomes *fully* object, as it does in pure engineering projects. While pure engineering projects might not exist in reality, the Engineering Imaginary does. It was expressed in the divorce during the Middle Ages of author from printer, architect from builder, and the general separation of immaterial design labor from the technical role of craftspeople (Ingold 2000) and what Deleuze and Guattari call 'Royal Science' from 'Nomad Science' (Deleuze and Guattari 1988).

Because the Engineering Imaginary is concerned with the manipulation of objects, it becomes suspect when existents who are normally considered *subjects* become the object of an engineering project. This is why the

engineering of bridges is rarely questioned while the prospect of social engineering - the engineering of social relationship - at least raises some eyebrows. Human beings are often understood as the ultimate subjects, the prototype upon which subjectivity in general is modeled. Manipulation of objects has no negative connotation; manipulation of people very certainly does. My guess would be that something similar is at work in fears about genetic engineering. On the subject-object continuum, plants and animals are somewhere between humans and minerals and crop plants derive some additional subjectivity from a certain continuity with the human body. 'Genes' have also been represented - especially in popular science literature - as being endowed with a particular sort of agency, to the extent that most behaviors have been interpreted as being at least somewhat determined by genetic 'scripts'. In any case, there is a certain feeling of transgression (or 'unnaturalness') in relating to organisms or their genes as pure objects, a worry that they are being manipulated "against their will".

With this in mind, what more might be said concerning the primitive genetic engineer narrative? Can those Neolithic farmers who participated in the beginnings of plant domestication be said to have been truly 'engineering' the genomes of emmer, flax and lentils? If not, when exactly does genetic engineering emerge out of other ways of doing plant breeding? With the rediscovery of Mendel? With tissue culture techniques in the laboratory? With the appearance of a class of plant breeding specialists? With transgenics? Perhaps, rather than looking for some single point of rupture, after which plant breeding was changed fundamentally and forever, it would be more productive to analyze certain plant breeding practices for relative degrees of engineering (ie informed by pre-fabricated design) and craftsmanship (ie informed through dialogue with the material agency). This distinction constituted a consistent theme in my fieldwork. How did plant breeders relate to the plant material? Transitively or intransitively?

Firstly, it must be reiterated that there is no such thing (yet) as the pure genetic engineering project. Even in the production of transgenic varieties, some element of craftsmanship remains, whether in the classical breeding required to make agronomically viable final products after the introduction of transgenes, or in the laboratory techniques themselves. Always, insisted the university plant breeders I met with, there is a role for intuition, sensitivity and receptivity. At the same time, many added, this role was becoming smaller. In field selection, the 'breeder's eye' is giving way to the use of genetic markers, even in organic breeding programs that place such emphasis on 'whole plant' selection. What becomes apparent is not a single point of rupture, but a consistent (if somewhat spasmodic and uneven) trend away from co-crafting and towards engineering, a trend that mirrors the displacement of landraces with broadly adapted modern varieties (Brush 2008).

Within this trend, Luther Burbank stands as an outlier, an "old-fashioned intuitive grower" with a remarkable eye and a strong distrust of Mendelian genetics. Once "regarded as one of the great American heroes", Burbank's name is often omitted from more recent histories of plant breeding, whose heroes contribute not through their intuitive labor but through scientific breakthroughs. Noel Kingsbury attributes Burbank's diminished legacy to the fact that *"he does not fit into the zeitgeist of turn-of-the-century plant breeding or into the history of plant breeding as a coming together of plant cultivation and genetic science"* (Kingsbury 2009).

Given the definition of genetic engineering adopted above - namely a relation to the plant as an object to be manipulated - it is probably safe to say that the vast majority of crop selection prior to the modern synthesis (of Darwin and Mendel) would not qualify as such. Stephen Brush (2008) makes the case that the emergence of crop genetics in the early 20th century led to a "qualitatively different type of crop evolution", one that is centralized, rapid, based on wide crosses and oriented towards a uniform image or 'ideotype'. He notes that there are very few recorded cases of farmers engaging in 'breederlike activities' - meaning relatively systematic processes of crossing and selection - and that even these cases occurred when peasant farmers observed the practices at a regional agricultural experiment station and imitated them in the village.

From an evolutionary framework like Brush's, the rupture occurs with the modern genetic synthesis. From a political economy framework, it comes with the introduction of hybrid seeds, the "mechanism for circumventing the biological barrier that the seed had presented to the penetration of plant breeding and seed production by private enterprise". For both, transgenic practices are not a radical departure, but an intensification of processes that emerged 100-150 years earlier. These in turn grew out of economic and conceptual transformations of the previous centuries, exemplified in the Enlightenment writings of Descartes, Locke and especially Francis Bacon. *"It is with the victory of the Baconian school that the image of nature moves from that of nurturing mother to that of the harlot"* (Stephens 2000)

One of the first applications of what I've been calling an 'engineering mentality' to plant forms comes from a passage in Bacon's utopian novel New Atlantis.

> *We have also large and various orchards and gardens; wherein we do not so much respect beauty, as variety of ground and soil, proper for divers trees and herbs: …In these we practise likewise all conclusions of grafting, and inoculating as well of wild-trees as fruit-trees, which produceth many effects. And we make (by art) in the same orchards and gardens, trees and flowers to come earlier or later than their seasons; and to come up and bear more speedily than by their natural course they do. We make them also by art greater much than their nature; and their fruit greater and sweeter and of differing taste, smell, colour, and figure, from their nature…*
>
> *We have also means to make divers plants rise by mixtures of earths without seeds; and likewise to make divers new plants, differing from the vulgar; and to make one tree or plant turn into another. (Bacon 2009)*

Two: The Breeder's I

During the Monsanto Tribunal I spoke with Vandana Shiva about the anthropocentric inclinations of the proceedings. She responded by saying that if she had her way, the tribunal would have represented the soil

itself, accusing Monsanto of ecocide. She also referred to countries in South America who have acknowledged “rights of nature” in their constitutions.

Why is it that non-humans, if legally represented at all, are represented as *victims*? Contrast the Monsanto Tribunal with a case from the 15th century:

> *"In December 1457 the sow of Jehan Bailly of Savigny and her six piglets were caught in the act of killing the five-year-old Jehan Martin. All seven pigs were imprisoned for murder and brought to trial a month later before the seigneurial justice of Savigny" (Cohen 1986)*

The case of these seven pigs was not atypical - such “animal trials” were relatively common in Europe from the thirteenth to eighteenth centuries. Often, the animals would be assigned a lawyer and hanged on the same gallows as convicted humans. More than simply a curious period in the history of jurisprudence, these animal trials (and their disappearance) are embedded social practices that reflect how the agency of non-human animals was conceptualized. Law reveals much about the societies in which it is practiced, and the replacement of the legal personhood of animals with the legal personhood of corporations (with ‘nature’ relegated to the role of victim) is particularly revealing. Despite its laudable intentions, the Monsanto Tribunal - like other corporate trials - is the product of a society that represents (incorporated) humans as activate and non-humans as passive.

This chapter is about such matters of representation and perception, not in the courtroom but in the domain of the plant breeder: the field, the laboratory, the garden show, the seed catalog. It engages with theories of art, perception and aesthetics from anthropology, ecology and philosophy. The “I” in the title refers both to the “breeder’s eye” - the term plant breeders often use to describe the trained senses and intuition that comes from long experience in selecting plants - as well as turning the eye inward, toward the I, the self. This is what Merleau-Ponty called the *reciprocity of perception*, that to see is always *to be seen*. How are the ways in which plant breeders perceive their plant subjects linked to how they think about themselves - as humans and as breeders - and the role of human plant breeding within the larger multispecies experiment that we call agriculture?

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A common trope about plant breeding is that it is both *science* and *art*. While scientific plant breeding only arose with the rediscovery of Mendel’s work around the turn of the century, these days it is the artisanship that is more often questioned. The ascendancy of laboratory techniques has also given rise to a perception of the associated breeding practices as increasingly technical, and of breeders as technicians/scientists rather than artists or craftsmen. This was a topic I made sure to raise during each interview and throughout the

fieldwork - what does it mean to call plant breeding an art?

According to Cleveland (2001), breeders often describe their practices as art-like because selections (at least during some stages of the breeding process) are based on intuition and "rapid visual comparison" (Wallace and Yan 1998) rather than solely on scientific principles. Such sentiments were indeed expressed by a number of breeders I talked to. It was generally followed by the argument that transgenic or gene editing techniques would never reduce plant breeding to a purely technical endeavor because the products of genetic engineering would still need to go through classical selection in the field.

What then makes classical breeding particularly art-like? One possibility is Western thought has come to associate art making with the intuition, and in fact has strongly demarcated the realms of intuition from those of rationality. "Rapid visual comparison" is therefore artistic by virtue of its relationship to rationality (specifically by its lack of it). However this conception of art - and indeed the dualism of rationality/intuition - is mainly limited to the post-Enlightenment. To keep the discussion open cross-culturally, it becomes necessary to turn to anthropological theory of art rather than relying on the localized, folk theory of intuition. Alfred Gell's *Art and Agency* (1998), which develops an anthropological theory of art, is one of the more influential recent works in anthropology and Gell's theory seems particular applicable to understanding breeding as an art. As an 'anthropological theory', it is not concerned with aesthetics in themselves, but in what art reveals about social relations. While Gell was occupied with only human-human relationships, one could also consider human-plant and plant-pest relationships as social. How does he distinguish art from other situations?

> *"I propose that 'art-like situations' can be discriminated as those in which the material 'index' (the visible, physical, 'thing') permits a particular cognitive operation which I identify as the abduction of agency"*

By 'abduction of agency', Gell means that an art object implies the social agency of its creator - the one who initiated the 'causal sequence' that resulted in the creation of the material index. For example, on seeing a painting (the material index), one would either consciously or unconsciously infer a painter (the agent). With stereotypical art objects like paintings, songs and architecture this is a relatively simple operation, but what about for living beings like plants? In his book, Gell only devotes a few short sentences to the subject:

> *"All living things are agents with respect to themselves in that their growth and form may be attributed to their own agency"*

Gell seems to limit this particular discussion to the class of 'wild nature'; I doubt he would make a similar statement about a Holstein dairy herd or a semi-dwarf maize plant growing in monoculture. The 'growth and form' of cultivated plants, considered as art-like situations, index their cultivators in addition (or instead of) their own internal agency. Domesticated species and bred cultivars are even more complex indexes, pointing

to the agency of either farmer breeders or breeding professionals who have steered the growth and form of not only individual plants, but entire genetic lineages. Gell uses the term *art nexus* to describe the inferential assemblage that links indexes (art objects), artists, recipients (of the art objects), and prototypes (the image represented by the index) in relationships of (active) *agent* and (passive) *patient*. Deconstructing the art nexus around domestic crop cultivars is the focus of this section.

The common-sense view of the artist-index relationship (in this specific case, breeder-plant) is of the artist as agent and index as patient; the material (e.g. clay, stone, pigment, paper) is considered inert until *acted upon* by the artist. However Gell makes it clear that this arrangement is only one of many permutations. Each entity can act as either agent or patient. The prototype acts as an agent in the case of a portrait or photograph. The recipient acts as the agent in the case of commissioned work. There is a quote from Father Roman Pane - who was asked by Christopher Columbus to study the indigenous people of the Antilles - that demonstrates how the index can also act as agent:

> *Certain trees were believed to send for sorcerers, to whom they gave orders how to shape their trunks into idols, and these 'cemu' being then installed into temple-huts, received their prayers and inspired their priests and oracles (Tylor 1871)*

Are the plants that participate in breeding projects conceptualized like a painter's palette, to be formed into an art object by the agency and genius of the painter? Or more like in the Antilles, where the trees give the orders? To analyze plant breeding practices as an *art* is therefore to follow and explore the agent-patient relationships that obtain between plants, breeders and other entities that in some way exert selection pressure on the cultivar. As my fieldwork progressed, it was these chains and webs of agency that I increasingly focused upon. No simple formulae emerged for describing the art nexus of university breeders vs biodynamic breeders vs company breeders, though certain patterns certainly did.

Plant breeding in the 21st century (at least in the global north) generally proceeds within complex institutional networks that structure, inform and constrain breeder-plant relationships, and therefore the breeder's agency (if any) is distributed broadly. The university breeders who constituted the bulk of my interviews often raised the issue of what they perceived as a loss of agency.

This was partly derived from lack of public funding for breeding, a situation I was already familiar with (because it is paralleled in many other fields of agricultural science) and which almost every university breeder I interviewed brought up without any need for my questioning about it. The public funding that began drying up in the 1980s and 90s led to research partnerships with large seed companies, whose market driven agenda is felt by some breeders to have affected the integrity of university breeding programs. The possibility for universities to patent and profit from genetically modified crop varieties was considered in a similar light (and appeared historically around the same time - the early 1980s).

Not all breeders interpreted this development as a loss of agency, and though the majority of those I met were working with private company partners, this was not universally the case. Some felt that private research sponsorship had not significantly influenced the objectives of their breeding programs, and others felt that the stipulations attached to public funding were just as bad or worse.

Those who did express concern cited that large seed companies were only interested in industrial-scale commodity crops, and that breeding for developing world crops (even staples like cassava) and varieties suited for smaller scale farms were being neglected. There was also criticism that the consolidation of seed and agrochemical companies meant that breeding objectives were oriented towards proprietary management regimes (Roundup Ready crops being the most notorious example).

Thus, the loss of agency is not from farmers and breeders to "the market" - market forces have acted as agents in plant breeding for thousands of years. Rather the worry is about the agency of what Fernand Braudel called the *anti-market*. These are forces exerted by monopolistic, hierarchy forming economic power, of the sort that defines today's food empires (van der Ploeg 2009). That the industrial breeding complex is fraught with asymmetrical power relations has long been recognized; the purpose of investigating plant breeding as art is not to unveil hidden or covert issues of power (as much critical theory strives to do), but to take agency (and the experience thereof) as the object of inquiry and simply follow where it leads, even to unexpected places.

One of Gell's key insights, shared with Daoist philosophy, is that the relationships that constitute systems of action like art are always already asymmetrical; they include both agent and patient, active and passive principles. Egalitarian and hierarchical relationships are therefore formed only over extended durations, the accumulations of either reciprocity or dominance. In "the moment", every action constitutes an agent and patient, which does not necessarily correspond with the general structural pattern over time.

As mentioned above, if one is accustomed to performing social analysis in terms of demystification of power relations, practicing Gell's analytics of agency can lead in surprising directions. For one, a number of plant scientists described their experience of the anti-GMO movement and its policy implications in much the same way as they experienced corporate pressure on university breeding - that is, as a constraint and loss of agency to powers that were far removed from the practices of breeding, beholden to ideology (of "naturalism", as opposed to neoliberalism), and unaware of the complexity and nuance of practical breeding work. One breeder related his bewilderment during the late 1990s when his research team simultaneously received heavy criticism from Monsanto (for saying that Roundup-Ready cultivars would inevitably lead to herbicide resistant pests) and organizations like Greenpeace, for being involved with GMO research. Whether or not these plant scientists' assessment of the anti-GMO movement - that it is un/anti-scientific and 'religious' (ie faith, rather than evidence based) - contains some elements of truth is another discussion entirely, and one could easily make a case for the breeders naivete in believing their science to be neutral. The point here is that the simple narrative of 'the people against the corporations' obscures the experience

of those caught in the middle.

Another surprise was discovering art-like situations in unlikely places. One breeder working with the new CRISPR-Cas gene editing techniques waxed poetically about the elegance of the system - an aesthetic valuation - compared to the unwieldy, invasive transgenic techniques of *Agrobacterium* and particle bombardment. He had come of age in the radical environmental movement and began working with transgenic crops right at their inception in the early 1980s, passionately believing them to be the most effective means of reducing the use of polluting, toxic chemicals in agriculture. In CRISPR, he saw a glimpse of genetic engineering's original promise as an environmental solution. Where transgenics were a brute force approach to manipulating plant genomes, CRISPR required a more skilled and sensitive touch, an openness and understanding towards the plant (or at least its genetic representation).

The cheaper cost of using CRISPR-Cas9 and its higher levels of precision were understood to reduce the respective agencies of corporate influence and the technology, restoring agency to the breeder. Yet if we are to take the experience of the breeder above seriously, it also bestows agency of a sort on the plants themselves. As my research progressed, I shifted focus from the well-tread terrain of farmer/peasant populism resisting (anti)market forces to an exploration of plant agency, from seed sovereignty to the sovereignty of seeds. How do plants themselves participate in breeding programs? Because plant agency is a *relational*, rather than *intrinsic* quality, it emerges in concert with the breeder. Does the breeder's eye resemble the disciplinary gaze of Foucault, exercising reproductive control over plant populations? Or is it receptive, reciprocal - open to being affected?

In Echzell, Germany - home of Bingenheimer Saatgut and a number of the biodynamic vegetable breeders from Kultursaat - I talked to a breeder of broccoli about how he interprets the becoming-desire of the plant. What does the broccoli desire to *become*? For broccoli, I was told that its essence lies in the stem. Modern varieties have generally selected for large, symmetrical and round heads of florets; often only a small piece of the stem is actually harvested. The challenge as a breeder was to accommodate consumer desires for round heads while remaining true to the broccoli idea and selecting for full expression of stems.

When questioned about how they had become familiar with the range of possibilities contained in the ideas of the vegetables they bred, biodynamic breeders pointed to both *depth* and *breadth* of perception. Deep perception corresponds to the Goethianistic, meditative techniques of stilling and opening one's mind to perceive the plant idea. However, they also emphasized that there is no substitute for the breadth of diversity experienced over a lifetime of working with a particular crop. A breeder's vision of what possibilities were available for a plant to become was said to largely depend on the range and quality of exposure to different varieties in different conditions. This was a sentiment also shared by conventional breeders.

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Returning to Gell's formula for art and agency, within the biodynamic framework of Kultursaat cultivated varieties of crops index not only the agency of the breeders but also of the plants and their transcendental ideas. The degree to which individual breeders engage and interpret this relationship varies tremendously from breeder to breeder. Likewise, non-biodynamic breeders also range the gamut in their recognition of plant agency. Some saw human mastery in manipulating passive plant forms as limited only by the rate of technological development. Others espoused an attitude of listening to, respecting and working with plants' 'natural' tendencies.

Gell is primarily concerned with what he calls the *abduction* of agency - the cognitive process by which an artifact is inferred to have come into being by the actions of some agent. What came to interest me just as much as the attribution of agency was the failure to do so. The research question could be inverted. Instead of asking why some breeders would assign agency to plants, to ask why others did not. Plant organisms clearly exert some causal influence (in fact the majority of it) on the eventual form of cultivars. Hardly any plant breeder would deny this. This led to what I have been calling the *subduction* of agency - the obscuring or obfuscation of agency within causal relationships.

The term subduction is borrowed from geology, where it refers to the process whereby one tectonic plate passes beneath another, moving below the Earth's surface. With plant breeding, subduction is happening when the causal influence of market and anti-market forces on breeding decisions is obscured by claims that these decisions are more sustainable, or necessary to 'feed the world'. Subduction is also happening when cultural conceptions of plants do not even consider them as potential candidates for agency. Commodity fetishism represents a specific case of subduction, whereby the social relations that underlie (and 'cause') commodity production are obscured. Commodities do not invite inquiry into how they came into being; in fact they actively suppress it.

Subduction is not inherently oppressive. In fact it is ubiquitous, far more so than abduction. Every artifact is the effect of countless causal relationships, the vast majority of which must be subducted in order to meaningfully participate in the world. If not, the sheer complexity would be overwhelming. So far, this discussion has only dealt with a few agent candidates: breeders, markets, anti-markets and plants. The full list would be far longer. There is, of course, what is often consolidated as the 'environment' - not a single entity but a multiplicity of biotic and abiotic relationships exerting selection pressure. Recall from earlier that Gell declared living things to be agents with respect to themselves. In some senses such a statement holds, but not from an evolutionary perspective. It subducts the agency of co-evolutionary relationships, and all evolution is co-evolution to some degree. Individual organisms do not, for the most part, exert selection pressure on themselves - the complex form of the selection-scape is molded along the lifeworlds of other beings.

We can move even further with uncovering the subduction, because concepts like co-evolution and gene x environment interaction tend not to include the practices of humans or human institutions. From the perspective of the evolving plant, there is no fundamental difference between a seasonal monsoon, a

migrating bird and an agrochemical management regime. All are in rhythmic, causal relationships with the plant and its cohorts, defining the shape of selection pressure. In other words, all could be considered agents with regard to the becoming-form of the plant variety. Theoretically there is a point of zero-subduction, the evolutionary equivalent of Laplace's demon, when all selection pressures are brought into the light. A resulting cultivar is then no more or no less than an (imperfect) *perception* of this multi-species selection-scape. The genetic apparatus could then be conceived as an organ of perception, the whole of evolution as an exercise in representation.

Genetic Literacy

> *"If the lettered world (my world) cannot know something, it represents that thing as having a weak hold on reality or even as not existing. At best, the lettered world considers that which it cannot know as literary fiction, myth, superstition, or symbol and deems it a belief, perhaps madness" - Marisol de la Cadena*

Speaking with Kultursaat breeders, I heard about an incident where university breeders from Sweden approached them to collaborate on a breeding project. Initially enthusiastic about the chance to engage with mainstream breeders (as well as the ample funding that was available), Kultursaat soon decided to withdraw from the partnership. As it was explained to me, the deciding issue was about what scale of perception to give primacy to. The university breeders, as was their habitus, interfaced with plant populations as genetic libraries. The Kultursaat breeders, as was theirs, took the (meta)physical form and growth of individual plants as paramount. In other words, the university breeders took genotype as ontological prior, the biodynamic breeders phenotype.

At issue here are interlinked matters of perception and conception. Is the essence of a plant what is open to the world (phenotype), or what is hidden deep inside the cell nucleus (genotype)? Questions of power also run deep - use of genetic markers, for instance, is often the line of demarcation between serious, 'scientific' breeding and hobbyists, farmer-breeders and peasant cultivation of land races. Plant breeding is often referred to as applied genetics. I have taken to calling this particular dynamic of power *genetic literacy*, for the way that it parallels the colonial dynamics of literacy and illiteracy.

As Marisol de la Cadena (2015) writes, *"in an era when states may pride themselves on multiculturalism—if they achieve it— modern literacy (and all that it encompasses in its semantic field) continues to set the limits of acceptable difference, or tolerates it at its own risk and until its expected failure"*. In her research on the political agency of Peruvian peasants, de la Cadena demonstrates how illiterate peasants are marked as unacceptably other. Reading and writing are the "cornerstones" of the modern state, and those who do not perform as literate citizens are denied participation.

I find this idea of “limits of acceptable difference” extends quite productively to what I observed in the world of plant breeding. There is a celebration, even a sacredness, of (agrobio-) diversity, but what the acceptable limits before it becomes radically other? Among existent crop cultivars, there is a sharp distinction between modern varieties (which are considered intellectual property, developed out of scientific principles and individual genius, and suitable for “serious” agriculture - the kind that feeds the world) and traditional varieties (considered the ‘common heritage of mankind’, developed by thousands of generations of farmers with no knowledge of underlying principles, and suitable for subsistence or hobby farming) (see Van Dooren 2008). Those still using the so-called traditional varieties are seen to be in the ‘waiting room of history’ (Chakrabarty 2009); that is, they are ‘behind’ in the linear path of development. If they happen to live in already developed countries, then they are written off as romantics, cultural (as opposed to economic) farmers.

The Genetic Literacy Project is also the name of one of the most prominent advocacy groups for biotechnology and GMO crops. The website bears the tagline “science not ideology”, the implication being that those who do not support biotech are genetically illiterate - scientifically disabled. The only reasons to oppose genetically modified crops are posited as illiteracy (lack of knowledge) or ideology (false knowledge).

Just as de la Cadena notes that multiculturalism recognizes and celebrates cultural diversity while refusing true difference, agrobiodiversity’s value is limited to certain domains - the safety of aesthetic/cultural appreciation and the utility of appropriating it as a resource bank of traits for developing new modern varieties. I call this dynamic *multicultivarism*, and it functions in much the same way as multiculturalism - allowing a harmless amount of variety to be expressed as a way of guarding against a true otherwise. There is no space within the thought of modern scientific breeding for self-doubt, that there could be a viable alternative to the line of descent from Mendel to Darwin to Donald Jones (and hybrid corn) to transgenics, the sort of viable alternative that biodynamics presents. The only alternatives are pre-scientific (those who haven’t yet caught up) or romantics who ‘look backwards’ towards a false golden age. The possibility of collaboration between the Swedish breeders and Kultursaat is notable because such instances are so rare.

Of the many bulwarks that decides what sort of breeding is considered serious and scientific, genetic literacy is one of the strongest. Assessment by phenotype is considered archaic, a relic of a pre-modern age of plant breeding. The choice to assess genotype versus phenotype is not a neutral choice, a mere matter of preference. Genetic markers are exceedingly expensive to develop, creating a significant barrier of entry for those who are not affiliated with large seed companies. Yet it is significant that it was Kultursaat who withdrew from the breeding project, not the university breeders. They made a very conscious decision *not* to pursue breeding by genotype, even when the financial resources were made available.

Kultursaat demonstrates that assessment by phenotype is not always a matter of lack of resources, knowledge or scientific development, but may also be a choice. Genetic concepts in the past century have often been shaped by textual metaphors that have conceived sequences of genes as a “language”. Genetic literacy privileges those with the willingness and resources to “read” it. Whether or not DNA sequences

constitute a language in the formal sense is up for debate, but it is certainly significant that our metaphors (even the use of letters for nucleotides) are principally linguistic. Charles Peirce, the American semiotician and philosopher, wrote that symbolic thought in general and language in particular was distinguished from other forms of signs (indexes and icons) in that symbols and language do not derive their meaning from a relationship to their real world referent, but from relationships with other words and symbols. In other words, symbolic language is not necessarily 'ground-truthed'. Although they offered many reasons for preferring to work with phenotypes, this issue of ground-truthing was especially significant. Like systems of symbols, the representations of plants through genetic markers were seen to have taken on a reality of their own, independent from the material forms that they referenced.

What is the real plant, the genotype or the phenotype? Eduardo Viveiros de Castro (2004) has coined the term *equivocation* to describe the 'communicative disjuncture' that occurs when people are using the same word but not talking about the same thing. Generally it has been applied to situations of quite radical disjuncture, mostly between indigenous people in South America and neo-colonial states or western anthropologists. However I believe there are also more subtle moments of equivocation as well, even between the university and biodynamic breeders who share much of the same culture and intellectual history. Both groups are entirely convinced that their techniques of perception (DNA sequencing and meditative observation) yield more direct access to the plant itself and a more 'truthful' picture of the diversity present in a given population.

This is only a partial equivocation; the biodynamic plant and the plant science plant do overlap in many ways. For instance, they generally agree on its empirical form, as well as many of the principles of heredity and the effectiveness of classical breeding techniques. Yet while both groups posit a supra-empirical, hidden dimension to the plant, they differ significantly on its nature. The scientific breeding world finds this in the genome, the 'molecule of life'. For the biodynamic breeders, it lies not deep inside the plant body but out in the cosmos. Unlike humans, plants are only partially incarnated, just as an individual plant phenotype is only a partial expression of a full genotype. The soul of the plant, they say, persists on the astral plane. Its organs are the planets.

Thus it would not be entirely correct to characterize biodynamic plant breeding as phenotype-oriented contra the genotype-orientation of scientific breeding. While phenotype does play a significant role in the assessment process (far more so than in typical university/corporate breeding), Kultursaat breeders also make selection and farm management decisions based on plants' astral qualities, what might be called their *xenotype.*

Such an analysis in terms of equivocation (Viveiros de Castro calls this activity 'controlling' the equivocation) thus reveals the contours of incommensurable difference while also uncovering surprising intersections. At first glance, genotype and xenotype present as entirely other - the polar opposites Enlightenment thought has made of science and mysticism. Certainly, this is what one might "expect" to find in a comparison of plant science and biodynamics. The approach of ontological agroecology however, is not primarily concerned

with comparison, but *attunement*. Plant science and biodynamics are not diametrically opposed; neither are they particularly analogous. Instead, they are partially overlapping, partially otherwise and internally heterogeneous assemblages of concepts and perceptual techniques that amplify certain styles of human-plant interaction.

Three: Cereal Monogamy

> *"It is with considerable difficulty that I remember the original era of my being: all the events of that period appear confused and indistinct. A strange multiplicity of sensations seized me, and I saw, felt, heard, and smelt, at the same time; and it was, indeed, a long time before I learned to distinguish between the operations of my various senses" - Mary Shelley 'Frankenstein'*

It is not uncommon in discussions about current issues of plant breeding to hear claims about the origins of agriculture invoked, generally without much in the way of archaeological or archaeobotanical evidence. This chapter explores the initial period of plant domestication as it pertains to contemporary debates in crop breeding. It is premised both on an idea of domestication as a continual process (that continues today) and a conviction that developing a better understanding of both origins and alternatives reveals useful perspectives of problem situations.

There are several reasons why the vast majority of literature on the origins of agriculture are limited to the Near East rather than the many 'hearths' of domestication on other continents. For one, according to all current evidence the subsistence patterns we label as agriculture simply emerged in the Near East chronologically prior to anywhere else. The archetype of the heroic inventor that characterizes our standard histories is not heroic just for the act of discovery, but for the act of discovering *first*.

A more mundane reason is that the arid climate has preserved artifacts (both man-made and otherwise) particularly well for study by modern archaeologists (Cowen et al 2006). This, combined with the sheer quantity of archaeological and archaeobotanical work from the region, means that we have a relatively complete (though still highly conjectural) picture of the emergence of agriculture and the domestication of plant and animal species.

There is of course the question of why so much archaeological research had been conducted in the region in the first place. The Near East has long been considered the birthplace of Western Civilization, and archaeological investigations take on some of the mystique of a personal introspective quest. Even after historians abandoned the Bible as a primary source, they still maintained that history proper begins some thousands of years ago, in the Near East, rather than much earlier, in East Africa (Smail 2007).

Dubious as the direct lineage of civilization from Sumer to Egypt and then to Greece, Rome and modern Europe may be, in terms of agriculture many aspects of the current industrial food regime are indeed inherited from Mesopotamian agriculture. Compared to the emergence of agriculture on other continents, including Africa, Australia and the Americas, there are several aspects that distinguish Near Eastern agriculture as unique, the two most relevant to the discussion at hand are (1) an accompanying shift in symbolic expression towards images of anthropocentric domination of nonhuman 'Nature', and (2) a tendency towards a complete shift from a foraging to an agricultural mode of subsistence, rather than a coexistence of the two.

Master of the Vegetable Tribes

> *"[Man] is master of the vegetable tribes, which, by his industry he can, at pleasure, augment or diminish, multiply or destroy" - George-Louis Leclerc*

Scholars have sought the origins of Western ideas of human exceptionalism and domination of nonhumans in many historical epochs. Many find it in the Enlightenment thinking of John Locke, Francis Bacon and Rene Descartes (Plumwood 2002). Others locate it in Biblical texts and exegesis (White 1967). Matthew Hall (2011) details how the silencing and exploitation of plants in particular was driven by the ascendancy of Aristotle's writings on plants over those of Theophrastus. Yet for archaeologists like Jacques Cauvin (2000) and Ian Hodder (2007), as well as philosopher Timothy Morton (2016), these are merely symptoms of an ontology of humans and nature that accompanied (or enabled) the Neolithic Revolution in the Near East.

This foray into the origins of agriculture and its conceptual milieu is not simply a matter of providing historical background to contemporary plant breeding, but is instead immanent in its central questions. Questions about what is permissible in breeding practices, what sort of goals should inform breeding programs and the role of seedbanks, crop wild relatives and plants themselves in the regeneration of agrobiodiversity hinge heavily on how the human/plant relationship is conceptualized and contested. After all, domestication is not an event but a process, one that is still in duration today (even though few 'new' species have entered this process for thousands of years) and within which all current breeding projects unfold. The reappraisal of plant breeding history as the nonlinear unfoldings of co-evolutionary dynamics between humans and crops destabilizes the event form that serves as the building block of internalist history, and explores the overlaps and frictions between *power* and *selection pressure*.

A second object of concern is question that has remained with me for some time: can there be hierarchy without domination? Much has been made by ecological thinkers about the legacy of Aristotle's Great Chain of Being (Lovejoy 2011), and how it's hierarchical ordering of the world has justified and naturalized expressions of structural domination from slavery to the patriarchy to exploitation of plants, animals and soils in agriculture. In the fieldwork with biodynamic plant breeders I was confronted with people who clearly

professed an Aristotelean hierarchy (at least between humans, animals, plants and minerals) yet related to nonhumans (specifically the crops they were breeding) in a manner at least as egalitarian as any group I had encountered. There is the important question of how to meaningfully engage with difference once we have moved away from human exceptionalism. Elizabeth Povinelli (2016) has raised the issues with practices of 'recognition', whereby concepts like agency, intentionality, culture and sentience are enlarged to include nonhumans, even though these concepts originated specifically for purposes of their exclusion. Might the possibilities of non-dominant hierarchy lend some insight into this dilemma? Louis Dumont, author of *Homo Hierarchicus* (1980), had argued that in any pair of conceptual opposites (such as those presented by the Structuralists), one is always considered superior and 'encompassing' of the other. Certainly this seems to be a fairly accurate description for many of the dualisms at hand here: human/nonhuman; culture/nature; domestic/wild. Why have these opposing terms tended to have been maintained so strictly - *radically* instead of *relatively* opposed? What other ways are possible?

Though there are many possible entry points, I've chosen to start where so many others have - 12,000 years ago, in the Fertile Crescent. As Timothy Morton (2016) writes, *"we are still within this twelve-thousand-year 'present' moment, a scintilla of geological time. What happened in Mesopotamia happens 'now'"*. What was it that happened in Mesopotamia? As mentioned earlier, Neolithic farming communities in the Near East were the first to leave evidence of a dominating attitude towards plants and animals. Ian Hodder (2007) demonstrates that for the Catalhoyuk site in present-day Turkey, although mother goddess figurines have received most of the popular attention, further excavations have shown that these feminine images are actually only a small subset of the symbolic repertoire. What this repertoire emphasizes most strongly is not mother images but those of violence, death and sex, including *"scenes of humans teasing, baiting, and killing wild animals"* where *"humans are dominating animals and interfering with them"*. Hodder proposes that such imagery and the rituals they were embedded in established the conditions for domestication of other species.

Even earlier, French archaeologist Jacques Cauvin (2000) had developed his theory of a 'Symbolic Revolution' that preceded the Neolithic Revolution in the Levant by half a millennium. While the preceding Natufian people created art that was *zoomorphic* - representing animals either realistically or schematically as was common throughout the Paleolithic - during what is known as the Pre-Pottery Neolithic B (PPNB) a new figure appears: the anthropomorphic, masculine bull god:

> *"The wild bull is not a symbol of equilibrium or of tranquil settled life. This symbol is suffused with the values of expansionism, when the human male is assimilated into ritual and raises blind impetuosity and instinct to respectability through the confrontation in the battle with the bull"*

Cauvin calls the PPNB the 'people of the bull', specifically those from the Mureybet site, on the west bank of the Euphrates. Though herds of wild aurochs (the ancestor of domestic cattle) were present in the landscape before, it was the Mureybetians who started hunting them regularly and developed the ritual battle between man and bull that recurs so often in the mythology of the Mediterranean. This was also the time when the

first experiments with domestication were initiated. The *PPNB suite* of practices first developed in Mureybet would spread through the entire Levantine Corridor. This suite was comprised of symbols of virility that pit humans against animals, animal domestication, glorification and decoration of weaponry, rectangular architecture and a tendency towards expansionism.

Both Hodder and Cauvin thus place an ontological shift - the separation of humans from 'nature' and the characterization of this relationship as one of competition or even domination - as a precondition for domestication in the Near East. For Cauvin, the shift is characterized by the emergence of a transcendent plane, a "vertical typology" wherein the divine realm is hierarchically above the mundane. This is the first appearance of *sovereignty*, first embodied in the figure of the Mother-Goddess and then represented by the tribal matriarch. The primordial sovereignty becomes the model for all subsequent forms of hierarchical social and economic organization: human dominance of Nature, Sky God mythologies, the sovereign rule of kings, the liberal subject who is sovereign over oneself and even, one might add, contemporary movements for food sovereignty and seed sovereignty. Those who agitate for seed sovereignty generally demand democratization over control of seeds, but for the most part do not question the underlying relationship of control between humans and plant reproductive material. Seeds as such are *encompassed*, in the sense of Dumont, within the sovereign folds of humanity.

Hodder also emphasizes the centrality of power for Neolithic Çatalhöyük. Feasts, for instance, demonstrated power and control over plants and animals, thus also reinforcing one's power over other humans. The co-evolution of humans and plants is "no longer a balanced relationship". Notions of power and sovereignty introduce a new suite of evolutionary selection pressures on those plants which had entered into a symbiotic relationship with humans. While David Rindos (2013) has made a strong case that crop domestication *could* have proceeded entirely through what Darwin calls 'unconscious selection', what data we do have seems to indicate the importance of, *"deliberate directed human choice rather than the slowly unwinding reciprocal plant/human interactions involving experimentation with numerous different taxa that would be characteristic of coevolution"* (Piperno 2011).

Now, ontological equality/domination and conscious/unconscious selection do lie on different axes. It is certainly possible for an ontology of plant domination to exert selection pressure on plants unconsciously, just as deliberate decisions regarding selection can be made within an ontology of reciprocal animism. Yet for the sake of simplicity it might be best to focus for the time being on conscious selection, and how selection pressures on food plants might interface with asymmetrical power relations.

Theophrastus, in *De Causis Plantarum*, already noted a *"clear distinction between the proper seed that reproduces the plant, and the fleshy part of the fruit which is appropriated by man"*. He questions whether the cultivation of crops ought to be considered 'natural', as it interferes with their "overall flourishing", and describes the participation of plants in agriculture as a sort of proto social contract. Plants give up some measure of their own autonomy and vitality in exchange for protection from competition and disease. Theophrastus compares different possibilities for farming practices - those that more closely resemble

slavery and those that respect the “awareness and autonomy of the cultivated”, for which he advocates.

In this distinction between the “proper seed” and flesh “appropriated by man”, Theophrastus gives an early account of what be described by modern plant breeders as harvest index - the partition of useful plant material to the rest of the plant, which is often simply glossed as ‘biomass’. It is through the heuristic of the harvest index that specifically human or Mesopotamian practices of domestication might be compared with animal-plant coevolution more generally. The edible, fleshy parts of seed only existed by virtue of the labor from a far older coevolutionary project - the 100 million year old collaboration between angiosperms and insects/birds/mammals that served as seed vectors (Nabhan 2016). It was this collaboration, unfolding on a field of environmental heterogeneity, that generated the vast crop and wild plant biodiversity now seen as a ‘common heritage of mankind’. These sets of coevolutionary partners demonstrated some degree of balance of power, leading to balance in the metabolism of angiosperms between producing plant parts to be appropriated by animals and the energy used to flourish and reproduce. Theophrastus noted (as Plato and Aristotle did not) that plants do not simply possess ‘bare life’ (Agamben 1998) but also *live for* something, that they also possess a *telos*, a destiny. As such it might not do to describe the consumption of fruit by animals as ‘appropriation’, at least in the Marxist sense. This consumption is not really an alienation of the plant from its metabolic labor, but an action through which the plant progresses towards its *telos*.

Any breeding project that involves conscious selection, from the initial steps towards domestication to post-harvest seed selection by peasant farmers to CRISPR-Cas gene editing, is informed by certain breeding objectives. To what degree do they consider the plants as ends-in-themselves? Do plants end in themselves or do they only end in humans? The ontologies of domination that first emerged in the Near Eastern Neolithic initiated the process of migrating vegetative *telos* into the human domain, as plants were conceptualized first as fellow persons, then resources, then machines (see: Descartes) and most recently pieces of information technology (see: Schrödinger). These conceptions of the plant are not sequential, mutually exclusive paradigms but are additive - mainstream agronomy simultaneously sees plants as resources (destined for human utility), machines (means of industrial production, based on a factory model; Weber defines machines as entities with ends “outside of themselves”) and information technology (divided into an internal software/genetic code/soul and external hardware/phenotype/body). Of course there are a great many people, even in the developed places of the world, who continue to treat plants as persons.

Max Weber (1946) referred to the removal of ends-in-themselves from the world characteristic of modernity as disenchantment. The additive process of plants as resources/machines/computers is then part of a *long disenchantment*, stretching back to the Neolithic and continuing in novel ways today. A more nuanced, ecological interpretation of enchantment would see things as not with ends not only *in themselves* but as being entangled, like root hairs, in their relational *lifeworlds*. A plant’s *telos* (what I have defined elsewhere as the entwined metabolic-semiotic chains perceived in futuro - Tanis 2016) is found not only in its individual (that is, withdrawn) flourishing or in future generations, but also in its pollinators, symbiotic microorganisms, the living soil, surrounding plant community and yes, even in predatory herbivores, including humans. Flourishing is not a solitary affair, or as Donna Haraway (1997) has noted - *“nothing comes without its world”*.

Parallel to the ontological disenchantment of plants through nature/culture dichotomies, Enlightenment doctrines of mechanism and hegemonics of the commodity form has been an *ecological disenchantment* through the severing or simplification of crop plants' social circles. If the idea of 'agricultural development' means anything than a significant trend has been the progressive enclosure and control of the agricultural niche, reducing the amount and complexity of ecological relationships that crop plants participate in and co-evolve with. There is the demarcation of the *field* and its subsequent homogenization (through tillage, fertilization and irrigation), disruption of microbial symbiosis and replacement with synthetic NPK, disruption of complex insect foodwebs and replacement with pesticides and alienation from the soil in hydroponics. The disenchantment of plants reaches its apogee in the various projects to grow vegetables on the International Space Station or on Mars, an absolutely sterile and controlled niche, alienated not only from the soil but from Earth itself.

While we might find the growing of crops in space 'enchanting' (or simply cool), *enchantment* in this sense is not an anthropocentric concept; it is centered on the plant, describing the quality and complexity of its metabolic-semiotic entanglements within which the plant realizes its *telos*. Each of these entanglements is also a co-evolutionary conduit exerting multi-directional selection pressure. As the lifeworld of crops is impoverished through simplification of the agricultural niche, selection pressures are likewise narrowed to the focused eye of the human breeding program. The ontology of human sovereignty over plants subsumes their future prospects, such that the greatest destiny a vegetable can aspire to is to be produced, profited upon and consumed by a human. Accordingly, conscious human selection informed by these conceptions will favor those traits that either ease production and consumption or increase profit. Often these traits stand directly at odds with plant *telos* - seedless fruit, semidwarf cereals, jumbo tomatoes. Plant parts to be appropriated in human production chains are augmented, as other parts are diminished. In many cases, crop plants are not expected to reproduce at all except within designated fields for seed multiplication or breeding, as with hybrid seed production or inducement of cytoplasmic male sterility. The biopower exercised over crop plants is far more total than control of human reproduction, except in the worst days of the eugenics movement.

When I discussed the 'naturalness' of certain breeding technologies with university plant scientists, the general consensus was that debate over whether genetic modification through transgenesis was natural or unnatural was a moot point, because plant breeding (in fact all of agriculture) in general was unnatural. As 'unnatural' life forms, plants are not afforded much moral consideration. This is not because plant scientists are unfeeling tyrants mercilessly oppressing their plant subjects. In no way does the unfolding of dominance imply any sort of malice on the part of those participating in it. Because plants are generally considered outside the sphere of moral consideration, it is difficult even to conceive what would constitute an 'immoral' act against plant life. Only 'biodiversity' (plant genetic resources) is considered to hold moral value; caring about individual plant lives is romantic, anthropomorphic or for gardening hobbyists. Plants therefore occupy a liminal position in what Elizabeth Povinelli has been calling *geontology* and *geontopower* - the drawing and policing of boundaries between Life and Nonlife. Unlike animals, plants are undoubtedly alive but only in the biological sense. While certain animals (whose form of intelligence most resembles human sensibilities, like cetaceans and primates) have been described even by scientists as 'nonhuman persons' and as a taxonomic

kingdom even enjoy marginal political representation (though not direct democracy) in the Netherlands via the Partij voor de Dieren (Party for the Animals), plants are continually slipping into the category of object - sometimes economic objects, sometimes aesthetic objects - but always passive and quasi-inert.

> *All beings are fond of life, like pleasure, hate pain, shun destruction, like life, long to live. To all life is dear – Mahavira*

The behavior space of plants is markedly different from that of humans; they generally move on a much longer time scale, communicate silently, and are often not so thoroughly demarcated from other individuals or abiotic surroundings as animals. In a limited, relative way, the radical othering and instrumentalization of plants could be said to have an element of 'naturalness' to it. Without sustained attention or regular practical engagement, plants can appear to behave passively, like objects. Matthew Hall (2011) has noted that Jainism presents a philosophy and practice of respecting plant life that is unique among Axial Age religion and thought (e.g. Christianity, Islam, Buddhism, classical Greece, Confucianism). *"Humans and plants are recognized as possessing a shared ontology"*. Notably, Jainism emphasizes that affinity with plants is not a natural state, but requires work:

> *As plants differ greatly in form and process from humans and animals, this evokes the need for an acute state of mindfulness when examining the possibility of life in a plant (Hall 2011)*

The teachings of Mahavira and other Jain sages are first and foremost practical; the vitality and moral value of plants is not solely categorical, it is also seen as being made in practice. Furthermore, there is a recognition that avoiding harm to plants is an impossible ideal and that minimization of harm requires compromises that must be worked out in the messy reality of multispecies entanglement. Appropriation of food that results in plant senescence is recognized as an act of killing, one to be avoided when possible, and when unavoidable to be conducted with full mindfulness of the moral ramifications. A Jain parable from Mahavira:

> *As they ran to the tree the first man said "Let's cut the tree down and get the fruit." The second one said. "Don't cut the whole tree down, cut off a whole branch instead." The third friend said, "Why do we need a big branch?" The fourth friend said, "We do not need to cut the branches, let's just climb up and get the bunches of fruit." The fifth friend said, "Why pick that much fruit and waste it? Just pick the fruit we need to eat." The sixth friend said quietly, "There is plenty of good fruit on the ground, so let's just eat that first." (Shilapi 2002).*

Though Jainism considers plants worthy of moral consideration, it does not feature a flat ontology. A soul can only achieve moksha (liberation) while in human form. Souls in plant forms must first be reborn as humans before proceeding in their spiritual development. There is still a hierarchical relationship between humans and plants, but it is a "relative, nonviolent hierarchy". In Jainism, *"the defining aspect of the human sphere of*

life is not constructed in terms of dominant superiority, but in the ability to act morally and to practice ahimsa (nonviolence)". This recalls the guiding question of this section - is it possible to have hierarchy without dominance? The question refers to hierarchy of beings, though even hierarchies of thought like Peircian semiotics tend towards dominance. Jainist hierarchy is distinct from the Aristotelean chain of being in that it is ordered along an axis of greater moral responsibility to practice nonviolence, as opposed to an axis that emphasizes superiority by virtue of capacity for rationality. The hierarchical relation that obtains between human and plant is not one of sovereignty, or even of the kind of opposition seen in Neolithic imagery.

Likewise, the anthroposophic teachings of Rudolf Steiner that underlie biodynamic practices of farming and plant breeding also feature a balanced and respectful hierarchy between human and plant kingdoms. My academic and political background (in critical social science and flat organizations) had always glorified the horizontal over the hierarchical, and so my initial encounter with the hierarchy of kingdoms in biodynamic agriculture was one of unease. Steiner's conception of the hierarchical ordering of human, animal, plant and mineral kingdoms was directly inherited - via the Medieval scholastics - from Aristotle's chain of being, which had historically justified not only domination of nonhumans but also practices of human slavery and patriarchy. If anything, biodynamic farmers and practitioners espouse a far more explicit hierarchy than do the majority of mainstream biologists, plant scientists and geneticists. At the same time, what I experienced both in my fieldwork with biodynamic breeders and in prior exposure to biodynamic methods, was a respect and consideration for plants (and animals and soil) *in themselves* that was rare even among small-scale organic growers.

In Aristotle's hierarchy, the *telos* of lower kingdoms are encompassed within and instrumentalized by higher ones:

> *"In like manner we may infer that, after the birth of animals, plants exist for their sake, and that the other animals exist for the sake of man, the tame for use and food, the wild, if not all at least the greater part of them, for food, and for the provision of clothing and various instruments"*

Besides an instrumental relation, the Great Chain of Being takes the (rational, male) human as its index and orders the other kingdoms according to what they lack. Plants are defined by their lack of rationality (i.e. against an anthropocentric criteria) and a lack of motility and sensitivity (i.e. against a zoocentric criteria). In both their identity and fulfillment of potential, plants are entirely encompassed by the domain of human utility.

Michael Hall contrasts Aristotle's assessment of plants to that of Theophrastus. While today considered the 'Father of Botany', Theophrastus was largely forgotten between 200 and 1500 CE - known as the 'dark ages of botany'. The works of Aristotle, by contrast, enjoyed a profound influence, and especially through Thomas Aquinas the idea that plants were *"naturally enslaved and accommodated to the uses of others"* became

official church doctrine. Theophrastus was a more keen and detailed observer of plants than Aristotle. Most importantly for the current discussion, he does not describe plants in terms of what they lack, nor does he *"seek to arrange these differences in a hierarchy of value"*. He does note ways in which plants display differences, but these also include areas where they demonstrate superiority over animals or humans.

In many ways, the biodynamic hierarchy could be said to be an integration of Aristotle and Theophrastus. It retains some of the segmentation from the Great Chain of Being - the arrangement of Human-Animal-Plant-Mineral - but the relations between them are not corollaries to a pre-assumed human superiority. This is not to say that the human is not accorded a kind of centrality. As was made clear in our conversations during the fieldwork, it is called *anthropo*sophy for a reason; the teachings are for people, not for plants. Humans are seen as unique in that their individual egos are incarnated physically in the body. Animal spirits reside in the astral plane and plant spirits on the level of the planets. The celestial hierarchy is a inversion of the earthly one, with mineral spirits inhabiting the plane of the fixed stars. Biological evolution is conceived as a progressive *infolding*, a "development of the microcosm out of the macrocosm" through the development of cell membranes, nuclear membranes, radial symmetry, bilateral symmetry, internal organs, eggs, placenta and encephalization. This results in the physical housing for an indwelling spirit, which is only present in human beings.

What struck me about this conception of hierarchy and humans as the bleeding edge of progressive evolution was that it did not lead to domination of plants; in fact it explicitly leads away from it. Perhaps this is a call to environmental critical theory that instead of critiquing hierarchy and progress myths as such, there needs to be more analysis of the relational qualities that are used to construct hierarchies and teleologies.

If biodynamic breeders are operating within an ontology that includes hierarchy but not domination, what does this imply for breeding practices and the co-evolutionary selection pressures imparted on crop plants? Plants, not encompassed in the sphere of human economic utility, are endowed with both some degree of individual agency as well as individual and collective destinies. In practical terms, this translates to breeding objectives that are balanced, not only between production, processing and consumption but also between human appropriation and plant flourishing.

One example of how this is institutionally arranged is in the division between Kultursaat and Bingenheimer Saadgut. Kultursaat, the association of biodynamic vegetable breeders, in many ways insulates the work of the breeders from market and production forces. Those operations are coordinated by Bingenheimer Saadgut, which consolidates, processes, stores and sells the seed. They are the ones who interface directly with the market and with production systems (including seed production). The breeders of Kultursaat interface directly with the plants themselves. According to them, the decision to create two separate organizations was consciously intended to balance the voice of the plant with the voice of the market.

Breeders' relationships to the plants they co-labor with is insulated from market pressure in other ways. Funding for the breeding work, for instance, is not contingent on royalties or sales but is steadily provided simply for doing the work itself. The decision to forgo breeder's rights and therefore royalty payments was made from the recognition that (1) if the breeding work was directly hitched to the market then market signals would drown out other co-evolutionary signaling and (2) that it would be disingenuous for an individual person or organization to claim 'authorship' over a cultivar in a way that obscures the co-laboring of the multitudes.

Neither should it be understated how the practices of perception that biodynamic breeders bring to bear on their plant subjects anchor these non-instrumental relationships. Anthroposophy draws strongly on the work of Goethe, who in the 19th century developed perception itself - particular that of plants - to a high art. *"If we want to behold nature in a living way, we must follow her example and become as mobile and malleable as nature herself".* Above all, Goethe was critical of scientific trends during his time to reduce whole organisms and phenomena to individual parts, as well as the reliance on both instruments (e.g. microscopes) and theoretical constructs instead of the human body's perceptive apparatus.

Goethe's approach to plant perception features prominently in the biodynamic mode of plant breeding, which emphasizes selection of *whole plants*, while mainstream breeding moves towards increased use of genetic markers that render whole plants as incidental to the breeding process. It also seems safe to say that sustained interaction with whole plants will tend to cultivate more respectful, even egalitarian relationships; recall that Mahavira emphasized the need for mindfulness and careful attention, and that Theophrastus developed a more inclusive botany than Aristotle partly because of the former's far more extensive observations of plants. Mainstream plant science has moved in the direction of spending less 'quality time' with whole plants and more time in the laboratory with plant parts alienated not only from their life world of symbionts but even from the rest of the plant individual. This is one piece of a larger constellation of practices and structures that facilitate the conceptualization and treatment of plants as objects incorporated into the human domain rather than autonomous beings.

The biodynamic approach to plant breeding presents one of the strongest and well developed non-hegemonic ontologies, one that counters the objectifying, dominating approach without defining itself in terms of resistance against it (as do many segments of the anti-GMO movement). Biodynamic farmers and breeders tend to be less politically active in the sense of outright resistance, and far more concerned with managing their web of relationships to plants, soil and community. In this they represent a possibly more robust challenge to the hegemonic ontology by demonstrating a viable, resilient alternative than a simply counter-hegemonic stance.

Critical scholars in general and the ontological turn in anthropological in particular have tended to invoke (or appropriate) radically non-Western peoples in their critiques of Western concepts. The project of ontological anthropology has been to *"lend the "otherwise" full ontological weight so as to render it viable as a real alternative"* (Holbraad et al 2014). Yet by focusing on the indigenous, even when given 'full ontological

weight' the otherwise remains at a distance - a radical otherwise. Biodynamics is unique in that it presents an otherwise that emerged from the very same conditions of Enlightenment, capitalism and modernity that gave rise to the dominant, hegemonic ontologies of late liberalism. It is alt-Western, and therefore holds potential for very particular mode of subversion.

He that would study and portray
a living creature thinks it fit
to start with finding out the ways
to drive the spirit out of it.
This done, he holds within his hand
the pieces to be named and stated
But, ah! The spirit-tie that spann'd
and knit them, has evaporated.

Goethe 'Faust'

Cereal Monogamy

"Cereals domesticated humans. The love affair between people and cereals is one of the great romances of human history" - Anna Tsing

I mentioned earlier in this chapter that the Near Eastern Neolithic was unique for two reasons. Firstly, agriculture emerged in Mesopotamia in conjunction with the vertical partitioning of the world into sovereign and subject. The second reason was that the emergence of agriculture preceded a complete switch from other modes of subsistence to farming. This was not in the case in, for instance, Africa, Mesoamerica or Australia, where cultivation became a piece of mixed subsistence strategies that included hunting, gathering, fishing and herding. While use of wild food certainly did not disappear entirely from the Near East, it became economically insignificant. Neumann (2005) writes that the characterization of the Neolithic developed out of archaeological research in the Near East and has been "uncritically transmitted" to other continents. She adds that the *"use of wild plants was an important element of African subsistence throughout the Holocene and continues to be successful up to modern times".*

The familiar, sequentialist notion of human societies passing neatly along from hunter-gatherers to farmers to industrialists, distinct as a string of rosary beads, has been debunked thoroughly and often. Yet there is one circuitous path - namely that of so-called 'Western Civilization' - that from a certain angle actually does

resemble such a model. The form of agriculture that developed out of the Near East, spread through Sumer, Greece and Rome, established itself in Europe and North America before being exported around the world through the Green Revolution has displayed a marked tendency both towards simplification and 'revolution' - that is, the complete replacement of prior ways of life by new systems imposed from the outside. Raj Patel (2013) has described the "long Green Revolution", and others have written about proto-Green Revolutions in the United States and Europe, but all of these can also be viewed as the latest emergences in a long series of 'nested', hierarchical revolutions going back to Pre-Pottery Neolithic B Mureybet.

The word 'revolution' itself has changed rather dramatically, initially referring to a circular continuity, to revolve, only later acquiring the meaning of turning something over entirely - to revolt. Why would the Mesopotamian lineage of agriculture have this 'revolting' tendency? Even now, there is insistence among the alternative agriculture movement that the industrial food regime is *systemically* corrupt, and should be replaced entirely by organic/agroecological/permaculture/peasant/local system. Is rupture the only way that we can imagine change?

While in the Near East the entire Mureybetian suite spread into concert (including domestication, sedentism, symbolism of warfare and domination over nature, as well as expansionism itself), archaeologists have shown that in other regions agriculture was simply added to the existing repertoire of subsistence practices. In the neotropics, the first gardens were not associated with permanent settlements, which only appeared significantly later. The same is true in Africa, where domestic animals became important much earlier than domestic plants, better complementing mobile, foraging lifestyles. In Australia, cultivation of yam and small grains was integrated into a diversified subsistence strategy that included wild plant foraging, hunting and fishing. Cecil Brown has shown that contemporary societies with mixed subsistence strategies tend to display significantly broader ecological knowledge than those who only forage or only farm (Brown et al 1985). The Near East is not the only region in which a primarily agricultural mode of subsistence develops (certain regions of Mesoamerica, for example), but it stands out for the rapidity and ubiquity by which it replaces hunting and gathering.

If the history of Western agriculture really is one of rupture, then it is initiated by that first rupture - between human and nonhuman, culture and nature - one intricately bound up with the appearance of agriculture in the Near East. This is moment proudly signposted by history textbooks as the origin of civilization, the dividing line between deep history (when humans were part of nature, and no more than particularly intelligent primates) and history as we know it (made by humans who are "like us", or at least will become like us given enough time to socially evolve). Domestication, the incorporation of plants and animals into the human historical project, has long been considered the first hallmark of civilization. Archaeologists have been quite insistent in recent years that plant cultivation and domestication must be considered as separate developments (even in the Near East, cereals were cultivated long before they were domesticated), but the notion that domestication, agriculture, and "our" human civilization occurred in the same moment has been difficult to dislodge.

A curious fact arises, one that reiterates why it is necessary to situate contemporary issues of plant breeding within the deep history of human-plant relations. There is a particular correspondence between the way that we *think* the Neolithic today (as a revolution), and the way the archaeological evidence indicates that it actually proceeded *in history* (as a rupture-type event). Why this 12,000 year correspondence?

Timothy Morton argues that we are still operating within the Neolithic rupture, in the same way that we are still within the Great Oxygenation Event that created the oxygen-rich atmosphere and altered the conditions for redox reactions. Rather than the appearance of oxygen as a ubiquitous electron acceptor, what emerged from the Neolithic rupture is what Morton calls agrilogistics:

> *"Agrilogistics promises to eliminate fear, anxiety, and contradiction—social, physical, and ontological—by establishing thin rigid boundaries between human and nonhuman worlds and by reducing existence to sheer quantity" (Morton 2016)*

Agrilogistics is provincially Mesopotamian. In the Neotropics, adoption of agriculture led to a more diverse diet and an increase in caloric intake, whereas in Mesopotamia it led to a simplification of diet and has been shown to be significantly maladaptive with regards to health. In Mesopotamia agriculture and civilization arose *"not out of grand visions but out of something like desperation"*, a profoundly rigid, hierarchical and dualistic vision of the world, born of climate-induced scarcity. It's metaphysics and anxieties are present in sharp delineations of land into wild or cultivated, people into foragers or farmers, plants into weeds or crops, animals into pests or livestock, and finds its singularity in the pursuit of uniformity in breeding and monocropping in production. It may also underlie assertions that transgenic crops are unnatural because they transgress sacred species boundaries.

Jan Douwe van der Ploeg (1993) has named the image of the "ideal plant type" as underlying the ambitions and practices of modern plant science. It walks hand in hand with standardization of technology and homogenization of field conditions. The maintenance of uniformity in the real (non-ideal) world requires consistent acts of violence, upon people, plants and soils, because, *"the push goes against the grain of (ecological) reality, with its porous boundaries and interlinked loops"*. In the same way that formal and folk Western ontologies see objects as 'prior' to their relations to each other, modern plant science takes the ideal plant type as ontologically prior to variation. European variety registers enforce requirements of distinctness, uniformity and stability, requirements that effectively preclude the commercial use of landraces and encourage hybrid breeding over open-pollinated varieties that have difficulty meeting standards of uniformity. It presents a barrier to the breeders of Kultursaat, who only breed open-pollinated varieties, although they reported that efforts had been made to develop different standards of uniformity for OP varieties.

Not all agriculturalists take standardization as their starting point. Van der Ploeg contrasts the ideal plant type of plant science with the way Andean peasant farmers relate to diversity. Stephen Brush writes that for these farmers, *"diversity within a single crop and field is a logical corollary of the variety of the world around*

them"

> *"The question ‘‘Why do you grow so many types of potatoes?’’ is silly and nonsensical to Andean farmers. Informants were surprised and baffled when asked. From their point of view, diversity is natural and a given of the Andean kaleidoscope rather than something strange or unusual to be explained" (2008)*

What I call Cereal Monogamy is the expression of Morton’s agrilogistics within the field of agrobiodiversity. It excludes diversity on multiple levels - a limitation to only domestic plants, a limiting of staple food to cereal grains, and a limiting of variety within individual cereals to uniform, broadly adapted types. Diversity itself is alienated from the crop plant, or perhaps the other way around. It persists *in situ* as wild types and on marginal land in Vavilov centers, or increasingly *ex situ* in gene banks worldwide. Once an obvious and inherent quality of the human lifeworld, variety is re-designated as an economic resource (Plucknett and Smith 2014) - *plant genetic resources* - one whose sovereignty is contested and which has been named has a key to ‘feeding the world’. A number of ethnobotanists have reported indigenous horticulturists who appear to delight in ‘diversity itself’, prompting speculation that it is something approaching a universal. In some cases it takes on some qualities of an economic instrument; often shamans or particularly adept farmers grow far more than the average number of manioc varieties, and can exchange them as gifts for prestige and all it brings. Still, only through the machinations of agrilogistics, drawing on the modern synthesis of Darwinian and Mendelian genetics, has diversity been so completely shorn of its ecological functions. *"The European penchant for collecting not only sired possession but also attitudes toward nature and the discipline of natural history"* (Brush 2008). As diversity was aestheticized and concentrated in the prints of colonial naturalists and botanical gardens (Findlen 1994), farm fields became uniform and standard, pushed from the domain of aesthetics into that of production and industry.

Cereal Monogamy refers to the drive towards dualism between categories and towards singularity within them. Not only should opposing categories (forager/farmer; wild/domestic; field/nature) not overlap or blend, their contents should be uniform. As with the ontology of domination discussed in the previous section, this has concrete implications for breeding objectives. The ideal of uniformity is built in, not only to the standards for new cultivars but into the entire agrifood chain. Diversity among the harvest is seen as an aberration instead of a norm, whether in the field, processing facility or supermarket. One point of possible subversion may come with the end consumer, for whom the crop ceases to be simply a commodity and regains its multi-sensorial potentialities; for the cooker and eater, aesthetics and the ‘natural’ human appreciation of diversity is free to act. An interesting case during the fieldwork occurred when we had just brought in a broccoli harvest for visiting representatives of the supermarket chain to judge. While the distributor removed all but the most uniform heads of broccoli, the shop manager returned the majority of them to the bin, saying that customers were actually quite tolerant and even enjoyed the variety and novelty.

Cereal Monogamy also refers to what Anna Tsing has described as the great romance between humans and cereals (Tsing 2012). Like other monogamous relationships, it is in many ways ‘exclusive’. In Mureybet, ground-zero for the complete PPNB suite of Neolithic symbolism and practices, archaeobotanical evidence

shows a dramatic increase in cereal pollen concurrent with declines in the diversity of other species used for subsistence - fishing almost disappears, hunting is reduced to a few species, and previously significant wild plants become marginal. The Near Eastern Neolithic rupture is not only from foraging to farming, but specifically towards cultivation of certain grasses. As Tsing notes, *"[i]ntensive cereal agriculture can do one thing better than other forms of subsistence: support elites".* Commodity trade of cereals had already been globalized for hundreds of years by the time the modern food regime rose to ascendancy, and provided the template for commodification and globalization of other crop markets:

> *"Across Eurasia, the rise of states and their specialised civilisations is associated with the spread of intensive cereal agriculture. In some places, states followed agriculture; in other places, agriculture followed states. In each case, states promoted agriculture through their symbols and armies. Sometimes they criminalised other forms of subsistence; only outlaws would refuse the gift of state fertility" (Tsing 2012)*

The capacities of cereal grains to create and buttress state power, to flow across vast distances as tradable commodities, and to support standing armies all derive from an underlying capacity to *accumulate*. This in turn results from that most common trait associated with domestication - *indehiscence*, otherwise known as non-shattering. While Tsing focuses on the larger seed size of domesticated grains and how they facilitated a rapid increase in rate of human population growth, seed size tends to be a quantitative trait (i.e. controlled by multiple genes) and takes longer to develop than indehiscence, a qualitative trait controlled by one or two gene loci (Weiss and Zohary 2011). The tendency of grass seed pods to shatter and spread individual seeds over a broad area when they fall to the ground is an effective and widely adopted dispersal strategy. A non-shattering mutation ensures that the entire seed pod ends up in the harvest baskets of humans, that the grain is not 'cheating' on humans by developing co-evolutionary partnerships in non-agricultural niches. Indehiscence is not necessary for efficient harvesting of grain species for subsistence; Jack Harlan (1975) has demonstrated this experimentally collecting Near Eastern wild wheat using recreations of Paleolithic tools, and indigenous North Americans have never developed non-shattering varieties of native cereals. One can still harvest efficiently by collecting grains earlier in their life cycle. However, grain harvested in such a way is greener, ill-suited for long term storage, accumulation or backing currency.

Mesopotamian agrilogistics is a jealous lover, like its gods (e.g. Yahweh and the city patron-gods of Sumer and Babylon). Indehiscence is that first hitching of that happy union of human and grain destinies, away from the promiscuous ways of foragers and wild grasses. Further selection pressure on cereal grains and human institutions has created a relationship of co-dependency. Cereals came to rely on humans for irrigation, sowing, and weeding, culminating in modern varieties that are attached to precisely arranged 'technology package' of inputs and procedures. Hybrid seeds, economically sterile, do not reproduce at all - they are rather produced over again, out of a complex seed production apparatus. Meanwhile, humans have come to depend a dwindling number of species - mostly cereal grains - to provide nourishment, fuel and fiber.

In fact, it is curious why so much agrobiodiversity exists at all. The selection process involved in the initial domestication of plant species creates a 'founders effect' whereby only a very small amount of the diversity

present in the wild relative enters the domestic gene pool. Agrobiodiversity itself has been selected for, a product of peasant farmers consciously cultivating it among patchy landscapes. Agrilogistic imperatives, the strictness and uniformity of Cereal Monogamy, have generally arisen not from farmers themselves but from political elites or anonymous markets. Stephen Brush identifies two opposing forces acting upon agrobiodiversity: a *centripetal force* of peasant farmers generating "greater diversity in fragmented landscapes" and a *centrifugal force* of plant scientists spreading particular genotypes over broad regions, thus reducing diversity. I would argue that this centrifugal force actually arises much earlier than the appearance of modern plant science, dating back to the beginning of agrilogistics and relationships of sovereignty between humans and between humans and nonhumans. It reduces both genetic diversity (replacing landraces with ideal plant types) and ecological diversity (severing ties with any symbiotic partner besides humans). Genetic and ecology diversity are entangled of course, as the 'environments' that plants adapt to are constituted by no more or no less than assemblages of ecological relationships.

While it would be easy to assume a simple dichotomy between diversity-promoting peasants and diversity-limiting scientists, the reality is more complex. Peasant farmers will often be growing both landraces and modern varieties simultaneously, for different reasons and in different field conditions. Meanwhile, most of the plant scientists I talked to very much wanted to see more diversity in fields, both variation within varieties and polycultural agroecosystems. They were often stymied by lack of funding or research goals that focused on cultivation of staple crops for the market, but not always. One research group was breeding to encourage mycorrhizal symbioses, the very sort of ecosystem relationship that modern breeding is often accused of severing.

What is there to learn from bringing in the Neolithic into contemporary issues of plant breeding? For one, it functions as an effective antibody against the characterizations of 'primitive breeding' invoked by both sides of the controversy. Perhaps more importantly though, it demonstrates to what degree current developments in the human-plant relationship can be called truly unique, and where they fit into historical (or deep historical) patterns.