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Roundtable: Agricultural History and the History of Science

Introduction

For several years now, a growing number of panels on the history of the agricultural sciences have appeared at the annual meetings of historical organizations, especially those of the Agricultural History Society and the History of Science Society. In many ways, this reflects a long-standing interest in the intersection between the history of science and agricultural history. As several participants suggest below, scholars have been exploring institutional and farm-based knowledge production for decades now. But despite the continuities, all of the contributors here suggest that something new is afoot as well. Current concerns—about how our food is produced and consumed, the environmental consequences of industrial agriculture, and the effect of global markets on local lives, among others—have brought renewed interest in agricultural history from a variety of specialists, including historians of science. In addition, social, political, economic, and environmental historians have been turning to perspectives found in the history of science—as well as those of science and technology studies—to answer questions about how historical actors have made and used knowledge about the material world.

It seems like a good time to pause for a thoughtful discussion about what these convergences mean. Our panelists are among the most active scholars working to apply the methodologies and perspectives of the history of science to agriculture. In what follows, they identify a broad range of topics animating new studies of agriculture, such as the plurality of knowledge, the history of capitalism, the ongoing tensions between cultural studies and political economy, and the global nature of knowledge production, to name a few. Beyond the contributors' robust and stimulating discussion, one of the more striking things about this roundtable is the bibliography they have assembled. It is extensive, and like the discussion itself, signals that the cross pollination between agricultural history and the history of science has yielded an extraordinary harvest in the last few years. As if to supply further evidence of that fruitfulness, this roundtable happily coincided with Kim Kleinman's review essay on Helen Anne Curry's *Evolution*

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Made to Order, which makes a similar point elsewhere in this issue.

The discussion took place via email from fall 2017 to spring 2018, mostly following the format we established with our "New Histories of the Green Revolution" roundtable in the summer 2017 issue. We continue to organize such roundtables on relevant topics and methodological approaches, and as always, we are eager to hear your ideas. As you will see below, these conversations present excellent opportunities to get out of the weeds and consider the big questions.

Albert G. Way and William Thomas Okie

Contributors

Deborah Fitzgerald is the Leverett Howell and William King Cutten Professor of the History of Technology in the Science, Technology, and Society Program at MIT. She specializes in the history of food and agriculture and is the author of *The Business of Breeding: Hybrid Corn in Illinois* (1990) and *Every Farm a Factory: The Industrial Ideal in American Agriculture* (2003). She is currently working on a book that explores how military demands of World War II permanently changed both the way Americans eat and the way farmers farm.

Lisa Onaga is Senior Research Scholar at the Max Planck Institute for the History of Science. Her book, *Cocoon Cultures: The Entanglement of Silk and Science in Modern Japan*, under contract with Duke University Press, examines how Japanese sericulture provided a practical means for understanding heredity during the late nineteenth and early twentieth centuries. Her work on Japanese genetic evidence in radiation disaster studies appears in a special issue of *positions: asia critique* entitled "Articulating Genba: Particularities of Exposure and Its Study in Asia."

Emily Pawley is assistant professor of history at Dickinson College. She has published on analytic tables, cattle portraiture, and counterfeit apples, and has a forthcoming piece on aphrodisiacs for sheep. Her book project, *The Balance Sheet of Nature: Agriculture and Speculative Science in the Antebellum North*, examines the kinds of knowledge that emerged to make sense of the rapidly commercializing landscape of post-Erie Canal New York. She is also interested in the transatlantic history of moon farming.

Denise Phillips is associate professor at the University of Tennessee, and a historian of science who works primarily on eighteenth- and nineteenth-century Europe. Her first book, *Acolytes of Nature: Defining Natural Science in Germany, 1770–1850*, appeared with the University of Chicago Press in 2012, and she has also coedited a volume with Sharon Kingsland on the intersection between agricultural history and the history of the life sciences. She is currently writing a book about an eighteenth-century man named Jacob Guyer, a skilled and charismatic Swiss farmer who became an international celebrity during the Enlightenment.

Jeremy Vetter is associate professor of history at the University of Arizona, who works on the history of science, technology, environment, agriculture, capitalism, and the American West. He is author of *Field Life: Science in the American West during the Railroad Era* (Pittsburgh, 2016), and editor of *Knowing Global Environments: New Historical Perspectives on the Field Sciences* (Rutgers, 2011). His current research projects include a biography of a scientific field site, which is now Agate Fossil Beds National Monument; agricultural science on the Great Plains before the Dust Bowl; and capitalism and science in the American West.

Editors: *Why is it important that we think about the intersections of the history of science with agricultural history? What do the methods and questions of the history of science bring to studies of agriculture?*

Jeremy Vetter: We are in an exciting time of reinvigorated cross-pollination between agricultural history and the history of science. Agriculture has long been neglected—and remains neglected—in the history of science, with the revealing exception of recent developments in molecular biology, intellectual property, and biotechnology, most often told from the perspective of elite academic science. Within agricultural history, science has usually been welcomed as part of the story, although its prominence has waxed and waned. Conventional accounts of US agricultural science nearly always emphasized public institutions, celebrating the rise of the land-grant universities and agricultural experiment stations. This consensus was sharply challenged by the

upending of the progressive narrative in the early 1970s, however, as projects rooted in political economy approaches critiqued agribusiness influence (e.g., Hightower 1973), along with kindred research in rural sociology.

At the same moment, historians of science were radically reshaping their own approaches, bringing social and political context to the forefront. In the 1970s, Charles Rosenberg (1972, 1977) and Margaret Rossiter (1975) brought history of science approaches into US agricultural history, focusing on the social roles and identities of experiment station scientists and the early importance of agricultural chemistry. Then, in the 1980s came other historians interested in agricultural science such as Alan Marcus (1985) and David Danbom (1986), who placed greater emphasis on tensions between farmers and professionalizing scientists at those public institutions. This work was extended still further by Deborah Fitzgerald (1990), who not only made a compelling case for more sustained interaction between the two subfields, but pointedly brought scientific research at private business enterprises into frame alongside public agricultural scientists.

After a period in which social structural and political economic approaches to the history of science were overshadowed by the same cultural and linguistic approaches that dominated all of historical writing, we are at a time of renewed engagement. We have taken on board key insights from these turns while no longer being trapped within their representational confines. The most promising pathways for history of science to influence agricultural history now are: 1) pluralism about knowledge, 2) place and practice, and 3) capitalism.

First, consider the radically capacious reframing of the history of science as more than just the history of expert knowledge, in favor of broadly conceptualizing the history of knowledge across different social groups. Most pointedly, this means taking seriously what, with overlapping but distinct meanings, has been called folk, indigenous, vernacular, or (my preferred catchall) experiential knowledge. This is a great boon for agricultural history, since a large percentage of the human population was engaged in agriculture until very recently, and all those people have possessed knowledge which we can study, on its own and in relation to expert science. What did farmers (and scientists) know, and how did they know it?

Second, historians of science in the field, lab, museum, and a multitude of other settings, have made place—and the practices that occur there—a central analytical framework for understanding the history of science. No longer do we see an agricultural experiment station, for example, as merely an institution

for enabling science to get done, but also as a place situated in a particular environmental context, with outcomes shaped by bodily experiences, tools and techniques, and social relationships such as the organization of work. This turn toward place and practice also builds bridges with agricultural history more generally because farmers have likewise been deeply shaped by environmental context and ground-level practices.

Finally, the recent boom in the history of capitalism, and that field's even more recent engagement with the history of science, is poised to enrich agricultural history. Even before the most recent explosion of interest in the history of capitalism, scholars in science and technology studies, such as Daniel Lee Kleinman (2003), were bringing attention to how structural forces in the larger political economy have shaped agricultural sciences, such as plant pathology (see also Warner et al. 2011). While so far historical work on the leading edge of bringing together capitalism and agricultural science has more often appeared in business history venues (Pietruska 2012; Pawley 2016), it could transform all of agricultural history and the history of science, especially if we can balance cultural approaches with a renewed grounding in political economy.

Emily Pawley: To understand what the history of science has to offer agricultural history, it helps to think about how complex farms are as objects of knowledge. Farmers perform any number of tasks to control biological processes. They spread manure to perpetuate invisible cycles of fertility; they build pens and stalls to defuse the instinct of cattle to stampede or encourage the instinct of ewes to mother; glancing over fields they pick out prickly or poisonous weeds or check leaves for signs of blight; they track shifts in the weather, select pigs to be killed or to pass on their genes, and weigh the risks of toxins, all the while trying to drag an agroecosystem toward profit. Just within that incomplete list are the concerns of a dozen disciplines, from meteorology to botany to animal behavior. This intertwined multiplicity is perhaps part of the reason that historians of science, who often follow a single discipline, have had difficulty coming to grips with agricultural knowledge-making.

As Jeremy points out, historians of science have worked their way through different facets of the farm landscape as they have developed new ways of recognizing the forms and circulation of agricultural knowledge. It is not too surprising, for instance, that the earliest histories of agricultural science focused on chemistry (Rosenberg 1972; Rossiter 1975). Agricultural chemistry met contemporary expectations about the practice and communication

of science: chemical analysis was performed in laboratories by experts who loudly claimed disinterested expertise in a recognizable discipline and was communicated to farmers who were cast as laymen, matching expectations that science communication would diffuse from high-information theoretical experts to a low-information practical public. In recent decades, however, diffusionist models of "popularization" have given way to more multidirectional, fine-grained understandings of the movement and making of knowledge. Far from passively absorbing diluted information, diverse publics selectively appropriated and adapted scientific ideas (Latour 1993; Cooter and Pumfrey 1994; Secord 2003). Moreover, the flow of knowledge often reversed: brewers' understanding of thermometers made possible physicists' studies of heat; indigenous and enslaved peoples supplied botanical knowledge along with specimens (Sibum 1994; Parrish 2012; Schiebinger 2017). Historians of science also began to recognize kinds of knowledge embodied not in theory but in practiced gesture or trained perception and communicated in proverbs or drawings or jokes (Collins 2010; Secord 1994; Shapin 2001).

This expansion reveals many more dimensions of agricultural knowledge. But recent histories of agricultural knowledge also challenge any simple division of "farmers" and "scientists" into tacit and explicit, vernacular and expert, local and cosmopolitan, practical and theoretical, or financially motivated and disinterested groups. For example, scholars have recently demonstrated the centrality of the markets in improved "blood" in the eighteenth and nineteenth centuries to the new theories of inheritance, race, and evolution (Ritvo 1996; Derry 2003; Müller-Wille and Rheinberger 2012; Kevles 2007). Here, however, they have uncovered a new community of experts—breeders—who maintained their own theories of bodily change manifested in highly formalized records and bolstered by their own standards of credibility. Farmers, planters, and landlords committed to "agricultural improvement" likewise established networks of knowledge and specimen exchange, which, by appropriating genetic material and environmental knowledge, strengthened and supported plantation culture and settler colonialism and ultimately shaped the institutions examined by the first histories of agricultural science (McCook 2002; Drayton 2005; Cohen 2009a; Sharma 2011; Jonsson 2013; Zilberstein 2013; Fullilove 2017). As we continue to explore the great masses of knowledge that have emerged from centuries of intimate engagement with ecologically and socially diverse cultivated landscapes, we should expect new groups of experts as well as new forms of local knowledge to come to light.

Deborah Fitzgerald: It is an interesting fact that the history of agriculture, by and large, has been little affected by work in the history of technology, the history of science, or science studies, despite the fact that agriculture in most of the twentieth century has been *defined* as based in science and technology. Indeed, one of the key problems of explaining agriculture and rural life in the twentieth century has centered on understanding how technology in particular has made rural life more, or less, conducive to survival, prosperity, and self-empowerment. The casual observer might well think that science and technology have only brought "debt and dispossession," in Kate Dudley's (2000) words, to most farm families. But is that true?

A number of agricultural historians have been attending to this relationship between agriculture and technology—Joe Anderson (2008), Pete Daniel (1986), David Danbom (1979, 1995), Donald Pisani (1984), Katherine Jellison (1993), Shane Hamilton (2008), Jenny Leigh Smith (2014), to name just a few. Yet in general we still tend to see technology as a set of objects—tractors, washing machines, milking machines, for example—applied to the farm enterprise, rather than as a system of production and consumption. The most suggestive writers in this regard are Thomas P. Hughes (2004), Ruth Schwartz Cowan (1983), and Bruno Latour (1987), each of whom introduced a style of analysis that has transformed our understanding of technology. Hughes' notion of large technological systems emphasized not only the physical machinery, but also the institutions, individuals, and theories that together created a system of production. Ruth Cowan famously demonstrated that modern technologies, far from saving work and worry, actually increased the time women spent on housework, cooking, childcare, and so forth. And Bruno Latour developed actor-network theory, a way of understanding technology as a web of relationships. All of these ideas offer tremendous insights and diverse methodologies to us in agricultural history.

Others who have used technology to understand the past bring other tools. Bill Cronon's (1992) story of Chicago depends heavily on the railroad and disassembly line of livestock production, as well as the technologies of trade and speculation in grain production. Donald Worster (1979) showed the inescapable interconnections between agricultural development, irrigation technologies, and the environment, all within a critique of capitalist rural development. In his *Working Knowledge*, anthropologist Douglas Harper (1992) studied a rural car mechanic whose knowledge and experience strongly resembles that of long-time farmers.

Some of the most provocative works use science and technology as ana-

lytical tools not because of professional training but because they are necessary tools in understanding the ways that agricultural practice has shaped the environment. Steven Stoll's (1998) work on California fruit becoming a national commodity, and Ted Steinberg's (2014) analysis of New York City as an important agricultural foodshed, are but two examples of this important and exciting approach.

Although historians of technology have not been strongly attentive to agricultural history (with some important exceptions), one cannot look at agriculture and rural life today without seeing the profound effect of technological systems over the last one hundred years. A tremendous research bonanza awaits young scholars interested in charting new ground.

Denise Phillips: If we travel back a few centuries, the history of science's neglect of agriculture becomes even more marked, despite the fact that farming was a topic of keen interest to early modern knowledge makers. The seventeenth century saw the appearance of a growing literature on agricultural improvement across Europe, and the eighteenth century was, to use Voltaire's term, an age of *agromanie*. Yet historians of science working in these centuries have paid relatively little attention to agricultural topics. Scholars of the Scientific Revolution have said a great deal about the importance of artisans and mechanics in the production of natural knowledge (Eamon 1994; Smith 2004), but much less about the rural activities of farmers, gardeners, and noble landowners. The literature on the so-called "knowledge economy" of the eighteenth century has had a similarly mechanical and industrial bent (Mokyr 2012; Jacob 2014). Recent work on early modern natural history and the enlightened "useful sciences" has begun to address this gap, but there is still much more that could be done (Koerner 1999; Spary 2000, 2003; Stockland 2013).

Until recently, historians of early modern agriculture have shown a similar lack of interest in literate knowledge about farming. Wary of older hagiographic accounts that granted excessive influence to a few famous improvers, they have often accorded little weight to the period's "book farmers." More recent work has begun to strike a better balance, acknowledging the complexity of exchanges between educated elites and farmers, but also allowing elite reformers some role in changing agricultural practice (Jones 2016; Ambrosoli 1997). But when "science" per se is under discussion, historians of agriculture still often describe science-agriculture interactions in this period in terms of what they lacked—before the mid-nineteenth century, there were no stan-

dardized trials conducted in experiment stations, nor was modern chemistry available to probe the secrets of soil fertility (Jones 2016; van Dülman and Rauschen 2004).

These assessments import an ideal of applied science back into a time period in which it did not yet exist. In fact, it is precisely these supposed "lacks" that make literate agricultural knowledge in these centuries so interesting. The early modern period had its own specialized field of knowledge related to agriculture—oeconomy, an intellectual tradition originally devoted to the management of (noble) agrarian households. It was not an obscure field; authors of agricultural works often apologized in their prefaces for contributing to the already mountainous literature on the topic. In many respects, early modern oeconomy offers an excellent gateway to many of the historiographical themes raised by my colleagues in their earlier contributions—as a science of the household (and by the late eighteenth century, a broader science of productive activity), it offers a useful site to examine how the history of natural knowledge intersects with the history of capitalism (for a sampling of recent work on eighteenth-century oeconomy, see Roberts 2014). It was also a tradition that took considerable interest in the material and epistemic complexities of farm work.

The early modern agricultural literature also complicates many of our standard views about literate natural knowledge in these centuries. Historians of physics have worked hard to recover the ways that experimenters were able to transform their local activities into universal knowledge (Shapin and Schaffer 1985). In contrast, early modern agricultural improvers often discussed their experiments as *necessarily* local and particular. Another major theme in the history of early modern science is the emergence of a commitment to unified natural laws (Shapin 1994; Gaukroger 2008; Dear 2009). Works on agriculture often pulled in the opposite direction, toward increased specification of spatial differences and contingency. Literate agricultural knowledge was an important part of early modern natural knowledge in general; once we have a better understanding of this part, our image of the whole will likely change as well.

Lisa Onaga: Recent discussions about global and local histories of science have highlighted new intellectual approaches to the study of knowledge production, including translating works across major language groups, encouraging transnational approaches, and working with an awareness of the coexistence of multiple historiographies and methodologies (Nappi 2013; Fan

2012). These same approaches can be applied to the history of agriculture.

Similarly, comparing historiographies, including different methodological approaches within agricultural history, can lead to new research opportunities in the field. Consider, for example, the importance of archaeological data for understanding the history of agriculture in the region known as China today. In one example of an effort to foster greater communication among scholars internationally, Zhao Zhijun's (2017) exacting archaeobotanical study on the introduction of wheat in China appeared in translation in the first issue of the new journal *Chinese Annals of History of Science and Technology*, edited by Zhang Baichun and Jürgen Renn and published at the Institute for the History of Natural Sciences, Chinese Academy of Sciences. Studies involving such data differ from science historians' emphasis on, for instance, scientific theories that have had more direct interactions with agricultural practices like plant breeding, as suggested by the special issue on biology and agriculture in the *Journal of the History of Biology* (vol. 39, no. 2, 2006). And of course, not all historians share the concerns about evolution and migration that animate Zhao's work. Yet, it may be useful to think about how global histories of agriculture and historical sciences, especially those driven by genomic analyses, may expand the temporal boundaries of the history of agriculture. For example, Erik Gilbert's discussion of how scholars have studied the movement of rice cultivars from Asia into Africa through Islamic and European expansion has resulted from a highly reflexive study engaging with rice genome analysis, African history, archaeology, and linguistics. Multidisciplinary conversations among historians, anthropologists, and archaeologists who study premodern and modern agriculture (e.g., Neubauer Collegium 2015) gesture to a productive opportunity to study the history of agriculture when particular temporalities or locations of concern do not allow the use of common categories like "science" or "technology."

Another way the discourse of global and local science may intersect productively with agricultural history would be through reconsidering what counts as an agricultural "object of interest." Projects such as *Rice: Global Networks and New Histories* (Bray et al. 2015) exemplify the incredibly productive syntheses that collaboration around a single node makes possible. Similarly, the history of making the South Korean varietal of Tongil rice shows strong connections between agriculture and development (Y. Kim 2005; T. Kim 2018). At the same time, studies by scholars such as Charlotte von Verschuer (2016), who argues that tubers and legumes have played a greater role in the diets of Japan's mountainous regions than previously imagined, caution

against overemphasizing the significance of staples.

We should also pay attention to how various fields approach nonfood-oriented agriculture in order to reflect upon how different intellectual communities contribute to historical understandings of agriculture or nonterrestrial cultivation practices. That is, how might objects representing desire rather than necessity dovetail with the history of agriculture? In the global history of Asia, topics such as textiles (indigo, silk), ornamental fish (koi), materials (rubber), medicines (tumeric, mushrooms), and fuels (oil palm, guano) reflect growing momentum at such intellectual fronts in the history of science, technology, and medicine (Kumar 2012; Cushman 2013; Lu 2013/2014; Onaga 2015; Zimmerman 2014; Tan 2018), environmental history (Aso 2018), literature (Lynch 2010), and anthropology (Tsing 2015; Taussig 2018). Some of these topics, including histories of experimentation with pathogenic or beneficial microbes, or the history of *umami* and monosodium glutamate (Lee 2015, Tracey 2018), signal new opportunities for agricultural history. Engagements with the Anthropocene and climate change may also prompt questions about the continuities between rural and urban farming (including vertical or underground farming), or how intellectual histories of gene-environment interactions have unfolded in different climates and different pragmatic agricultural and institutional scientific settings. An inclusive strategy toward the methodologies, literatures, and languages used to build knowledge in the history of agriculture should help bring attention to exciting untapped opportunities for individual *and* collaborative studies.

Editors: *Several of you alluded to the influence of broader historiographical and methodological trends in discussing the production of various types of knowledge in agricultural contexts. Can you elaborate on where you see this renewed interest in agricultural knowledge making coming from? And how might studies in agriculture and the history of science contribute to broader historiographies of political economy being generated in other fields?*

Lisa Onaga: I want to start by asking what it could mean to recognize a "renewed" interest in the history of agricultural knowledge production. If we take a look at the publication of Jack Kloppenberg's prophetic political economic history of biotechnology *First the Seed* (1988), it might not surprise that the University of Wisconsin Press reprinted it in 2004, but it might also intrigue us to learn that a Korean translation was issued in 2007. To what extent was agricultural biotechnology then gaining attention in South Korea? According

to a study of plant science trends by a John Innes Centre researcher, publications across Asia ramped up in 2003, especially in South Korea (exhibiting a 27 percent jump from the previous year), followed by China and India, reflecting the expansion of transgenic plant science in the region (Vain 2006). Journals aside, the South Korean pharmaceutical, food, and nutraceutical sectors have offered technological and industrial support to venture capital funds in anticipation of benefits for biotech research and development. These trends have been balanced by public concerns about risk and safety of genetically modified organisms (Sabine 2005; Kim 2014). These developments might help explain why that text was relevant to a Korean audience, academic, scientific, or otherwise.

A sample size of one book limits what conclusions we might draw, but the translation prompts a critical question about the audience for the history of agriculture in the twenty-first century. Together with the growing number of recent efforts to translate and distribute influential papers and books in the history of science into various languages, the Korean Kloppenberg encourages a discussion of how the readership and consumption of agricultural history scholarship has expanded and changed. For example, in a forthcoming edited volume organized by the History of Science Society and the Max Planck Institute for the History of Science, a selection committee represented by seven different societies identified Jonathan Harwood's "Peasant Friendly Plant Breeding and the Early Years of the Green Revolution in Mexico," originally published in *Agricultural History* in 2009, to be translated into Chinese alongside eleven other articles and excerpts published originally in European languages. In other words, the extent to which new audiences are proactively identified for scholarly exchange (not only for overcoming linguistic hurdles) seems worthy of contemplation if we are to discuss the formation of new historiographical interventions within the history of agriculture. This seems to be in tandem with understanding how the worlds we currently inhabit also inform the writing of agricultural histories.

Efforts among historians of science to reconsider what were once colonial peripheries as active sites of scientific and medical knowledge production instead of passive peripheries points to a redistribution of how histories are written (e.g. Espinosa 2013; Hoggte and Pieters 2013). Should these knowledges be expected to contribute to a corpus of global *qua* universal or shared transnational knowledge, or global *qua* plural knowledges, or both? These questions about universal and local knowledge are reflected in the choices made at the intersection of history of science and agriculture. As emphases

on commodities and model organisms get challenged in the history and philosophy of science, there are some productive tensions that seem relevant for understanding historiographical developments. These resonate in terms of the standpoints chosen when selecting a research subject that may, for example, allow a plant to serve as a focal point instead of prominent human figures. Feminist works such as *Plants and Empire* by Londa Schiebinger (2004), which discusses the abortifacient *flos pavonis* (peacock flower), have brought attention to things that fall outside of the category of commodity and their roles in histories of producing both knowledge and ignorance. In the history of biology, model organisms have long held scholars' attention, but this tight gaze has simultaneously yielded additional discussions of what other kinds of living things can be fruitfully examined. Rachel Ankeny and Sabina Leonelli have argued in a seminal paper that not all experimental organisms count as model organisms, which are standardized in order to better serve as proxies for understanding biological phenomena in other whole organisms, and have specific epistemological characteristics such as a shared research community (Ankeny and Leonelli 2011). The responses to such questions, in turn, circle back rather productively to the category of "commodities" as they expand the boundaries of agricultural history beyond living organisms cultivated for food to include those cultivated for convenience or pleasure as well.

These animals, plants, and their objects of convenience or pleasure, are indeed addressable through the scope of cultural histories of heredity and genetics. They can also be discussed more explicitly in tandem with the literature on pests and pathogens. In Japan, for example, the history of silk and pearl cultivation has required not only the study of breeding the domesticated silkworm, cultivating oysters, and the creation of capital, but also discussion of the knowledge and control of their disease agents (Onaga 2013; Ericson 2017). Objects of desire, in other words, complement what is known about agriculture for food production and thus add to the historiographical texture of agriculture.

The cultivation of nonfood objects especially raises awareness of the politics of knowledge related to plant or animal science if we pay attention to the technological production and rendering of objects from natural resources (Westermann 2015). The processes needn't be new (e.g., soap from oil palm, ethanol from corn), but research approaches toward agriculture that cut across science *and* technology—as Deborah has emphasized—parallels a growing awareness about how human choices about capital and economy have shaped life on the global scale. The resultant repercussions for localities and envi-

ronments that emerge are not just exciting but a responsibility in a changing world to ask ourselves how the history of science, technology, and agriculture could be written not only with political economy in mind but with political epistemology. Issues such as the epistemic barriers to sustainable agricultural production, of concern to scholars such as rural sociologist Michael Carolan, go hand-in-hand with the labor and economic issues associated with managing a state and producing a global commodity (Carolan 2006; Martin 2006; Schmalzer 2017). Reckoning with the consequences of the global distribution of food for altering labor patterns, and the ownership of—or forgetting of—knowledge and know-how appears in various forms. The *Washington Post*, for instance, ran a 2017 Thanksgiving Day feature article about the growing number of young urban Americans eschewing desk jobs for farming (Dewey 2017). Is this an example of an epistemological barrier overcome? If addressing epistemological issues in relation to political economy will be a relevant task for history at the crosshairs of science and agriculture, let's think critically about what it may mean to write for a broader audience that complements scholarship produced for students and academics in different fields and disciplines.

Jeremy Vetter: I am intrigued and pleased that Lisa opened our conversation in this round by referring to the recent translation of works by rural and environmental sociologist Jack Kloppenburg and historian of science Jonathan Harwood into Korean and Chinese, respectively, since both of these scholars have exerted significant influence on my own thinking. I would like to build on Lisa's remarks about Kloppenburg and Harwood, using them as entry points to a wider discussion about the sociology and political economy of agricultural knowledge.

As a big-picture account, Kloppenburg's influential *First the Seed* (1988), emphasizes global political economy to such an extent that some readers—especially historians, with our love for complexity and local contingency—might be surprised at how capacious such a political economy framework has proven to be in framing scholarly analysis of ground-level challenges to that larger system. During the last few decades, as food activists, reformers, and alternative farmers have challenged what they—for good reason—consider a dominant system of conventional, industrial agriculture, rural and environmental sociologists have produced analysis and conceptual reframing in response. Such work often has emphasized oppositional and alternative knowledge systems rooted in grassroots political movements. The democrati-

zation of agricultural knowledge and the emergence of a horizontal system for transmitting knowledge are especially prominent in this literature (Hassanein and Kloppenburg 1995; Hassanein 1999; Bell 2004).

More recently, sociologists of food and agriculture have discovered the multiplicity of ways to "democratize" the production of agricultural knowledge in both sustainable and conventional agriculture (Carolan 2008), as well as how agricultural scientists seeking to promote environmental change also operate within larger structural realities (Henke 2008). At the same time that agricultural scientists have responded in a variety of ways to the critiques leveled at the existing system of knowledge production since the 1970s (Buttel 2005), food studies scholars have pointed out how the existing research infrastructure could be redirected toward greater study of alternative farming systems (Carlisle and Miles 2013). Might we, as agricultural historians, complement this valuable work by sociologists of food and agriculture, not only by applying our historical methods and tools to the past few decades, but perhaps even more important, by examining how the dominant system that has been challenged so much in the past few decades became established in the first place?

We might also ask, in response to the present moment: what can historians say about the longer-term lineage of alternative systems of agricultural knowledge production? One historian of science, already attuned to alternative systems of knowledge production, including in agriculture, is Harwood, mentioned by Lisa for his work on "peasant-friendly plant breeding" that has been included on a recent, highly selective list of articles across the entire history of science chosen for translation into Chinese (Harwood 2009). But Harwood's work has also included a fascinating study of "academic drift" in the agricultural colleges of Germany in the late nineteenth and early twentieth centuries, emphasizing how scientists' competition for funding and recognition led them to focus on work that was further removed from the everyday practices of farmers (Harwood 2005). Such historical perspective responds to the present moment by showing not only the reasons for the rise of a dominant system of agricultural knowledge production, which I mentioned above already, but also the dynamics by which such a system is maintained and reinforced over time.

Another notable feature of Harwood's framework is its insistence on connecting the histories of science and technology—perhaps the single most pervasive trend in the best of recent historical work on agricultural science (e.g., Curry 2016; Saraiva 2016), and a salutary one—but without so much

analytical blurring that the distinction loses its value entirely. In a moment when the rhetoric of "technoscience" has become predominant not only in academic precincts but also in the wider economy, society, and culture, we would do well to consider the histories of science and technology together, without yielding to the temptation to portray their indistinguishability as inevitable rather than a historically contingent achievement. At the same time, scholars in US agricultural history have written about other important topics in the highly structured and hierarchical political economy of knowledge, such as the fraught relationship of agricultural science with more traditional disciplines in history of science, such as ecology (Hersey 2011), and the movement of knowledge through places and institutions previously ignored in history of science (Berlage 2016; Gilbert 2015).

This all points toward a provisional response to the final question posed for this round, concerning how histories of agriculture and science might contribute to the resurgent scholarly interest in political economy. The most obvious referent would be the new history of capitalism, which has focused not only on the history of banking and finance, as well as the urban upper class, but also, notably for agricultural historians, on the relationship between slavery and capitalism. Although I do not have space here to review this emerging subfield in any detail, it is worth noting that in the excellent overview of the emerging history of American capitalism by Sven Beckert written several years ago, we find a few works in the history of technology discussed but none really in history of science, except for a brief mention of the history of economic thought. Specifically, Beckert credits such works for "historicizing economic change and the denaturalizing of the economic order," thereby "support[ing] the view that economic theorizing is not just a scientific endeavor, but also a production of ideology, related to political conflicts and interests" (Beckert 2011, p. 321). This seems a comfortably deconstructionist approach to take for us historians of science, and undoubtedly we are on the cusp of offering many sophisticated contributions in this vein. As historians of science and agriculture, however, I hope that we can also offer bolder framings of the political economy of knowledge that reveal patterns of articulation between science and capitalism in different historical periods and places.

Deborah Fitzgerald: The topics that we think of as living within the history of agriculture and rural life, no less than those that live within the history of science and technology, don't really belong to us anymore, if ever they did. Food, livestock, land use, chemical inputs, mechanization, and so forth have

been migrating throughout the scholarly community for some time, receiving fresh contextualizing and interpretation from our colleagues in anthropology, geography, rural sociology, Latin American history, European history, and, as Lisa points out, Asian studies. I think that this has breathed new creative life into some of our own field's most established themes and categories; certainly my own work has benefited enormously from colleagues working across disciplinary borders.

Within anthropology and cultural geography, scholars have found food to be a very useful and provocative vehicle for exploring social and cultural issues. Susanne Friedberg's work on "baby veg" production in Africa for the French and English consumer markets is a classic study of how vegetable production is organized through both local custom and international expectations. Friedberg's deft analysis of the technological system within which this production is accomplished, her attention to families and labor in rural areas, and her assessment of the costs of global food chains, have much to tell us about farming, marketing, and consumption of food generally (Friedberg 2004). Similarly, Heather Paxson's ethnography of artisanal cheese making provides historians with some new ways to understand small-scale production at a time when large-scale farming is becoming more difficult and exposed to ever-changing global food trading patterns, regulatory demands, and familial succession problems. She is primarily interested in the moral demands of cheese making, and the notion of "goodness" in the farmers, in their communities, and in their products, issues that have resonance in rural history. Raising and processing livestock is another growth area for anthropologists and political scientists, as seen in work by Tim Pachirat, Brad Weiss, and Alex Blanchette. Pachirat's ethnography of an industrial cattle slaughterhouse, Weiss's study of heritage pigs, and Blanchette's analysis of pork production, tackle questions familiar to historians of agriculture and science. How do we value "other lives" and how does our industrial system make that easier or harder? Which food production operations are in plain view, and which are remote and fairly hidden, and how does that situating raise questions about our values (Pachirat 2011; Weiss 2011; Blanchett 2015)?

Recent scholarship in the history of capitalism and commodities, as Jeremy points out, brings agricultural labor, finance, food chains, and politics into excellent alignment with history of agriculture and science as well. Sven Beckert's (2014) work on cotton, April Merleaux's (2015) work on sugar, Tiago Saraiva's (2017) work on pigs, and Ines Prodohl's (2016) work on soy all provide excellent models of international research, trade, and food politics.

And they often also raise important issues of food versus nonfood uses of farm products. Prodohl's study of soy nicely illustrates the flexibility of soy as a primary food in some places and times, an industrial lubricant in others, and an invisible (and insidious, if you are allergic) additive to many processed foods in yet others.

Why are so many scholars not primarily engaged in agricultural history suddenly interested in such topics? One reason is simply growing personal interest in where our food comes from and how people become defined by what they eat. This interest seems to have crossed into virtually every field of research and writing. Yet another reason may be that after many years of tentatively crossing our disciplinary borders, scholars are becoming more sure-footed in identifying robust and intellectually compelling topics. I think that the turn toward global and commodity history is of this type. Agricultural and rural historians surely have an important role to play here, not only in defining some of the key questions to ask in such scholarship, but in making sure that our own borders are elastic enough to welcome this kind of new work.

Denise Phillips: There are a lot of interesting thoughts to respond to here, but to narrow things down, I'll pick up on Jeremy's comments about the new history of capitalism to discuss the various ways I see these themes being developed in current work in European history.

There's been a lot of discussion among German historians over the last few years about the need to expand from the history of science (*Wissenschaftgeschichte*) to a broader history of knowledge (*Wissensgeschichte*), and one of the best-realized examples of this approach was in fact a book on the history of agriculture, the environmental historian Frank Uekötter's *Die Wahrheit ist auf dem Feld* (2010). Uekötter's study, a nuanced examination of German farming's knowledge-driven transformations since the late nineteenth century, has been justly praised by fellow scholars, but Roman Köster had an interesting criticism of the book that I think is relevant to the issues we are discussing here. Köster points out that although Uekötter carefully reconstructs the technical knowledge relevant to farming practice, his "history of knowledge" leaves out farmers' *economic* understandings of the wider transnational networks and markets in which they participated. Köster points out that we need both these elements to write the history of farming knowledge, and that seems to me a good concrete example of what engagement with the new history of capitalism might look like.

There are also conversation partners to be found among historians of economic (and political) thought. John Shovlin's *The Political Economy of Virtue* (2006), for example, makes it clear that the Physiocrats were only one group within a broader field of eighteenth-century writers interested in generating prosperity through agricultural improvement, and in reading his study you get a strong sense of just how central the countryside was as a symbolic site within eighteenth-century political imaginaries. Bela Kapossy's recent book does similar work in contextualizing Rousseau (Kapossy 2006). In the Swiss republican settings that Kapossy explores, images of rural virtue and simplicity were often (perhaps surprisingly) quite important to urban-centered debates about the need for civic rebirth. Pestalozzi, the grandfather of modern early childhood education, came from these same Swiss circles. When I recently read Megan Birk's *Fostering on the Farm: Child Placement in the Rural Midwest* (2015), it struck me that the tradition of seeing rural life as superiorly virtuous, and rural economic activity as superiorly ethically rewarding, casts a very long shadow, not just in political thought, but also in discussions of pedagogy and childrearing.

Recent historical work on European food systems is well worth mentioning in this context, too. Emma Spary's *Feeding France* (2014) looks at eighteenth-century medical and cultural debates around food, in a period that saw both the emergence of a discourse of gastronomy and the origins of industrialized food. Moving into the nineteenth and twentieth centuries, Corinna Treitel's (2017) new book looks at the emergence of organic farming and "natural" diets in Germany after 1870, and she convincingly casts this history as a set of interlocking medical, political, and agricultural debates. She is particularly interested in the shifting political valences of "natural" diets, which start out in the mid-nineteenth century as a cause championed mostly by liberals and socialists, but which gained significant right-wing support by the 1930s. The history of "eating naturally" includes some troubling chapters: Hitler was a vegetarian, and Dachau had an organic herb garden.

To pick up on a point that Lisa made earlier, we might think of both of these books as studies that introduce significant complexity into the status of food as commodity. The value of organic produce, in Treitel's history, is embedded within the broader networks of German biopolitics; Spary shows the complex negotiations involved in fixing the value of new manufactured foods. That seems one interesting option offered by the current state of the field—the chance to continue to historicize terms like "commodity" or "exchange."

Emily Pawley: Like Denise and Jeremy, I'm most familiar with the literature on the history of capitalism, and I'd like to step back to address some very broad points.

At a fundamental level, I would say that historians of political economy are still struggling to come to terms with the differences between wealth generated from animals and plants and wealth generated from factories or mineral extraction, in part because in looking for capitalism in agriculture they still tend to look for features that remind them of capitalism in industry—the elements of the "factory" farm. This is not to say that factory resemblances are not important. As we know from Deborah Fitzgerald, "factory farming" became an important ideal shaping the rise of corporate agriculture in the twentieth century (Fitzgerald 2003). Moreover, some kinds of farms, like broiler chicken operations, have come to resemble factories almost entirely, with conveyor belts moving animals from incubator or gestation crate to slaughter (Boyd 2001). Recently, of course, Ann Greene has shown how integral animal bodies were to the actual rise of factories, and Caitlin Rosenthal has reversed the expected flow of knowledge and practice by tracing the origin of particular forms of labor discipline, calculation, and control associated with factories back to attempts to wring greater efficiencies from enslaved people on American plantations (Greene 2009; Rosenthal 2013).

However, when the farm diverges from the factory, particularly in ways that seem to be governed by "nature," it's important not to automatically see it as "tradition" pulling against modernity. For example, where industrial capitalist time has become less and less seasonal, measured out famously by the rise of the minute and the hour, agricultural capitalism has moved the other way (Thompson 1967). The seemingly seasonless world of the grocery store is a sleight of hand made possible by astounding acts of geographic coordination, linking massive pulses of flowering and fruiting across the globe, pulses produced not by factory workers but by migrant laborers, who follow harvest seasons from south to north and crop to crop (Hahamovitch 1997). The history of agricultural knowledge can help demonstrate how the expansion of capitalist production has demanded unfamiliar kinds of knowledge about living systems. Where scholars of industrial production encourage us to look at the clock, for example, recent work by Kate Wersan encourages us to look at the early melon, which eighteenth-century improvers around the Atlantic used to calibrate the timing of tasks across very different seasons (Wersan 2017).

Staying with the theme of time, Denise's point about the longevity of the idea of rural virtue reminded me of the ways that histories of agricultural

knowledge disrupt expectations about modernity based on industrialization. Raymond Williams points out that the nostalgic idea of rural virtue as declining before a recent influx of vulgar wealth and urbanity is centuries old, stretching back at least to Roman authors like Horace, Virgil, and Pliny, and made a cliché in European literature through the standard features of polite education (Williams 1975). It is this same education, perhaps, that makes it so easy to see farmers as resistant to change and the blandishments of the city, even at times when they are introducing novel crops, colonizing territories, purchasing new machinery, participating in new markets, and making new forms of knowledge. But even as classically inflected texts (including those of the modern slow food movement) have lamented a permanently receding age of rural "tradition," improvers and agricultural modernizers have consistently used the Roman Empire as a model for any number of possible agricultural futures, a model complete with an agricultural literature, specialized export landscapes, a complex transportation system, luxurious vines and orchards, specialized fertilizer recipes, agricultural machinery, large slave-worked estates, and expansive settler colonialism (Cohen 2009b; Sweet 2003; Hannickel 2003). As someone who studies an "Empire State" dotted with towns like "Rome," "Troy," and "Ithaca" I wonder what different timelines we might perceive if we took these modernizing evocations of the past more seriously.

As well as raising questions for historians of political economy, however, I think historians of agricultural science might do well to take on board some of the recent lessons of the cultural history of capitalism. Our tendency is still to tell stories of the rise of capitalism in terms of stabilized value, calculation, and expanding systems of rationality. Recent cultural histories of urban capitalism, however, have begun to refocus on economic volatility, unpredictable cycles of boom and bust, and the instability of both credit and credibility as permanent features of capitalism (Sandage 2005; Lepler 2013). It would be interesting to write histories of agricultural knowledge that acknowledge this instability, as well the profit that shifting value can offer to those who bet accurately, and the role that agricultural scientists and other knowledge makers have played, not only in arbitrating disputes about value but in stirring them up and profiting from them.

Editors: *What has been left unsaid here? What needs elaboration? What needs to be challenged? What new (or old) directions would you like to see this conversation take in the future?*

Jeremy Vetter: A dominant view has emerged over the past few decades—at least since the cultural turn, if not before—that the main aim of the historian should be to challenge dichotomies and distinctions and to argue for the contingency and complexity of history, eschewing any focus on structured patterning in favor of variability, uncertainty, and even irony. This point of view is capably and persuasively articulated by Emily in both rounds of comments. In the first round, she lauds recent histories of agricultural knowledge that "challenge any simple division of 'farmers' and 'scientists' into tacit and explicit, vernacular and expert, local and cosmopolitan, practical and theoretical, or financially motivated and disinterested groups." In the second round, she also champions recent histories of capitalism that emphasize instability and irrationality, arguing that even agricultural science itself has not consistently stabilized value and rationalized nature. To be sure, there is a lot of historical evidence for such interpretive moves, if one looks carefully at the historical record, but I still wonder if we might complement this with a view toward larger generalizations, patterns, and explanations in the political economy of agricultural science (e.g., Carpenter 2001; Harwood 2012), effective deployment of sharp analytical distinctions between different—if sometimes overlapping—types of social roles and forms of knowledge (e.g., Finlay 1992; McKittrick 2018; Weisiger 2012), and the ways that agricultural science was not only pursued to stabilize and rationalize, but actually did produce such an outcome more often than not, even if it was not natural or inevitable (e.g., Kumar 2012; Selcer 2015). To generalize beyond any of these specific places or topics is conjectural, of course, but I wonder if we might not benefit from risking another look for larger historical patterns.

Deborah Fitzgerald: I appreciated Jeremy's point that agricultural historians might aim to identify broader patterns of agreement, or even institutional hegemony, as opposed to our current obsession with difference, lost opportunities, and pushbacks of all sorts. It reminded me of a European rural history conference I attended in Fall 2017, where research groups from two countries were hard at work trying to develop overarching rubrics that could account for agricultural change. In both cases the attention was on the state and the tension between large scale vs. small scale; extensive vs. intensive; national-market orientation vs. local or regional; capitalism vs. something else. I continue to wonder how such overarching rubrics might be developed to describe the American agricultural situation, and whether, given the vast diversity of both landscape and climate in America, such general histories are even possible. I

find such analyses very appealing, but it is hard to figure out what the unit of analysis might be. Perhaps it is scientific and technological innovation (which transformed American agriculture earlier than European in general, though there are some exceptions), or perhaps it is trade agreements (especially as a result of wars), or perhaps it is simply the winds of political change. It is an interesting exercise.

Getting back to the history of capitalism, we could learn a lot by following the plants and animals that became global commodities in the twentieth century. We know a lot about sugar and cotton, imperial products, but what of wheat, rice, beef, pork, and fruit, to name a few others? How did regional American farm practices get transformed into global food widgets, traded on global stock exchanges, profoundly removed from their origins as local food? This is really a history of science and technology story as much as an agricultural and business story, which is why is it so hard yet so satisfying to explore.

Lisa Onaga: Given the exciting historiographical dimensions we've identified so far, I wonder if we could dwell a bit on their implications for shaping historical research on intellectual/theoretical scientific knowledge within agriculture. The history of capitalism certainly opens up new opportunities for historians of agricultural knowledge. I'm yet intrigued by the broadening of *Wissenschaftsgeschichte* described by Denise that subsumes the history of all manner of knowledge. The deliberate inclusion of capital in historical research will expand as well as limit what scholars might choose to analyze within the historical scope of field, laboratory, or home practices. Musing about how "thinking with capital" can specifically change the study of historical epistemology thus seems relevant in order to reflect upon the editors' prompt about the questions and methods that the history of science can bring to agricultural history.

To synthesize some of our discussions so far, at least two methodological opportunities seem to emerge from the history of capitalism for writing dynamic comparative histories of agriculture with technology at the fore. One is a lateral expansion to inedible objects of desire. As Deborah indicated, research on things like soy that can be rendered into nonfoods illustrate growing momentum behind new global commodity narratives. I think attention to these processes of making new materials like plastics, fuels, and cosmeceuticals offers rich historical grounds for the complementary study of expert knowledge and agriculture. Another opportunity, mentioned by Jeremy, involves connecting post–1970s "alternative" agricultural systems to lineages

preceding their public consciousness. This work of deepening genealogies could include analyses of material objects in order to complement text-based histories or to forge comparative histories of agricultural practices when texts are not always available. Our discussions have mainly framed agricultural knowledge relative to the positive production of things and less explicitly the work of limiting other natures or acts of production—the making of knowledge rather than ignorance. The study of systemic issues and matters of scale in agriculture could also illuminate new opportunities to study the uneven generation or distribution of scientific agricultural knowledge.

Jeremy Vetter: Lisa raises an important point about how capital's inclusion in our work can both expand and limit our histories of science and agriculture. Not only does this remind us to include times and places before or beyond the reach of historical capitalism, but even within the capitalist world there are things that have remained relatively uncommodified, or domains where alternative ideas about value still hold sway, which deserve our attention. In particular, I would like to respond to her second main point, regarding the "other natures or acts of production" that are concealed by an exclusive focus on the "positive production of things," and how we might use material objects beyond texts to recover those lost alternatives, in a way that is fundamentally different from document-based social history (Stroud 2003). This is a compelling point, and I can think of many examples that work along the lines that Lisa has advocated, as well as studies that use the role of organisms to challenge standard narratives in other ways (Olmstead and Rhode 2008).

But a turn to material objects also could decenter humans in our historical narratives, which may inadvertently occlude analysis of the uneven power relations that Lisa rightly advocates. And here I may be taking this conversation in an unexpected direction. In important recent books, both Ed Russell and Tim LeCain make bold moves along these lines—laudably, both also engage in the "lateral expansion" that Lisa calls for beyond food to encompass cotton and silkworms, respectively—by examining the intertwined evolutionary histories of humans and biological organisms (Russell 2011) and by putting an even broader "postanthropocentric" neo-materialism at the center of history, including the causal influence of material objects as revealed through scientific evidence (LeCain 2017). In my view, such approaches are provocative, refreshing, and well worth engaging, but I do think they might evade the central role of historical capitalism in producing uneven power relations and thus in shaping human interactions with the environment in the modern

world, including through agriculture. Even as we turn to materiality as a way to recover lost alternatives, we also need to keep in mind that both humans and other forms of matter are embedded in the "Capitalocene" (Moore 2017) and that economic forces have shaped the perception of nature as much as vice versa (Hahn 2011).

Emily Pawley: First, responding to Jeremy's piece, I gladly acknowledge my debt to the cultural turn, but I would resist the idea that cultural history questions lead us away from big picture stories. Rather, I would argue, new ways of categorizing people and knowledge have revealed patterns in agricultural development that simplistic categories made invisible. Lisa points to unacknowledged "lineages for 'alternative' agricultural systems"; I would add new lineages for what we call "conventional" agriculture. For example, noticing unexpected reversed flows in the direction of knowledge can help us see the ways that formal institutions of agricultural science have repeatedly harvested the knowledge and practices of people whose expertise is rendered invisible by their social position. We can see this in the work of Linda Nash (2006), who shows how migrant laborers exposed to organophosphates on a large scale had to organize politically in order to make the poisonous effects of pesticides visible. In the twentieth century, this dynamic, in which exposed, marginalized populations have fought to make their experiences with new chemicals credible (often in the face of intentional dissimulation from apparent experts) is a crucial pattern. Work by Kloppenberg (1988) and Schiebinger (2017) showing how genetic material has been appropriated, also provides a useful model for such stories. Acknowledging the grand scale of "reversed" flows, of ideas, drugs, foods, fibers, and practices seems even more important with the resurgence of white supremacist claims of superiority based on Eurocentric narratives of technological development. The "mestizo" landscapes of modern agriculture seem ideally placed to counter such claims, if we can tell their histories convincingly (Menard 2006).

Denise Phillips: Reading through our last round of exchanges, I find myself wondering if Emily, Lisa, and Jeremy are not just looking at different parts of the same elephant. It seems to me that we are all essentially in agreement that when we do see large-scale patterns, these patterns have been produced in historically contingent, specific ways; in that case, questions of proper scale (or proper categories of analysis) would always need to be worked out with reference to specific material. Lorraine Daston once called for historians of

science to pay more attention to the histories of universalization, the processes whereby things became widely distributed features of reality, and maybe that rubric describes some kind of common ground (Daston 1994). That's obviously not all we are talking about here, but it seems like a way of labeling one kind of process we have been discussing.

Jeremy Vetter: I think Denise is probably right that we are all imperfectly and partially perceiving different features of the same multifaceted historical reality. At root, this is more a debate about emphasis than anything else. As a group, historians in recent decades (or maybe even before that) have usually tilted toward complexity, countercurrents, and reverse flows. I have myself happily contributed to this in some of my work, and I think it is valuable, even essential, to look beyond the dominant systems and patterns—not least, because, as Emily points out, the knowledge of marginalized or alternative social groups has often been appropriated or delegitimated. And our history is dangerously incomplete without such narratives. What I am mainly calling for is for historians of science and agriculture to also embrace the search for larger-scale patterns and explanations for longer-term historically produced systems of power relations. I'm not sure that anyone disputes that such work is valuable, but I think we as historians often gravitate toward the counter-examples and alternative currents, which are difficult to understand or explain without the bigger picture. Daston's historical vision, which Denise invokes, is certainly one great example of maintaining that bigger picture while still preserving the culturally embedded texture of historical change.

Emily Pawley: As we try to sketch our common elephant, I find Denise's mention of universalization and Deborah's mention of institutional hegemony to be particularly productive. The rise of identifiable "scientists" in experiment stations and agricultural colleges in the middle to late nineteenth century clearly remains a sea change in the making of agricultural knowledge. It's clear that the institutions of agricultural improvement and *agromanie* had a similar reach, though very different practices and forms of authority, from at least the eighteenth century onward. The scholarship described in earlier entries can help us reinterpret the role of these institutions, not just as centers from which knowledge diffused but as structures for systematically harvesting knowledge from seeming peripheries (here I find myself influenced by Jeremy's work [Vetter 2016]). I would love to see history of long-term continuities of knowledge harvesting—from Royal Society questionnaires to

biopiracy. We still need to link these institutions more clearly to timelines of formalized agricultural knowledge in other centers, Imperial China, for example, or the Ottoman Empire. In the European and American context, we should add a parallel institutional timeline for commercial networks, which have been overshadowed in the scholarship by gentlemanly and scientific institutions. Thus, for example, we know a lot about botanical gardens, less about nurserymen; a lot about chemists, but little about fertilizer manufacturers, even though plants and manures only worked as commodities in the context of larger chemical and botanical ideas about their action and stability. (I see good movements in that direction from Marina Moskowitz and from Sarah Easterby-Smith [Moskowitz 2006; Easterby-Smith 2018].) Advertising still seems enormously neglected as a forum where ideas and practices gain and lose authority. Paying attention to the alternative institutional histories of commerce would allow us to see some other crucial shapes of the history of agricultural knowledge.

Lisa Onaga: One of the most fascinating things that this forum has foregrounded for me is the dialectical tension between examining locally grounded histories of agriculture and scaffolding large-scale explanations that seek to interconnect histories of science, technology, medicine, and environment. Dwelling upon this tension itself has been obligatory for many who work on historical projects that on the one hand seek to restore history and agency to local actors who were easily overlooked due to neo-Marxist global systems analyses. Studies on agriculture or commodities such as in postcolonial India (Gupta 1998) and cotton at the Mexican borderlands (Walsh 2008) have thus pursued local histories in which the redistribution of narrative perspective occurs not in spite of but due to awareness of or interest in contributing to broader histories of globalization. These gesture to the focus on unpaid labor, which the Capitalocene framework also highlights (Moore 2018).

On the other hand, scholarship on smallholder agriculture in Borneo (Dove 2011/2012) has also drawn out historical arcs of production or precapitalism that predate the early modern Columbian Exchange. This is not to overlook the importance of colonial science in agricultural settings (Aso 2009; Maat 2013; Stephens 2017); I heartily agree with Emily that comparison of agricultural knowledge harvesting and processing across empires would be useful. Actively thinking about the history of Asia in the coalescence of technology, power, and agricultural exploitation of natural resources can also remind us to continue asking what gets to "count" as agricultural history in

"global" settings (see Dressler 2010). Francesca Bray's seminal work on rice economies (Bray 1994) has provided a generative model for thinking about periodization without the imperative to locate equivalents for developmental markers on standards of success established in Europe. Recent work such as by Richard von Glahn (2016) reconstructs a political economic landscape of competing kingdoms and imperial instabilities that have contributed to understanding the dramatic historical expansion of rice cultivation in the Yangzi River Delta, crucial to economic transformation between the Tang and Song periods (755–1250).

The notion of "mestizo" landscapes that Emily gestured to also left me deeply curious, and I am already looking forward to further opportunities to explore this alongside other methods. What might the field gain if we use the neo-materialist approach to highlight key moments in agricultural theory, practices, and languages that contribute to various human world-making processes? The Moving Crops and the Scales of History working group, consisting of Bray, Barbara Hahn, Tiago Saraiva, and John-Bosco Lourdusamy, is currently undertaking an exciting conceptualization of crop mobility as a means to bridge different periods, geographies, hierarchies, and economic scales of production in agricultural and horticultural histories and to rethink the multi-dimensional roles of agriculture in both local and global historical process (https://www.mpiwg-berlin.mpg.de/research/projects/moving-crops-and-scale-history). Such collaborative approaches, coupled with attention to new kinds of transnational and otherwise mobile agricultural knowledge seekers and makers in borderlands, noncolonial, and postcolonial contexts (e.g., Lavelle 2014; Lin 2015) make for an exciting historiographical horizon.

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