MINING EMPIRE, PLANTING EMPIRE: THE COLONIAL SCIENTIFIC LITERATURES OF THE AMERICAS

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of PhD in the Department of English and Comparative Literature

Chapel Hill
2012

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Abstract

ALLISON MARGARET BIGELOW: Mining Empire, Planting Empire: The Colonial Scientific Literatures of the Americas
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"Mining Empire, Planting Empire" examines the literary roots and settler ideologies of the colonial scientific discourses of Anglo and Iberian America. Agriculture and mining are the foundational material practices of settlement. Without the former, there is no food to sustain a population, and without the latter there are no farming tools. But they are more than just key nodes of scientific improvement; they are also the discursive forms that perform the cultural work of the largest empires of the seventeenth-century Atlantic world. By comparing the scientific theories and practices explained in technical treatises, instruction manuals, promotional pamphlets, and legal documents, a literary corpus almost as fanciful as the period's works of imaginative fiction, this book argues that English and Spanish writers invoke the terms of colonial agricultural and mineralogical science – planting and possessing, mining and amalgamating – to naturalize their American settlements. Iberian science provided the language of mineral classification, the sorting into "castas" of racialized *metales mulatos* and *negrillos*, while the technology of amalgamation underwrote a discourse of purity (*limpieza*) and incorporation that resonated powerfully in the founding of colonial life. Absent the mineral wealth of Spanish America, Anglo colonists instead engaged the evocative language of agricultural improvement to lay claim to heathen "heaths" and racialized moorlands in England's foreign plantations. Although they drew from two different

colonial scientific archives, both Anglo and Iberian colonists enlisted seventeenth-century scientific practices in the rhetorical and material service of empire. This comparative framework of similarity and difference helps us to understand important points of continuity and rupture among and between early American scientific literatures.

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"Oye hueón es tan rica la mina." At once signifying "Hey, man, that mine has great metal" and "Hey, man, that woman is so fine," this was the kind of expression that I often overheard as an English teacher in the Cerro Colorado copper mine, located in northern Chile some two hours between the port city of Iquique and the Bolivian border. Like the other eight women who worked on-site among more than 700 men, I was probably not supposed to hear these miners conflating their work in the mine (*mina*) with their sexual relationships with women (*minas*, in Chilean slang). But I thought the culturally-specific ideas of gender and sexuality that informed this play of language were worth investigating. After I finished my first semester in the mine, I applied to graduate school and began digging in the colonial Iberian archives to determine what the historical record might reveal about the gendered systems, racialized language, and cultural work of mining and metallurgy. In the national archives of Cuba, Bolivia, and Peru, I found stories that I had not expected to uncover – a community of enslaved African copper miners and their descendants who resisted the crown's biopower by appealing to orthodox veneration of the saints, an indigenous Andean woman who discovered her own silver mine, extracted her own ore, and organized her own male indigenous workers to oppose the appropriation of the site by a powerful male colonist, Iberian women in Alto Perú who ran their own silver refineries and mercury processing plants. Were these cases proof that the history of American mining needed to be reconsidered, or were they the aberrant exceptions that proved the rule?

The story of colonial mining and metallurgy in Latin America is one dominated by accounts of the misogynistic attitudes and widespread womanizing of poverty-plagued miners who are exploited and dehumanized by owners whose wanton disregard for safe working conditions and labor rights is compounded by their wasting of ill-gotten money. It was, as mining historian Peter J. Bakewell puts it, "intemperate, arrogant, defiant" work performed by the unfortunate souls amalgamated into the lot of "the determined, the ambitious, the avaricious, the very needy, or, in the case of Indians going to the *mita*, the compelled." As more recent studies of labor relations in the Andes have shown, however, by 1600 the overwhelming majority of indigenous miners refiners – some 60 to 70 percent of the workforce – was composed of independent wage earners who negotiated the terms of their own contracts. Our ideas about what colonial mineralogical arts and sciences looked like derive in part from the material practices performed by these people, labor-intensive practices like tunnel excavation and refining, and in part from the language in which these procedures were described. If archival documents like articles of incorporation, *relaciones de méritos y servicios*, and last wills and testaments suggest ways to reconsider what the technical processes entailed, and the degree to which we might appreciate their racially- and gender-inclusive material practices, published treatises on mining and metallurgy also show the importance of revisiting the key terms of colonial Iberian mineral science.[1]

The language lifted from colonial Iberian mining and metallurgical treatises was enlisted in the political genesis of the early republicof the United States – especially metallurgical technologies like amalgamation, an industrial-scale method developed in the 1550s in New Spain to treat mixed silver mineralogies common in the Americas. This

language was heavily-fraught with colonialist ideas of purity (*limpieza*) that shape material processes of mixture and incorporation, ideas that were imported into Anglo-American natural vocabularies. In Iberian America, this colonial scientific discourse was the language helped to produce taxonomic categories of an emerging racial/ethnic hierarchy: silver ores mixed with iron and sulfur were systematically classified within "castas de metales" (metallic castes) and named "metales mulatos" and "negrillos" (little black ones), the same classificatory modes that would organize through language and policy the new demographic mixtures of indigenous, African, and European peoples in the colonial Americas. Through the writing of Thomas Jefferson (1743-1826), who read Spanish-language natural histories like Antonio de Ulloa's *Relación historica del viage a la America Meridional* (Madrid, 1748), these racialized terms of seventeenth-century Iberian science were separated from the material practices and technologies that produced them, and the language of amalgamation became a culturally authorizing metaphor through which Anglophone political writers articulated their anxieties about racial mixture in the new national project.[2]

To understand how colonial Iberian science underwrote the complex process of political formation and population management in North America, it is helpful to compare the colonial scientific literatures of Anglo- and Iberian-America: agriculture and mining. That the legacy of silver mining and metallurgy lies at the heart of the black legend has been well-documented, and, to a lesser extent, so too have scholars attended to the place of the "white legend" in copper metallurgy.[3] But less well-studied are the ways in which marginalizing the epistemological sophistication and technological advances of Iberian mineralogical science contributed to the powerfully cohesive narrative of, as Sir

William D'avenant (1606-1668) so formatively staged it, *The Cruelty of the Spaniards in Peru* (1658). And especially understudied are the ways in which later generations of Anglophone writers synthesized colonial Iberian- and Anglo-American scientific terms of amalgamation and agriculture in the cultivation of racial anxieties about the new national project. While seventeenth-century English writers invoked the metaphors and material process of agricultural science to describe their settlement in England's "forraine plantations," including Ireland, the North American mainland, and the Caribbean, writers of the early republic and the antebellum periods instead turned to colonial Iberian mineralogical science to explain and justify their positions on racial mixture and the newly independent body public.

Without the mineral wealth of New Spain or South America, a fact much bemoaned by adventurers like Sir Ralph Lane (1530-1603) upon essaying into copper-poor Virginia in the hope of finding "a marveilous and strange Minerall," English colonists had no need to develop the technical competencies and richly metaphorical language of mining and metallurgy that characterized seventeenth-century Spanish American arts and sciences.[4] They turned, rather, to agricultural scientific discourse, and they used this language of sowing and setting to define their plantings in the New World. The rhetoric of planting has been well-studied by historians and literary scholars of early Anglo America as political policy, scientific enterprise, and spiritual metaphor, but despite the remarkable amount of scholarly attention, especially to the privileged place of planting in New England, no study has yet to integrate colonial Iberian and Anglo American scientific writings into a cultural history of the early Americas. In the authorizing terms of settlement, the material practices of agriculture were invoked by

colonial apologists as metaphors to sanctify the planting of British America, while the technologies of mining and metallurgy were was ascribed to Iberian America, especially, in the seventeenth century, to Spanish America.[5]

But these were not separate colonial discourses that developed independently of each other; the central organizing metaphors and economies of the colonial agricultural and mineralogical science drew from the same natural scientific foundations and used the same received traditions of the past to authorize their settlements in the New World. The metaphorical terms of settlement – the rising generation of English planters and the amalgamated body publics of Iberian America – and the material innovations contained in the colonial scientific discourses of planting and refining were indeed different. And yet these natural scientific vocabularies were enlisted in the same way. The comparative framework of both similarity and difference can help us to identify those moments in which colonial scientific knowledges overlap and diverge. This book therefore investigates the two foundational settler ideologies of Anglo and Iberian America by exploring their mutually-constitutive literary and scientific roots.

Agriculture and mining were critical to colonial settlement and imperial aspirations. Without the former, there was no food to sustain a population, and without the latter there were no farming instruments, as early modern metallurgical writers like the German Georgius Agricola (1494-1556) and the Spaniard Bernardo Pérez de Vargas (ca. 1500?-1569) were quick to point out. Both were, in the seventeenth century, the preeminent discourses performing the cultural work of the two largest empires of the colonial Americas – the planting and possessing of British America and the mining and amalgamating of Spanish America. The development of gold mining in the interior

regions of Brasil would extend this ascription to Portuguese America in the eighteenth century.[6] On this point the mining historian Peter J. Bakewell makes what he calls the "crudely psychoanalytical" observation that "the Iberians' success in mining in America and the unparalleled miscegenation that they set in motion in the sixteenth century have common origins in aggressive Iberian colonizing energy combined with America's relative geographical, political, and biological openness compared with most of the non-European world."[7] According to some of the finest historians of colonial Latin America, then, the material production of mining and metallurgy – unearthing and mixing, purifying and refining – helps to texture the reproductive labor of colonial Iberian settlement and the ways in which those settlements are understood within and without the Iberian world.

In economic terms, this overlap in scientific discourse and cultural paradigms makes sense, given the central place of mining and metallurgy in the development of seventeenth-century Spanish America. Economic historians Osvaldo Sunkel and Pedro Paz note that the industrial-scale mining and minting of silver in New Spain and Alto Peru enabled the development of quality control mechanisms, large-scale agricultural complexes, long-range religious networks, and distribution channels around priority ports that connected Caribbean islands, the Mexican basin, and the Spanish American mainland to each other and to the imperial metropolis. Dennis Flynn and Arturo Giráldez, meanwhile, point out that colonial silver enabled currency standardization in an empire that, after the establishment of its outpost in Manila in 1571, trafficked American silver to Asian markets in exchange for goods and peoples bought and sold in Europe and Africa.[8] If the mining of precious metals is driven, at least in the popular imagination, by chances

and whims and the quite literal prospect of striking it rich, the reality in the colonial era was less the stuff of fancy and more of commercialized applications of natural knowledge.

To organize the extraction and refining of silver in the Andes and the central Mexican highlands into efficient global distribution networks required new technologies of metallurgical processing, new transportation methods, and new labor systems. In time, and with steps and missteps, skilled miners and metallurgists, expert engineers, savvy investors, and shrewd opportunists developed the epistemological and material infrastructure to support the large-scale mining and minting of silver throughout the Spanish viceroyalties. The challenging topography of the central Mexican highlands led to a constellation of innovative transportation networks, while the lack of water in Potosí sparked the design of efficient water delivery systems and methods of crushing and washing ore. The central accomplishment of colonial Iberian mineralogical science, however, was not its engineering projects so much as its development of a large-scale and commercially-viable method of treating silver with mercury (*azogue*).

This new benefit of amalgamation was invented by a Sevilla-born merchant who, in the mid-sixteenth century, left his home city and profitable business to explore a radically new theory that had reached him through "pláticas con un alemán" (conversations with a German). In this often-analyzed phrase, Bartolomé de Medina does not reveal anything about his interlocutor, other tan that he was a German man, nor does he explain how thye met, how often they spoke, or what types of ideas they shared. But somehow through these conversations Medina became convinced "que se podia sacar la plata de los metales sin fundición, ni afinaciones y sin otras grandes costas; y con esta

noticia determine venir a esta Nueva España dejando en España mi casa e mi mugger e hijos….” (that it was possible to process silver without smelting or refining or other great costs; and with this notice I determined to come to New Spain, leaving my house and wife and children in Spain). Working with indigenous, African, and European practitioners in the mines and refineries of the *Nuestra Señora de la Purísima Concepción* complex, located outside of Pachuca, Medina determined that the dominant conceptual frameworks of the sixteenth century could not account for the productive relationship of like to like in the case of silver and mercury. While these theories suggested that similar bodies could not generate new matter or cause it to take shape, the results of the experiments in New Spain were clear: the “amistad” and “simpatía” of silver and mercury generated remarkable amounts of *pella*, a gray-black amalgam that brought silver particles into body. The chemically-based method of amalgamation, unlike the earlier smelting methods designed only for native silver (Ag), made it possible and profitable to extract silver from all mineralogies, including the most common mixtures of silver, ferrous, and sulfuric particles, called *metales mulatos* and *negrillos* in the racialized terms of colonial science.[9]

By 1572 the method had been introduced to Alto Perú, where multiethnic teams collaborated and competed to modify it into a heat-based treatment (*cazo y cocimiento*) better suited for the region’s colder ambient temperatures and higher mineral weights. The science of amalgamation incorporated the mineralogical knowledge and embodied labor of New and Old World practitioners, putting into practice the same types of generative mixtures contained in its theoretical formations. In reconfiguring the received traditions of Empedoclean root theory and Aristotelian natural philosophy, colonial

miners and metallurgists developed an innovative conceptual framework and material practice that underwrote the physical settlement of Spanish America – administrative centers and port cities that regulated the flow of miners and mineral wealth to the interior mining regions, and haciendas and religious communities galvanized to offer material and spiritual sustenance.[10]

To the dismay of English adventurers like Ralph Lane and Sir Walter Ralegh (1552-1618) there were no such mineral deposits to be found in North America, so they turned instead to planting. According to the estimates of Russell Menard and Lorena S. Walsh, agricultural laborers made up nearly eighty percent of the workforce of early British America, and agricultural improvements like hybridized husbandry methods, farming instruments, and crops provided the knowledge, practices, and capital that underwrote colonial economic growth.[11] African and European rice planters in the Lower South developed elaborate irrigation systems, blended rice strains, and improved the cleaning process to generate surpluses for export. In the Chesapeake, the soil and labor conditions that made wheat a poor choice of grain led farmers to adapt indigenous methods like tree girdling (removing the bark so that the tree dies, slowly, but leaves a canopy under which to plant crops like corn and tobacco).[12] These blended practices and innovations were worked out in the daily realities of competition and collaboration between and among African, indigenous, and European practitioners, and in that process they provided the material foundations and cultural terms of settlement in the Anglo-American North. Some of these innovations proved remarkably successful, while others were material or commercial failures. As in the case of Iberian American essays, the failed enterprises – and the language in which they were promoted – reveal as much of

the cultural work of colonial science as do the explanations of inventions that ultimately proved more lucrative.

While much of the historiography has focused on the large-scale plantation economies that were underwritten by monoculture crops like tobacco and sugar – the crucial counterpoints (*contrapuntos*) of the extended Caribbean, and important sites of technology transfers across imperial and cultural borders – small-scale industries like silks, wines, and honey were also important sites of scientific development and colonial designs. If tobacco and sugar were the realities of the imperial economy, niche markets in sericulture, oenoculture, and apiculture were the nodes of alternative visions of what English expansion could look like. Searching for a "more natural" sweetness than sugar, and a more refined source of income than what John Ferrar calls "that beggarly Indian weed," the type of commodity that could replace tobacco as colonial English currency and, perhaps, counter the hegemony of Spanish silver in global markets, agrarian reformers in the transnational Hartlib circle eagerly exchanged ideas and material samples to advance the silk industry of Virginia. Equating silk with elegance requires a careful omission of how, exactly, the fibers are excreted from silkworms and wound, spun, and processed. John Ferrar could distance the finished product from its origins in silkworm bottoms because he did not contribute any of his own results to the Hartlib circle dialogue. Instead, he reported the findings of experiments designed and conducted by his daughter, Virginia, and he sent this multivocal assemblage of prose and poetry to Hartlib, which was printed in London, in 1652, as *A rare and new discovery of a speedy way, and easy means, found out by a young Lady in England, she having made full proof thereof in May, anno 1652* (Richard Wodenothe). In 1653 Ferrar sent an enlarged edition

of the report, and two years later Hartlib appended Ferrar's original letter and the postscript to other missives on silkworm cultivation and he published, in London, *The Reformed Virginian Silkworm; or, A rare and new discovery of a speedy way, and easy means, found out by a young Lady in England, she having made full proof thereof in May, anno 1652* (John Streater for Giles Calvert). The circum-Atlantic circulation of these reports takes them through time and space, forming over the course of four years an extensive epistolary relationship that connected informants in England, Ireland, Central Europe, and Virginia.

In the winter of 1651, Virginia Ferrar began preparing her experiments. Colonial informants had consistently remarked on the abundant mulberry trees that grew in the colony after which John Ferrar had named his daughter, and yet early efforts at silkworm cultivation had failed. Virginia Ferrar designed an empirical study to test what she suspected to be the underlying causes of the problem – improper food sources and inadequate lodging for the worms. Over the winter she assembled silkworm houses for indoor and outdoor cultivation, populated them with worms, and identified two different food sources, mulberry leaves and lettuce. When the insects began to emerge from their cocoons in the spring, she moved half of the group outside. At the end of the 45-day lifecycle, she measured the worms and compared their success rates. The outdoor worms had grown larger and generated more silk fibers per worm than the indoor worms, while the lettuce-fed lot died before she could harvest their silk.

Virginia Ferrar's carefully designed experiment and her findings made their way into reformist communities like the Hartlib circle by way of her father's account of her work. Like other silkworm treatises, the Ferrar letters extol the benefits of colonial

sericulture and suggest that the industry might be easily reformed with the knowledge confirmed in Virginia Ferrar's experiments. But unlike other works in the genre, the gender pronouns of the treatise do not shift in accordance with changes in the natural matter – that is, following other silkworm manuals, when the worms mature or when they are prepared to mate. In agricultural instruction books like Sir Hugh Platt's *Jewell House of Art and Nature* (London, 1594) and Gervas Markham's *Book of the English Husbandman* (London, 1635), the pronouns that refer to soils and seeds shift in accordance with their changing states of fertility and production. The generic conventions of pronoun changes are strikingly absent from the Ferrar treatise, as the fixedly feminine pronouns refer at once to the female sericulturalist, the feminized silkworm, and the Virgin colony. By tracing the gendered language of silkworm treatises, I show how we can appreciate Virginia Ferrar's contributions to the programs of agrarian reform designed for colonial Virginia. While feminist historians of science have often argued that the gendered language of early modern scientific treatises indexes a misogynistic subordination of a feminized model of Nature, I propose that multivocal, transnational missives like those exchanged by Hartlib circle correspondents provide an alternative way to analyze the gendered work of lanauge in seventeenth-century scientific discourse.[13]

In this double voiced treatise, we also see the very different attitudes of the female experimenter and the male amanuensis toward the natural knowledge of indigenous sericulturalists in the colony. Virginia Ferrar asks, through her father, that colonial planters collective native knowledge and assemble their own reports on silkworm lifecycles, habitats, mating, and feeding habits, and that they share this information with

her as a way "to advance Virginia's Prosperity." Her father, meanwhile, doubts that there are any sericulturalists "born with Brains" in the colony, and he dismisses the value of native knowledge outright.[14]

Silkworm cultivation in the colony did not, as we now know, develop into the type of industry that could counter the dominance of tobacco in local markets or silver as a global currency. But the authors of silkworm treatises could not have known how the market would or would not grow, so for the scholar of early American attitudes and imperial aspirations, the genre is deeply revelatory. The gendered language of silkworm cultivation, the experiential orientation of the planting of silkworm colonies, and the incorporation or rejection of natural knowledge throughout the circum-Atlantic republic of letters – with contributions from and dismissals of indigenous, Anglo, Irish, and central European agents – suggests some of the ways in which seventeenth-century agricultural letters perform the cultural work of empire and index the aspirations of the emerging English empire in particular. In English colonial letters, agricultural work, and specialized segments like sericulture, were more than just a physical fact of the continent, a set of emerging technologies and hybrid foodways, or a shaper of settlement patterns: they were the authorizing logic of those settlements.

The cultural work of agricultural and mineralogical language and images were given powerfully cohesive expression by imaginative writers like Lope de Vega (1562-1635) and John Milton (1608-1674), and the broader circulation of agricultural and mineralogical discourses in these artistic enactments helped to solidify the ascription of agriculture and mining to the Anglo and Iberian empires in the Americas. The language of setting and sowing, amalgamating and refining were foundational material practices that

were transformed by seventeenth-century technologies, underscoring my argument that colonial scientific discourse provides a helpful framework through which to interpret imaginative fiction and read the remains of the past. A more careful attention to the language of scientific literatures, or a method of applying literary practices of close reading to non-imaginative texts like technical treatises and instruction manuals, allows us to appreciate the overlapping discourses of religioscientific paradigms and new technologies; technical terms like *ley* (metallic weight/religious salvation) and *heathland* (uncultivated wasteland) also register the spiritual states and cultural conditions of the people who purify metals and cultivate barren plots.

Just as a literary approach to historical documents can help us to better understand these archival sources, so too can a better understanding of the history of colonial American science allow for a new interpretation of imaginative letters. By contextualizing the technical innovations and epistemological sophistication of the mid-sixteenth century New Spanish method of amalgamation alongside the famous dismissal of Aristotelian contrarieties articulated by the seventeenth-century Sor Juana Inés de la Cruz (1651-1691), we begin to see the Mexican nun as less of an intellectual aberration and part of a broader culture of critique. In the interstices of New World and Old World knowledges and practices, skilled miners and metallurgists from Africa, the Americas, and Europe, plus expert engineers, unskilled laborers, and shred merchants collaborated to reconfigure natural philosophical principles of the attraction of like to like. According to Aristotelian traditions of natural knowledge, mercury and silver were too similar to generate new matter or cause it to change shape, but New Spanish practitioners working in various degrees of freedom and unfreedom revised these received definitions of

similarity and contrariety as they developed a remarkably productive and efficient method of bringing silver into body. Sor Juana's experiential trial of Aristotelian theories of contrary natures, waged in her study of the different effects of sugar and oil on egg yolks and whites, has been widely read as a domestication of knowledge that culminates in her affirmation of women's "filosofías de cocina" (kitchen philosophies) and her assertion that "Si Aristóteles hubiera guisado, mucho más hubiera escrito" (If Aristotle had cooked, he would have written much more). Sor Juana has long been marked in literary scholarship as an exceptional figure, a *rara avis* whose intellectual capacity and prolific literary production place her outside the conventions of colonial lives and letters in Spanish America.[15] A more nuanced understanding of the epistemological sophistication of the New Spanish method of amalgamation, specifically in terms of its received theories of similarity and difference in natural philosophy, can help us appreciate the ways in which Sor Juana's examination of Aristotelian theories of contrariety might be placed into a genealogy of critical intervention in the colonies. This avenue of inquiry opens up new possibilities for comparative analysis of imaginative engagements with seventeenth-century scientific theories, as in the humoral theories and elemental analogies of Anne Bradstreet's *Quaternions* or the divine distillations of the Rose of Sharon and "enoculate[d] mentall eye" of Edward Taylor's *Preparatory Meditations*.[16]

Literary scholars and historians have long asked whether the Americas share a common history or literary history, but the division of scholarship on South and North America does not take its cues from the colonial record. It is not the print art or visual aesthetics that cannot be contained in national or linguistic borders, or the ideas and material goods that circulate along official and contraband networks, or even the many

groups of people who, as Jack Greene put it, "were so inconsiderate of later geopolitical developments as to occupy an area transected by a subsequent boundary."[17] Instead, I argue that it is science – or, more properly put, an idea about scientific progress and modernity – that continues to divide scholars of the early Americas along the national and linguistic borders that did not exist in the sixteenth or seventeenth centuries. The multilingual approach to colonial American science adopted in this book shows how Iberian and Anglo apologists employed the same natural philosophical traditions to organize the people and things around them through language, and how they applied new technologies into different patterns of settlement. The terms of similarity and difference emerge from the scholarly historiography of American history and literary history and also from the primary texts themselves. In the seventeenth-century Americas, similarity and difference were scientific principles informed by the elemental theories and analogical thinking of natural philosophy, and they were social categories that shaped early modern understandings of relationships between animate beings – peoples, plants, and minerals alike. This book seeks to provide a comparative framework of similarity and difference that incorporates both seventeenth-century Anglo and Iberian arts and sciences on their own terms, and in so doing I hope that it will invite new interpretations of the traditions of oppositional thinking in early American historiography.

When they have been compared at all, English and Spanish settlements in the Americas were typically read by historians and literary scholars as yet another manifestation of difference: Protestant and Catholic, North and South, proto-capitalist and feudal. But as recent work in religious history and Atlantic history has suggested, the lines between Protestant paradigms and Catholic convictions, English models of planting

and Spanish frames of conquest, were never as clear as nineteenth- and twentieth-century historians had suggested. Katherine C. Little's study of sixteenth-century Protestant paradigms of work and works has shown the remarkable degree to which reformed theology continued to engage with "the symbolic imagination of medieval Catholicism," while John Huxtable Elliott's careful reading of colonial literatures has demonstrated that the self-styled English idea of planting was "never far away" from the idea of conquest more often associated with the Iberians. Even as they recuperated Roman imperial frameworks in different ways, the early modern English planter and Spanish conqueror were always mutually constitutive.[18]

Historians like Patricia Seed point to the different policies of topsoil and subsoil land rights in British and Spanish America to support the narrative that the English planted and the Spanish extracted, and that the industries of agriculture and mining are mutually exclusive, but legal historians like Lauren Benton and Alan Watson have demonstrated not only the dramatic "jurisdictional jockeying" produced by overlapping layers of civil and ecclesiastical authority in colonial and metropolitan regulatory frameworks of emerging early modern empires, but also the simple truth that it is difficult to determine much about a society just by reading its printed laws.[19] The seventeenth-century lawyer Gaspar Escalona y Agüero (1598-1659) admits as much in his survey of the gap between colonial Spanish mining laws and their officially tolerated non-compliance in the Andes. While the law prohibited the construction of a refinery (*ingenio*) without a license, the legal compiler notes that the refining industry developed apace even though he cannot recall any such license beng granted: "bien presumo, que sin ella se ha- edificado en varias partes, y ha se tolerado por aora, por escusar el rigor de

la demolicion" (but I presume that without the license many refineries have been built in various parts, and it has been tolerated for now, to excuse the rigor of demolition).[20] To this work in religious studies and legal history scholars like Elliott, Jorge Cañizares Esguerra, and Ralph Bauer have shown more broadly that the political, biocultural, and artistic borrowings both wide and deep between Anglo- and Iberian-American colonies were much more substantial than earlier studies had suggested.[21]

That the literatures and ideas of the colonial era did not respect the linguistic, national, and disciplinary borders to which we are now accustomed should not be surprising. This, after all, is a period in which free and unfree African, Flemish, Italian, Portuguese, and English silver miners arrived in highland regions controlled by imperial Spain and financed by a German family to collaborate and compete with indigenous Andean miners whose metallurgical technologies had been inspired by agricultural practices that predated the arrival of the Inca empire in the area. This is a time when English officials invited German metallurgists who had trained in Hungary and studied Italian metalwork to organize mining companies in England's supposedly agriculturally-underproductive midland heaths and upland moors. The colonial borders of natural science were largely if not wholly dismissive of the kinds of borders that organize scholarship of the early Americas into discrete national and linguistic communities to be studied by different disciplinary conventions of history, history of science, and imaginative writing.[22]

The material realities and imaginative traditions of analogical thinking make seventeenth-century science an especially helpful frame through which to read the remains of the colonial past. Knowledge and technology passed widely along networks

that connected South and North America to essayists into the circum-Atlantic theater of nature, as agricultural instruments like mills were adapted to crush metals, and metallurgical technologies like incorporation were enlisted to naturalize political frameworks and explain demographic mixtures in the amalgamated body politics of Anglo and Iberian America. Not all of the agents of science surveyed in this book read each other, of course, or even knew of each other's existence. Many practitioners were not lettered, in the Western sense of the term, though their modes of reading landscapes and communicating their features into maps, herbals, and technical manuals may very well constitute a form of what Walter Mignolo calls "writing without letters." It seems safe to say that indigenous Andean women who hired themselves out as migratory contract wage workers (*yanaconas*) in silver mines and mercury refineries knew nothing of, say, English agricultural writer Sir Hugh Platt's recipes for distilling and preserving food, and that Platt knew nothing of indigenous women's mineralogical knowledge or the validation of their technical competencies by the same Spanish empire that he demonized to the delight of his female readers.[23]

And yet these groups were indeed more closely integrated than they may have realized. Platt (1552- ca. 1611), for example, joined many of his compatriots in recommending mercury as a purifying cosmetic for European women's skin, especially for faces that were plagued with red blemishes. He instructed English women to combine with "great labour" four ounces of powdered mercuric chloride ("sublimate") with one ounce of "crude Mercurie," allow the mixture to "incorporate" over six or eight hours, and then wash the solution clean with water twice a day for seven or eight days. Afterward, the women were instructed to apply this "minerall focus" with white poppy

oil as a sympathetic whitening agent. Although Platt does not declare the provenance of this mercury-based remedy, the cosmetic use of chemically-related red cinnabar by indigenous Andean women had led earlier waves of European men to analogize the human applications of cinnabar to non-human orders in new technologies of mineral purification.

When in the mid-sixteenth century the Portuguese national Enrique Garcés (ca. 1520-1595?), then resident in Lima as owner of a stationary shop and paper importation company, observed that native women cleaned their skin with cinnabar (HgS), he analogized the mineral's purifying properties to those of mercury (Hg), a mineral substance that mid-sixteenth century New Spanish mineralogical scientific agents were developing into a ten-step chemical treatment for silver (Ag). Garcés's theory was of such interest to colonial officials in Peru that his petition to travel was quickly granted.[24] When Garcés returned to Lima, he and a New Spanish mining colleague, Pedro de Contreras, applied for and received exclusive rights to the mercury of Huancavélica. Upon learning of the mercury deposits and their application, the viceroy don Francisco de Toledo (1515-1584) is said to have pronounced the union of Potosí and Huancavélica "el casamiento de más importancia del mundo" (the most important marriage in the world). Once Garcés had made his fortune as a silver miner and metallurgist, he resumed his work in the emerging literary markets of Lima, first by assisting local printer Antonio Ricardo, who specialized in the publication of epic poems of the conquest of Chile and Perú, such as Pedro de Oña's *Arauco Domado* (Lima, 1596), and then by translating the Portuguese epic *Os Lusíadas* and Petrarchan sonnets into Spanish. Garcés wrote original verses, too, and he related his deep experience with colonial mining and metallurgy in the preeminent

scientific and emotional terms of the industry: unearthing and mixing, hoping and failing. Framing his essays into the colonial scientific archive as one of trial and error, Garcés describes his retirement with the full force of weariness, and something of the pleasure of inverted syntax:

> "Y en fin ello ha parado
> En desterrar de aquí la plata pura
> Y agora una mixtura
> Quieren que tome el pobre jornalero
> Que es plomo, estaño, y cobre sin estima."

[And finally this thing has finished / In unearthing here the silver pure / And now a mixture / They want the poor journeyman to take / Which is lead, tin, and copper of little worth.]

The alliterative play of "plata pura" rhymes with the temporal frame of the present ("agora") to reveal the gap in the splendor of the raw material and the paradoxical debasement that gives the ore its value in circulation. Only by combining the base metals of lead, tin, and copper with his noble silver can this "poor journeyman" of a miner make something of value. This combinatory logic is the rich paradox of mining and metallurgy, at once a set of technical competencies that Garcés had mastered and helped to disseminate in the region, and also a symbolic lens through which to view and make sense of his contributions in colonial arts and sciences. Years later, Enrique Garcés would return to the Iberian peninsula, where his translations of Petrarch, praised by Cervantes, were published in Madrid in 1591 by Guillermo Droy, the same printer responsible for bringing Juan de Arfe Villafañe's well-regarded metallurgical treatise, *Quilatador de plata*, into the literary market seven years later.[25]

The story of Enrique Garcés is one in which natural science and print culture circulate along the same inter-American and circum-Atlantic networks, defying any sort

of easy linguistic, racial/ethnic, or national category: the natural knowledge of native Andean women is analogized to non-human interactions by a Portuguese national who uses it to translate the German-inspired New Spanish method of amalgamation to the viceroyalty of Peru, making possible and profitable the industrial-scale mining and minting of silver in Potosí and underwriting his own literary career in Italian, Portuguese, and Spanish translation. Whether the English agricultural writer Sir Hugh Platt read the Iberian mineralogical author Enrique Garcés or not, both men drew from the same natural philosophy of antiquity, deep traditions of analogical thinking, and early modern alchemical practice to convert the application of natural knowledge of minerals by or for indigenous or European women into profitable publications and professions.

Agriculture and mining have often formed the root of bipolar readings of English and Spanish colonialisms. Literary critics, for their part, have underscored the faithful cultivation of industrious labor in imaginative enactments of plant husbandry in formative fictions like Milton's *Paradise Lost*. Historians of Latin America, meanwhile, have argued that the region's underdevelopment stems from a colonial concentration on extractive industries like mining rather than a productive sector like agriculture. However, as new work in early American literature and history shows – much of it hemispheric, with a cultural approach to the history of colonial science – it is simply untenable to insist upon the bipolarity of Anglo and Iberian colonialisms or their colonial sciences.[26] Early modern agricultural and mineralogical scientists took their cues from the same fragmentary classical texts, like Empedocles's explanations through hexameter poetry of his elemental root theories and the assemblage of lecture notes on sub- and supralunar phenomenon compiled by students and disseminated under the name of

Aristotle. They drew also from the same medieval commentaries on the disputations of antiquity, like the medical theories of Avicenna (980-1037) and Averröes (1126-1298), and the glosses of Saint Isidore of Seville (d. 636), Saint Albertus Magnus (1193-1280), Roger Bacon (1213-1294), and Ramón Llull (1232?-1316).[27] What is more, the overlapping roots of agricultural and mineral science in the colonial era were not limited to textual modes of transmission. Technologies developed for agricultural processes were transferred to mining operations by illiterate and literate European and indigenous practitioners, as in the case of pre-Inca stone vegetable grinders that were repurposed to crush silver in the arid conditions of the Andes, where large-scale agricultural estates came into being to support the massive population drawn or forced to the mines and refineries of Potosí.[28]

Likewise, metallurgical technologies and mining histories from Spanish America provided some of the practical terms and imaginative roots of English agricultural discourse. Hartlib circle contributors like Gabriel Plattes (ca. 1600-1644), for instance, retold the story of the indigenous miner Diego Gualpa's revelation to the Spaniards in 1545 of the Cerro Rico de Potosí. Plattes invokes the history of "the great Mountaine called Potersee" to encourage agricultural reformers to root out the hidden potential of the English landscape. In Book IV, chapter six, of his *Historia natural y moral de las Indias* (Madrid, 1590) father José de Acosta (1540-1600) contrasts the sterility of the soil of Potosí with the richness of the mineral wealth discovered to the Spaniards by Gualpa, a Chumbivilca from the Jauja valley, the site of the first Spanish capital before it was moved westward to Lima. Plattes draws from Acosta's account to explain to his Anglophone readers how Gualpa climbed to the top of the mountain, "tooke hold of a

young Tree to stay himselfe withal; and thereby plucked it up by the rootes, whereunto there did adheare good Silver Oare." The intertwined roots of mineral discovery and botanical bodies in this retelling of the "discovery" of Potosí orient Plattes's agrarian readers to the potential for *A Discovery of Subterraneal Treasure* in England by showing how their already deep knowledge of soil conditions and native horticultural lines might be applied in a related field. But the passage does something else, too: it suggests the ways in which a mid-sixteenth century example of the mining and metallurgical work of an indigenous agent might be recorded by a late-sixteenth century Jesuit priest like Acosta and circulated well into the seventeenth century by transnational Protestant communities of natural scientists.[29]

Like the story of Enrique Garcés and indigenous Andean women's cosmetic use of cinnabar, and Sir Hugh Platt's recommendation of a similar application of mercury to purify English women's skin, the retelling of Diego Gualpa's discovery by Acosta, and the retelling of Acosta by Plattes, helps to show the porous borders of natural knowledge across time and space, religious profession and ethnic identity, linguistic and national communities. Four years after Plattes's account was published in London, and certainly without the knowledge of this obscure English-language metallurgical treatise, the heirs of Diego Gualpa also recuperated this story of discovery in their petitions to be recognized by the Spanish crown with the inherited privileges of discovery. In 1642, Diego Quispe Usca Guaman and Diego Rodríguez, the husbands of Inés Amanca and María Amanca, both nieces of Diego Gualpa, appealed for and received the rights associated with marriage to a descendant of the mine discoverer. The nieces had proved the legitimacy of their own bloodlines with their own testimony, and corroboration from

witnesses, that they had been raised partly by Gualpa ("criar y alimentar en su cassa"). The privileges associated with discovery were substantial, and they included perpetual freedom from debtor's prison despite whatever debt they might accrue, a permanent government position as *alcalde mayor* (councilmember), *protector de los naturales* (defender of the Indians), or interpreter, exemption from *mita* contributions in commercial and non-commercial forms (taxes and forced labor), and permission to carry a weapon.[30] Diego Gualpa could not have known in 1545 that his story would sound so widely across the Atlantic and throughout the seventeenth-century Americas, but the same story of the revelation of Potosí was enlisted in different ways and for different ends by these two circum-Atlantic communities. In the mid-seventeenth century, both Andean elites and Anglophone agrarian reformers drew from the intertwined genealogical and etymological roots of plant extirpation and mineral discovery to suit their own purposes.

The sanctified rhetoric of cultivation and the embodied practices of agricultural work – often divorced from the realities of slave labor – have long been invoked as the privileged cornerstones of exceptionalist histories that carve from the stories of yeoman farmers the inevitably democratic and capitalistic roots of what became the United States. As Andrea Wulf recently put it after studying the letters and landscapes of the Virginia plantations of George Washington, Thomas Jefferson, and James Madison alongside the Massachusetts farm of John Adams, "it's impossible to understand the making of America without looking at the founding fathers as farmers and gardeners." And while there is much to recommend the study of horticultural practices and metaphors in early American letters, an English-only approach to the field obscures the overlapping languages and technologies of agricultural and mineralogical sciences. For example, the

metallurgical resonances of "founding" – the material technologies of what Jefferson calls "amalgamation with the other color" – figured prominently into his view that "the natural progress" for white and indigenous Americans should be "to intermix, and become one people, Incorporating themselves with us as citizens of the United States." These metallurgical terms of assay informed his model of racial mixture in the new republic as much as agricultural metaphors of cultivation, nativization, and hybridization. Tracing the colonial Iberian scientific antecedents in the political rhetoric of planting, peopling, and possessing in eighteenth-century Anglo America allows for a broader understanding of the transcultural, multilingual origins of early republican Anglophone political discourse. A more integrative understanding of seventeenth-century scientific arts and sciences will, I hope, open up new possibilities for historians and literary scholars of the periods following independence. The language of cultivation remained an important organizing metaphor and material practice for eighteenth- and nineteenth-century Anglophone writers, but the metallurgical terms of amalgamation and incorporation took on a central role in political frameworks and imaginative enactments of racial mixture. That the turn to nationhood and national imaginaries in the United States was accompanied by an incorporation of colonial American scientific vocabularies of agricultural and mineralogical archives has gone largely understudied.[31]

What the comparative study of Anglo and Iberian colonial scientific literatures makes possible is a new interpretation of the widely-studied colonial discourses of planting in the American North and mining in the American South. The story of colonial American settlement is not just that the English planted and the Spanish (and, later, the Portuguese) extracted; this is a history of intellectually sophisticated reformulations of

received theories and technological innovations in agricultural and mineralogical arts and sciences, the types of epistemological advancements and material improvements that provided colonial American practitioners and apologists with the cultural terms of settlement. The material practices and metaphors of planting and refining underwrite the colonial economies of Anglo and Iberian America, performing the cultural work of their respective colonial enterprises and offering to each other models both to imitate and denigrate. Because the tendency for scholars to read English and Spanish colonialisms in what the historian Charles Carroll Gifford calls "bipolar theory" stems in part from a cultural reading of the two foundational practices of settlement, the deeply entrenched idea that the English cultivated a spiritual garden and the Spanish extracted ungodly wealth, it is especially important to revisit the colonial agricultural and mineralogical archives.[32] "Mining Empire, Planting Empire" therefore applies the methods of close reading – taking texts in their original languages to root out the epistemological play of discourse and mine the coloniality of power – to a literary corpus that falls somewhere between history and literary study: technical manuals, epistolary exchanges, and legal documents that I put in dialogue with more familiar texts like imaginative fiction and promotional pamphlets.

In moving from colonial scientific theories of amalgamation and planting to the practices of amalgamated body publics and transplanted colonists, the five remaining chapters in this book aim to speak to and with early Americanists South and North. It is a large and ambitious project that may perhaps be read generously as a contribution to an important body of scholarship emerging in the interstices of history, history of science, and literature, and to the community of scholars who are dedicated to telling the stories of

the colonial Americas.

Chapters two and three focus on the overarching epistemological similarities of English and Spanish colonial scientific discourses, namely their reliance upon the same natural philosophical traditions of analogical thinking. Because early modern universities shared the same curriculum and corporate structure that granted citizenship privileges to foreigners, these centers of learning produced large flows of learned, literate multilinguals who migrated throughout Western Europe, as historians of science like Edward Grant and Ann Blair have shown. Without understanding the received traditions of natural philosophy in early modern agricultural and metallurgical sciences, we cannot appreciate the ways in which the miners and metallurgists of Spanish America reconfigured the science of sameness to develop their revolutionary new benefit of amalgamation. Nor can we understand how this technical method of mixture informed English understandings of the nature of difference. Chapter one therefore situates the production of early modern knowledge within a pan-European framework, and it explains the socioeconomic, political, and cultural contexts that shaped the practices of agricultural and mineralogical sciences in Europe and the Americas as they recuperated principles from the natural philosophy and rehabilitated Roman imperial precedent to suit their own purposes. In English letters, political theories of *res nullis* fused with the natural scientific principle that *natura abhorret a vacuo* to justify agriculturally-informed colonial policies, borne out by the English experience as an agricultural colony of Rome and replicated, in turn, by the English in the New World. Meanwhile, Spanish writers like Acosta and Luis Berrio de Montalvo (1597?-1659) explained how Spain's experience as a source of mineral wealth for the Roman empire prepared it to mine the New World. Like

the translation of empire and civilization, the mining knowledge and technical practices of colonization followed the westward course of the sun. Both English and Spanish colonists naturalized their presence in the Americas, but they employed different natural vocabularies to do so.[33]

Chapter three builds from the general frame of the first chapter to show how English agricultural practitioners and Iberian miners and metallurgists apply the same theoretical principles of correspondence in different ways. While the English uphold the traditional idea that fertility, growth, and increase can only be wrought from the land by combining contradictory elements, writers like the New Spanish physician Juan de Cárdenas (1563-1609) and the priest-metallurgist Álvaro Alonso Barba (1569-1662), resident in Alto Perú for nearly 50 years, transform the foundational similarity or "virtuous friendship" of silver and mercury into a generative relationship whose outcomes are narrated in the intimate terms of desire: "abraçar," "penetrar," "amar" (embrace, penetrate, love). I argue that this scientific reworking of similarity is indebted to the cultural, economic, and demographic conditions of colonial Iberian mining and metallurgy. Miners and metallurgical writers who owned the sites of production, such as Luis Capoche (1546/7?-1613) in Potosí and Berrio y Montalvo in New Spain, studiously avoided this language of affection, while these terms form the core of the accounts of writers who did not have a direct stake in the commercial viability of the mines and refineries.

The fourth and fifth chapters concentrate on questions of similarity and difference regarding the linguistic and cultural gender of colonial scientific discourses and material practices. Chapter four argues for the utility of a multilingual English-Spanish

comparative approach to the study of gender and seventeenth-century science, a debate that has typically been framed in terms of a highly-literary, Anglophone, Baconian model.[34] Because cultural and linguistic gender were collapsed in the gender shift of English, I argue that reading English agricultural authors like Sir Hugh Platt and Gervas Markham (1568-1637), in comparison with writers whose use of obligatory gender in Spanish helps to distinguish linguistic and cultural gender in natural scientific letters, can more fully explain the marking role of gender in seventeenth-century science than the Anglocentric definition of science has generally permitted.[35] Although literary scholars have focused their studies of gender and seventeenth-century science on single-author texts that fall largely within the purview of natural philosophical theory or medicine, I show how a multilingual, comparative approach to collectively-authored texts, like the agricultural treatises circulated by the Hartlib circle, can redefine the terms of seventeenth-century science in a way that more fully accounts for the complex work of gender. The collaborative, gender-inclusive, transnational, and explicitly commercialized modes of practice and production of knowledge advocated in the treatises puts pressure upon some of the longest-held readings of gender and early modern science, but it accords with the commercialized and experiential conventions identified by cultural historians of science.[36]

This shift in genre and gender is completed in the discussion in chapter four of archival cases of women in the Andes whose broad participation in colonial Iberian mining and metallurgy has been understudied. Compounded by the marginalization of colonial Iberian science within histories of science and by the tendency to assume the same conditions of patriarchy and subordination in Anglo and Iberian societies,

indigenous and Iberian women's work in seventeenth-century Alto Perú has been strikingly overlooked by historians and historians of science.[37] In the archives of Sucre, Chuquisaca, Bolivia, and Lima, Perú, I found cases of women who discovered mines, assayed samples, extracted ore, and refined metals using precise combinations of reagents and heat sources. They also combined their technical competencies with organizational skills to manage laborers, negotiate mercury prices from royal suppliers and private distributors, invest in mine-site expansions, and run their own mining companies. Although some feminist historians have suggested that the mechanistic and commercial nature of seventeenth-century science led male scientists to replace real women with a vision of a feminized Nature – a powerfully cohesive argument that my own work is indebted to – my research joins a growing number of scholars like Susan Scott Parrish, Londa Schiebinger, and April Lee Hatfield, all of whom have found that the opposite was true in the colonial Americas.[38] In particular, women's participation in colonial Iberian mining and metallurgy was enabled by legal policies that cared more about protecting mineralogical work than disciplining gender relations.[39] Multivocal legal documents from the colonial Iberian archive, like articles of incorporation, appeals for patronage, and powers of attorney, therefore contain important details about technical practices, labor relationships between indigenous and Iberian practitioners, and accommodations of colonial administrative policies by mining women and men. These details can help us to place Andean women's mining and metallurgical work within the broader context of seventeenth-century science, revealing the depth and richness of a historical archive that takes seriously the technical advances of colonial Iberian science without ignoring the exploitative conditions of mining and metallurgy. For better and worse the Iberian mining

and metallurgical industry capitalized upon the systems of indigenous mineralogical knowledge and practices that had existed in the region before and after the arrival of the Inca empire. Colonial miners and metallurgists repurposed the tailings of traditional *guayra* ovens into the amalgamation method and they replaced Andean overseers with Spanish managers who maintained the Inca system of *mita*, or tribute labor for non-Inca or low-status Inca. Without an established pre-Inca framework and Inca imperial precedent, these technological capacities and labor systems would not have been as readily available nor as conceptually or practically rehabitable.[40]

The sixth chapter analyzes the demographics of Iberian mineralogical science and English agricultural work in more detail. The foundational work of historians like Bernard Bailyn has suggested that, as Patricia Seed puts it, the practices and policies of peopling is a "specifically English colonial desire." Insofar as the study of peopling has been framed in terms of English agricultural metaphors of planting, this reading is supported by the literature.[41] But if we consider the rhetoric and practice of peopling through the language of mining and metallurgy, we can appreciate the institutional religious frameworks and race-based strategies of population management of Iberian America. By reading Manual Gaytan de Torres's 1620 survey of the copper-rich Aroa River Valley, Venezuela, for the ways in which terms like *ley* (mineral weight/religious salvation) and *fundir/fundar* (smelt/settle) express technical concepts and religio-political frameworks, I show how peopling in Spanish America was defined in terms of the soul rather than the exclusive purview of the physical body. For the English, "peopling" meant planting English bodies amid a colonial plot, while for the Spanish, to people a region was to incorporate souls into the church – white, black, or copper-red bodies counted as

“almas” in census records. This broadly spiritual platform enabled marginalized groups, like the copper mining slaves of eastern Cuba, to argue against the crown’s strategies of population management, as archival documents show. The seventeenth-century Spanish crown had successfully moved African and European men and women in various degrees of freedom and unfreedom throughout the empire, importing Canary families to whiten Cuba, exporting “seditious” African slaves to Mexico and Peru, and enticing German metallurgists from Michoacán to relocate to El Cobre, Cuba. But the royal slaves resisted the crown’s order and argued that their relationship to the *Virgen de la Caridad del Cobre* rooted them to the easternmost copper regions.[42]

In the colonial period, Cuba and Venezuela represented the most important sites of copper excavation and refining. In our own day, the centrality of copper mining and metallurgy in the Caribbean basin is easy to forget, given the dominance of Chilean copper mining in the global industry. The copper mines that now belong to Chile were once divided among the independent republics of Chile, Peru, and Bolivia. It was only in the aftermath of the late-nineteenth century War of the Pacific and a remapping of the region in 1928 by Herbert Hoover, mining engineer, accomplished translator of colonial mineralogica, and president elect of the United States, that the copper depoits of Tarapacá and the Atacama desert fell under Chilean jurisdiction. Hoover’s assessment of the capabilities of Bolivian mining sciences in particular, relative to those of the British-supported Chilean industry, led him to assign the mineral-rich copper regions of the disputed territories to Chile.

From 2004-2005, I taught in one of the mines that used to belong to Bolivia, a now landlocked country that has become one of the poorest in South America. The

consequences of marginalizing colonial Iberian science, for the nearly 10 million people who live in Bolivia today, and its exodus of migrants, are real. I have no illusions about the impact of my work, and I know that no single scholarly monograph can correct for a deep legacy of political corruption and economic exploitation, waged most recently by Bolivians against other Bolivians. However, I do believe that I have an opportunity and a responsibility, or what former Chilean president and current director of U.N. Women Michelle Bachelet calls "responsibility with epic and beautiful and noble tasks," to tell the story with nuance and depth. I hope that this book might be a small but important contribution to the collective effort of scholars and storytellers of the colonial Americas.

Like by Like, Like by Unlike: The Nature of Difference and the Science of Similarity

Between 1568 and 1570, waves of Iberian miners and metallurgists like the Portuguese national Enrique Garcés traveled from the viceroyalty of Lima to the central Mexican mining town of Pachuca, some 100 kilometers north of Mexico City, where African, indigenous, and European practitioners were developing a new method of amalgamating silver with mercury. In turn, Mexican miners like Pedro de Contreras accompanied them on their returns to Peru to help adapt the new metallurgical technology to the environmental conditions and silver mineralogies of South America. When Pedro Fernández de Velasco, one such intracolonial mining specialist, arrived in Peru from New Spain in 1572 and revealed the newly developed amalgamation method to local government officials, the viceroy don Francisco de Toledo was said to have pronounced the union of silver and mercury "el casamiento de más importancia del mundo entre el çerro de Potosí y el de Guancavélica." As recorded by the historian Fernando Montesinos (1593-1655), the celebration of this fruitful union of the high-mountain mines of silver (Potosí) and mercury (Huancavélica) as "most important marriage in the world" underscores the central role of mining and metallurgy in colonial life in Spanish America and in the global ambitions of imperial Spain.[43]

The history of mining and metallurgy in colonial Latin America is precisely this marriage of natural resources with natural knowledges – the raw materials of silver and mercury and the knowledge of how to combine them for human benefit. Much of the popular imagination was captivated by the former, the legendary deposits of silver in

what Potosí governor Juan Manrique de Lara (1764-1815) called "un Pueblo levantado tumltuariamente por la codicia al pie de la riqueza que descubrió una casualidad" (a town raised in tumult by jealousy at the foot of wealth discovered by accident). But it was the large-scale infrastructure and engineering projects, and the development of an industrial-scale metallurgical technology, that made possible the large flows of American silver to the eastern markets of China and Japan by way of Spanish ships.[44] This *nuevo beneficio* (the new benefit) or *beneficio del azogue* (the benefit of mercury) was a ten-step process that used chemically-related mercury as a reagent to bring finely-ground silver particles into body. Earlier refining methods included washing with solutions and smelting, either in European-style furnaces (*hornos castellanos*) or, in the Andes, holed *guayra* ovens. Because the ovens were placed on mountain tops, air would flow through the holes and simulate the effect of a bellows, taking full advantage of the contrasting air temperatures of daytime and nighttime currents. The costs of firewood and charcoal far outweighed the value of the refined metal for all but the highest-grade silver, while the washing solutions could only be used on native silver. But unlike these treatments for unmixed silver (the variety with the highest mineral weight or *ley*), the New Spanish method of amalgamation could be used on every mineralogical variety of silver, and it could be applied equally on lodes and ores.

This new metallurgical technology was especially instrumental in revitalizing the silver industry of Potosí. Within thirty years following the revelation of Potosí to the Spaniards by the Chumbivilca miner Diego Hualpa, the high-grade deposits found closest to the surface had been exhausted. In the 1570s, Potosí-based miners from northern, eastern, and southern Europe, in conjunction with indigenous and African miners and

metallurgists, began to experiment with the New Spanish method of amalgamation that would revive ("reviver") the region. Refiners in the Andes first applied the New Spanish technology to the top-level deposits that were mixed with iron and lead, called *ppacos* and *oques* in Quechua, or "reddish" and "friarish," after the gray-robed Franciscans. But what made colonial silver the true "gift of God," or what Álvaro Alonso Barba, among many likeminded miners and metallurgists, identified as "divine providence" was not only the "abundance of every sort of metals" and "the fertility of the most copious veins," so much as the technology of amalgamation and the responsibility to apply the knowledge rightly. With this new method, refiners could extract large quantities of silver from the mineral varieties that had been "resistant" to heat: the mixtures of copper and sulfur, called, in the racialized language of colonial Iberian mining and metallurgy, *metales mulatos* (mulattos) and *negrillos* (little black ones).[45] Because *negrillos* were among the most common silver mineralogies in the Americas, the new method of amalgamation made it possible to treat every composition on a commercially-viable, industrial-size scale. The science of amalgamation took the received theories of natural philosophy, namely the elemental theories of Empedocles and the analogical thinking of Aristotle, and reworked them into a productively generative industrial-scale metallurgical technology that underwrote the very founding of colonial life: the administrative centers and port cities that regulated the flow of miners and mineral wealth to the interior mining regions, and the large-scale agricultural estates and religious communities galvanized to offer their material and spiritual sustenance.

Analogy, then, was a way to make sense of the natural and built world – a way for natural philosophers, scientific practitioners, government officials, and imaginative

writers alike to explain, oversee, and explore the possibilities of the study of nature and its application for the improvement of human life. In the seventeenth century, analogy was the preeminent conceptual framework and discursive formation of lettered men and women. The natural philosophical underpinnings of early modern university curriculum ensured that the men who would go on to practice different professions as physicians, lawyers, priests, and tutors would share some of the same theoretical bases for their work. The corporate structure of the university, meanwhile, ensured that these theories were shared by universities whose Western European host countries, Italy, Spain, France, Germany, Austria, the Netherlands, and England, were organized by richly diverse cultural norms, economic relations, political principles, and religious practices all expressed in different languages. Against these substantial differences, then, early modern science and its place in the Western European university – inherited as it was through the texts of antiquity that coursed through medieval Islamic centers of learning – helped to bring continuity and coherence to these different geolinguistic cultural traditions. Natural science was, as the historian Joyce Chaplin has argued in the case of the English, "the foundation of colonization that cut across the differences among the many ventures that disparate English people put together in different parts of the new world."[46] But as historians of Iberian science like Jorge Cañizares Esguerra and Antonio Barrera Osorio have shown, the same can be said for Spanish and Portuguese settlements in Africa, Asia, and the Americas. The flows of the natural philosophy performed the work of analogy throughout the Old and New Worlds: it created relationships of similarity where there was also difference.

These terms of similarity and difference are the traditional frames of comparative

American history and literary history. When they have been compared at all, English and Spanish settlements in the Americas were typically read by historians and literary scholars as yet another manifestation of difference: Protestant and Catholic, North and South, proto-capitalist and feudal.[47] But as more recent hemispheric studies of the politics, legal policies, and literatures of the Americas have demonstrated, the historical record does not always support this oppositional thinking.[48] The content and structure of seventeenth-century science and its analogical traditions, the subject of this chapter, provide another example of the powerful pull of similarity in the history and literary history of the colonial Americas. In the first part of this chapter, I situate early modern science in a multilingual, pan-European framework that informs English and Spanish scientific letters and, in its analogical traditions, social applications of the scientific ideas of similarity and difference.

The most important application of these principles emerges in early modern friendship theories that prescribe codes of interpersonal relationships and political alliances based at times on the virtues of sameness, alternately called "friendship," "analogy," or "sympathy," and at other times on the values of difference, glossed most commonly as "enmity," "contrariety," or "antipathy." Although they drew from the same early modern theories of friendship and natural philosophy, English agricultural writers and Spanish mineralogical writers employed these analogical traditions in different ways. The comparative framework of both similarity and difference allows us to identify those moments in which colonial scientific discourses overlap and diverge.

The second and third parts of the chapter are dedicated to the ways in which English and Spanish writers engage with these scientific ideas of sameness and

difference, wherein science is part of a larger, complex cultural context. Without understanding the relationship of agricultural and mineralogical theories and practices to the received systems of natural philosophy, and understanding the English and the Spanish in relationship to each other, we cannot fully appreciate the epistemological sophistication of the Spanish American method of amalgamation or the complex rhetorical moves performed by the English to appropriate the language of amalgamation and separate the term from its origins in Iberian innovation.

But why compare English books of agriculture with Spanish books of mining in the first place? Agriculture and mining are key nodes of seventeenth-century scientific improvement and foundational acts of settlement that perform the cultural work of the empires in whose service they are enlisted. Without agriculture, there is no food to sustain a population, and without mining or metallurgy, there are no farming tools.[49] But beyond – and below – this material reality, there is the cultural work of the matter of husbandry, namely the richly symbolic appeals to visions of Edenic recovery and professions of Adamic cultivation, and the cultural work of mining and metallurgy, primarily the ideals of spiritual purity and vocabulary of mixture that were applied in sweeping biopolitical moves to human and mineral bodies alike. The terms of planting and refining – sowing and setting, mixing and purifying – are not just the natural vocabularies of colonial agricultural and mineralogical science. They are also the key terms through which Anglo and Iberian settlements were naturalized in the Americas.

The tendency to frame English and Spanish colonialisms in what the historian Charles Carroll Gifford calls "bipolar theory"[50] stems from a cultural reading of these two foundational practices and scientific nodes. Historians and literary critics like J. Martin

Evans and Jill Cassid, taking their cues from the language of the colonial archive, have aligned the material practices of agriculture with the planting of English settlements in the Atlantic world, while the material work of mining and metallurgy has been ascribed to Iberian America, and, in the seventeenth century, to Spanish America in particular.[51] The development of gold mining in the interior regions of Brasil would extend this ascription to Portuguese America in the eighteenth century.[52] This should not suggest that the English were ignorant of mining and metallurgy, or that the Spanish did not develop crucial agricultural scientific competencies; to the contrary, some economic historians have argued that it was the Spanish sheep industry that enabled its colonization of the New World, and that it was the development of mining and metallurgy in England that enabled that country's industrial rise. Certainly, the industrial mining and minting of silver in Spanish America would not have been possible without large-scale agricultural estates to supply food to the people who migrated to the Andean and central Mexican highlands, just as British adventurers would not have so eagerly issued into South America, North America, and Greenland without the search for precious metals inspired by Iberain precedent. As the foundational sciences of colonial American settlement, agriculture and mining played crucial and crucially overlapping roles in Iberian and Anglo America.[53]

But neither agriculture in Spanish America nor mining and metallurgy in British America carried the cultural weight of their colonial complements, Iberian-American mining and Anglo-American planting. On the conflation of the material and cultural work of colonial Iberian mining, historian Peter J. Bakewell makes what he calls the "crudely psychoanalytical" observation that "the Iberians' success in mining in America and the

unparalleled miscegenation that they set in motion in the sixteenth century have common origins in aggressive Iberian colonizing energy combined with America's relative geographical, political, and biological openness compared with most of the non-European world."[54] In other words, the very matter of mining and metallurgy – unearthing and mixing, purifying and refining, amalgamating and incorporating – helps to texture the reproductive labor of colonial Iberian settlement. Meanwhile, as scholars who rightly read Milton's Eden in terms of England's colonial designs, the metaphor and practice of planting – preparing the earth, sowing the seed, and rooting out the productive value of transplanted seeds in native soils – performs the cultural work of seventeenth-century Anglo Atlantic colonization.

Seventeenth-century English agricultural books and Iberian mineralogical scientific texts, then, are at once the foundational material practices and authorizing discourses of settlement in the Americas. Both the English and the Spanish naturalized their colonial enterprises by describing their presence in richly symbolic language and imagery of agricultural work and nodes of botanical flows or, in the case of the Spanish, to the technical and political language of *casta* classifications, purifying treatments, and technologies of incorporation for mineral bodies and amalgamated body politics. The same rhetorical strategies – namely, their invocation of natural vocabularies to explain and justify their presence in the New World – are represented differently because seventeenth-century English and Spanish writers draw from the different archives of agricultural and mineralogical sciences. This comparative framework allows us to appreciate the points of rupture and continuity, the broad similarities and the telling differences, between the two largest empires of the seventeenth-century Americas.

I. Different, But the Same: Analogical Thinking in Seventeenth-Century Science and Society

I take the terms of similarity and difference from the scholarly historiography of American history and literary history and also from the primary texts themselves. In the seventeenth-century Americas, similarity and difference were at once scientific principles informed by the elemental theories and analogical thinking of natural philosophy and social categories that shaped early modern understandings of relationships between animate beings – peoples, plants, and minerals alike. Like their peers in Europe, writers of colonial scientific literatures and histories mapped human traits and emotions onto metals and mines, and soils and seeds. These cosmological bodies also provided ways to analogize human bodies and behaviors to agricultural and mineralogical processes. Seeds planted in rich, happy fields or those sadly "worn out of heart" were described as "children," while minerals were classified in color-based "casta" systems and named accordingly as *metales mulatos* or *negrillos*.[55] Colonial scientific writers likened the preparatory work of plowing and the processes of mineral purification to religious paradigms of salvation and incorporation in the church universal, as the colonial scientific frameworks of planting and possessing, mining and amalgamating, provided the root paradigms and religioscientific terms through which Anglo and Iberian colonists explained, justified, and quite literally naturalized their work. Because English books of agricultural science and Spanish books of metallurgical science emerge from the same natural philosophical tradition and perform similar work in the service of empire, these colonial scientific corpora share enough substantial similarities to helpfully illustrate their differences.

The lettered conventions of early modern natural philosophy emerge from and are

produced by universities that, like the sites of colonial American science were also multilingual, transnational spaces of received knowledges. In the silver mines and refineries of the Andes and the central Mexican highlands, and the copper pits and foundries of eastern Cuba and northwest Venezuela, in the drained marshlands of Narrangaset Bay and the irrigated rice plains of the South Carolina low country, the gardens husbanded with non-native species and the native plants adapted to plantation economies of scale in the extended Caribbean, multilingual communities speaking any number of African, indigenous American, and European languages collaborated and competed to develop new technologies that would allow them to deliver new products in large scale to newly interconnected global marketplaces.

In the Old World, science had long brought people from diverse linguistic and cultural traditions into contact, if not on the scale of colonial scientific enterprises. The transnational nature of the early modern Western European university was indebted to what the historian Edward Grant calls the corporate structure of the medieval-era institution, a structure indebted both to classical antiquity and to the practical orientation of professional artisans and commercial merchants. According to Grant, as medieval sites of learning developed into universities, they began to attract teachers and students throughout Western Europe. Following the precedent of artisan and merchant guilds, these itinerant men incorporated into a university so that the foreigners could access the same privileges available to the citizens of the town or city. By the sixteenth century, some 64 universities were actively instructing students and drawing faculty across a region that spanned from Poland in the east to Portugal in the west, from Sweden in the north to Sicily in the South such that "in any given year from approximately 1250 to

1550, we may rightly assume that thousands of students matriculated at these universities." These thousand folds of students held diverse religious convictions and faith relationships, felt at home in different languages, and lived their lives with all of the rich textures of individual experience, but they had shared formative years of rigorous education steeped in the natural philosophy. That shared intellectual inheritance came to form what Grant calls "a worldview shaped by Aristotelian natural philosophy, a worldview they carried with them wherever their careers took them." This new way of seeing the world – a world that was itself expanding into hemispheres unknown to earlier generations of Europeans – represented a new social and scientific phenomenon: "For the first time in history, a large number of scholars with similar training in natural philosophy, and therefore with a reasonable level of contemporary scientific knowledge, were absorbed into the broader reaches of European society."[56]

Upon graduation, these students acquired a *licencia ubique docendi*, the right to teach at any other university in Europe. This policy that produced large, transnational flows of learned, literate, multilinguals throughout the continent. Before ever arriving in the Americas, as many of these students would in their professional capacities as administrators, lawyers, priests and physicians who botanized and refined with interest, science had already proved itself a powerful mode of bringing people into linguistic and cultural contact.[57]

The corporate framework of the university provided the institutional stability to host, sponsor and receive these highly mobile communities of students and teachers, and it ensured a degree of transnational coherence in matters of pedagogy and curriculum, allowing, as Grant concludes, for "the teaching of natural history to develop as the basis

of all university learning in the four faculties that comprised a major university, namely, arts, theology, medicine, and law" (146). The structure of the university, and its shared curricula in the natural philosophy, is why Spanish professors like Juan de Celaya (1490-1558) and Luis Coronel (d. 1531) could be found using the methods of fourteenth-century Oxford University instructors as they led their own students through the natural history curriculum in Parisian universities.[58] These epistemological borrowings evidence the transnational, multilingual institutional orientation of the early modern university, a framework that existed long before the study of nature would be applied in the service of Anglo and Iberian empires in the Americas. That those empires continued to borrow from and bear upon each other in their social, political, and biocultural practices and policies underscores the relevance of a comparative approach to colonial science.[59]

The content of the natural philosophy program was just as transnational and multilingual as the institutional structure in which it was taught. The curriculum consisted largely of Aristotelian texts that had been translated into Latin by Christians who found them in Greek treatises contained within Arabic manuscripts. Every teacher knows that the presence of a text on a syllabus says nothing about the way that book will be taught or what elements will be underscored in any given term. With texts that were assembled over the course of one thousand years and through multiple cultural and linguistic translations, and banned texts whose content circulated nevertheless by way of lectures, it is especially difficult to speak with confidence about a singular hegemonic tradition. And yet for all of the variations in the Western European university curricula, some patterns do emerge in subject matter and methods of instruction. According to Grant, the Aristotelian texts that formed the basis of the natural philosophy curriculum were studied

in one of two main ways: with a master lecturer reading a passage and glossing its complexities, either in speech or in writing, or by reading the passage and then offering a commentary, either his own or one of a handful of earlier readers like St. Thomas Aquinas. Other standard pedagogical practices included summarizing the entire work, paraphrasing a portion of a treatise, or selecting a portion to dispute as a discrete question or objection (*questione*). Although most of the Spanish and English metallurgical and agricultural scientists studied in this chapter would not have had Aristotelian texts or commentaries on hand as they wrote, they would have been familiar with the structure of Aristotelian natural philosophy, particularly Thomist Aristotelianism, and its method of disputation. The question-based approach acted as a kind of insurance for the whole of the theory; by encouraging disputation on particular points, what the historian Ann Blair calls the "doctrinal flexibility" of the Aristotelian tradition protected itself against wholesale rejection. The structure of the Aristotelian curriculum in natural philosophy and the corporate structure of the medieval university helped, then, to ensure a remarkable degree of coherence among diverse sites of learning throughout Western Europe.[60]

The multivocal ways in which readers engaged with Aristotelian philosophy – through the translation, glosses, and marginalia of years of commentators – both destabilized and stabilized the texts. In their transmission and translation, their copying and recreation over immense spans of time and space, the stability of the written word was undercut and the idea of single authorship of a scientific work, never really a concern to early modern readers, was impossible to ensure. Renaissance science, even in its abstract and highly literary forms, to say nothing, yet, of the experiential trials and

practical applications of these received theories, was always collaborative and communal. But these factors also ensured the important place of Aristotelian natural philosophical texts in university curriculum: they became, as the historian of science Scott Montgomery puts it, "a classroom assembly rather than a textbook." As Montgomery goes on to argue, the common curriculum and approaches to these materials united students and professors across the vastly different cultural landscapes Western Europe and for a seemingly unimaginable span of four hundred years. The movement of scientific texts through time and space, at once a conservation of established ideas and an accommodation of received theories to new epistemic sites, allows for historians of scientific writing like Montgomery to conclude that "viewed from the perspective of translation, and from the physical realities of writing and study, the twelfth to the sixteenth centuries appear as a single extended epoch." Montgomery explains, in a passage worth quoting at length, that the multilingual, transnational modes of engagement with Aristotelian natural philosophy produced both similiarities and differences in early modern scientific literacies:

> No doubt this is too large an era for modern historians to consider all at once, in any unified sense. Yet it clearly was a time of particular linguistic focus, during which Europe created, recreated, and transformed a dozen textual traditions by taking into its fold the achievements of the Arabs, Jews, Greeks, Romans, and – secondhand – the Indians, Persians, and Syriac-speaking Nestorians and Monophysites as well. Through the powers of translation – and the adaptions and transformations that came in its wake – the scholars, students, universities, court societies, and book publishers of late medieval and Renaissance Europe forged a series of intellectual communities centered on specific groups of texts, whose

ultimate source materials were hugely diverse, indeed unmatched in this regard. The material realities of the texts, their compilation, recompilation, and translation through the diverse linguistic geographies of the Old World through the sixteenth century, produced a kind of early modern science that informed and was transformed by the colonial science of the New World in the seventeenth century. English agricultural writers and Spanish mineralogical authors, like their colleagues throughout Europe, drew from these text-based traditions and they translated the inherited patterns of analogical thinking to new problems and secrets in the Indies.[61]

Although Aristotelian natural philosophy represented the major intellectual paradigm of antiquity recuperated in Renaissance science, most of the classical theories on generation and decay did not originate with Aristotle. Instead, it is the Greek philosopher Empedocles, one of the many pre-Socratics to articulate an idea that was given paradigmatic coherence by Aristotle, wherein we understand a scientific paradigm in Thomas Kuhn's famous definition as "a model from which springs particular coherent traditions of scientific research." The fragmentary hexameter verse of Empedocles forms the basis of the powerful legacy of analogical thinking rehabilitated in Renaissance science, and Empedoclean root theories in particular are foundational material and epistemological elements of the traditions ascribed to Aristotle. Understanding the place of similarity and difference in the natural philosophy of antiquity will allow us to appreciate the ways in which seventeenth-century writers both conserved and reformulated the scientific and social principles of sameness and contrariety.[62]

When Empedocles (ca. 495-435 BCE) observed that the forces of Love and Strife motivated almost every human action and informed nearly all of our behaviors, he

formulated a set of micro- and macrocosmic analogies to suggest that these same forces governed the world entire. The animate plants, animals, minerals, and oceans of the sublunar realm and the stars, planets, and constellations of the heavens, were not only composed of the same four primary elements, albeit in different proportions of water, earth, air, and fire, but they also followed the same rules of push and pull of like and unlike bodies, the creation and destruction of matter that, too, was characterized by one of four natures, hot, cold, wet, and dry. This analogical thinking informs the theories of generation and decay in the cosmological order of soils, seeds and minerals, as outlined in the writings of later natural philosophers like Aristotle, Saint Albert Magnus (ca. 1200-1280), Saint Thomas Aquinas (1225-1274) and Tomasso Campanella (1568-1639), as well as the theories of union and separation in the human order of friendship and enmity, as described in the theories of friendship articulated by Cicero (106-43 BCE) and Michel de Montaigne (1553-1592), discussed in chapter two. Under the auspices of Love, two unlike or contrary elements were drawn together in a generative union that would be ultimately undone by Strife, a divisive force that would tear the opposite pairs apart and send each element to take comfort in its own likeness. Love, therefore, was responsible for the attraction of like to unlike, while Strife precipitated the conflict that would make like attract like. In the cyclical flows of the two opposite forces, a delicate kind of cosmic equilibrium was created: the contrariety of Love and Strike balanced each other to ensure the continuation of life, a process of generation and coming together complemented and completed by the ensuing separation or tearing asunder.

Medical writers like Hippocrates (ca. 450-380 BCE), Galen (ca. 130-200 BCE), and Dioscorides (ca. 40 BCE – 90 AD) translated this idea of balance back into human

terms by aligning the properties of cold, wet, dry and hot with the humors of the body (black bile, phlegm, blood, yellow bile) and, then, to the particular dispositions of individuals (melancholic, phlegmatic, sanguine, choleric). A person with a "cold" disposition, for instance, was therefore determined to have an excess of black bile and was diagnosed as melancholic; the restoration of health was achieved by rebalancing the humors into a tempered state. These temperaments were believed to share affinity with the stages of life, seasons of the year, and planets in the skies such that a friendly union connected human bodies and behaviors to larger patterns of nature in the sublunar realm and the heavens alike, ultimately disclosing what Harold J. Cook calls "one's inner nature to the outward world."[63]

By the late-seventeenth century, these transnational threads of natural philosophy were applied in explicitly nationalist models of correspondence, reflecting important changes both in the position of the natural philosophy within scientific thought and the position of the idea of a nation as a people within a complex global landscape. Joseph Blagrave (1610-1682) provides one such example in his *Ephemeris* (London, 1659), in which he analogizes the cold, dry properties of the element of mercury to the astrological influence of the planet Mercury. This planet was said to rule in the sign of Gemini, so Geminis, Blagrave argues, are a "prattling and deceitful" bunch, a "busy, unsettled sectary" that he ascribes, on the eve of the Restoration, to two particular and particularly Protestant groups: "I believe the Scot and Hollander is much concerned therein."[64]

This turn to Scots and Hollanders represents a departure from earlier English books of agriculture, some of which had argued that foreign ideas, practices, and species could improve English agriculture, and some of which argued for an English-only

approach to husbandry. Hartlib circle correspondents like Dr. Robert Child and Dr. Arnold Boate debated these questions with especial vigor. Child argued for the universal applicability of good husbandry, supposing "that whatsoever plants thrive in one hot Countrey, they will also thrive in another." Because natural differences like climate or soil conditions were less influential in determining the success of a planterly enterprise, Child suggested that a successful practice in one region should, given similar enough environmental conditions and human capacities, deliver the same positive outcome in another region. Likewise, poor knowledge and bad husbandry or dairying would also determine the results of one's planting or cheesemaking more than the plants or cheeses proper. The different qualities and rates of cheese production in England and Holland have less to do with the different climates and food webs of their respective ecologies, Child insisted, and more do with "the good skill and clean handling of the Dairy Maid … for that good or bad Houswifery maketh or marreth Cheese is very well known."

But not all Hartlib circle contributors afforded such a large role to human agency in the still-mysterious matter of agricultural production. Other contributors, like Dr. Arnold Boate, insisted that natural conditions like access to sunlight, precipation, wind patterns, and soil composition were ultimately more influential than human industry in shaping foodways productions. Successful returns on one's agricultural labor depended largely upon mastery of highly localized natural knowledge and an especial ability to match agricultural practices to local particulars. "Art and Industry," Boate argued, are not enough to flatten the particular environmental conditions and local customs that give agricultural products region-specific tastes, flavors, and textures. Child had suggested that by modeling the best practices of Italian and Dutch cheesemakers, English dairy

farmers could produce parmesans and goudas to rival the finest cheeses of their Southern and Northern European rivals. But Boate could not support this universalist orientation toward natural knowledge and absolute faith in English agricultural practices. For, he argued, no amount of human intervention can erase the fact that "there is something in the particular nature of different waters and different soils, and of the food for Cattel thereon growing."[65]

The Hartlib circle debate over nature and nurture, or the extent to which human hands could intervene with right knowledge and best practices to improve foodways production, represented an important question in seventeenth-century agricultural letters. It showed the ways in which agricultural practitioners tried to reconcile competing ideas of universality, at once an earlier model of Adamic natural knowledge and shared brotherhood, and emerging ideas of national body publics. What were the limits of national knowledge of nature in an era of colonial planting and foreign plantations?

Joseph Blagrave's astrological reading, at once newly nationalistic, also represents an important point of continuity with the natural philosophy of antiquity. That is, Blagrave uses correspondence theory or analogical thinking to connect the element of mercury (Hg), the planet Mercury, and the cosmological mutability of Gemini with the politically and religiously mercurial Scots and Dutch. He draws from the same intellectual commonplaces to suggest, for instance, that planetary bodies determine the dispositions, physiques, and professions of the women and men in whom they find cosmic sympathy. The conceptual and discursive structures of analogical thinking lead Blagrave to identify the rule of the planet Saturn with "such which are addicted unto Husbandry" and "such which till, mine, or delve in or upon the grounds" (12v). Whether

miner or husbandman, these Saturnine practitioners will share the same type of physical body: "a middle stature, of a swarthy or palish complexion, thick lips and nose, little beard, thick of broad shoulders, sometimes crump shoulders, sad brown hair" (12v). A human being's physical body registered the cosmic sympathy between one's occupation and outlook. The introduction of nationally-specific traits in Blagrave's *Ephemeris* hints at the limits of analogy, but on almost every other matter – profession, personality, physicality – correspondence theory and analogical thinking still provided a way of understanding one's relationship to the world in the late-seventeenth century.

Although analogy has been dismissed as a "poverty-stricken" form of knowledge by Michel Foucault, new work in cognitive science has helped to show that abstract analogical processing represents a specific cognitive ability virtually unique to humans. Analogy enables us to identify a relationship of sameness between sets of dissimilar objects. Cognitive scientists Dedre Gender, Keith J. Holyoak, and Boicho N. Kokinov provide the following example. When human beings (and specially-trained chimpanzees) are presented with three sets of shapes, like a pair of triangles, a pair of circles, and a set with one triangle and one circle, humans will see analogical correspondence between the first two groups. Although there is no similarity of shape between a triangle and a circle, we understand that two triangles share the same relationship to each other as the two circles. In fact, it is precisely the difference between triangle and circle that makes possible the analogical connection between the two images. Analogical thinking, then, defines similarity and difference according to the nuances of context: what is at once like can also be made unlike.[66]

These terms of likeness and unlikeness are the key scientific principles and

cultural terms of colonial science. They circulated through the newly recuperated texts like Diogenes Laertius's *Lives*, "made English by several hands" in 1688, and the letters of early moderns like Erasmus (d. 1536), who wrote the introduction to Georgius Agricola's *Bermannus* (Basel, 1530), the precursor to his renowned and widely-read *De re metallica* (Basel, 1553). In their rehabilitated forms, the terms of classical similarity and difference informed the humoral theories used to read the physical and human natures of America and American Indians.[67] Their fixedly fluid frameworks – fixed because of their established place in the natural philosophy, and fluid because their habits of analogical thinking, by definition, create networks of similarity from nodes of difference – are the crucial foundations of agricultural and mineralogical sciences in the Americas. The flexibility afforded by Aristotelian natural philosophy enabled English agricultural authors to uphold the traditional idea that growth and creation resulted only from the union of opposite forces. The same platforms of like and unlike allowed Spanish metallurgical writers to reshape the relationship between similar bodies into a generative and productive outcome. These ideas of similarity and contrariety, likeness and unlikeness, were commonplaces that were accommodated differently within and between colonial American scientific literatures.

For Aristotle the the fundamental problem of correspondence theory in which its deep traditions of analogical thinking were grounded was the linguistic gap between "equality," or sameness, and "correspondence," or significance. Because of the fluid borders of analogy, the same word or idea could carry different meanings in different contexts: "'correspondence,' though it means equality in the *quantum*, means similarity in a *quale*." In other words, it was unclear whether things were really different, or whether

they were just organized by a language that suggested difference, for "every term which possesses a variety of meanings includes those various meanings, *either* owing to a mere coincidence of language, *or* owing to a real order of derivation in the different things to which it is applied."[68]

This critique of natural scientific language was reinforced by Francis Bacon (1561-1626) in the *Novum Organum*. Alongside his well-studied anatomy of the "idols" or human impediments to human understanding – individual tendencies to generalize from limited particulars (Idols of the Tribe), collective patterns of misreading (Idols of the Cave), and fantasies inspired by imaginative arts (Idols of the Theater) – Bacon identifies the Idols of the Marketplace, or the uneasy and unreliable "alliances of words and names" as "the most troublesome of all." The inadequacies of language to properly express even the most rightly-observed phenomena are revealed for Bacon in two primary ways. Firstly, language deceives the understanding by making available a range of things that do not exist or those "which do exist but are muddled, ill-defined, and rashly and roughly abstracted from the facts" like the concepts of "fortune, first mover, planetary orbs, the element of fire, and fictions of that kind whose origins lie in vain and deceitful theories." The problem of language in this first set is resolved easily enough with proper correction "by making the same obsolete."[69]

The more insidious second set, that "which springs from wrong-headed and ignorant abstraction," proves more "convoluted" and deeply rooted. Bacon's example of this second class is, not without coincidence, "moistness," or the same humid principle and root associated with the climatic theories used to explain the degeneracy of the New World. The word "moist," Bacon writes, is applied to such a range of applications that it

is practically devoid of meaning: "For it signifies what easily spreads round another body; what in itself lacks firm boundaries and cannot stay stable; what easily gives way everywhere; what easily divides and disperses itself; what easily concentrates and collects itself; what easily flows and sets in motion; what easily sticks to another body and wets it; and what is easily reduced to liquid or is melted when it was consistent before." As all of these properties are signified by and contained within the same word, the scientist cannot possibly describe the role of humidity with any stability or consistency of meaning: "Thus when you come to predicating or imposing this term, if you take it in one way flame is moist, if in another air is not; if in another fine powder is moist, in another, glass; so that it easily appears that this notion has been rashly abstracted without any due verification only from water and common, everyday liquors." As goes the theory or what the word "signifies," so too its practice or "predication or imposition," such that the word and concept of "humidity," for Bacon, means very little; it cannot hold up to the trials of experience or "any due verification."[70]

If Bacon found the language of elemental theory and the natural philosophical traditions of analogical thinking to be frustratingly imprecise, agricultural and mineralogical writers found them to be conveniently flexible. Both English agricultural writers and Spanish mineralogical writers employed the terms of Empedoclean root theory and Aristotelian natural philosophy to explain the processes of generation and decay in the natural world. In the English discourse of colonial planting, the received systems of antiquity correctly described the ways to increase natural fertility, occasion agricultural growth, and reap the profits thereof. According to the natural philosophy, and English agricultural letters, the way to wealth in the agricultural order was in the

successful manufacture of difference: the introduction of cold seeds to hot soils, for instance, or the fertilization of moist earth with dry chalk. But as Spanish American treatises on the new benefit of amalgamation suggested, the inherited traditions of the natural philosophy did not get the borders of sameness and difference quite right. Received theories that assigned generative capacities only to contrary forces, for example, could not account for the successful results of the miners, metallurgists, and merchants who collaborated and competed to develop a new way of treating silver with chemically-similar mercury. Silver and quicksilver (*azogue*) should have been too similar to generate new matter or cause it to change shape, but the results of the mid-sixteenth century experiments in New Spain were clear, and the late-seventeenth century modifications for Alto Perú confirmed the effectiveness of the technology. Demographically and economically mixed teams of indigenous, African, and European experts, investors, and unskilled laborers working in various degrees of freedom and unfreedom reconfigured the natural philosophical paradigms of sameness and difference to develop a revolutionary new method of large-scale and commercially-viable amalgamation.

The next two sections of this chapter explain more fully the scientific understandings of similarity and difference in English and Spanish letters, while chapter two examines the social conditions in which these colonial scientific discourses developed and were deployed – the demographics, economics, and religiopolitics of colonial planting and amalgamating.

II. "a soil that will stand in constant opposition:" Productive Difference in English Agriculture[71]

English agricultural writers largely upheld the traditional dictates of analogical

thinking and recommended that husbandmen pit contrary or unlike force against each other to fertilize soils and encourage plant and cereal growth. They also used a deeply affective language to categorize these oppositional relationships in the intimate terms of human emotion and behavior – terms of preference and particularity, love and desire, hatred and disgust. This affective language reveals a way of understanding non-human interactions in essential human terms, as when Dr. Robert Child (1613-1654), in a letter published by the Polish émigré and Puritan reformer Samuel Hartlib (1600?-1652), bemoans that a plot of infertile land is "too much out of heart." Or, as the Presbyterian minister John Flavell (1630?-1691) glosses the semasiological union of human hearts and husbanded fields, "It is best ploughing when the earth is prepared, and mollified by the showers of the rain; then the work goes on sweetly and easily, and never doth the heart so kindly melt, as when the gospel-clouds dissolve, and the free grace and love of Jesus Christ comes sweetly showering down upon it; then it relents, and mourns ingenuously."[72]

At other times, English husbandmen extend emotional agency to botanical specimens like soils and seeds, as when Joseph Blagrave (1610?-1682?) remarks that coriander "loveth a good Soyle," or John Worlidge (fl. 1660-1698) finds that "The Hop delights in the richest Land." Gervas Markham (1568-1637) also assigns a pleasure-filled preference to unmixed legumes, arguing that grains of sand, "simple and uncompound, as being perfect in their own natures, without the help of other mixtures … taketh delight in Rye, because it is a Graine which loves warmth."[73]

The mutual love of simple soil and rye was just one of the many forms of botanical desires to be narrated by human observers. For these writers, there was no

doubt that plants, herbs, and flowers possessed the agency of desire, and that these botanical bodies would exert clear preferences for particular soil compositions and husbandly care in a way that was signified by their outer forms and inner humoral essences. For example, as Markham explains in an extensive discussion of humoral properties, pennyroyal was considered hot and dry in the third degree, and its two forms, male and female, both "delighteth most in moist earth." When hot, dry pennyroyal seeds mixed with the watery properties of a wet soil like the moors of the upland or upper Midland regions, the contrary forces rooted out from the earth the type of Strife necessary to sprout new botanical life. While onions "love a fertile earth," Lombardy Loveage, "being hot, and dry is very purgative, it desireth a very fruitfull ground," and equally hot, dry Rue "is very soveraigne against all inward infection, putrifactions, and impostumations, it joyeth in any reasonable ground." Cabbage-seed, hot in the first degree, dry in the second, and apparently less selective, "delighteth in any well husbanded ground." These hot, dry vegetable seeds could thrive in any soil so long as it was of high quality or sufficient "reason," Markham's particular form of expressing the adequacy of a type of soil or its suitability for a specific crop. In the English uplands, where wet soils predominate, cereals were considered more forgiving. Oats, especially, became the staple of Derbyshire Peak, south Lancashire, the Staffordshire moorlands, the Yorkshire dales, and parts of Wales because they would grow "indifferently" in "the barrainest ground" but "in great abundance" should "the ground have any small heart." So long as the clayish ground was "reasonable," the husbandman could be less attentive in his preparation of the land, for oats were able to grow where more sensitive crops, like vegetables or fruits sown from seed, could not. And so Markham concludes that "because

Oates will grow very well if they be sown upon reasonable ground," more husbandmen should grow oats instead of peas, for "it is better to have good Oates than naughty Pease...." The seeds of cereals like oats, and vegetables like peas and pennyroyal, loved, desired, and delighted in different kinds of soils, each seed seeking its opposite energy in the earth.[74]

In addition to the seminal nature of desire, soils, too, revealed their own right reasons and expressed their desire for specific forms of husbandly attention. In addition to the "reasonable" white or gray clay that could bear oats, Markham invokes the affective language of appetite to explain what the husbandman ought to do when his "barraine" white sand was found to "craveth more care and cost, both in ploughing and manuring thereof" (74). This rich language of love and desire guided the literate and "season-observing" husbandman in his essays into what one sixteenth-century writer called the second of his "two wives." His first partner, woman, represented "the soules joy," but he was also husband to "Earth the bodies nurse."[75] This affective language is commonplace in husbandry manuals, herbals, and horticultural books, but it was not the only register available to or employed by seventeenth-century English agricultural writers. Alongside the generic conventions of deeply emotional terms of botanical desire and husbandly love, the same agricultural treatises also explained plant processes and instructed readers in the art and science of sowing in procedural terms and plainly put observations.

The same authors who waxed poetic in garden plots also used more neutral natural vocabularies. For example, although at times he extols the affective capacity of plants in remarkably human terms, at other times Markham simply states that leeks

"would have a fertile ground" and strawberries "groweth best" in shady conditions when they are grafted, or "set of the plant, and not sowne from the seed." Captain John Smith (fl. 1631-1670) argues for the merits of planting over grafting in the case of elm trees, affirming that "the Elme will require the best and deepest Moulds, but beareth no Seed, therefore must be planted by Plants or Setts."[76]

Verbs like "groweth best," "have" and "require" suggest a far less affective register than the soils that "love" certain seeds and "taketh delight" with their planting; the coexistence of the two registers reflects the shifting discursive states of seventeenth-century natural knowledge and vocabularies. This was a moment of tremendous agricultural innovation in early modern England, indebted to greater contact with American and European natural knowledges and practices. To feed its growing population, early modern English husbandmen adapted new cycles of field rotation, learned new methods of setting seed, and introduced new kinds of non-native species to landscapes that had been engineered into productively fertile spaces, like the drained fens and the fragmented moorlands. Agricultural writers could categorize these spaces in the rich terms of human desire, but they could just as easily avoid these discursive nodes by framing human-plant interactions with neutral verbs. What they could not do was separate the material improvements in English agricultural practices from the symbolic resonance of improvement as a way of cultivating the known world and ushering in a time of Adamic recovery.[77]

Agricultural writers contested the nitty-gritty details of sowing and setting, and they argued alternately for one method over another, for the merits of grafting relative to planting, or for the superiority of a particular farming instrument. At the turn of the

seventeenth-century, writers like Sir Hugh Plat and Edward Maxey debated the economics of setting rather than sowing in technical terms and cost/benefit calculations that served as the backdrop for religioscientific treatises on the planting and settling of England's foreign plantations. Amid the newness of these English plantings at home and in the New World, the affective language of agricultural letters – setting England with the board and settling English America with the seed drill – revealed the continuity of the influence of natural philosophical traditions.[78] The affective language of writers like Markham, Blagrave, Child, and Worlidge drew from a syncretic natural philosophical tradition in which human behaviors and emotions were models for the natural world, and the natural world served in equal measure as a "similitude" for spiritual husbandmen who found themselves as "worn out of heart" as the fields they plowed and prepared. This vision took its cues from both classical analogies of micro- and macrocosmic relations and an explicitly Christian reading of the Book of Nature. The affective bonds of botanical bodies and human husbandmen were put to work in the manufacture of difference; the active verbs that signal the agency of plants that prefered, seeds that loved, and soils that desired were pitted against each other to precipitate the conflict or Strife that would generate growth. While engineering projects required new tools, and grafting depended upon the sympathetic union of rootstock and scion, planting was a material practice that necessitated difference and contrariety to bring forth new life.

Walter Blith (1604?-1654) explains with particular clarity and religioscientific terms how English husbandmen might yoke together opposite forces to cure the postlapsarian world of its "Barrennesse." By harnessing the generative power of the *concordia discord*, Blith argues in his *English Improver; Or, a New Survey of Husbandry*

(London, 1649), that English husbandmen can feed the country's growing population with their virtuous labor of cultivation. The key to this spiritual and material Edenic restoration is the mastery of difference, "for whatever causeth Barrennesse, be sure to provide a Soyle that will stand in constant opposition to it, and so though one waste another, and both are weakened, yet the Earth is thereby bettered." The wasting, warring, and "constant opposition" of cosmological bodies pitted against each other by the husbandman occasions the fertile sprouting of seeds and the productive growth of plants. And so when the husbandman successfully "occasions Quarrells and Contentions," he sees real returns on his labor, "For in all Soyles and sorts of Earth, there is a Combustible and an Incombustible Nature; Each Wrestling with other, and the more you can occasion Quarrells and Contention by these, that is, the more you adde to that which is predominant, and so allay the distemper in the end, the more gaineth the Earth thereby." The theoretical principle of difference informs Blith's religioscientific vision of agricultural labor in a postlapsarian world, revealing the ways in which scientific ideas of contrariety operated in the material and spiritual orders of English foodways and population management. "For I suppose there is a kind of contrarietie in Nature, it was ever so from the fall, and ever will be till all swallowed up again in one," Blith concludes, suggesting that the universal imbalances ("all Soyles and sorts of Earth") of this fallen world can be productively tempered or corrected by English planters who understand that the manufacture of difference is the way to spiritual and material wealth. Indeed, for Blith and for agricultural writers like him, the work of difference was a constant reminder of the fallen condition of Adam and the "Second Adams" whose good husbandry might bring about the end of earthly time, or at least provide food security for a growing

population in the meantime.[79]

Blith supports his theoretical reading of the nature of difference with a practical example rooted to the nitty-gritty details of agricultural work: fertilizing and planting. Lime, he explains, is considered a "hot" essence in its raw form ("whilst in the Stone, and Unslacked"), but once it is ground into fertilizer it takes on "a very cold Nature" that makes it an excellent fertilizer, "natural and sutable" for "hot" soils like "your light sandy land, and mixted sound Earth, so is also your Gravell, but not so good…" When it was used as a fertilizer for these sandy soils (and, to a lesser extent, gravel), lime converts the "light" land "into such a Capacity as it will beare exceeding good Lammas Wheate or mixted Corne." The increase of those "exceeding good" crops is borne of a marriage of like to unlike. The remedy for "whatever causeth Barrennesse" is delivered in the husbandman's carefully and "seasonably apply[ing] to such Lands as are most different from the nature of itselfe": cold lime or heavy marle, which "saddens the Land exceedingly," when added to hot sand or warm gravel, begets healthy, sprouting crops, while dry, warm sand "something inclining to Saltishnesse," mixed with a moist, cold earth will produce the type of friction, or "contest" in whose sparring "the Earth steales from both, and is much Advanced thereby" (110).

Gervas Markham agrees that the mixture of sand and clay is an excellent way to harness the generative potential of their contrary natures, for "when they be mixt together, the sand doth give to the clay such hardnesse and drynesse, and the clay to the sand such moisture and coldnesse, that being fixt together they make one hard body." The productive and reproductive value of contrariety extends to the relationship between seed and soil, too, as when Markham instructs his readers that "If the ground whereon you

meane to sow your Wheate be a rich, blacke clay, stiff and full of fertilitie, you shal then (as neere as you can) choose your seede from the barrainest mixt earth you can finde." And the same in the next year's cycle, for "the seed which cometh from the fat ground being put into the leane, hungrinesse of the ground, but brings foorth increase contrary to expectation." Although it may have seemed counterintuitive, English agricultural writers insisted that this mismatching of soil and seed was indeed the best way to ensure profitable returns on one's planting. The better husbanding of England, whether set or sown, is wrought from the manufacture of difference, the fertile union of what Blith calls matter "most different from the nature of itselfe." Difference, in these English agricultural letters and the traditional doctrine of the natural philosophy, is productive, generative, and profitable; the mixture of different soils provides the fertile ground from which spring staple crops and luxury comestibles, native species and non-native varieties alike, while the pairing of the best seed with the worst soil roots out the contrary energies of both cosmological bodies.[80]

The scientific value of difference helped colonial planters in New England to justify rhetorically their preference for the region's less fertile soils, at least relative to the land in the Chesapeake and the extended Caribbean. The material mismatching of soil and seed in English crop science, coupled with the Christian trope of inversion, provided colonial apologists like John White with a conceptually available religioscientific paradigm through which to articulate his vision of a "new planted Colony, that from small and contemptible beginnings, it may grow into a settled and well formed Church." White responded to the imagined objective of fellow planters that a new settlement would be more effectively planted in the "richer soyle" of the West Indian islands by insisting

that "the truth is, there is more cause to feare wealth than poverty in that soyle." Calling this point "an unanswerable argument," White argues that "If men desire to have a people degenerate speedily, and to corrupt their minds and bodies too, and besides to tole-in theeves and spoilers from abroad; let them leeke a rich soile, that brings in much with little labour; but if they desire that Piety and godlinesse should prosper; accompanied with sobriety, justice and love, let them choose a Countrey such as this is; even like *France*, or *England*, which may yield sufficiency with hard labour and industry." The principles of contrariety responsible for generating agricultural growth were also the guide posts of colonial planting in North America: to cultivate the right way, the chosen planters had to select the worst soils in which to make their new homes. By mismatching soil and seed, or by transplanting the best specimens of the English (themselves) into the poorest earths (the New English lands), writers like John White synthesized the lessons of English agricultural science into a framework of colonial settlement.[81]

Anglophone agricultural writers throughout the circum-Atlantic republic of letters argued for the necessity of difference in bringing forth productive material, spiritual, and colonial harvests. Whether they positioned themselves as non-native transplants in new soil, as in the planters on Narragansset Bay, or whether they outlined methods to domesticate foreign strands of people and plants in England, agricultural authors called upon their readers to better understand the work of difference. Some writers did so with an especial attention to the concerns of the overlapping literary and herbal marketplaces. Two examples from Joseph Blagrave's *Supplement* (London, 1674), a discussion of non-native rhubarb varieties and the long-domesticated anaphrodisiacal Agnus-Costus tree, demonstrate how agricultural writers engaged the seventeenth-century scientific idea of

difference in economic terms of increase and commercial terms of marketability. Positioned in the literary market as a corrective to the exclusively national domain of the *English Physician* (London, 1652), written by the astronomer and medical doctor Nicholas Culpeper (1616-1654), Blagrave's *Supplement* catalogs the medicinal plants in England and those "from any part of the world" that are "to be sold in our Druggist and Apothecaries Shops." He details the "Dangers and Corrrections" of some 179 botanicals whose novelty would excite the curiosity of English consumers, including chocolate, coffee, ginger, galbanum, Guiacum, Honduran sarsparilla (for the French disease), lime and lemon ("the two sorts the Male and the Female"), Mechoacan (from Mexico and Peru, "also effectual in the French disease"), Myrobolans ("Indian purging plums"), and pepper, and he suggests ways to increase the yields of native species alike.[82]

This extensive catalog of native and non-native agricultural commodities – the material fruits of planting in America and trading in Africa, Asia, and Europe – includes and the "five or six sorts" of rhubarb that exist in the known world: "the true *China*, and oriental, the Bastard, and such sorts as grow in *England*" (179). By Blagrave's count, there are at least three kinds of "True Rhubarb, or Rhubarb of *Pontus*, or English rhubarb, called Hippolapathum maximum, roundisolium exoticum, sive Rhaponticum, Thracium, vel Rubarbarum verum," whose "root appeareth of so fresh and lively a colour, with fresh coloured Veins running thorow it, that the chiefest of that Rhubarb, brought to us from the *Indies*, doth not excel it, which Root being carefully dryed, will hold his colour almost as well as when it is fresh." The interchangeable masculine and neuter pronouns of "his" and "it" lead into a fourth category of rhubarb, "the true Rhubarb and Rhapontick, of China, and of the shops: Rhubarbarum ponticum genuinum &

officinarum" (180). In this catalog of botanical specimens, then, there are multiple forms of "true": the English variety that excels the Indian species, and the Chinese and the commercial strand. Even the vulgar or "bastard" variety has a Latinate name, *Hippolapathum roundisolium, vulgare*. Despite their differences in origin, color, leaf shape, value and medicinal application, Blagrave proudly declares that "All these sorts of Rhubarbe do grow with us in our Gardens" (181) with the right sort of natural knowledge and agricultural practice.

Those knowledges and practices are indebted to the analogical thinking of natural philosophy and its understanding of concord and discord. Culpepper, "with a great deal of foolish nonsense," had aligned the rhubarb with "the government of Mars," but for Blagrave, the proper assignment is with the "particular influence" of Jupiter, because "the leaves of these kinds of Docks do a little mollifie and and loosen the Belly, being boyled in Broth and taken; but the Roots have a more opening and purging quality in them; some more, some less than others, according to their quality" (182-3). Culpepper's misreading of the sublunar material – the physical structure of the leaves and their inner medicinal properties, what Milton would call "sap sciential" – caused him to identify a planetary relationship that did not correspond to the true nature of the matter. By improving his agricultural knowledge, Blagrave suggests that the English husbandman can manipulate natural difference to domesticate non-native varieties of rhubarb – to take the foreign species, take advantage of its difference, and offer a new product to English consumers. A more nuanced understanding of planetary correspondence and the doctrine of signatures, or the idea that a plant's physical shape revealed its inner properties, could lead to the better husbanding of England, not only "For the benefit of my Countreymen," but also for

the farmers who sold crops and the writers who sold herbals and instruction manuals. Blith and Blagrave disagreed quite plainly on the role of planetary influence in agricultural interactions, as the former dismissed it as "ridiculous and superfrilious Tearmes" full of "Vanietie and Wickednesse" and the latter insisted that it provided the key terms to unlocking sublunar and supralunar correspondence in human bodies, behaviors, professions, and personalities.[83] But both writers agreed that what Blagrave calls "wrangling and difference" is the root of natural generation and the key to the materially and spiritually profitable application of English agricultural science to the country's fields and fens. The productive value of difference works equally with non-native species like rhubarb and near-native crops like Agnus-Costus.

According to Blagrave, the Agnus-Costus tree, "hot and dry, in the third degree; and of a very astringent quality," shares a "great antipathy" with "the benevolent sociable *Venus.*"[84] This so-called "chast tree" drives away both snakes and venereal diseases like syphilis, or the "French disease" that was remedied by "Indian purging plumbs" and "Honduran sarsparilla." The tree operates under the rule of Mars, which "makes use of him to check the too much salacious entertainment of Venus." Only by understanding the cosmic sympathies of the masculine plant and the warring planets of Mars and Venus can the husbandman ensure the maximum increase of this "procurer of chastity," a "singular remedy for those whose nature prompts their desires to venereal sports" (2). By taking advantage of the generative force borne of the yoking together of opposite properties, the "hot and dry" nature of the Agnus-Costus tree counterbalances the lusty force of the planet Venus. The husbandman who understands these interactions, moreover, can grow a market-ready remedy for unchecked desire. Ever the physician to his own field,

Blagrave's saturnine husbandman increases the fertility of the "chast tree" to temper the cosmic play of Love and Strife among human consumers.

The Agnus-Costus tree was an especially good investment for a planter because it was recommended by herbalists, physicians, and agricultural writers who agreed with each other on little else. For example, in 1655 Culpepper, the physician responsible for introducing British American readers to the doctrine of signatures, led a team of three other physicians in producing an English-language edition of Lazare Rivière's (1589-1655) *The Practice of Physic*.[85] His co-translators were William Rowland, the "Knowing Physitian," Abediah Cole (*fl.* 1602–1664), who "hath practised Physick twenty nine years in the Service of three of the greatest Princes of Europe" (in Western Europe, Turkey, and the Americas, according to the *DNB*), and one who wished to remain anonymous, serving "the good of Man-kind" only because "it is more rational, manly, generous, and Christian." The book was marketed to two very different groups of men and women. According to the printer Peter Cole, one body of readers included "industrious men that know no more languages than their Native one," that is, men who mostly attend to "the Necessities of the Poor." As Cole puts it in his address to the reader, "These Books will teach such persons how to go upon good grounds, and to be able to give a solid Reason for what they do, and of Empericks, make them Rational Physicians, if they be men of good Natural Parts, though they be ignorant of all Tongues but their Mothers" (3). The second audience consisted of two groups that were united by their biological sex: "diligent Midwives" who treat other women and the lettered "Ladies and Gentlewomen" who might use this book "as in Looking Glasses" to diagnose their present conditions before they consult a true doctor or "thereupon crave the Advice and Assistance of the

learned Physician." Because this English-language edition of French medical theory was designed, in part, for women and female medical practitioners, remedies for women's illnesses became particularly important points to address in the translation of continental medical knowledge. The Agnus-Costus tree was suggested as one such cure for the "womb furie" that plagued the early modern female body.

In a remedy for this "*Eroticus affectus*," glossed as "Love-Melancholly" and defined as "a sort of Madnes, arising from a vehement and unbridled desire of Carnal Imbracement," Culpepper and the translators render into English Rivire's call for "frequent" but not "sharp" clysters of "Vinegar allaied with Water" to "cool and gently purge" the "sharp stinging Seed" (419, 418). The choice of the term "allay" (allaied) is especially interesting in this context of a book that bridges French medical knowledge and English medical practice for monolingual men and women, and it is one that I will return to shortly. But for now, I would like to note two other treatments recommended by Culpepper's team, "cooling Ointments" made from camphire, nightshade, henbane, rose and water-lilly extracts rubbed upon "the Loyns, Privity, the Share, and between the Water-gate and the Dung-gate," and an injection of an herbal "opiate" of one half-ounce rose, water-lilly, violet and "Agnus Castus" conserve mixed with one ounce of preserved lettuce stalks and one dram of coral and smaragd distilled in a syrup of violets and water-lillies (419). Herbal writers and practitioners who agreed on little else, like whether the planets influenced human behavior or whether the English physician should prescribe non-native herbal remedies, could nevertheless agree on the efficacy of the Agnus-Costus tree as a cure for a range of sexual conditions, from the syphilis of the Americas to the excessive female desire that Culpepper calls "Madnes from the Womb."[86]

The scientific principle of difference informed both writers' endorsement of Agnus-Costus in planting and physic. Agricultural practitioners were instructed to plant the tree during the period of Mars because of the sympathetic correspondence between the "chaste" tree and the rigorous warrior planet; planting under the "too much salacious entertainment of Venus" denied the tree the contrariety required for botanical growth. The same principle of contrariety that guided husbandmen in their planting of the tree informed the use of Agnus-Costus trees by women and men to remedy excessive sexualities; the hot, dry nature of the tree tempered the desirous body and restored it to a well-balanced state of health.

On the larger scale of the body politic, writers like Walter Blith called on English husbandmen to "allay the distemper" of the physical earth as they cultivated a more fruitful "Remembrance to this Poore Nation." The science of seventeenth-century English plants – alternately cultivated for medicinal use, grown as staple crops, and marketed for luxury consumption – was, then, the science of difference: a rich compendium of natural knowledge and practice that harnessed contrary energies and warring opposites into generative relationships of fertile growth and profitable increase. In the context of the New World, this language of plants and planting was the discursive and material frame through which English colonists and their apologists explained and justified their places: the "unsetled and confused Chaos" in Bermuda that gave way "to receive a disposition forme, and order, and become indeed a Plantation"; "our first planters" whose efforts to "plant the gospel" in New England are celebrated in Mather's "Christography" of the New World; the call for "this noble realme of England, to discover, people, plant and possesse the like goodly lands and rich countreys not farre from us, but neere adjoining &

offring themselves unto us."[87]

The science of difference in New World plantings continues in chapter two, where I compare the oppositional thinking of planting and sowing with the practices of grafting, a Chinese technique in which English agricultural writers endorsed the pairing of like to like. The relationship of fundamental similarity required to successfully graft a fruit tree may have led to improved practices in husbandry, but this language of sameness did not become the metaphorical terms of colonial English experience. The English in the New World were not grafters or pruners who did "Go, bind thou up young dangling apricots / Which, like unruly children, make their sire / Stoop with oppression of their prodigal weight." Rather, they fashioned themselves the planters of "the seed of God" whose own hearts threated to become "miscarrying soul[s], unless the Great Husbandman plough thee up the second time, and sow thy heart with better seed."[88]

These religioscientific root paradigms organized communities in the Old World and the New World into particular social configurations like manorializations and settlements. In the case of wild moorlands and undomesticated fenlands, they especially marked the necessity of technical competencies in wetlands management and underscored the centrality of authorizing spiritual paradigms for the cultivation of those spaces. The upland moors, those spaces darkened by the evaporated turf that "reduce[s] all things into its own nature," may have been the seat of evil in imaginative works like *Beowulf and Macbeth*, but they were celebrated by agricultural writers like Sir Hugh Plat precisely because of their mystical natures. Plat praises the moorlands as the best seat of natural instruction because their soil compositions resist easy classification or stable treatments: "the best naturall phylosophie that euer I coulde learne in this point, was

neither out of Aristotles physicks, nor Velcuries naturall philosophy, nor *Garsceus* meteors, nor out of any of the olde philosophicall Fathers, that writ so many hundred yeares past; but that little which I haue, I gathered it on the backside of Moorefields."[89] In contrast to a stable tradition of textual transmission, the knowledge gained "on the backside of Moorefields" was experiential and applied, the fruits of first-hand learning in a dynamic environment whose subtle changes required careful observation and analysis by those who wished to put the space to profitable use. The dominant blackness of the English moorfields was so preeminent a site of instruction that, according to the *OED*, by 1687 agricultural writers referred to a professional "mooreman," or one who specializes in the domestication of the blackest earths in arable or pasture regimes.

Hartlib circle agricultural practitioners like Dr. Robert Child and Dr. Arnold Boate read Plat's assessment and debated the nature of blackness in the moorlands. While Boate argued that moor-logs became black by absorbing the properties of blackness from the earth, Child insisted that "all multiplicative Acts proceed from such spiritual things, and not from bodies." The blackness of the moorlogs did not stem from their taking root in putrified soil, or in externally dark "Vapours, Fumes, or *Effluvia*, call them what you will," but instead from an internal, essential blackness endowed with "an innate power to transmute other extraneous things into their own nature." For Boate, these were physical alterations wherein the soil could "change these Trees into it's turfy nature," but for Child the transmutation was waged on the level of the most intimate core.

The debate about the nature of blackness in the moorlands was not just a theoretical disputation about English soil; it was also a matter of application in England's foreign plantations. These wild, resistant, blackened spaces provided the forms of

instruction and practical competencies that the English would need to develop the timber industries of the North American mainland, where Hartlib circle contributors like Child argued, "I know that in *Virginia* and *New-England*, that *Pines*, and *Firs*, and *Cedars*, do grow wonderfully in such *Moors* or *Swamps*." If the debate turned on philosophical principles that could be corrected by knowing readers ("This is in briefe my Philosophy concerning *Moorlog*, if I am in errour, *I* will thank him that shall shew me the truth"), the analysis of the nature of the moorlands also emerged in the applied context of the colonizing labor of planting English. The richly evocative language of cultivation of the moors and heaths, in other words, could easily be analogized into human orders within scientific discussions of color and symbolic representations of blackness.[90]

It was only a small jump for Hartlib circle contribuer Robert Boyle (1627-1691) to move from the scientific to the symbolic. Boyle's observations of the optical nature of blackness – "a Privation of Light" in which "Shadows and Darkness are near of Kin" – set up his larger discussion of the matter of blackness in human and cosmological bodies. Boyle concludes that in general terms "Blackness seems to proceed from the Paucity of Beams Reflected from the Black Body to the Eye, I say the Paucity of Beams, because those Bodies that we call Black, as Marble, Jeat, &c. are Short of being perfectly so, else we should not See them at all." As he points out the misnaming of black bodies, for if they were truly black "we should not See them at all," Boyle also segues into his discussion of the nature of skin color: whether hue is derived from environmental effects of the sun or instead from "some Peculiar and Seminal Impression." After reviewing the reports of the Dutch naturalist Willem Piso (1611-1678) in Brasil and the English sailor Andrew Battell (fl. 1590-1610) in Angola, and exchanging ideas with "an Intelligent

acquaintance of mine (who keeps in the *Indies* about 200 of them as well Women as Men to work in his Plantations)," Boyle concludes that human hue is only determined by the "thin *Epidermes,* or outward Skin" rather than the vaporous essences or transmutative properties that other Hartlib circle contributors identified as the natural roots of blackness in soils and seeds. Piso's gory dissection of black bodies in Brasil revealed with especial clarity the superficial level of color: "their Blackness went no deeper than the very outward Skin, which *Cuticula* or *Epiderms* being remov'd, the undermost Skin or *Cutis* appear'd just as White as that of *Europaean* Bodyes." When it came to human bodies, unlike the cosmological elements to which earlier seventeenth-century writers analogized natural behaviors and principles, the borders between white and black were theoretically transgressible, or "at least as possible," Boyle suggested. However, it would be more common to find "that White Parents may sometimes have Black Children" rather than "that *African Negroes* should sometimes have lastingly White ones" because of the darkening effects of the sun. But whatever external changes might be writ large upon the body, Boyle resolved, no permanent modifications would be transmitted to the next generation. The matter of skin color in humans, unlike color in nature, was superficial at best. As Hartlib circle correspondents like Boyle, Boates, and Child debated the analogical limits of black and white in human and non-human bodies, they synthesized agricultural scientific essays and alchemical readings of nature in England with the accounts of learned travelers in Ireland, Africa, and America. The localized particulars of the English moors contributed to a transnational and multilingual debate about the scientific principles of color and their symbolic registers, or the material and immaterial nature of blackness and whiteness.[91]

A similar dynamic emerged in seventeenth-century discussions of the draining of the fenlands in the flood-prone lowlands of west England. Because in an era of colonial planting the technological innovations tried in England could be quickly mapped onto the religiotechnical practices of settlement in the circum-Atlantic republic of letters, seemingly localized discussions about fenlands drainage came to inform marshland colonization in Narrangansett Bay. In the late sixteenth century, the owners of heavily manorialized estates in the west English lowcountry began experimenting with irrigation systems that would give them better control over their marshy soils; by the 1620s, large-scale plans for arterial drainage and polder development in common fields proceeded haphazardly but energetically. At roughly the same time, a plague swept through the coastal regions of Massachusetts but, curiously for the minister and colonial apologist John White, the disease did not proceed beyond "twenty or thirty miles up into the Land." Reflecting in 1630 upon the epidemic of "about twelve or sixteen yeeres past" that had affected only the indigenous population, "the *English* in the heate of the sicknesse commercing with them without hurt or danger," the removal of the native communities from the rich, alluvial soils of the coast aligned with the development of English competencies in marshland and fenland agriculture. Because "there is no person left to lay claime to the soyle which they possessed," White claimed, the English planted in Massachusetts "may assure our right: we neede not feare a clear title to the soyle." The English "acquaintance with the soyle and Natives there," or the technical skills of the planters in terms of agriculture and intercultural negotiation, compounded with the salubrious effects of the dry air upon the English body, led White to believe that the bay region was an especially "fit Country for the seating of an English colonie" and,

therefore, “for the propagation of Religion.” The decimation of the native communities of the marshlands was ascribed to the work of providence rather than germ vectors – a divine clearing of the way for planting English – but the ability to cultivate low-lying fenlands was also a relatively new technology that underwrote the physical settlement and settler ideology of the Narragansett Bay.

English agricultural practitioners would not perfect the methods of marshland farming until the completion of the large-scale draining of the fens engineered by Dutch experts in 1637, but by 1629 the Dutch engineer Cornelius Vermuyden, invited to England by Charles I, had managed to divert the rivers, increase water flow, and prevent flooding of the royal lands of Axholme by installing drains to remove water from the fenlands. By 1634, four years after White had encouraged the planting of Protestants in New England, some 200 Protestant families emigrated from the Low Countries to England to settle and cultivate the newly-drained fenlands. Although a long-term solution to the drainage problems in England eluded Vermuyden, who returned to the site three years into its flood-plagued operation, the changes to the social and economic landscape of the region felt quite permanent to the local residents whose methods of farming and networks of economic and social exchange had been disrupted by the new physical conditions. The example of late-sixteenth and early-seventeenth century fenland technologies that drew Dutch farmers to England, and their adaptation into marshland technologies that allowed the English to plant in Massachussets, reveals the ways in which agricultural science was both a site of technical innovation and a religioscientific root paradigm that sanctified the work of Protestant planters. The Dutch technologies of fenland drainage in England helped to create the technical competencies necessary for the

marshland settlement of the Narragansett Bay that Puritan planters like John White would cite as authorizing experiences readying the cultivatable path in the New World. The discourse of planting was a crucial intersection of religious conviction, political justification, and scientific improvement.[92]

What I have tried to do in this section is to demonstrate the ways in which English agricultural authors engage with the natural philosophical traditions of analogical thinking, and to show where and how difference emerges as a key site of natural knowledge and profitable practice. The final part of this chapter examines the reception of the natural philosophy in the preeminent scientific discourse of seventeenth-century Spanish America: mining and metallurgical sciences. But before that, I want to return to the thorny question of the word "allay," a term invoked by writers like Culpepper and Blith to describe the restoration of humoral balance in the diseased body and the body politic. The term's complex etymology, engagement with metallurgy, and its circulation in technical manuals and imaginative fiction make it an important interstitial site of colonial-era planting.

In suggesting that the husbandman "allay the distemper" of his field, Blith draws on a phrase and concept long-established within natural philosophy, and one that is complicated by the embedded Christian and Islamic valences that course through its use in the fields of early modern sciences. According to the *Oxford English Dictionary* (3:1), from the fifteenth century onward, the meaning of the verb "to allay" was "completely identical" to the metallurgical practice of tempering a precious metal like gold with a base metal like copper, of intermixing silver and iron such that the value of the silver decreases, but the iron increases. This metallurgical meaning was mapped onto early

modern English understandings of both the image of Christ's earthly body, a debasing of the heavenly form by condescending to humans and improving their lot, and to the language of Christ, namely the parables with which he spoke. As a term that intermingled speech acts ("allege") and humoral ideas of balance that informed metallurgical and alchemical practices ("temper"), "allay" at once reveals its medieval Christian roots that echo echo Christ's condescension and its natural philosophical inheritance in which health is understood as a properly balanced mixture of the elements, called *aljiza* in the Islamic medical tradition of Abū ʻAlī al-Husayn ibn ʻAbd Allāh ibn Sīnā (Ibn Sina or Avicenna, 980-1037) and Ibn Rushd (Averoës, 1126-1198).

These multivocal, transcultural resonances were glossed by early modern writers like the anonymous "T.B." (Thomas Bowes, *fl.* 1579–1589) the Cambridge-educated Puritan translator who brought into English the French writer Pierre de la Primaudaye's (b. ca. 1545) *French academie* (1586), a book of platonic moral philosophy. Texts like these presented serious problems for writers and translators who were dedicated in equal parts to the improvement of English agriculture and to what Walter Woodward calls the religioscientific paradigms of seventeenth-century agrarian reform circles. How might early modern English writers accommodate into their native language the natural and moral philosophies of competing Catholic and non-Christian traditions more broadly? Should they do so at all?

Bowes replies with a carefully constructed explanation of his methods as a translator and his beliefs as a Christian, performing in his address to the reader a dance between his insistence upon the infallibility of God's word and his belief in the utility of pre- or non-Christian sources, a spiritual going between that complements his movement

between languages. One the one hand, he writes, "I grant that the word of God is onely perfect, and containeth in it an absolute rule both of pietie towards God, and humanitie towards men." But in the same breath he seeks to rehabilitate non-Christian scientific traditions for human benefit: "but it followeth not therefore, that we may not vse the benefit of humane precepts, or tread in the steps of heathen men, so farre foorth as their learning and liues dissent not from the truth of holy Scriptures." The delicate relationship between the Book of Nature and the Book of Scripture, what is useable about the former in confirming the superiority of the latter, hinges on the translator's use of the verb "allay." In his prescription for authors to use the right kind of language, namely "the holy and sacred Scripture, which being the Mistres of all humane arts and disciplines, vseth them as hir handmaids to serue and obeie hir," Bowes admonishes "the ambassadors of Gods word (vnto whom indeed the knowledge of toongs and humane arts is a singular helpe)" not "to vse these gifts otherwise than as handmaids in their studies and meditations to setue the Scripture to the more plaine and pure exposition of it, seeing they are sent to edifie others, and not to set our themselues" (5v). In a series of rhetorical questions, Bowes inveighs against the wrong kind of linguistic and spiritual mixture, asking why on earth one would want "to alay the strength of the word of Christ with the waterish sayings & fables of men? to put vpon the naked and glorious face of God the beggerly clokes of *Poets & Philosophers?* When the Lorde hath sanctified, not the corruptible seede of the sayings of men, but the incorruptible seede of his owne most holy worde to the begetting of faith, are not these new begetters ashamed to bring in another way of regeneration?" This turn to the seminal language of spirituality – what Calvin calls the "seed of religion" that God had sown "in all men" – conserves the language of

combination just as it moves the verb "allay" away from its metallurgical context of mixing and debasing and into the language of planting – and planting faith at that.[93] The religioscientific language of agriculture also provides the terms of "another way of regeneration," a generative "begetting of faith" performed by "these new begetters," a language that marries the physical labor of cultivation to the spiritual restoration of Adamic empire.

The loss of that empire is relayed with language that sings in book 10 of *Paradise Lost*, where the multiple valences of the verb "allay," the emerging imperial identity of English planting, at once a transplantation of English families and an uprooting of native communities, and the power of imaginative fiction to solidify these scientific and political discursive formations meet in Milton's description of the fallen angels.[94] They who once reigned "As lords, a spacious world, to our native heaven" are now the angels who find with great bitterness that they have been removed from their native seat and by "taste / Deceived." They grow "parched with scalding thirst and hunger fierce" in this "new-created world" whose fruits are mere shadows of the harvest, the early modern version of Allen Ginsberg's "peaches and penumbras" piled high in empty abundance in a California supermarket (10.467, 481). And so the fallen angels

> fondly thinking to allay
> Their appetite with gust, instead of fruit
> Chewed bitter ashes, which th' offended taste
> With spattering noise rejected: oft they assayed,
> Hunger and thirst constraining, drugged as oft,
> With hatefulest disrelish writhed their jaws
> With soot and cinders filled; so oft they fell
> Into the same illusion, not as man
> Whom they triumphed once lapsed" (10.564-572).

Here Milton's alchemical language – "to allay," "assay," "drugged" – invokes the

disorder of the refinery where ovens burn, metals melt, and engines run continuously "With spattering noise." What Spenser would famously call the "endless worke" of the refinery represents the repeated transgressions of the fallen angels, their failure to learn from their own trials wrought "oft" in the fire of experience and converted into "soot and cinders" that collect in the pit of the refining oven and sit heavy upon the tongue. The verb "allay" (l. 564), in rhyming with "assayed" (l.567), separates the passage's two invocations of "taste" (ll. 563 and 566) and frames in explicitly alchemical language the embodied, sensory nature of the deception of the fallen angels in a world whose failure they have so recently precipitated. The false fruits of intemperance and appetite unalloyed recall Eve's revelation to Adam with "distemper flushing" how she partook of what Satan calls the "sacred, wise, and wisdom-giving plant, Mother of science" (9.680, 679), how she distempered her soul and physical body with the taste of that "plant sciental sap" (9.837). These were the oppositional root paradigms through which English planters understood and wanted to understand their work in the New World, not as a balanced metallurgical mixture that decreased the value of one metal to increase the value of another.

Temperance may have been an admirable personal quality and the measure of what John Flavell analogizes the as "spiritual experience" of a "Christian mediocrity" to the husbandly care of an arable field neither "dressed too much, nor two little" but rather kept "in heart … as best fits it for fruit." Flavell's recommendation of "competency" as that which "best fits for the fruits of obedience" was directed toward a husbandman with a mature faith relationship and an established garden plot – a spiritual planter who had kept "the golden bridle of moderation upon the affections" as he made his way "in the

midst of so many tempting objects." While the land offered Flavell a symbolic lens through which to understand a Christian middle way, the lessons of daily life offered agricultural writer Walter Blith an analogy for husbandry. Just as "Food and Bread sustaineth nature, but Gluttony destroyes it," so too would a too vigorous "Over-tilling" into cold, clayish soils or overmowing in upland pastures "weaken Land" and "force out the heart." If plowing was "a soveraigne means of Advancement," overplowing was the way to "lose the Land," spoiling not only its outer physical layers or "Carkas" but also its subterrean essence or "strength and vertue which is the Heart and Life of it." Overplowing on mixed soils was especially counterproductive, Blith suggested in a series of fluid gender pronouns, because the too frequent intervention of the plow would mean that the mould would not "be wrought to her perfect tendernesse, and true Mixture, whereby it may yeeld more fruitfulnesse." The flexible gender pronouns that shift between feminine and neuter positions as agricultural writers reconcile competing ideas of fertility is discussed at length in chapter four, but for here the point is that mediocrity and balance were important states of agricultural knowledge, especially in matters of mature soils and mixed plots. The merits of temperance were more difficult to map in a tradition that both rehabilitated classical paradigms and insisted on Christian virtue.[95]

According to Blith, the virtue of the middle way was underemphasized by agricultural writers who found it more appealing, and perhaps more profitable, to appeal to rigorous models of industriousness rather than a more circumspect form of moderation. How could one sell books that advocated the agricultural improvements of doing nothing? For Blith, the invocation of moderation was both the point of agricultural knowledge – to know when to plow and when to let land lie fallow – and a way of

distinguishing his treatise from others that marketed agricultural practices better fit to be "cryed downe by all." Although the rhetoric of agricultural letters may have championed zeal and industry in the early stages of planting, instructional manuals like Blith's and spiritual guides like Flavell's cautioned that "Extreames on either hand are dangerous, and destructive" in the more advanced stages of human and ecological life cycles.[96]

The "middle state" applied to adult Christians and seasoned fields, but the way to generate agricultural growth in the first stages of plant husbandry was by manufacturing difference and ensuring the continuation of conflict. As Gervas Markham puts it in a passage on mixing black, white, and red soils, "although some Husbandmen in our Land" try to reconcile these different colored earths to "one temper and goodnesse, reasoning thus … so that what the mixture of the one addeth, the mixture of the other taketh away and so maketh them all in one fruitfulnesse and goodnesse: but in our common experience it do not fall out."[97] The theory of temperance was one thing, but the material value of its application and its validation through "our common experience" was another.

What Blith identifies as the occasioning of quarrels among contrary bodies and ensuring their continual opposition in English crop science finds its spiritual counterpart in what the Puritan minister John Flavell calls "lusting, *(i.e.)* desiring the mutual ruin and destruction of each other." For the contrary elements of fire and water, and the spiritual opposition of sin and grace, which "are so opposite, that if sin should cease to oppose grace, it would cease to be sin; and if grace should cease to oppose in, it would cease to be grace," are both expressions and understandings of the productive union of opposites framed and phrased in religioscientific paradigms.[98] In acts of material and spiritual husbandry, the production of difference and its application for human benefit was the

scientifically-informed way to plant wealth and the spiritually right way to cultivate a second Eden. Difference was not just a symbolic frame through which seventeenth-century agricultural writers read faith relationships and negotiated interactions with neighbors who were like and unlike them – it was a scientific principle that guided colonial planters in their essays into a better nature.

III. "a explorar la cavidad del mineral escondido en el secreto de la tierra … un nuevo continente se levanta de la más secreta materia de mi poesía": The Science of Sameness in Colonial Iberian Mining and Metallurgy[99]

If the successes of English agricultural science depended in large part upon the productive yoking together of contrary forces, early modern Iberian mineralogical science converted the union of like properties into the profitable industrial-scale mining and minting of American silver. The major innovation of colonial Iberian mining and metallurgy was its development of a cost-effective, large-scale method of amalgamating diverse silver mineralogies with mercury, two metals earlier natural scientists had found too similar to generate the kinds of productive warrings celebrated in English agricultural letters. While traditional methods of refining in the New and Old Worlds alike had used heat to separate different metallic particles, the new method of amalgamation used the chemical properties of affinity or "friendship" to draw these different particles into one body. Like their peers in England, seventeenth-century Spanish writers engaged the affective language of micro- and macrocosmic analogies to describe natural processes like the generation of minerals and to explain human-powered technologies like mineral refining. But unlike their English counterparts, they did not so closely follow the received traditions of the natural philosophy's science of sympathy.

The principles of similarity and difference were well-established within the

mineralogical texts of writers like the German Georgius Agricola (1494-1555), the Czech Lazarus Ercker (d. 1594), and the Italian Vannoccio Biringuccio (1480-1539), all of whom emphasized the productive value of difference in metallurgical science. Because these writers explained the methods of amalgamating precious metals like silver and gold in natural philosophical terms of temperance and balance, they have been credited by some historians of science with the development of the technologies of amalgamation so profitably employed in Iberian America. But as historians like Tristan Platt and Modesto Bargalló point out in their reviews of the historiography of amalgamation, a historian's own linguistic or national background often correlates with or is predictive of her assessment of the technology's origins. Hispanophone scholars in Latin America and Spain tend to locate the amalgamation method in an Iberian genealogy, while Anglophone academics and European historians north of the Pyrenees tend to align the method with Western and Central European traditions.[100]

The ascription of the origins of amalgamation to European habits of mind might stem from a conflation of eighteenth- and seventeenth-century sources. In September 1788, a team of four German metallurgical scientists and seven practitioners arrived in New Spain to instruct late-colonial miners and metallurgists in the heat-based modifications that Ignatius Edler von Born (1742-1791) proposed for the amalgamation of silver. Their experience in New Spain was chronicled by one of the metallurgists, Frederick Sonneschmidt (1763-1824), and published in five German- and Spanish-language editions between 1804 and 1831. Baron von Born's theories of amalgamation had been printed in German (Wien, 1786), French (Vienna, 1788), and English (London, 1791) to the delight of the readers of his earlier studies of monks and the central

European mining regions, the former arranged into a Linneanean system of classification and the latter to the surveying gaze of the traveler. The widely multilingual circulation of Sonneschmidt's and von Born's treatises and the contributions of German metallurgists to late-colonial metallurgical science in New Spain may have led some historians to map the eighteenth-century exchange of European knowledge and American practice back onto their readings of the colonial archive, supposing that European metallurgical technologies had been more advanced than Spanish American mineralogical science in the seventeenth century, as well.[101]

As I argue here, the origins of amalgamation cannot properly be situated in either an American or a European context, because the history of amalgamation is not one that adheres to national or linguistic borders that did not exist in the colonial era. This is a story of the transcultural, multilingual transmission of the knowledge and exchange of methods from willing and unwilling agents of science.

Iberian practitioners indeed drew from the natural philosophy of Agricola and the experiential orientation of Biringuccio; without the learned and practical underpinnings of a German physician who treated miners and published in Latin and an Italian metallurgist who studied in Germany before founding weapons and coins in privately-owned refineries and, later, at the Vatican, the chemical method of amalgamation developed for American silver would not have been possible. But without a multilingual and transnational flow of mining and metallurgical knowledge and practice in Europe, neither could Agricola, Ercker, or Biringuccio have published their works or developed their competencies in natural science. In the 1550s, amalgamated teams of African, indigenous, and European miners and metallurgists in New Spain innovated from the

multilingual, transcultural epistemic inheritance of metallurgical science to developed a commercially-viable, industrial-scale method of refining silver with chemically-similar quicksilver. When the method was adapted for the environmental and mineralogical variations of Peru, they innovated once again. There were elements of the *nuevo beneficio* that were, indeed, quite new, but there were other parts of colonial American metallurgical science that represented important continuities with the received traditions of Europe and America. The complex story of the technology of amalgamation, and the role of that technology of bringing new people into contact, cannot be reduced to one linguistic tradition or cultural community.

Amalgamation, in its most basic sense, was not new. Roman writers like Strabon (ca. 63 BCE – 21 AD) and Pliny (23-79 AD) had described methods to separate gold from other metallic bodies, most often silver, by treating it with materials like mercury, cinnabar, vinegar, salt, sulphuric iron, or soils rich in aluminum, and their texts had been glossed by metallurgists like Agricola, Ercker, and Biringuccio. But these methods were time-intensive, costly and necessarily limited to small batches dry treatments of powders and soils, rather than wet processes involving acids and reagents, and they could not be used on silver lodes or veins of silver ore. Moreover, they were suitable only for high-grade silver or native silver, a comparatively rare mineralogy relative to the many varieties of silver that contain mixtures of lead, copper, iron, and sulfur.

The amalgamation method developed in colonial Spanish America, by contrast, could be used to treat silver ores with lower assay values, thus making available a large store of material that had never before been possible to refine without losing money in the process. For the first time in recorded history, it was possible to refine every silver

mineralogy on an industrial, commercially-viable scale. The components of the reaction – reagents like mercury, catalysts like salt, supplies like firewood, and, especially, skilled and unskilled miners and metallurgists who were alternately forced laborers or independent wage contractors – arranged into complex supply chains, distribution channels, and transportation networks formulated to carry large amounts of material and flows of laborers over long distances and challenging terrains. The mountainous topography of the central Mexican highlands led to constellations of innovative roadways, while chronic water shortages in Potosí inspired the development of water-efficient irrigation systems, riparian refineries (*ingenios* constructed along the Ribera de Potosí), and methods of washing ore in standing pools (*lagunas*). The dense concentration of miners and metallurgists – as well as the merchants and ministers who attended to them – would also require the development of large-scale agricultural systems to produce enough food for the new populations of free and unfree laborers and intracolonial migrants who populated the region. In short, if the technical treatment of amalgamation had existed before its large-scale application and dissemination in America, there were nevertheless enough social, scientific, and economic differences surrounding the American practices to make the chemical method seem at once suggestively profitable and suspiciously new.[102]

In its most basic outline, the amalgamation method as developed by the Sevilla-born merchant Bartolomé de Medina at the mine of Purísima Grande and his hacienda outside of Pachuca, in New Spain, followed a 10-step process of heating the ore (1), crushing it (2), sorting it into piles (3) and treating the piles with a series of three reagents (mercury, salt, and *magistral*, a solution of distilled copper, sulfur, and salt, 4-6).[103] After

being left to absorb the solutions, the silver particles would incorporate the mercury (7) and become a solid mass of 20 percent silver and 80 percent mercury. This amalgam, called *pella*, would sink to the bottom of the wash tub where it could be shaped into 45-pound pineapple-like forms, or *piñas*. Some of the *pella* rose to the top of the tub, but miners could recover these particles with a sifter and treat them following the same procedure as the rest of the batch. In the 1560s, the development of a non-hydraulic, mechanized wash vat in Zacatecas greatly reduced the loss of material in this step. Refiners would sort the *piñas* from the unincorporated mercury (8), wash the metal (9) and send it either to privately-owned and operated refineries (10a), where it would be melted into ingots, or else to the royal clearinghouse and mint (10b), where officials would remove the king's fifth, the *quinto*. As with most inventions, the chemical method of amalgamation was adopted unevenly throughout the region, as African, indigenous, and European miners continued to experiment with the new method. They suggested heat-based modifications, like an extra roasting step (*tostación*) at the beginning of the process or an additional administration of heat during the middle stages, and they determined the effectiveness of these methods by experimenting with different sources of heat, like open- and close-topped ovens and dual- and single-blast furnaces.[104]

By the 1560s most professional miners eagerly embraced the new benefit and abandoned their earlier methods of refining, while others, especially indigenous miners and metallurgists and Iberians who practiced the technique as a secondary profession, continued to operate small-scale refineries to process the highest-grade ores. The *alta ley* or high mineral weight of these silver varieties made their amalgamation cost-inefficient, unlike the lower-grade varieties for which the technology of amalgamation represented a

profitable improvement over earlier refining methods. In both New Spain and Peru, these refiners often chose to send their batches of low-grade silver to other metallurgists for chemically-based amalgamation. The networks of amalgamators and refiners gave rise to what historian Peter J. Bakewell identified in both silver producing regions as dual channels of silver refining: an amalgamation industry that was primarily owned and operated by Iberians who controlled access to mercury, and a smelting industry that was largely run by indigenous miners and metallurgists independent of the Iberian markets. The technical, commercial, and cultural modifications in New Spain that followed Medina's original method, tested with trial, error, and correction that led to improved fortunes for some and detrimental outcomes for others, would be crucial to the successful introduction of the technology to the Andean silver industry.[105]

To account for the colder ambient temperatures and higher mineral weights of Alto Perú, metallurgists heated the mixtures of silver and mercury; the heat-based method of *cozo y cocimiento* reduced the incorporation time from twenty-five days to five or seven days. They built specially-designed holding tanks (*cajones*) large enough to handle 5,000 pounds of material and sturdy enough to be suspended over flames. These modifications underwrote the conversion of the Andean silver industry from one dominated by indigenous technologies and labor systems to one that revolved around Iberian methods of amalgamation; between 1575 and 1590, silver production at Potosí increased by an estimated 600 percent. The remarkable degree of innovation and experiment, some theoretical or epistemic, some applied in engineering projects and new instruments, some genuine improvements and some sham proposals, was practiced on an industrial scale that attracted people from far and wide to collaborate and compete in the

mining and minting of the silver that became the standardized currency of the global economy. The scale of the industry was new, the demographics of its practitioners were new, and so too were the theoretical underpinnings of the new method of amalgamation.[106]

Amalgamation was not only a powerful and profitable new metallurgical technology developed in the interstices of New World and Old World epistemological paradigms and material practices – it also reshaped the economic channels, population dynamics, and cultural landscape of Spanish America. If the technology of amalgamation and its consequences for economic, environmental, and cultural history have been widely appreciated by historians, economic historians, demographers, and ethnographers, the language of the treatises of amalgamation has been surprisingly overlooked. For many scholars who study the history of science, or the history of mining in Latin America, the analogical thinking revealed in these manuscripts reflects a deeply alchemical inheritance whose backwardsness does not cohere with the Spanish American silver industry's role in the emerging economic order of capitalism and the modernity presumed by such an economic shift. What I want to show by taking seriously the natural vocabularies of accounts of amalgamation, however, is that the language of amalgamation is very much worth studying. By tracing the key terms of these treatises, we see how the language instantiates the very cultural and demographic incorporations that the new technology would make possible. The terms used to explain the technique revealed what theoretical frameworks, exactly, were new about the *nuevo beneficio*. In the metallurgical technology of amalgamation, the generative power of difference – the ability to create matter or bring it into body – was extended to two metals that natural philosophical literatures had

marked for their fundamental sameness, sympathy, and similarity. By tracing key terms aligned with similarity and difference, namely the affective language of friendly love and generative desire, we can appreciate how colonial Iberian mineralogical scientists revised these inherited paradigms into new scientific and cultural relationships of sameness and definitions of difference.

Earlier metallurgical writers like the Siennese metallurgist Vannoccio Biringuccio had upheld the natural philosophical theories of similarity and difference, and they had proven the soundness of these theories through years of experience. In a passage from book 1 of the *Pirotechnica* (Venice, 1540), Biringuccio, the Papal smelter who had studied in Germany for at least four years (sometime before 1507 and again in exile from 1526-1529), illustrates the traditional understanding of contrariety as he explains how to refine silver with lead. "For Nature has made a certain alliance of friendly union between these metals and stones, by which the humidity of lead is joined to the aridness of silver, and the heat to the cold. Thus they temper each other and that which is hard becomes suitably soft and liquefiable and issues from the torment of the fire more quickly than it would have done by itself, so the silver is saved."[107] In addition to the "evident reasons why these ores act in this way," Biringuccio's coworkers confirm their knowledge of mineralogical properties through "the fact of our experience and of having seen it every day." Biringuccio rejects the scholastic debates of Agricola and instead celebrates collaborative practical experience that he intersperses with jokes about materials and reagents. For example, in response to Albertus Magnus's descriptions of the powers of certain stones to attract oil, vinegar and wine, Biringuccio exclaims "Thus there is lacking only the one that produces greens and salt for men, so that, possessing it, they

could make a salad wherever they might be, and having a plate and a little bread, they could have a fine meal!" For Biringuccio, a "friendly union" consists of opposing properties: the contrariety of lead and silver, hot and cold, provides the mutual attraction that separates silver particles from the rest of the lode. Agricola, too, accords with this understanding of the generation of mineralogical bodies, although his discourse on the origin of metals in the *De ortu et causis subterraneorum* (1546) is framed in the explicitly scholastic terms of Aristotelian natural philosophy rather than the experiential lens of Biringuccio's workplace-oriented practice.[108]

The same idea of the generative force of the *concordia discors* informs the metallurgical scientific writings and practices of colonial Spanish America, where writers like the priest-metallurgist Álvaro Alonso Barba (1569-1662) demonstrated their nuanced familiarity with Empedoclean root theory and Aristotelian natural philosophy, the "fundamento de estos maravillosos efectos" and "gustosísimo espectáculo" (the foundation of these marvelous effects and most enjoyable spectacle).[109] As Barba describes the cosmological flows of antipathy or discord (*discordancia*) and sympathy or convenience (*conveniencia*) in the sublunar and supralunar worlds, he traces the long line of natural philosophers whose traditions he has inherited: Empedocles, who established the "origin and universal seed of all of the generation and decay of the world" from the subterreanean mines of precious metals " as far as the heavens celebrated by the "elegant verses" of Manilus and "the rudimentary lessons of judicial astrology." Barba places the natural origins of the similarity, concord, and friendship of some elements, and the difference, discord, and enmity among others, in orthodox traditions of natural and moral philosophy. He applies these cosmological conventions of similarity and difference to his

metallurgical essays, explaining the particular friendships and antipathies among the mineral bodies of Alto Perú, namely lead and tin, and clarifying the role of iron and mercury in the method of amalgamation: "sólo del plomo es amigo el estaño, a los demás destruye y aborrece. Con particular virtud recoge y junta el hierro al plomo y revivifica al azogue, ya casi muerto y destruido. El imán de la plata es el cobre, que con justa admiración de los que lo ven, atrae a sí lo que estaba hecha agua y la reduce a cuerpo: experiencia antigua en el mundo, y que pudiera mucho antes de ahora haber abierto los ojos a los que han tratado de metales, para por su medio sacarles más seguro y fácilmente la plata que tuvieran" [only tin is a friend of lead, for it destroys and loathes the rest. With particular virtue iron gathers and unites lead and revives the mercury, which had been almost dead and destroyed. The magnet of silver is copper, and with the deserved admiration of those who see it, it attracts to itself what was in the water and reduces it to body: a time-honored experience, and one that much earlier could have been used to extract silver with more certainty and ease had they who worked with metals opened their eyes.]

Barba's appeal to standard analogical thinking informs his metaphorical language -- "el imán de la plata es el cobre" -- and circumscribes the newness of his "nuevo beneficio." Instead of emphasizing the novelty of his heat-based amalgamation technique, Barba appeals to the "experiencia antigua en el mundo," the long tradition of metallurgical practitioners who operated with the same natural philosophical theories and, therefore, could have identified the same refining methods to treat silver more efficiently. The passages that lead up to his description of the amalgamation method, then, accord with and indeed reproduce the established conventions of the natural philosophy.

But in his explanation of the amalgamation process, Barba reconfigures the very terms of similarity and difference about which he has so carefully demonstrated his theoretical mastery. He draws upon the concepts of sympathy and friendship to describe the amalgamation of silver and mercury, but he also extends a generative potential to their sameness when he describes the reaction. First, Barba establishes the essential sameness of mercury, a cold and humid viscous body ("un cuerpo líquido … de sustancia viscosa, y muy sutil, abuntantisima con humedad, y muy frio"), with metals in general, suggesting that despite its difference it is yet the same as other metallic bodies. Mercury, by nature, shares "tanta conveniencia" (such convenience) with metals, "que aunque no es ninguno de ellos, es convertible en todos, no sólo por ser uno de los principios de que se compone, como los más de los filósofos afirman, y prueba la facilidad con que con todos se une e incorpora, sino también porque con toda su sustancia se transmuta en metal verdadero que como los que de naturaleza nacieron tales sufre los exámenes del fuego y del martillo" [although it is not one of them it is convertible into all of them. And this is not just because of its principle components, as the philosophers affirm, and is proven by the ease with which it unites and incorporates with all metals, but also because all of its substance is transmuted into true metal, the same as those metals that by nature are born to suffer the trials of fire and hammer].[110]

For Michel Foucault, this "convenience" marks the boundaries of sameness and difference, for "Those things are 'convenient' which come sufficiently close to one another to be in juxtaposition: their edges touch, their fringes intermingle, the extremity of the one also denotes the beginning of the other."[111] But for Barba the fluid physical properties of mercury also mark the porous borders of its interaction with other metals in

the amalgamation process: the friendly sympathy of likeness becomes the profane desire of unlikeness. On the one hand, mercury is not a metal, and so it is different from the other *castas* (castes). But on the other, because it can be converted universally into the metallic kingdom, it is like any other metallic body. With the intervention of human agency, as experience proves, rather than textual modes of transmission "que quizá no se entienden" (which are perhaps not understood), mercury can transmute into a metal like cold, moist silver. This conversion, "when one suspends the credit due to the written word," which, after all, was poorly understood, has been first-hand and first-sight by the many local miners and metallurgists ("son tantos los testigos de vista en estas Provincias") "que tienen oy, y guardan plata refinada muchas veces por copella hecha de azogue por sus mismas manos" (who have and hold silver that many times has been refined with their own hands using mercury and a cupel). So it was that mercury and silver shared a common nature (*naturaleza*) that Barba recognized with the language of similarity and agreement – "conveniencia," "la natural conveniencia y concordia." Or, in the case of *caparrosas* (iron sulfates, $FeSo_4$), a mineralogy that Barba glosses in the racialized language of caste and identifies with its indigenous name ("de cuya casta son las que llaman Copaquiras"), he invokes the language of antipathy and enmity: "La Caparrosa, sola, enemiga capital del azogue, le dá el color que llaman plomo falso," "son mortals enemigos del azogue y los desbaratan" (the *caparrosa*, alone, is the capital enemy of mercury and it gives it a color that they call false lead; [*caparrosas*] are enemies of mercury and they destroy them).[112]

For the New Spanish physician Juan de Cárdenas, these same principles of friendship and enmity shape cosmological interactions between and among planets and

plants, minerals and men. The "particular amistad y conveniencia entre los planetas del cielo y algunas cosas deste universo" are also observed "acá, entre las mismas cosas y cuerpos inferiores deste mundo, ay algunas que tienen entre sí grandíssima amistad y analogía y otras, al contrario, terrible enemistad y odio" (the particular friendship and convenience among the planets in the heavens and some things of this universe are also seen here, among the lesser things and bodies of this world, where there are some that have among themselves such great friendship and analogy, while others, to the contrary, have such terrible enmity and hatred).[113] Mercury and silver are, without a doubt, friendly bodies – "por la ya dicha amistad," "como es tan amigo y familiar a la plata," "la tal amistad y analogía," "es tan semejante a la plata" (for the aforementioned friendship, as it it is such a friend and so similar to silver, such friendship and analogy, it is so similar to silver). These analogous friends are attracted to each other by their virtuous sameness: "Esta Amistad podemos conjeturar que procede de la gran similitude que estos dos minerales tiene, pues son tan semejantes que en color, en complessión, en peso y apariencia exterior casi no se differencian" (This friendship, we might conclude, procedes from the great similitude of these two minerals, for they are so similar that in color, complexion, in weight and in exterior appearance they almost cannot be differentiated, 118). Sameness and similarity, as philosophers like Aristotle, Cicero, and Montaigne had argued, were the defining elements of friendship among human bodies, and so in the analogical thinking of early modern natural philosophy, it was both logical and conventional for two minerals of similar composition and nature to unite under the auspices of friendship. But the love of human friendship was a sympathetic affinity that was decidedly not generative, while the friendship of the sympathetic metals of silver and

mercury proved remarkably effective in causing matter to change shape. If the language of friendship and analogy was conventional, the generative power that colonial Iberian miners and metallurgists ascribed to the friendship of metals in the new method of amalgamation was wholly unconventional and, indeed, quite new.

The material technology of amalgamation and the cultural work performed by the language in which the method was explained transformed friendly sameness into a relationship dominated by desire, appetite, embrace, and penetration, the kind of productive terms typically reserved for the generative couplings of opposites. According to Cárdenas, it was precisely the foundation of friendship that enabled the amorous, generative embrace of silver and mercury in the amalgamation process, as "el azogue, por la ya dicha amistad, se abraça con la plata" (mercury, through the aforementioned friendship, embraces silver).[114] Cárdenas continues, positing friendship as the enabling condition of embrace in his description of the mineral mixture: "se hechan y encorpora el azogue, a fin de que, como es tan amigo y familiar a la plata, mediante la tal amistad y analogía lo abraçe" (they are cast together and the mercury incorporates the silver, such that it embraces the silver through their friendship and analogy, as the mercury is such a friend and so familiar with the silver).

After their elaborate explanations of the theoretical principles that inform the friendship of silver and mercury, Cárdenas and Barba use two different rhetorical strategies to conclude their discussions and explain the productive power of sympathy. Cárdenas analogizes the friendly relationship of silver and mercury to other materials, likening their embrace to the bond of iron and magnets, and their need for heat and time to the conditions required for medicinal cures to take effect in the human body. The

metallic analogy allows Cárdenas to insist that a basic comprehension of the theoretical conditions of the friendship is required to appreciate the technologies of amalgamation, expressed in medical analogy. First, the metallic analogy of friendship transformed, like the mercury itself, into a form of desire: "El fin para que todo esto se ha dicho es para que entendamos que el azogue y la plata tienen entre sí tanta amistad, analogía y conveniencia que, con la misma inclinación y propensión que la piedra imán llama y se abraça con el azero, por la amistad que le tiene, de esse mismo modo se ha de presumir que se aman y apetecen la plata y el azogue, procurándose mediante la dicha amistad abraçar y unir el uno con el otro" (The reason why all of this has been said is so that we understand that mercury and silver have among themselves so much friendship, analogy, and convenience that with the same inclination and propensity with which the magnet convokes and embraces steel, in this same way one must understand that silver and mercury love and appeal to each other, securing through their friendship an embrace and a union, the one with the other, 118). Then, he explains how their amalgamation requires heat and time "para poderse incorporar y fermentar, ansí esta massa de plata, metal, y azogue, para poder entre sí recozerse, abraçarse y encorporarse" (to be able to incorporate and ferment itself, so too this mass of silver, metal, and mercury, to be able to gather, embrace, and incorporate itself). This "acto y obra de abraçarse" (act and art of embracing) requires a stimulus "para aver abraçarse con la plata" (to be able to embrace silver), just like medications need our heat ("nuestro calor") and elapsed time to take effect in the human body (119). In the tradition of analogical thinking, the interaction and mutual needs of silver and mercury were explained in the same terms as the medical treatments recommended by the author of what historian Jorge Cañizares Esguerra calls a

"pathbreaking" work of colonial science.[115]

Barba, for his part, confirmed the technical importance of heat and the use of analogical, affective language to explain the application of heat to the mineral mixture. With only a little heat ("Bastante es pequeño fuego") the priest-metallurgist of Alto Perú suggests that mercury will embrace the whole of the silver – "a abrazar todo el mundo," "el azogue abrazará la plata." He found this kind of mineral union to be proportional to the "natural animal heat" of other animate bodies ("El calor natural en los animales, está sujeto al mismo inconveniente, y proporcionalmente pasa en los cajones de metal lo propio," 85, 86). The syncretic vision that here guides Barba to frame animal and mineral attraction in the same language as human terms of friendship and desire comes from natural philosophical traditions of analogical thinking and Christian readings of the Book of Nature. These analogical patterns and theoretical principles were confirmed, Barba argues, by the experience of miners and metallurgists who witnessed the transformation of mineralogical similarity into a more intimate union.

In Barba's explanation of the Peruvian adaptation of the New Spanish method of amalgamation, the language of friendship and analogy give way to one of desire and difference. The productive union of likes is naturalized by the compositions and effects of the minerals themselves, as he explains that "El azogue es en su naturaleza está dispuesto para brazar la plata y unirse con ella" (mercury is in its nature disposed to embrace silver and unite with it), for "La vecinidad y conveniencia que tiene la naturaleza del azogue con la de los metales, bastante se manifiesta, cuando faltasen otros argumentos, por la facilidad con que ellos se une, los penetra y embebe conviertiéndolos en lo que llamamos Pella; compañía que con ninguna otra cosa hace..." (The closeness and convenience that

mercury has naturally with metals is clearly shown, absent other arguments, by the ease with which it unites with the metals, penetrates them and becomes imbued, converting them into what we call Pella; it keeps no such company with any other thing).[116] So when the philosophical explanations of their similarity fell short, the friendship of mercury to silver was proven by its unique ability to convert silver into *pella* or an amalgamated body. This insistence upon the primacy of experience and the (slightly subordinated) explanatory power of analogy crystalize the ways in which contradictory conceptual frameworks and discursive formations circumscribed and made possible the epistemological and technical advances of colonial Iberian mining and metallurgical sciences. A friendly union enabled by "closeness" or "convenience" was one thing, but acts of "union," "embrace," and "penetration" that cause matter to change shape suggest a different type of relationship.

In these accounts of amalgamation, the language of friendship – "amistad," "amigo," "analogía," "conveniencia" – is intermingled with the deeply embodied language of a more than friendly union, its fluid borders of essential sameness opening up into an erotic act of embrace and penetration informed by mutual appetite. The language of difference and desire in the letters of Cárdenas and Barba – "se abraça," "se aman y apetecen," "abraçar y unir" – brings to the fore the carnal implications of "encorpora," to incorporate or become one body, the material act of transformation that underwrote the founding of colonial life in Spanish America.

The affective language of desire commanded by Barba and Cárdenas to explain the new technology of amalgamation also provided the terms through which colonial administrators accounted for the problem of population. In his *Pretensiones de la villa*

imperial de Potosí (Madrid, 1634), the doctor Sebastian de Sandoval y Guzmán, *procurador* (attorney general) of Potosí employed the overlapping discourses of metallurgical technologies and population management to explain how the material work of mining and metallurgy authorized the religious and cultural work of the Spanish empire in the Americas. The "concession" granted to the Catholic Kings, Sandoval y Guzmán argues, is contingent upon the propagation of the faith and the incorporation of indigenous Americans into the church universal: "que auian de promulgar nuestra santa Fé Catolica en aquellas partes, y reducir por todos los medios que pudiessen a los Indios, para que la abraçassen, y permaneciessen en ella" (they had to promulgate our Holy Catholic Faith in those parts, and reduce the Indians to civilization by all available means, so that they embrace the faith and belong ever to it). Reduction (*reducir*) was both a political framework inherited from Roman jurisprudence and the metallurgical process of crushing that was performed in the first stages of mineral refining. Like "embrace" (*abrazar*), the term signaled its continuity with an authorizing precedent and at the same time marked the ways in which colonial Iberian writers were transforming the received traditions of the past. Chapter two explores in more detail the biopolitical consequences of this language new and not new.[117]

The material and cultural work of the new benefit of amalgamation was naturalized in the received language of antiquity just as Renaissance scientific writers innovated – for better and worse – from the inherited paradigms of Aristotelian natural philosophy and Roman imperial precedent. By analogizing mineral interactions to micro- and macrocosmological relationships, colonial Iberian mineralogical writers identified a vocabulary and conceptual framework with the linguistic and doctrinal flexibility to

accommodate the newness of the *nuevo beneficio*. Because historians and historians of science have been more interested in the measurable economic results of this revolutionary invention, or the countable advancements in new mining instruments that the method of amalgamation occasioned, they have dismissed the language of these treatises as a kind of embarrassingly alchemical vocabulary "con palabras de sentido poco preciso" (with words that have little sense).[118]

But these terms do, in fact, hold great sense – the shift in the affective language of friendship to that of desire marks the moment in which colonial Iberian scientists reconfigured the epistemological paradigms of the natural philosophy. The inherited language of friendship or similarity was transformed into a language of desire or difference in the conversion of matter into a new form: *pella*, a slippery, shiny, gray-black amalgam in which the contradictions of received natural philosophy and the lived social conditions of the Americas come to a head. Friendly bodies did not express this type of desire, for friendship – which was based upon a fundamental sameness and coincidence in virtue – could not be generative, nor could a union of like to like cause matter to change form. That productive and reproductive capacity was reserved only for the yoking together of contrary bodies like male and female, or hot and cold. For whatever the attractive properties of sameness may have been, it was only "la diferencia que causa novedad y despierta el deseo" (difference that causes novelty and awakens desire), as Dorotea puts it in the eponymous work of Lope de Vega (1562-1635).[119]

And yet Barba insisted that it was "natural" for mercury to adopt this singularly transformative role and to combine with silver, a friendly body, in intimate union: "por alguna semejanza que le tiene," "por razón de la natural conveniencia y concordia" (for

some similarity that it has with it, because of its natural convenience and concord, 80). Because the method of amalgamation suggested a new meaning of friendship and similarity, but because novelty was suspect in a world in which there was "nothing new under the sun," writers of amalgamation treatises developed a richly symbolic language through which to naturalize the novelty of their new benefit. Likewise, these methods had been proven by collective experience, but knowledge was validated by coherence with received principles transmitted from the texts of the past. In their negotiations of the continuities and interventions of colonial Iberian mineralogical science relative to the received wisdom of the past, then, writers and practitioners like Barba and Cárdenas helped to formulate the terms through which the diverse linguistic and cultural communities brought into contact by the silver industry would be classified.

I have so far underscored the role of similarity and difference as scientific epistemes that were reworked in colonial Iberian amalgamation treatises, but key terms like "casta," "mulato," and "negrillo" used to taxonomize metallic bodies were also applied to organize the mixed-race human populations who developed their mineralogical knowledge and applied their labor to the profitable mining and minting of silver. Whether the terms originated in human interactions and were mapped onto metals, or whether the metals inspired the use of these terms in political and social categories is difficult to determine, as matters of origin always are. But what is clear is the coeval rise of mineral science and colonial society: the new technology of amalgamation and an increasingly complex system of color classification and mineral sorting were practices perfected by increasing numbers of mixed-race peoples whose emergence brought forth a proliferation of terms designed to taxonomize these new demographic amalgamations.

In the deep tradition of analogical thinking, the same terms that were used to classify human relationships – terms of friendly and romantic love, negotiations of purity and caste – were applied to the mineral bodies of silver and mercury. According to Barba, when it was necessary, mercury could be "cleaned" to increase its generative ability in embracing and gathering silver: "que lo limpie, para que major abrace y recoja la plata" (80). The term "limpiar" echoes the language of the *limpieza de sangre* applied to explain and rank the reproduction of human bodies, two animate groups whose analogical continuity was revealed in their overlapping classifications. Like so many human bodies, metals were organized into "castas" or caste systems that proved mutually constitutive with the racial and categories that were used to categorize the physical body in terms of color and composition, and to classify one's inner essence in varying degrees of savageness (*metales salvajes*) or cleanliness (*metales limpios*), of states of purity (*pureza*) and or evil (*maleza/malicia*). The silver varieties named by the Spanish as *metales mulatos* and *negrillos* were the most common silver mineralogies of the Americas, and they were also marked as the most "resistentes al fuego" (resistant to fire). Because of the complex mineralogical composition of these black hued bodies, they could not be treated with mercury or other reagents without first being heated. But the longer they remained in the fire with the goal of being cleaned and purified ("se limpiaran y purificaran"), the more vile and impure they became: "pues al paso que dura más la quema, se aumenta y aviva la maleza."[120]

The solution, as Barba explains in prose and engineers like Simon de Corona y Orihuela and the physician Lope Saavedra Barba revealed in their designs of new open-topped ovens, was to combine elements of the Iberian method of amalgamation with

indigenous Andean methods of heating ore. As these metallurgists discovered through trial and error, *negrillos* needed to be heated before they could be amalgamated. The open-top ovens developed by Corona y Orihuela and Saavedra Barba allowed more sulfurous particles to burn off as the mixture was exposed to heat. This innovative design led to greater yields of silver because more of the precious matter was retained during the various stages of metallurgical processing.[121] In collaborative experiments and exchanges of ideas, then, colonial mineralogical science performed in real material terms the kinds of generative amalgamations of New World and Old World knowledges and practices contained in its theoretical formations. The metallurgical practitioners who had reworked the inherited traditions of the natural philosophy and redefined the borders of sameness and difference were also the people who formed the newly amalgamated body politics of Iberian America. In some treatises, the technical explanation of amalgamation converged with the prominent place of indigenous and African miners and metallurgists in making possible the new technology. In chapter two, I explore in more detail the economic underpinnings of these different natural vocabularies. After all, not all writers emphasized the work of African and indigenous miners and metallurgists, not all writers incorporated non-European practitioners into their technical accounts of the amalgamation method, and not all writers used the language of affection, either friendly or erotic, to narrate the reaction. But the writers who test the analogical limits of affective language do so strikingly.

In the eighth step of the amalgamation method, mercury and silver became one body and miners became responsible for separating the excess mercury from the refined silver. The ability to join and to separate, what the New Spanish priest Alonso de la Mota

y Escobar (1546-1625) would identify as the particular skill of indigenous miners and metallurgists, was reinforced by the literary incorporation of human laborers into the treatises of Cárdenas and Barba. In other words, when these minerals were united under the bond of their great friendship and sameness, Cárdenas and Barba incorporate into their narratives the synechdotic human hands and feet responsible for the process of metallurgical amalgamation. For these authors in particular, the language of the technology instantiated the cultural work of amalgamation; as the physical amalgam of silver and mercury took shape in the newly generative attraction of like to like, so too did colonial Iberian writers bring to the fore the embodied labor of indigenous and African men and women. Cárdenas in particular foregrounds the role of African women and indigenous men in producing the *pella* amalgam that "es lo que se desliza al tiempo de lavar y esto es lo que hallan las negras o indios en el río, cuando van a buscar polvillo y pella" (slides away in the washing process, and this is what black women or Indians find in the river when they look for dust and amalgams).[122]

These technical practices of sorting and classifying drew from the codes of daily life, both the color categories that came to constitute or deny personhood, like terms like *negrillo* or *mulato*, and the broader frameworks of social relationships that were catalogued under the name of friendship and profaned as desire. The epistemological paradigm of friendship or similarity, and the racialized terms of colonial mineralogical science, helped to give the language and images of mining and metallurgy their foundational positions as authorizing discourses of settlement. Color – black, red, copper, and white, but also blue, green, and yellow – is an important indicator of mineral composition, but like any of the other senses used to detect and classify metals, such as

taste or touch, it was notoriously suspect. For example, some natural philosophers misclassified the humid humors responsible for mineral shine, causing Barba to complain in his discussion of the white lustre of silver, "no sé con qué ojos la miró Cardeno, cuando le pareció negra" (I don't know what eyes Cardeno used when he looked at it and thought it black). Experienced miners would also fall prey to a misreading of mineral colors, especially when the metals in question were considered especially sympathetic or similar. The power of color to shape naming practices in Potosí was not limited to the Iberian colonizers, however. Spanish speakers followed Andean miners and metallurgists in benefiting "ppacos" (reddish) and "oques," a Quechua term that Barba translates as "frailesco" (friarish), a grayish ore so named by indigenous miners after the gray-robed Franciscan friars who missionized throughout Peru. Despite the broad borrowing of indigenous terms in color classifications and metallic caste systems, however, the use of indigenous languages to name metallic bodies (*oques*, *Llipta*), labor systems like independent wage contractors (*yanaconas*) and forced laborers (*mitamayos*), and mining processes like sorting (*pallar*) and technologies like ventilated ovens (*guayras*) did not carry the same cultural or economic weight as the naming practices of Spanish speakers and their racialized terms of *metales mulatos* and *negrillos.*[123]

And yet the tendency of metallurgical writers like Barba to intermix Spanish, Quechua, and Aymara names for metals, especially in cases where the color variations of the ore defied categorization in any single "caste," is illustrative of the hybrid material practices produced by colonial mineral science. The power structures were remarkably asymmetrical, to the say the least, but the naming practices and hybrid technologies transferred within and throughout the "two republics" reveal the closeness and

convergence of New and Old World agents of mineral science. In one of the most detailed explanations of the "suertes o diferencias generales" (types or general differences) that miners use to classify and "reduce" minerals, Barba's taxonomy of "Pacos, Mulatos y Negrillos" reveals both the fluid borrowing of indigenous terms and the power structures embedded in color classification of mineral bodies.[124]

The term "ppaco," from the Quechua "p'aqo," (reddish), "en la lengua general de esta tierra, quiere decir Bermejo, color que más o menos encendido es el ordinario de las piedras, que llaman Metal Paco" (in the common language of this land, Paco means Bermejo, which is more or less the fiery color that we ordinarily associate with rocks, so they call the metal Paco), Barba explains in the conventionally circular language of the treatises. But this classification adopted from Quechua speakers is anything but stable, as the term "reddish" could be applied to ores with significant copper components, which would make them appear turquoise, the color of untreated copper, and the name of the metal could vary from region to region: "aunque también a metales verdes cobrizos llaman en Berenguela de Pacjaes, Pacos, y en estas provincias a los que cualquier color, a diferencia de los acerados y espejados, y otros que llaman Negrillos" [although copper-green metals are also called Pacos in the town of Berenguela, and in these provinces they use the term for any metal that is not steely or glassy, because those are called Negrillos].

The border between a paco and a negrillo, or a red and black hued silver ore, enjoyed a linguistic fluidity that was at odds with the material composition of these silver mineralogies; the mixtures of ferrous particles in pacos and sulfuric elements in negrillos meant that the two forms of silver would require different amounts of reagents, heat, and processing time. As Peter J. Bakewell concisely glosses the very different natures of these

silver mineralogies in the context of New Spain, where miners used the Spanish term "colorados" to describe the red-hued ores, "The basic distinction was between black and red."[125] These silver varieties also occupied different places in mining history, as the surface-level pacos had been exhausted in Potosí before practitioners began amalgamating the more common mineralogy of the negrillo, found at much greater depths. It was the exhaustion of the top-level ores that led Andean miners and metallurgists to practice amalgamation in the first place, and it was the introduction of this mercury-based treatment that underscored the different natures of pacos and negrillos. The chemical method of amalgamation proved that it was possible to harvest the productivity of negrillos in a way that heat-based refining techniques could not.[126]

If pacos and negrillos represented two ends of the silver mineralogy spectrum, the mediating place of "mulatos" as a red-green body underscored even more the importance of color classification for metallurgical technology and the limitations of language to express the nature of mineral mixture. Barba defines the "Metal Mulato" as a metallic body that is somewhere between the Quechua-named "Paco" and the Iberian-defined "Negrillo." "Metal Mulato, es un medio entre Pacos y Negrillos, y así lo crió la naturaleza entre los dos: tiene el color bazo, y de ordinario le acompaña alguna Margarita: hay menos de esto que de los otros dos géneros…" [The Mulato Metal is a middle way for Pacos and Negrillos, and so nature created it between the two: it is splenetic in color, and ordinarily it is found alongside marcasite, and there are fewer mulatos than there are pacos or negrillos].[127]

Writing in the eighteenth century, the colonial historian Bartolomé Arzáns de Orsúa categorized the seventeenth-century understanding of a mulato metal as one that

either contained silver veins, like a negrillo, ("los unos tiene plata hilada (y esta se ve también en algunos quijos negrillos)"), or a green-hued variety that could be "reduced to pacos" with metallurgical processing: "son de color de cascaras de nueces verdes, y algunos son muy ricos y arman sobre espejuelos blancos que tocan algo en amarillo y tienen mucha plata blanca (algunos reducen este genero de metales a pacos)." The term "mulato," then, was used interchangeably with the label of *paco* for metals whose green exteriors gave off a white shine that tended toward yellow and contained a lot of white silver, and it applied just as frequently to the grayish *negrillo* ores so-colored by their lead sulphate and silver mixtures. If these are the foundational categories of mineral classification and constitutional categories of personhood, the descriptions of reddish pacos, green-black-silver mulatos, and black-gray negrillos arranged into metallic castes reveal how difficult it was to find a language that could accurately convey the outer composition and inner properties of human and non-human beings. These unstable color classifications speak to the tremendous degree of variation within a category, to say nothing of the fluid borders of color taxonomies and racialized colonial scientific terms used in relation to each other.[128]

After first establishing an elaborate color taxonomy based on stable color properties that run from white to black, gray, blue, green, yellow, red, and purple, Barba explains how to classify mineral varieties that share multiple hues. Light-blue stones are "jaspe, called bórea," while green-blue or blue-green stones are "cardenillo, armenia, or cibairo." A white stone that "tends toward red" (tira a rojo" is called "la afrodisíaca," while a red stone that is whitened ("que blanquea") is called "xanto." "De negro entre rojo, la batrachite. De negro que tira a purpúreo, el alabandico. De blanco que amarillea,

el topacio" [From black to reddish, batrachite. From black that tends toward purple, alabandico. From white that yellows, topaz] (63). The names and descriptions of each color property reveal just how easily an ore could move from red to white and white to red or yellow, from black to red or purple, or how one stone like egitilla could contain "two veins, one white and one red, that run parallel" (63). Color seemed very much to matter, but the matter of color could cross easily from complexions that were analogized to human bodies and humors like black, yellow, red, and white, into taxonomies that were not mapped onto human beings, like purple, green, gold, and blue. The mulato metal was, for some practitioners, so-named for its blackish exterior, which became, in the analogical tradition of Aristotelian natural philosophy, the "bazo" or "spleen" that Barba uses to classify its position relative to other blackish and reddish silver ores. With the intervention of human practitioners, green ores like copper could be made reddish, and black ores could be washed clean with mercury.

The mulato metal was just one of many silver mineralogies that fell somewhere between pacos and negrillos. "La Tacana," for example, was a high-grade silver ore that took a Spanish-language name when the mineral appeared in its blackest form, but was called "Llipta" (limestone) when it looked gray or ashy ("parda y cenicienta"). When it was smelted like lead, the blackish "tacana" could be reduced to a red-hued "paco," and so it was named "plata bruta" (crude silver), for "suele ser negro, pardo, ceniciento, verde, blanco y naranjado que llaman Suco" (customarily it is black, gray, ashy, green, white, and orange, which is called Suco). In the caste system of metallic taxonomy and the metallurgical technology of amalgamation, color was both an important property that guided classification and a notoriously unreliable mode of identification. This is because

the elaborate color classification was based on sight, or that faculty and mode of perception that Barba called "the most certain disillusion of the senses ("el más cierto desengaño de los sentidos").[129]

Part of the instability stemmed from the limits of human powers of observation, and part of the fluid color terminology reflected the material changes of the ores as they went from their raw state to their processed forms. Although the "negrillo" was so named by Iberian practitioners for their knowledge of its color ("conocimiento su color"), the name could not adequately cover all black metals. As Barba puts it plainly, "no todos los metales negros se comprenden debajo de nombre de Negrillos" (not all black metals are understood by the name Little Black Ones). Likewise, although the reddish color of Quechua-named "pacos" could also be applied to describe raw copper, and the black "negrillo" was also found tinged with copper or copper-like properties ("Lo que en el Negrillo principalmente prevalence es el cobre, o actual o virtual"), the reddish paco and the blackish negrillo were nevertheless the colors and mineralogies through which the "mulato" was defined in its intermediary position. What fixed some of these color values and accompanying naming practices was not the original states of the ores, but rather their appearances after processing. The color of ores when they were first extracted from the earth may have been flexible and unstable, and given to additional changes during the administration of heat and chemical reagents, but after the refining processes of reduction or crushing ("reducción"), purification ("purificación"), and cleaning ("limpieza"), the color properties of metallic bodies could be firmly established, and appropriate names could be mapped back onto those fluid outer forms. As with so much of the technology of amalgamation and of colonial Iberian mineralogical discourse, the problem of language

and color classification in particular is at once inherited from earlier traditions and one whose consequences would extend to new contexts and conditions in the Americas.[130]

The importance of color and the possibilities for misreading stem, both in learned Iberian discourse and in practical application in the Americas, from a long tradition of mining and metallurgical benefit. Color classification at once represented a point of continuity with earlier writers and an important point of departure. They could not have known so when they were writing in the early colonial era, but by the late colonial period the color taxonomies so carefully assembled by seventeenth-century writers became the foundational classifications of personhood in casta systems developed to put human beings and bodies into hierarchical order. What they did know, however, was that they were drawing from earlier traditions of mineral classification, especially those of the Roman empire upon whose imperial mines in Iberia so many seventeenth-century Iberian writers fashioned their accounts of mining in the Americas. According to New Spanish mining administrator Luis Berrio de Montalvo, the Romans did not just take precious metals from Spain. Rather, this glorified empire also planted its political and legal traditions ("Emperadores") in Iberian soil, preparing the peninsula with the policies of good governance and initiating the Adamic naming practices that the Spaniards would need to rightly colonize the Indies: "no solo se sacaba de España oro, y plata para el Imperio Romano, sino ta[m]bien Emperadores q[ue] la governassen." The translation of mineral knowledge from the Roman empire to the Spanish empire established a mineralogical precedent that would be performed anew in the naming of "New Spain," the region whose precious metals revealed their "similitude" with "todo lo qual se ha hallado junto, en España." As they referenced Roman imperial precedent to circumscribe

the novelty of Iberian mining and metallurgy, writers like Barba and Cárdenas moved away from color taxonomy and into explanations that would allow them to suggest that the "new benefit of amalgamation" was not entirely new.[131]

The writers of antiquity had long noted the similarity or friendship of silver and mercury and the interchangeability of the metals in their color and resemblance. According to Cárdenas, these metals were so similar that they had consistently confused the miners and metallurgists who were responsible for their classification and benefit. The one resembles the other to such a degree that their different mineralogical forms were collapsed into one one Adamic act of misnaming: "Y assi movidos los latinos desta gran semejanza llaman *argentum* a la plata y al azogue, y por esta misma semejança procuran cada día los alchimistas convertir el azogue en plata, aunque es todo su trabajo en balde" (and so moved by this great similarity the Latins call both silver and mercury by the name *argentum*, and for this same resemblance the alchemists seek incessantly to convert mercury into silver, although all of their work is in vain). The complete agreement of mineral body signals the limitations of human observation and marks the boundaries of natural knowledge – the epistemological formations of antiquity and the technical language that could properly classify what Barba would call in the racialized terms of colonial science, "esta casta de metal" (this caste of metal).[132] So the fundamental similarity of silver and mercury – their remarkable sympathy of physical body and elemental essence – was well-established in the natural philosophy of antiquity and in the confused language that miners and metallurgists applied in their readings of the two metals. But in colonial Iberian mineralogical science, the problem of language as a classificatory mode would be applied to new demographic conditions and silver

mineralogies, just as the same theories natural philosophical of friendship and similarity would be given different interpretations in the colonial scientific method of amalgamation. But not all writers used the language of friendship and desire to explain the chemical reactions of amalgamated metals, and not all writers transformed the language of friendly sameness into a generative union of profane love.

In their amalgamation, silver and mercury may have followed the same cosmological principles of friendship and antipathy as other minerals, such as the "embrace" of magnets and steel, but other metallurgical interactions often took a more neutral language and other writers avoided these affective registers entirely. According to Barba, the most widely-studied colonial metallurgical author and a great promoter of the shifting terms of metallic friendship and desire, the mercuric particles of lead, for example, simply resist melting ("ni se derrite al fuego"). There is no elaborate language of affection or desire in Barba's description of the cold, dry, porous metal that "si no es el más precioso, el más necesario de todos los metales" (if it is not the most valuable, it is the most necessary of all the metals), as abundant as silver "en aquestas provincias fertilísimas de todo genero de ellos, aunque nadie se ocupa en su labor" (in those provinces teeming with all species of metals, although no one sees to their benefit).[133]

Like their early modern English peers, colonial Iberian scientific writers like Barba and Cárdenas could describe the interaction of silver and mercury in the richly symbolic terms of human emotion and behavior – friendship and desire, appetite or embrace – or they could adopt a more technical register composed of what Cárdenas calls "términos o bocablos de repassar, encorporar, juntar y otros semenantes" (terms or words like mixing by hand or foot, incorporating, joining, and other such phrases) that are

unfamiliar to "aquellos a quien Dios ha hecho tan señaladas mercedes de no hazerlos mineros" (those whom God has granted such great mercy in not making them miners). When Cárdenas explains the amalgamation method with verbs like "se mezcla, encorpora y repassa hasta venir a tomar la ley" (they are mixed, incorporated, and stirred by hand until the silver comes to its grade or weight), he employs technical terms that, he claims, more general audiences might not understand (because God has spared them from the labor of mining and metallurgy).

These more neutral terms were rather preferred by writers like Luis Capoche (1585) in Potosí and Gonzalo Gómez de Cervantes (1599) and Luis Berrio de Montalvo (1643) in New Spain, all of whom described the interaction of silver and mercury with verbs like "tomar," "recibir," "sacar," "amasar," "cuajar," "incorporar" (take, receive, remove, amass, come together, incorporate).[134] When Cárdenas narrates mineral interaction in the language of human behavior – appeal, embrace, love – perhaps he thinks that he is clarifying the process of amalgamation for his readers. But all five writers described the same physical reaction and technical process with the same set of inherited traditions and Barba, it is worth pointing out, makes no such claims about clarity of language or natural vocabulary.

The reason why these authors narrate the same metallurgical technologies in remarkably different terms is the subject of the next chapter. What I have emphasized in this chapter are the ways in which the same natural philosophical traditions are understood and applied in different ways by early modern English and Spanish scientific writers. Only by reading the preeminent scientific discourses of the two largest empires of the Americas, the agricultural letters of British America and the metallurgical texts of

Iberian America, can we appreciate the ways in which they converge and diverge. The English and the Spanish have often been read in terms of their fundamental difference, especially in the histories and literary histories of the Americas, but the question of similarity and difference goes beyond historiography. These are the scientific principles through which early modern practitioners understood what made plants grow from grafts and sets, how to purify and process metals, and where this work might fit in a topsy turvy world of analogical thinking and Christian inversion. But similarity and difference are also the social terms through which writers framed their relationships to others like and unlike their own kinds, and they are the fluid terms that, paradoxically, were firmly rooted to the particularities of context. As Aristotle had insisted, that which was like could also be made unlike, depending on the larger context.

As the next chapter suggests, it was the contextual economics of mine ownership, rather than any scientific theories or results, that led some colonial Iberian scientific writers to adopt a natural vocabulary of friendship and desire and others to endorse a more neutral register. By comparing the conditions in which Iberian mining and metallurgical sciences were developed with the context in which English agricultural theories and practices emerged, I make the argument that the shifting ideas of sameness and difference in Iberian sciences informed and were informed by the new modes of collaboration and competition occasioned by the new demographic mixtures of the colonial Americas. The generative idea of mineralogical friendship newly naturalized by writers like Cárdenas and Barba, in other words, is indebted to and helps to texture the social, political, and economic definitions and applications of what Michel de Montaigne (1533-1592) famously calls, in a fine agricultural metaphor, “the sweetest and most

perfect fruit of human life."[135]

The Incredible Likeness of Being:
Friendship and Sympathy in Colonial Science and Society

English agricultural writers and Spanish mineralogical writers drew upon the same traditions of natural philosophy, and they framed their work at home and in the Americas within the conventions of Empedoclean root theory and Aristotelian analogies. In the last chapter, I examined how the natural philosophical principles of similarity and difference – like and unlike, friendship and enmity – informed agricultural and mineralogical sciences in different ways. The agricultural science of planting that became the preeminent discourse of Anglo American settlement was based upon the productive or reproductive value of difference. By pitting contrary forces against each other, English husbandmen brought out the contrary forces of soils and seeds whose "constant opposition" generated new botanical matter and produced fertile harvests of market-ready crops. But in colonial mineralogical science, the preeminent scientific discourse of seventeenth-century Spanish America, the same principles of like and unlike were applied in a different way. Miners, metallurgists, and merchants in New Spain and Alto Perú identified a generative potential in two metallic bodies long celebrated for their inner and outer sameness. According to the natural philosophy, silver and mercury should have been too similar to cause matter to come into body, but colonial metallurgists revealed that these analogous ores could be profitably put to work. By mixing silver ores with mercury, the "friendship" of the two cold metals proved mutually attractive, the one seeking its resemblance in the other and drawing it to its likeness. Just as human friends

were attracted to each other by a correspondence or similarity of virtue, so too was semblance or sameness the cementing agent of sympathetic metals like silver and mercury. But unlike the human friendships to which this metallic mixture was analogized, the friendship of silver and mercury gave way to a more intimate union whose ability to cause matter to change shape and bring the amalgam *pella* into body suggested a form of love that earlier natural scientists had only ascribed to the attraction of opposites and unlikes. The theoretical principles and practical applications of the new technology of amalgamation, then, suggested the ways in which mineral bodies refined for human benefit might reconfigure the definitions of sameness and difference inherited from the natural philosophy of Empedocles and Aristotle, and how the new method of amalgamation in colonial Spanish America might also remap the borders of friendly affection and erotic love.

All of the metallurgical treatises that dealt with the new benefit of amalgamation employed the same theoretical frames and described the same technical processes, but they used two very different natural vocabularies to explain the material and human interactions involved in the technologies of mining and metallurgy. Some writers, like Álvaro Alonso Barba and Juan de Cárdenas, narrated the interaction of mercury and silver in the intimate language of a friendship that crosses into desire, while other writers, like Luis Capoche and Gonzalo Gómez de Cervantes, avoided this affective language altogether. Still others, like Luis Berrio de Montalvo, drew from natural philosophical vocabularies of friendship and sympathy but did not invoke the terms of erotic love to signal the moment when metallic friendship became productive. These differences within Iberian metallurgical letters owe something to the Aristotelian and Ciceronian language

of friendship that was rehabilitated by Renaissance writers like Montaigne. As historians and literary scholars like Tom MacFaul, Alan Bray, Laurie Shannon, and Lorna Hutson have shown in their recent studies of early modern friendship theories, sameness was central to that era's ideas and idealizations of friendship. In their complex recuperations of classical models of friendship, early moderns developed frameworks through which markers of difference like gender and class position, and, later, race, could be both solidified and reconfigured through dramatic enactments of the bond of equals.[136] This impressively detailed body of work, alongside anthropological and sociological scholarship,[137] is important for understanding the ways in which English agricultural writers and Spanish mineralogical authors fashioned their ideas of friendship among equals – that is, how they represented their relationships to and collaborations with other Anglo planters or Iberian miners, and how they analogized the sympathies and antipathies of human and non-human beings.

But the philosophers of antiquity offered another definition of friendship that was more useful for understanding political friendships, or the political function of friendship, more characteristic of colonial scientific collaborations. In the *Politics* and *Nichomachean Ethics*, Aristotle articulated a model of friendship whose analogical capacity to forge a bond of similarity in the presence of difference allowed buyers and sellers, citizens and non-citizens, and masters and slaves to identify in their very different interactions a kind of friendship. The commercial and political context of Aristotelian models of friendship, or what MacFaul calls an "ideology of friendship" in the context of patronage appeals like Spenser's to Raleigh and Elizabeth, are key elements in colonial Iberian mineralogical texts and their descriptions of collaborative work of indigenous,

African, and European practitioners in developing and executing the new method of amalgamation. Most studies of friendship in the seventeenth century have focused on humanistic traditions and the politics of friendship, separating the social world of human relationships from scientific studies of nature for human benefit. Even in histories of science, friendship is analyzed more for its ability to connect natural scientists, collectors, patrons, and practitioners in collaborative networks of epistemological and material exchange. Less studied are the ways in which friendship and sympathy serve as organizing scientific principles.[138] As the last chapter showed, friendship was a foundational term received from the natural philosophy of antiquity, and inherited definitions of similarity and sameness guided human essays into agricultural and mineralogical scientific study and practice. It was also, in analogical fashion, a frame through which to understand the relationships between and among the planters and husbandmen and miners and metallurgists who used their study and experience to practice their crafts. In this chapter I try to bring these two applications of the terms of friendship into dialogue. How might the science of friendship impact its social meaning in collaborative scientific practices? What might be the relationship between colonial scientific writers' participation in these friendly networks and the theories of similarity or difference that they endorsed in and through their work?

Chapter one focused on the scientific applications of the principles of friendship or similarity, while this chapter looks at their analogical applications in human relationships and behaviors. Because of the scientific and discursive prevalence of analogy and analogical thinking, the human and the elemental, the social and the scientific, were two sides of the same coin in seventeenth-century scientific letters. All

bodies in the sublunar realm, whether human, plant, or mineral, were animated by the same divine forces and understood in terms of their correspondence. By comparing the differences between and among English agricultural letters and Spanish books of mining and metallurgy, we can better understand the ways in which these texts put pressure upon the social and scientific meanings of like and unlike – the ways in which colonial planting and amalgamating test the limits of analogy as a conceptual and discursive maker of similarity and difference. Because friendship has been so well-studied in early modern English letters, and because the collaborative modes of scientific thought and practice have been discussed in excellent detail within the larger British Atlantic world, this chapter provides only the briefest of summaries of the English context and focuses mainly on the Iberian side of the story. With a more nuanced understanding of how the received ideas of friendship and enmity were reconfigured in colonial technologies of amalgamation, I hope to provide scholars of the early Americas with a new interpretation of the hemispheric Iberian roots of Anglo-American narratives of friendship as social cement and scientific property.[139]

Following the historiographical paradigms established in early modern accounts of lettered men like Thomas Spratt (1635-1713), the history of English science once revolved around the institutional model of proto-scientific societies like the Royal Society. Spratt, the preeminent writer of English mercantile scientific visions, suggested that technological improvements originated in metropolitan centers like London and radiated outward, plotting a progressive course upon the broad terrain of English science -- "from the Shops of *Mechanicks*; from the Voyages of *Merchants*; from the Ploughs of *Husbandmen*; from the Sports, the Fishponds, the Parks, the Gardens of *Gentlemen.*"[140]

When historians of science like Raymond Phineas Sterns began to acknowledge a more dynamic model of exchange between colonies and metropolitans centers, they focused on the substantial contributions of an island like Jamaica to English scientific advancement. According to Sterns, “If both quantity and quality of scientific communications to the Royal Society be considered, Jamaica excelled all of the English colonies in the western hemisphere during the seventeenth century." But while these studies succeeded in making known to Anglophone scholars the broader, circum-Atlantic nature of seventeenth-century English natural science, they did not often acknowledge the Iberian scientific antecedents in Jamaica. For one hundred and fifty-odd years the Spanish empire controlled the island and experimented with agricultural, botanical, and medical sciences on the island, in alternating modes of collaboration and competition with native people, Africans, and diverse groups of Europeans.[141] As recent work in history, history of science, and historical archaeology makes clear, the scientific history of Jamaica is incomplete without reference to both imperial projects and their incorporation of native and creole knowledges and practices. Jamaica is an especially interesting case because of its physical landscape; its karst topography is like that of Puerto Rico and would have enabled Iberian colonizers to transfer natural knowledge and best practices between the islands, while settlers from the British Isles would have been more experienced negotiators of island microclimates.[142] Since the cultural turn in the history of science, historians of science, historians, and literary scholars like William R. Newman, Sarah Irving, Susan Scott Parrish, Ralph Bauer, and Walter Woodward have shown the ways in which dynamic circum-Atlantic exchanges of ideas, technologies, and material samples cemented the collaborative and commercial networks that underwrote scientific

advancement.[143] The important role of personal friendships and collaborative partnerships, and the valuable contributions shared among members of friendly societies and along communicative networks has been well-established in colonial British Atlantic scientific communities, like the Hartlib circle,[144] though the same cannot be said for the collaborative networks that also characterized seventeenth-century Iberian science.[145] This chapter joins a growing body of Iberian science scholarship and seeks to provide a comparative perspective that will contribute to the work of historians, historians of science, and literary scholars of the British Atlantic, to whom my own studies are indebted.

I. "coupled in strayte amitie, and unspeakable companie": Early Modern Friendship Theories

Friendship and love may spring from the same verb, as Laelius reminds his rapt interlocutors in Cicero's *De Amicitia*, but their shared etymological origins divide along the fault lines of similarity and difference: friendship is a union of similarity, while love is a bond of difference. Although "loue and friendship of suche knyttynges of good wills is sette on fyre for both *Amor* and *Amicicia* ben deryuyed of *Amando*," the learned Laelius says in the garden remove, the "knyttyng" and the metaphorical flame that characterizes the union are practiced in two very different ways, each befitting its own kind.[146] Friendship, which depends indispensably upon and draws its "grettest force" from complete unity of personhood, aims, and emotions ("willes studyes and felynges") can only exist among men who are completely self-sufficient and "hath no need of ony other outward helpe but thynketh that in hym self is all that he had need of" (75, 76v, 80v). The only way to be a friend, then, was to not need one – to have the innate "stableness & constau[n]ce" to stand alone, but also the good virtue to attract a similarly

good-natured soul: “they whiche ben good loue good folks and ioyne them vnto them” (85v). We are friends with people like us, the analogical thinking goes, because like attracts like: “ther is nothing that draweth ony thing vnto it ne that holdeth it faster than lyklynes draweth friendship,” for “ther is nothing more desirous of his lyke and semblable” (85v). Human friendship was based upon similarity and defined, then, against other types of love that were based on difference, namely biological kinship and romantic coupling. The union of like-minded and like-virtued men was superior to these other forms, Cicero argued through Laelius, because it operates outside of the reproductive economy and therefore is voluntary: we can choose our friends but not our families. Friendship was therefore defined as a more restricted form of love – not in the sense of devotion expressed by friends, but rather in terms of eligibility. Humans were universally capable of mating and producing families, but not everyone was found “most apte to friendship” (97). A person incapable of standing along – “Sely wymmen,” “they that were nedy,” and “they that were wretchid” – would seek to profit from the “helpe of frendship” instead of working for the “loue” and “Ioyous” experience of mutual reciprocity (84, 85). Because they are unwhole, women and poor men were considered wholly unfit for Ciceronian friendship, an exalted form of personal relationship characterized by the noble virtue, self-sufficiency, and fundamental sameness of one man of excellence drawn by his own volition to love one who was just like him.

Early modern writers throughout Western Europe eagerly responded to the Ciceronian definition of friendship as they carefully worked through the thesis that like attracts like in the human order. Baldassare Castiglione (1478-1529), in the edition of the *Book of the Courtier* that was “Englished” by Sir Thomas Hoby (1530-1566), ascribes the

attractive properties of friendship to a sameness that was grounded in "reason," for "reason willeth, that such as are coupled in strayte amitie, and unspeakable companie, should be also alike in will, in minde, in judgement, and inclination."[147] The firm bonds of friendship, then, represented the complete alignment of one's self with that of another. One hundred years later, the foundational role of sameness in learned definitions of friendship had changed very little. As the scholar Robert Burton (1577-1640) argues in the compendious section of the *Anatomy of Melancholy* that is devoted to melancholic forms of love, "similitude of manners ties men in an inseparable link, as if they be addicted to the same studies or disports."[148] The correspondents of the Hartlib circle would agree with these conventions, for as John Dury puts it in his description of his friendship with Hartlib, the Polish émigré, and Comenius, the Czech scholar, "though our taskes be different, yet we are all three in a knot sharers of one anothers labours, and can hardly bee without one anothers helpe and assistance."[149] Sameness was the cementing covenant of friendship, a powerful pull of similarity that connected like-minded and like-spirited individuals across national lines and native languages.

For Michel de Montaigne (1533-1592), whose essay "On Friendship" bisects the hundred-year gap and thousand-odd kilometers between Spain, where Castiglione was stationed as nuncio, and England, where Burton exercised his vocation as a priest, the virtues of sameness made friendship a more desirable union than heterosexual couplings. Montaigne praised same-sex attraction, in the form of friendship, for its temperance and moderation, noting how different it was from the suspiciously mercurial and mutable inconstancy of the bond of unlikes. The flame of heterosexual love "is more active, more scorching, and more intense" than that of friendship, "But it is an impetuous and fickle

flame, undulating and variable, a fever flame, subject to fits and lulls, that holds us only by one corner."[150] By contrast, he characterized the spark of friendly attraction as "a general and universal warmth, moderate and even." This "constant and settled warmth," terms inherited from the Ciceronian idea of a stable and well-balanced self, was "all gentleness and smoothness, with nothing bitter and stinging about it." The reason for the "fickle" and "feverish" nature of unsame-sex love was, Montaigne insisted, the same "silly women" of the Ciceronian tradition: "to tell the truth, the ordinary capacity of women is inadequate for that communion and fellowship which is the nurse of this sacred bond; nor does their soul seem firm enough to endure the strain of so tight and durable a knot" (167). In Montaigne's dismissal of woman's suitability for friendship, the language of faculty psychology and spiritual resolve was wedded to the image of a diseased body struck by "fever flame." In this triple convergence Montaigne reinforced the ways in which most women were intellectually, spiritually, and physically unfit to be friends. Men and women were, in Montaigne's formation, fundamentally and irrevocably different; they were not made for the mutual pleasures of voluntary friendship, but to join instead in the institution of marriage, a "constrained and forced" contractual obligation" designed "ordinarily" for "other ends."

The ideal relationship is not that of the "one flesh" shared by Adam and Eve, but the "one soul" shared within "two bodies." Standing in "ardent affection" as he bears witness to "the complete fusion of our wills," Montaigne narrates this "truly perfect" union of friendly bodies and wills: it consists of two souls that "with a like affection revealed themselves to each other the very depths of our hearts" (171). This "intermingling" with another represents an act of incorporation so complete that it

obscures its very origins: "our souls mingle and blend with each other so absolutely that they efface the seam that joined them, and cannot find it again. If you press me to tell you why I loved him, I feel that this cannot be expressed, except by answering: Because it was he, because it was I" (169). Or, to use the terms of agricultural and mineralogical science, the mixture so "perfectly" unites the two bodies that their original essences can never again be "uncompounded." "[I]t is," Montaigne writes, "I know not what quintessence of all this mixture, which, having seized my whole will, led it to plunge and lose itself in his; which, having seized his whole will, led it to plunge and lose itself in mine, with equal hunger, equal rivalry" (169). The language of mixture and the elusive alchemical "quintessence" serve as Montaigne's emblematic expression of the inexpressible transmutation of "one soul in two bodies." This deeply felt pouring of one into another, a process in which nothing is generated or lost and no new matter comes into being, shares with agricultural and mineralogical texts its basis in natural philosophic theories. And this is why, for all of his ecstatic celebration of the excellence of true friendship, Montaigne is careful to distinguish his theory of friendly affection from "that other, licentious Greek love" (168). The union of friends is by definition non-productive; whether it is a matter of human friends or the sympathies of animate plants and minerals, the sameness of the friendly bodies and souls forecloses the generative properties of contrary forces. So when colonial Iberian writers like Cárdenas and Barba reframed the scientific properties of similarity and extended a generative capacity to the friendly bodies of silver and mercury, they came dangerously close to suggesting an analogous shift in the ideas of sameness and difference in human friendships.

In fact, the science of amalgamation did produce new modes of collaboration

among humans from the New and Old World who labored together and competed against each other in different states of freedom and unfreedom. The new demographics of colonial Iberian mining and metallurgical sciences united indigenous, African, and European miners, metallurgists, and merchants in the extraction and processing of silver. These multiethnic, multilingual groups developed innovative transportation networks and infrastructure, improved methods of mineral washing and crushing, and formulated epistemologically sophisticated theories – like the reconfiguration of natural philosophical ideas of sameness – that were tried and reframed in accordance with their experience.[151] These modes of human labor, at times collaborative and enabling and at times exploitative and coerced, developed in tandem with the reworking of scientific ideas of mineralogical similarity and difference. The lived realities of individual miners and metallurgists determined, I think, whether a particular writer adopted an affective or neutral vocabulary to describe the theoretical framework and material practice of amalgamation. When mineralogical writers had direct contact with multiethnic laborers, and when they did not own the sites of production, as in the cases of Barba and Cárdenas, they explained the mixture or Montaignean "intermingling" of silver and mercury in the intimate language of human experience: friendship and love. But when they owned the mines and refineries in which the work was performed, mineralogical writers like Luis Capoche in Potosí and Luis Berrio y Montalvo in New Spain adopted a more neutral natural vocabulary. Mercury did not "embrace" or "appeal" to silver, it "collected," "received," or "took" it; the minerals were not "such close friends," they just had similar humoral profiles dominated by their cold, humid natures.

The collaborative modes of colonial scientific work carried out in the refineries –

and especially the mines – would certainly fall outside the parameters of "friendship" as the term was defined by the humanistic traditions from which all of these writers took their cues. But these exchanges of knowledge, material samples, and technical practices between and among miners and metallurgists from the Americas, Africa, and Europe – ethnic and cultural communities with as much within-group diversity as without – did seem to influence the type of language that a particular writer would command. In the next section, I explain why the social and economic conditions that circumscribed colonial mining and metallurgy helped to determine whether an author appealed to affective language or followed a more neutral register in outlining the conceptual frameworks and material practices of amalgamation.

II. "que hablando en los propios términos de mina y mineros dice que los pobres que trabajan en ellas son entregados a crueles y despiadados verdugos, y no tienen amigo" [speaking in the true terms of mining, the miners say that the poor people who work in the mines are given to cruel and faithless executioners, and that they have no friends]: Friendship and Difference in Alto Perú and New Spain[152]

The Ciceronian insistence that sameness is the cementing glue of friendship has its origins in the Aristotelian definition of the "perfect friendship": a relationship of absolute equality among men whose goodness and "manly nature" position them at the top of the social hierarchy. As formulated in the *Nichomachaen Ethics*, the supremacy of the one friend is reflected in and confirmed by the presence and virtue of the other – a perfect copy of the original, for "his friend is another self." The friend, "being another self," willingly shares the soul that is divided into two bodies.[153] The voluntary nature of friendship distinguishes the relationship between equals from the bond of unequals, a union characterized by obligation. Aristotle's *Politics*, the text used by Juan Ginés de Sepúlveda (1489-1573) to justify the subordination of American Indians to the

encomienda system, makes clear that only "those which are incapable of existing without each other must unite as a pair." Necessity, not free will, is what links these pairs of fundamentally different individuals in "naturally" productive relationships; men and women unite "for breeding (and this is not from choice; rather, as in the other animals too and in plants, the urge to leave behind another such as one is oneself is natural)," while master and slave are joined "for preservation." For despite the differences between "that which naturally rules and that which is ruled," Aristotle affirms, "master and slave benefit from the same thing."[154] While the *Politics* leaves unanswered the question of whether the relationship between master and slave can be considered a form of friendship, the *Ethics* resolutely rules in the affirmative.

In Book 8 of the *Ethics*, Aristotle distinguishes between three types of friendships: the ideal friendship that becomes the basis for the Ciceronian tradition, and two "less noble" forms. While like-minded men of excellence pretend to the first, "inferior sorts" seek friendships of pleasure and convenience, while "the commercially minded" pursue friendships of utility and advantage. These commercial unions, a less idealized if equally necessary set of relationships, are sometimes solidified by the buying and selling of commodities (*quid pro quo*) and sometimes by a more flexible system of gift exchange ("moral"). While Hartlib circle participants would insist that political giving is not true giving, and that political friendship is not true friendship, the flexible Aristotelian framework of friendship provided a convenient lens through which the practitioners of commercialized colonial sciences could frame their collaborative modes of study and practice.[155] According to Aristotle, interested exchanges provided a space through which each party could find a sort of common ground with the other, a platform of experience

and mutual necessity that reconciled their different natures, virtues, and dispositions into a bond of similarity forged by commerce. While this economy of exchange is far from the virtuous sameness of Ciceronian friendships, there is nevertheless a kind of friendship that is produced in these integrative moments. "For where there is nothing common," as with "ruler and ruled, there is not friendship either, since there is not justice," but because both parties agree to the terms of their union – the fixed terms of exchange-based relationships – they find a kind of justice. This is the key distinction for understanding the utilitarian model of "friendship" in colonial scientific knowledge and practice; the Aristotelian model of human friendship, enabled by the analogical traditions of the natural philosophy, provides the doctrinal flexibility through which markers of difference can be understood as prisms of just similarity.

The best example of the transformative potential of analogical friendship is Aristotle's theory of friendship among master and slave. When the slave is understood only in his capacity to benefit the master's estate, akin to the relationship "between craftsman and tool, soul and body," master and slave share no friendship, for "the latter in each case is benefited by that which uses it" and "there is nothing common to the two parties: the slave is a living tool and the tool a lifeless slave. Qua slave then, one cannot be friends with him."[156] But when the slave is recognized for his humanity rather than his ontological status as slave, then friendship is possible "in so far as he is a man, for there seems to be some justice between any man and any other who can share in a system of law or be party to an agreement." Aristotle provides in the identification of a shared humanity the conditions through which the slave can be taken as or made to signify a friend, but this recognition depends paradoxically upon the slave's willingness to abide

by the master's legal codes and contractual stipulations. If he agrees to be a slave, then the master can agree to treat him as a friend. If they could not be one soul shared among two bodies, they could nevertheless share a kind of physical closeness: "the slave is a sort of part of his master like a sort of living but detached part of his body." The slave's unsuitability for freedom was written on his body – "strong enough to be used for essentials," unlike the master who was "useless for that kind of work, but fit for the life of a citizen" – and yet the flexible doctrine of friendship allowed for the most embodied of differences to become points of a shared but restricted continuity.[157] As long as he remains a slave, then, the slave remains conceptually available for friendship. The willing or coerced collaboration of indigenous, African, and European miners and metallurgists fits within this Aristotelian idea of friendship: a mode of wringing similarity from relationships of difference. These relationships, lived with the full contradictions of competing forms of human emotion and affection, threw into sharp relief the inequalities, exploitation, and opportunism that existed alongside meaningful exchanges of ideas, collaborative developments of new technologies, and the realization of profitable gain for the men and women who migrated to the interior mining regions in unequal degrees of autonomy and coercion.

Mining and metallurgy was hard, ugly work. Miners stumbled through rough and poorly-lit channels, plunging into increasingly deep tunnels for ever diminishing rewards. For whatever the providential wisdom of the Author of the Book of Nature, it was a cruel reality that the richest ores were placed at the shallowest depths. No amount of technological innovation, like the system of *socavones* (tunnels) celebrated by Acosta, could mitigate the dizziness, stomachaches, and fluctuations between hot and cold

suffered by the miners in their descent into the mine, or their slow climb back to the surface, doubled over with loads of dirt and silver.[158] Those piles of dirt then had to be sorted by workers who could identify mineralogical formations and separate by hand the valuable pieces from the rough mass of rocks; in Potosí, indigenous women were preferred for this task, and the work of sorting was commonly described by Iberian writers with the Aymara term *pallar*, and the workers were known as *palliris*.[159] As Barba puts it, "El buen acierto para sacar la ley a los metales, comienza a zanjarse cuando *se pallan* o escogen" (The best way to a high grade has its foundation in the sorting ["se pallan," my emphasis] or selection of the metal).[160] The chosen ore was crushed, heated, and mixed with different amounts of reagents by workers whose long turns in the refineries – full of dangerous fumes and open fires – kept the sites operational day and night.[161] So well-known were the dangerous conditions in the refineries that colonial chroniclers referred to them as what Luis Capoche calls the animal-powered and hydraulic "molienda de los metales en sangre y agua" (the crushing of metals in blood and water), and what Fray Miguel de Agia identifies in the same terms ("Los ingenios o trapiches, vnos son de agua, y otros son de sangre") as human- and water-powered mills. As environmental historians like Kendall Brown and Daviken Studnicki-Gizbert and David E. Schecter have shown in their studies of mercury and silver mining in Huancavélica and New Spain, it is almost impossible to underestimate the long-term consequences of these conditions in terms of human and environmental heath.[162]

The conditions of mercury mines were especially and notoriously horrific, a perfect storm of what one colonial observer described as debilitating environmental factors like the "evil and viscosity of the metals," "the narrowness of the place," and "the

lack of air." The dangerous environmental factors in sites like Huancavélica were compounded by the disruptive intervention of "the weight of such heavy work" performed with "the danger of tumbling downward, the little or almost no security of the bridges and support beams in the tunnel," "the corruption of the air caused by the sweat of their bodies and other impurities and viscosities," "the dust exhaled from the metals when they are hit with metal hammers." What little light there was came from tallow candles that gave off "heavy smoke," and after climbing to "the mouth of the tunnel" they emerge from "the immense summit … weighed down and sweating," taking little refreshment from filling their overheated bodies ("el grande calor que traen") with "the coldest water" and "food of little sustenance." The nature of the deep-tunneled mercury mines, exacerbated by industrial-scale excavation of unstable metallic matter, led the Franciscan observer to recommend closing the site so that the "many millions" of Andean miners "que tiene muertos y sepultados sin otros muchos que estan por morir" (who are dead and buried, and many others who are about to die) might be more profitably applied in other aspects of the silver industry, like the discovery of other mines or the development of open pit mining ("para que descubran alguna gran riqueza de metales: los quales puedan labrar a tajo abierto"). In thinking as both a Catholic and as practical demographer, father Miguel Agia (fl. 1563-1604) could not find a way to justify the tremendous loss of life – especially the loss of skilled miners without whose contributions the region would be "de todo punto sin indios, y despobladas de Españoles" (on all points without Indians, and abandoned by Spaniards"): "And I feel in God and in my conscience that the Lord God our Father does not have enough Indians in all of the Provinces of Peru and New Spain for that mine to consume them and finish them in so

short a time." That the fate of the mines would determine the fate of the population is borne out in the historical record by censuses and surveys that document the coeval rise and fall of silver production and colonial subjects. But the integrative registers of mining technologies and population management are also suggested by terms that are common to both scientific discourse and cultural demography. Just as a region could be "despoblada" or abandoned by its subjects, so too were worn-out mines described by Iberian men as "despoblada por auerlo estado mucho tiempo" and refinery complexes marked as "despoblado arruynado sin minas," in this case by a native community that used Iberian legal frameworks to legitimize its taking possession of a female refiner's property. And so too did a mine owner whose property had been confiscated complain that she or he was "despoblado de minas."[163]

Agia did not, of course, call for the end of forced labor in mining and metallurgical work, partly because "God and nature did not provide gold and silver so that they would be hidden in the bowels of the earth so much as put to human use," and partly because skilled miners and metallurgists came to the region despite the the well-chronicled heavy work of and dangerous conditions. These independent wage laborers were so well-known for negotiating their own labor arrangements that Iberian writers used the Quechua term "mingar" (hire) to describe their arrival in Potosí: "vemos el dia de oy en Potosi muchos millares de ellos, que de su voluntad se van a mingar, o alquilar alos ingenios donde se benefician los metales" (we see today in Potosí many thousands of Indians who of their own volition *mingar* or hire themselves out in refineries where they process metals).[164] We might be skeptical of an Iberian claim that this extremely taxing work not only did not "exceed the forces of the Indians," but also that Andean miners and

metallurgists willingly contracted to mining and metallurgical offices, but Agia's account of migratory patterns in Potosí is supported by census records and demographic studies.

In Potosí, as historians like Alberto Crespo and Thierry Saignes have shown, Africans and indigenous people forced to work in the mines and refineries met independent indigenous wage laborers who came from various ayllus, including those identified in colonial-era documents as Quillacas, Atacamas, Uros, Collana, and Ylabi, and other kinship ties identified by historians as Lupaqua, Laymi, Chinchaysuyu, Aullagas, Asanaques. A particularly large number of female and male miners and metallurgists, especially highly-skilled refiners, migrated from the province of Carangas and hired themselves out as wage-laboring *yanaconas*.[165] These demographically-mixed Andean populations were joined Europeans, primarily Germans, Flemish, Italians, Portuguese, English, and Spaniards, such that one sixteenth-century commentator worried that the "mixture of Indians from so many nations" would threaten the cultural viability and socioeconomic stability of Potosí.[166] As it turned out, the most violent clashes in the city were those waged by rival groups of Spaniards during the *Guerra de vicuñas y vascongados* in the mid-1620s.[167]

Archival sources and manuscripts evidence with particular clarity the demographic flows of miners and metallurgists from North, Central, and Southern Europe in the Andes. While many millions of indigenous workers were forced into labor in the mines and refineries of Potosí, no small number of women and men negotiated their own labor arrangements, extracted their own ore, refined it on their own terms, and delivered their own products to indigenous-owned markets. Likewise, while most of the European miners and metallurgists enjoyed considerable power over indigenous and

African practitioners, the nature of natural knowledge made this power unevenly distributed within European communities. Anglophone writers may have demonized Iberian miners as cruel and exploitative, but there were important numbers of English migrants who participated directly in the mining and minting of American silver – and indirectly, in their use of Iberian silver in local and global markets. In Potosí, English miners and metallurgists collaborated and competed with Iberian, Dutch, German, and Andean miners and metallurgists to form intercultural mining companies like those described by late-sixteenth century chronicler Luis Capoche. According to Capoche, these intercultural partnerships were important sites of innovative practices – and, occasionally, disastrous outcomes. For example, he describes one such Italian-English mining company run by Enrique Sandi (Henry Sands?) of London and Nicolás del Benino, a native of Florence but long resident in the region ("persona antigua y de los viejos del pueblo"). Near the "veta de los Flamencos," so named for the Dutch miners who discovered and benefited the site, del Benino had discovered a vein, or at least registered one in his name, and had worked the site for some fourteen years when Sandi arrived in the region. Sandi proposed a new blasting method that would make it easier to remove the large stones from the back stope. After igniting the fire for blasting, Sandi fell asleep while "the Indians were loading the flint but with all of the smoke they had nowhere to breathe, and they were filled with such false hopes that they lost their reason and could find no exit, so Enrique and all of the Indians died." Capoche's procedural relation of the event emphasizes the dangerous conditions of sixteenth-century mining, and the devastating losses of life that result therefrom. But it also underscores something else – the collaboration of Italian and English supervisors in a Dutch-owned vein worked

by Andean miners draws no special attention from the colonial chronicler, which suggests that these intercultural practices were, if not standard, then at least common enough to be considered unremarkable.[168]

The same risks and opportunities negotiated by Andean wage contractors also enticed large flows of Europeans to migrate to the inland region of Potosí. Skilled and unskilled English, Italian, Dutch, German, and French miners and metallurgists invested in mine sites, tried new methods of excavation, and experimented with refining operations. Although Spaniards remained the largest European group of in the region, the 60-year union of the crowns of Portugal and Spain allowed for Portuguese miners and metallurgists to play an important role in the underwriting of colonial life. The stories of Portuguese miners and metallurgists have been somewhat better studied than those of other European groups, as their substantial demographics relative to Northern and Central European miners, and their contributions to the new method of amalgamation, have made them central contributors to colonial Iberian mineralogical science. One such instrumental intracolonial scientific and cultural go-between was Enrique Garcés, resident in Lima as of 1547. The Portuguese national traveled to New Spain in 1558 to study the theories that the Sevilla-born Bartolomé de Medina was putting into practice following his own "pláticas con un alemán" (conversations with a German). Having observed that indigenous women used the reddish-hued cinnabar (HgS) as a purifying cosmetic, Garcés speculated that the chemically-related mercury (Hg) being applied in a new treatment for silver (Ag) might also serve a purifying function in the new method of amalgamation. If cinnabar whitened and purified the complexions of native women, perhaps mercury could do the same for native silver, Garcés speculated. He returned to

Peru with the New Spanish miner Pedro de Contreras, and successfully petitioned for a 12-year license for mercury rights at the Huancavélica mine, presumably to test methods of purifying silver with the clear-toned mercury.[169]

While Garcés's idea for mercury amalgamation may have been inspired by native women, the *patio* method of amalgamation came from the Sevilla-born merchant Bartolomé de Medina's contact with German ideas. This exchange of ideas convinced Medina to leave his family and profitable business and move across the ocean to try his hand – for the first time ever – in metallurgy. As Medina wrote from Jilotepeque in 1555, "tuve noticia en España, de pláticas con un alemán que se podía sacar la plata de los metáles sin fundición, ni afinaciones, y sin otras grandes costas; y con esta noticia determiné venir a Nueva España," where he would perfect the method in a series of frustrating experiments ("lo probé muchas y diversas veces y habiendo gastado mucho tiempo, dineros y trabajos"), compounded by his solitary life in the mines of Pachuca, "dejando en España mi casa e mi mujer e hijos."[170]

After studying with Medina in New Spain and making his fortune in Peru, Garcés returned to the Iberian peninsula and began translating into Spanish the unrivaled epic celebration of Portuguese imperial glory, the *Lusíadas* of Camões. Enrique Garcés crystallizes the type of give-and-take that characterized the discursive and material practices of colonial American science; his is a multilingual story in which an intracolonial and transatlantic migrant's willingness to play with received natural philosophical ideas about similarity and difference among human and mineral bodies enables the development of an extremely profitable and useful scientific practice. Garcés's position as a scientific intermediary parallels and makes possible his literary

career as a translator. In making the *Lusíadas* available to Spanish-language readers, Garcés promotes imperial Iberian rivalry by narrating in belletristic letters the cartographic and navigational achievements of the Portuguese. The historiography of amalgamation has often been narrated within monolingual traditions or national frameworks that belie the conditions of colonial Iberian mineralogical science: an always multilingual and transcultural assemblage of knowledges and practices. English-, French-, German- and Czech-language scholars and translators like Jean Girardin, C. Henry Haring, Herbert Hoover, Lou Henry Hoover, Anneliese Grünhaldt Sisco, and Cyril Stanley Smith have insisted upon the Saxon origins of the amalgamation method, while Spanish-language scholars like Eugenio Maffei, Ramón Rúa Figeroa, Francisco Fernández del Castillo, and Modesto Bargalló have credited Iberian America with the innovative development in metallurgical technology. What I am arguing here is that the commercially-viable, industrial-scale method of amalgamation belong not only to Spain or New Spain or Alto Peru, but to the traffic in scientific knowledge and practice of an early modern world in which indigenous, African, English, German, Dutch, Italian, Portuguese, and Spanish miners and metallurgists collaborated and competed with and against each other.[171]

After the dissolution of the Iberian union, the experience of Portuguese miners and metallurgists in the Andes became quite different. In 1642, two years after the formal division of the two crowns, administrative officials in Alto Perú swept through refineries like those in Los Lipez, where they surveyed the Portuguese population, confiscated their weapons, and then banished them from the region. Many of the miners and metallurgists, such as the 37-year old Julian Rangel de Maudo, who worked at the mine of San Antonio

de Padua, and the 28-year old Manuel Carvallo, who mined at Nuestra Señora del Rosario, had lived most of their professional lives in Alto Perú, establishing contacts, marrying local women, and starting families, identified as "criollas de la tierra" (4v). As a sign of the changing power dynamics in the region, colonial officials enlisted Spanish-speaking indigenous miners like one Melchor Quispe and Pedro Apoma to witness the reading of the declaration against the Portuguese and to bear testament to their expulsion.[172] This is not to suggest that indigenous agents were on equal footing with Iberian colonizers, but rather to show that the nature of power was uneven and ever shifting. At times, European miners and metallurgists positioned themselves in opposition to Andean practitioners – and they created an elaborate legal and religious framework to authorize this bipolarity. But at other times, in moments like those of the Rosario refinery following the dissolution of the Iberian union, the within-group differences mattered more than those without.

While colonial commentators like Fray Miguel de Agia underscored the fundamental opposition ("son dos contrarios opuestos ex diámetro") of the "conditions, lives, and customs" and the "complexions" and diets produced by climate and sustained by nature of Andean and Iberian subjects – the former was naturally humble and without jealosy, while the latter was arrogant and "extremely jealous," the one phlegmatic and "amenable to order" ("amigo de mandar") and the other coleric and an enemy to service ("enemigo de seruir") – it was the divisions within indigenous communities that caused Agia to caution against top-down population management strategies in Potosí. If the Iberian crown tried to relocate Andean families to the region, Agia argues, the environmental disconcert ("temple") and cultural clash of different "nations, inclinations,

and customs" would threaten the health of the population ("poniento la salud y vida de los indios a gran peligro y riesgo") and undermine the mining region's safety and security. Citing Aristotelian theory and the historical precedent of the Germans in the mining regions of Hungary, Agia insists that "Ninguna cosa ay mas aparejada para sediciones y tumultos, que la mistura de varias naciones" (Nothing is more apt to bring forth seditions and tumults than the mixture of various nations). Although the Andean and Iberian body politics were organized into two republics – the *republica de indios* and the *republica de españoles* – the borders between these groups were impossible to police. Agia, among others, suggested that a better form of population management would be the formation of a single republican region in which there would be both indigenous and Iberian "feet that walk, and hands that work, and heads that govern and some that rule and others that serve." Just because "the Indians were not Spaniards, or to the contrary, the Spaniards Indians" did not mean that they were somehow not responsible for each other's care, or that they were not both part of the single "cuerpo mystico desta Republica Indiana" (mystical body of this Indian Republic). What these negotiations of the diverse body publics of Potosí suggest, apart from a persistent concern for the state of human mixture in the region, is that the development of industrial-scale mining and minting of silver brought indigenous, African, and European miners and metallurgists into contact in ways that had yet to be resolved by religious frameworks or public policies, and that the within-group differences mattered as much as those without.[173]

These new demographic mixtures enabled by the new method of amalgamation also characterized the mines and refineries of New Spain, where African, indigenous, and European miners and metallurgists collaborated and competed in the nascent silver

industry and the development of metallurgical technologies that underwrote its expansion. The mines and refineries of Zacatecas pushed some Africans and indigenous peoples from their homes and pulled them into contact with other groups of mineralogical practitioners, a multilingual and intercultural convergence in which Spanish became the default language. Although the 800 enslaved Africans in the region had little control over their own labor, an unknown number of black and mixed-race miners and metallurgists contracted themselves out as independent agents in the agricultural-mining complex of Zacatecas. According to one survey, these independent contractors, "some free who come and go, and rent themselves on ranches, as laborers, and in the mines," found equally "bad and vicious, the free men as well as the other slaves," adopted Spanish as the "general language of the city" that would allow them to move with more flexibility among mines and refineries. Because there were so many different indigenous communities who relocated to the region either by choice or by force, the "mexicanos, otomíes, tarascos y de otras naciones" too adopted bilingualism as a profesional competency that would enable these Tarascan miners to negotiate with Otomi metallurgists, and Mexica miners with African refiners.[174] A commentator in Potosí suggested that indigenous miners who worked with African metallurgists in New Spain fared particularly poorly, for there Iberian owners would prefer that "ten Indians die before a black who will cost them their money."[175] This conventional justification of slavery in terms of a master's financial investment in chattel property suggests the shifting modes of inter- and intra-group affiliation made possible by cultural contact in coerced conditions: African and indigenous practitioners could have built intercultural alliances against a common Iberian overseer, indigenous miners may have tried to align

themselves with the Iberians to discourage importation of African metallurgists, or, if we take the statement at its word, they may have reinforced ties to their own communities in opposition to Africans who received preferential treatment. In this last imagined scenario, indigenous agents from north, central, and southern Mexico who would have had little reason to think of themselves as part of the same community before their contact with African and European miners and metallurgists might now identify in each other a shared affiliation. The epistemological sophistication of the new method of amalgamation and the commercial success that it produced galvanized women and men from diverse ethnic and linguistic communities to collaborate and compete in the same work of mining and metallurgy. They may not have unified by their perfect sameness, but their mutual dependence and overlapping interests aligned them with an Aristotelian model of political and commercial friendship that might have led some writers to analogize these collaborative modes of labor to reworked paradigms of mineral friendships.

The new demographic mixtures enabled by the technology of amalgamation underscored in particular the substantial contributions of skilled miners and metallurgists from the New World and the Old World. Where histories of mining in colonial Latin America once emphasized the brutal exploitation of enslaved Africans and forced indigenous laborers, a new review of the literature has shown that skilled black and native practitioners commanded more control over their knowledge and labor. Africans and their descendants in Potosí organized their own mining companies, held and exploited their own mines, and negotiated their own contracts with indigenous and European refiners,[176] while indigenous miners and refiners developed channels of mineral extraction and refining that were sold in an Andean market (*qato*) that stood largely

outside the framework of Spanish regulation, given what Luis Capoche calls the "little zeal" of colonial administrators who were less concerned for "the good of the Indians" than they were motivated by their "particular interests."[177] Capoche also notes that because so many indigenous miners contracted themselves as independent wage laborers who could direct the fruits of their work in the mines to Andean channels, "la experiencia ha mostrado que el metal que se saca con indios de cédula tiene más ley que lo que se labra con indios mingados, por lo que les hurtan" (experience has shown that the metal removed with Indians organized by the state [*indios de cédula*] has a higher grade [*ley*] than the metal worked by hired Indians [*indios mingados*] because of what they hide). The high-grade ores were less profitable in Iberian methods of amalgamation, so Capoche's assessment indicates that coerced miners delivered to Iberian owners more of the metal that better suited to indigenous smelting methods than to the new method of amalgamation. The independent contractors, meanwhile, dutifully extracted silver during their shifts, but, if Capoche is to be believed, they reserved for themselves the ores that could most profitably be amalgamated, and they diverted these varieties of silver to indigenous metallurgists and marketplaces. While these individual stories by no means erase the large-scale dehumanization of African and indigenous people within the system of forced labor at Potosí, they do nevertheless open up a space that recognizes the dynamic modes of operation and ownership available to technically skilled and commercially shrewd practitioners.

In New Spain, the existence of native networks of silver mining and minting enabled all silver miners to take advantage of Spanish colonial policy. Silver extracted by a miner and refined in her or his own plant was supposed to be taxed at a rate of ten

percent, while refiners and merchants who purchased their silver from a miner were supposed to pay twenty percent. In practice, it was nearly impossible to determine whether silver had been processed by the miner or purchased from one, so everyone paid the lower tax rate.[178] The deep mineralogical knowledge and commercial command of indigenous agents of science led the bishop Alonso de la Mota y Escobar (1546-1625) to note the centrality of indigenous miners and African refiners in the silver industry of Zacatecas. By repeating words like "saber" (to know a fact) and "conocer" (to understand a concept), de la Mota y Escobar underscores the place of mineralogical knowledge and practice in determining successful silver outcomes: "de más primor es el echar la salmuera en los metales e incorporarles el azogue y saber conocer cuándo ha tomado la ley" (the greater art that follows this step is the addition of salt solution to the metals, incorporating them into the mercury and knowing how to understand when it has reached the desired mineral grade).[179] According to de la Mota y Escobar, indigenous metallurgists were skilled in both the large-scale chemical method of amalgamation and the traditionally small-scale technologies of refining, as he noted their "facilidad que en conocer metales y en desazogar y en juntar la plata, y en hacer las cendradas y crisoles tienen" (faculty that they have in understanding metals and in removing mercury and in joining silver, and in making hearths and crucibles).[180] The type of treatment administered to the metal, namely heat-based refining, chemical amalgamation, or some combination thereof did not depend upon the "the will [*voluntad*] of the miner" so much as the nature of the material. It was the job of the miner, then, to know how to read a variety of mineralogical bodies – native silver, *negrillos*, *mulatos*, and *pacos* alike – to determine the most beneficial benefit. In terms of their mineralogical literacy, de la Mota

y Escobar ranks indigenous practitioners as superior to Spaniards and Africans: "El saberlos lavar, el desazogar y apartar la plata del azogue, afinarla y hacer la plancha" represents the "gran conocimiento y liberalidad" of the Indians, "a lo cual no llega el ingenio ni habilidad de los negros, ni aun de muchos españoles" (to know how to wash the minerals, remove the mercury from them, separate the silver from the mercury, refine the silver and cast it into a cathode represents the great knowledge and generosity of the Indians, to which neither the wit nor ability of the blacks, nor many Spaniards, arrives). The technical skills in underground mineral detection and excavation, in addition to the deep knowledge of silver mineralogies commanded and perfected by indigenous agents of mineral science, led de la Mota y Escobar to conclude that "sin indios no se puede sacar plata en la Nueva España" (without Indians it is impossible to extract silver in New Spain). If it is true that non-European and European miners and metallurgists were subjected to inhumane working conditions, it is also true that the same people and institutions that denied their full personhoods also acknowledged their substantial contributions to colonial mineralogy.[181] African miners developed particularly deep knowledge of surface-level or open-pit copper excavation and metallurgy, so their skills and technical competencies were more in demand in the copper-rich regions of eastern Cuba and the Aroa River Valley of Venezuela than in the adits of Zacatecas or Potosí. The cases from the copper mines and refineries of the extended Caribbean, and the place of African miners and metallurgists in the biopolitical making of the region, are discussed in chapter five.[182]

There was only problem with native miners and metallurgists, de la Mota y Escobar argued in an inverted version of Juan de Solórzano's claim in the epigraph to this

section that indigenous miners have "no friends" among the Spaniards. That is, Iberian writers complained, despite the technical proficiencies and mineral knowledge of indigenous practitioners, they were not "good friends" to their work for the Spanish mine owners. The Spaniards could be made redundant if only "hubiera en indios fidelidad y fueran amigos de trabajar totalmente" (there were loyalty among the Indians and they were friends of working completely). For this work, they were paid between five and eight *pesos* per month, plus, as in the compensation system of Potosí, a bag of silver reserved for personal use. For their private earnings, indigenous miners of New Spain often selected high-grade ore better suited to traditional smelting methods than to the new benefit of amalgamation, called *pepena*, "que en lengua española suena lo mismo que escoger" (which in the Spanish language means to choose).[183] As mining historian Peter Bakewell has shown, this metal typically passed through small-scale refineries over which the Spanish crown had little jurisdiction.[184] With a little lead and a small furnace, refiners could process enough silver to make a profit, but not enough to attract the attention of the state. Iberian miners had to offer somewhat favorable work conditions – or at least compensation that would make a metallurgist choose to work for one miner over another. Some of this compensation was strictly material, as in the *pepena* ore and direct cash payments, while other benefits like room, board, and clothing for the mining families that lived in mining estates (*haciendas de minas*) could not be evaluated only in cash value. "While living conditions in the haciendas obviously cannot be idealized," Bakewell writes, "and inevitably would have varied from employer to employer, they were probably at least as good as those to be had in the Indian barrios of the city," such that the hacienda structure of extended kinship and intercultural community "may have

served, incidentally to its main purpose as a refining plant, as a stabilising influence on the labour force." In the New World, many African and especially indigenous metallurgists possessed the technical skills and commercial channels, then, to make the conditions of the mines and refineries somewhat more attractive, or at least to justify migrating to the mining regions to work for wages, if not for friendship.

What, then, might friendship have meant in the mines and refineries of Spanish America? It was not a virtuous attraction of sameness, but the collaborative modes of exchange cemented with overlapping common interests and mutual necessities had something of the Aristotelian ideas of politically convenient friendship. If the scientific borders of similarity and difference were at once channeled through Aristotelian traditions and innovated from them, might it be possible to say the same of the social categories of friendship? Put otherwise, can the collaborative types of human relationships developed in the colonial American silver industry help to explain the reworked definitions of friendship and sameness that informed the new method of amalgamation? Can the reconfigured scientific ideas of similarity help us to understand the changing nature of friendship in the amalgamated body politics of colonial Iberian America?

This book argues yes. By studying the different natural vocabularies of colonial Iberian accounts of amalgamation we can begin to map out the relationship between the scientific principle of similarity and the social bonds of friendship. While all mineralogical writers framed their accounts at some level in the analogical traditions of early modern science – refracting human and non-human reactions and relationships through same cosmic principles of like and unlike, similarity and difference – only some

writers applied the natural philosophical language of friendship and love to the mixture of silver and mercury. Those writers, I am arguing, tended to be the miners and metallurgists who did not own the sites of production. When an author was financially invested in the silver output of a mine or refinery, he explained the material incorporation of silver and mercury in a natural vocabulary outside of the rubric of friendship; in the accounts of Luis Berrio de Montalvo and Luis de Capoche, unlike Álvaro Alonso Barba and Juan de Cárdenas, military language, population management terms, or neutral verbs like "take" and "receive" translate the unfamiliar chemical reaction for eager audiences.

III. "le buscaua platta para poder pagar los jornales a ottros yndios por el amor que le tenia y ser su compadre" [he looked for silver for him to pay the wages of other Indians because he loved him and was his friend]: Friendship and Collaboration in Colonial Iberian Mining and Metallurgy[185]

Like their seventeenth-century English peers, writers of colonial Iberian scientific texts freely drew from a natural vocabulary that described cosmological interactions in the intimate terms of human affect: the English plants that loved certain soils or desired particular seeds were quite like the minerals that loved and desired each other in Spanish America. But unlike in the case of English agricultural authors, Iberian mineralogical writers applied this language of desire and difference to a mineral reaction in which the primary agents shared fundamentally similar outer natures or complexions and inner essences or humoral dispositions. Almost all of the Iberian writers drew from this affective language, but only some applied it to the moment in which silver and mercury were united by human hands and ground by human feet to form the amalgam that produced such staggering flows of bullion throughout the Spanish empire and global economy.[186]

The writers who transformed the language of friendship into a natural vocabulary

of desire have relatively little in common – one was a physician who published in the late-sixteenth century after having studied and lived most of his life in New Spain, while the other was a priest who published in the mid-seventeenth century after having studied in Spain and lived most of his life in Alto Perú, where he developed a keen interest in silver metallurgy and learned that he was quite good at it. Based on geography, we might expect Juan de Cárdenas's *Problemas y secretos maravillosos de las Indias* (México, 1591) to use a language similar to that of Gonzalo Gómez de Cervantes's *Memorial* (México, 1599) or Luis Berrio de Montalvo's *Informe del nuevo beneficio* (México, 1643), or to find a comparable overlap in the language of the Potosí-based accounts of Luis Capoche (1585), García de Llanos (1609) and Álvaro Alonso Barba (1640). But this is not the case, as Cárdenas in New Spain and Barba in Alto Perú command the same affective language and transform the terms of mineral sympathy into an erotic coming into body, while other writers in Mexico and Peru do not.

Based on chronology, we might expect the late-sixteenth century cluster of Cárdenas, Capoche, and Gómez de Cervantes to describe the amalgamation method in similar terms, or for the mid-seventeenth century authors, Berrio de Montalvo and Barba, to explain the act of incorporation with a similar vocabulary. But instead it is Berrio de Montalvo, Barba, and Cárdenas who transmit the natural philosophical terms of sympathy and analogy, but only Barba and Cárdenas who translate the language of friendship into a union of desire to describe the interaction of silver and mercury. Capoche, García de Llanos, and Gómez de Cervantes employ a non-affective vocabulary to describe the same technology of amalgamation. So what do Barba and Cárdenas have in common? Or, put otherwise, what -- besides language -- separates the discursive

affective register of these writers from the others?

I suggest that it is a question of experience, or, rather, of life history. Although much remains unknown about the lives of these mineralogical writers, there is enough biographical data to formulate a tentative hypothesis that might explain the different language of the treatises.[187] All of the writers seem to have practiced mining or metallurgy first-hand in the demographically-mixed conditions of the colonial silver industry. The only exception is Cárdenas, who, like the German physician and mineralogical writer Georgius Agricola, learned about mining and metallurgical practices and their consequences by treating patients. In diagnosing human bodies and identifying cures, Cárdenas and Agricola's medical practices accorded with the same humoral principles that miners and metallurgists used to devise methods of ore extraction and metallurgical processing techniques. So Cárdenas shares the same learned background as his peers. But if Cárdenas was not working hands-on with metals, and Barba was, something besides practical experience might lead them to describe the material processes of amalgamation in the same terms.

Let us consider the scant biographical records of the other writers. Berrio de Montalvo, recently appointed to the mining ministry of New Spain, describes the methods of the Tasco-based miners Pedro Garcia de Tapia and Pedro de Mendoza Melendez, the men with whom he assayed mercury samples in Tasco, Ajuchitlán, and Pachuca, and discovered the mine of San Gregorio.[188] What we know of the life of Gonzalo Gómez de Cervantes comes almost entirely from a manuscript recovered from the British Library in the mid-twentieth century and from Alberto María Carreño's careful reconstruction of other fragmentary documents. The Mexican-born Gómez de Cervantes

served as *alcalde ordinario* in the capital (1589, 1594) and in various capacities of judge, *alcalde mayor*, and governor (1598) in Tlaxcala, Tepeaca, and Huejotzingo, communities surrounding the central city of Puebla. The historian of science Modesto Bargalló identifies Gómez de Cervantes as "propietario de minas" (mine owner) and in his own account the Mexican attorney general testifies to his personal knowledge ("que lo sé") and his consultation with other miners "de mucha conciencia y experiencia." His manuscript contains incredibly detailed descriptions of the new technology of amalgamation and the earlier refining methods that he claims had been abandoned by Spanish practitioners for nearly thirty-five years. The text also reveals a particular sensitivity to the economics of mining; the four "instruments" that a miner or metallurgist requires, Gómez de Cervantes argues, are mercury, salt, laborers, and credit ("dineros"). So important was this last category that the colonial official proposed the formation of an investment bank whose resources would only be available to miners and metallurgists.[189] Little too is known about the Potosí-based mine overseer García de Llanos; like Gómez de Cervantes he reveals deep mineralogical knowledge culled from first-hand experience, and like the civil administrators Berrio de Montalvo and Gómez de Cervantes, García de Llanos avoids the affective language that characterizes the work of Barba and Cárdenas. The accounts of the remaining two authors based in or around the Cerro Rico de Potosí are more biographically complete. Barba and Capoche both made their livings in Potosí, Capoche as the owner of two refineries during the boom years of the late-sixteenth century, when the new method of amalgamation had been perfected for low-grade silver and indigenous smelting techniques continued to provide a market for high-grade silver. Barba, the best-studied of all of these writers thanks to the careful biographical

scholarship of Josep María Barnadas, began his career in Alto Perú in the late 1590s as a priest. His discovery of silver mines led him to begin experimenting with metallurgical techniques to adapt the New Spanish method of amalgamation to the colder ambient temperatures and different mineral compositions of Peru. His preeminent contribution, known as *caza y cozimiento*, was introduced in 1609 and recorded in what is perhaps the most widely-studied treatise on colonial metallurgical science, the *Arte de los metales* (Madrid, 1640).

As Barba tells it, from his post in Tarabuco, some eight leagues outside of present-day Sucre (what is today a one-hour drive), he was inspired to "experiment with one or two methods that I had read about to solidify [*cuajar*] mercury." These experiments led to the industrial-scale heat-based adaptations that successfully accommodated the climatological and mineralogical differences between New Spain and Alto Perú. In his own words, Barba claims to have contributed "great service to Your Royal Magesty, increases in royal fifths and common good" through his "continual study and experiences that I have communicated without any semblance of interest whatsoever." Moreover, he insists that despite the allure of mining and metallurgy, the fruits of which are delivered in hard currency, he has remained committed to his calling as a man of faith: "in more than thirty years I have exercised my office as a Priest without interruption and I have had other important responsibilities in the most serious positions and highest ministries of this Archdiocese in Lipez, Pacajes, Oruro, Potosi, and the Ciudad de La Plata, in which I have always tried to increase merit and not to pretend to or solicit recognition."[190] Appeals for patronage are notoriously fraught with this type of rhetorical pretension to selfless service, but Barba describes a number of specific

examples that reveal how his commercial acumen comes to support his religious profession. On one occasion, for instance, he traveled to Oruro to purchase discarded metal ("deshechos o escorias") because he needed a low-cost supply of material with which to test his theory that significant amounts of silver could be harvested from the tailings of smelted *negrillo* ore. Once he determined that the method was successful in extracting "no pocos millares de pesos de plata" (no small sum of silver pesos), he shared the technique with other miners and metallurgists in the region such that "today with my example they know how to take advantage of everything." Barba's metallurgical skill and commercial saavy helped him to develop a profitable application for the discarded ore, and it improved upon earlier methods in two key ways. First, Barba's method recovered usable material from the slag pile, decreasing the costs of extraction by allowing metallurgists to process silver that had already been removed from mine sites. Second, because the method was designed for *negrillos*, the most common silver variety and one whose complex mineralogical blend of silver ore and sulfurous particles made it difficult to treat through heat- or chemical-based methods alone, Barba's "example" could be widely adopted by other miners and metallurgists.[191]

To satisfy his intellectual curiosity, Barba wanted very much to participate in alchemical trials like those that sought to convert water into gold. But to satisfy his sense of "Christian honor" he limited his work to the materials and methods whose industrial-scale implementation would improve conditions in colonial Alto Perú and the Spanish empire more broadly – matter that had been discarded as useless, like the tailings of smelted *negrillos*, technologies that had been imperfectly adopted in the region, like amalgamation, and instruments that were made of common materials that could substitute

for those designed originally with expensive or rare components. After finding a use value for the discarded *negrillo* piles, Barba modified existing technologies like the amalgamation method, and he devised new ways to fabricate crucial metallurgical devices like mixing glasses for *agua fortis*. Because metallurgists in sparsely-populated provinces had limited accesss to glass, Barba instructed miners and metallurgists how to make mixing glasses out of readily-available clay. Barba applied his interest in metallurgy, and his understanding of economic demand, in the service of the empires he believed in – the Spanish empire and the Holy Roman Empire, and he seems to have directed his energies toward improving upon existing metallurgical technologies and instruments. Indeed, if anything links Barba's experiments with heat-based modifications to the amalgamation method, trials of *negrillo* tailings, or clay mixing glasses, it is that he specialized in materials whose productive values had been overlooked or underappreciated by his peers. I have not found evidence of his receiving payment for the silver output that resulted from any of his physical or intellectual property, or anything to suggest that he took his calling as a priest any less seriously than his metallurgical work. Rather, these examples speak to the ways in which Barba's religious profession and metallurgical practices complemented each other in advancing both interests.[192]

However, he certainly benefited from his mine discoveries and metallurgical innovations in indirect ways, as his impressive work in metallurgy facilitated contact with royal officials like Juan de Lizarazu (d. 1644), the President of the Audiencia de los Charcas. This high-level government official helped to bring Barba from provincial Alto Perú to San Bernando parish, in Potosí, where he completed his manuscript and subsequently had it published in Madrid at Lizarazu's expense. Barba's advancement

within the church enabled him to command a higher salary and to exercise more responsibilities, and the publication of his book and its positive reception helped to solidify his reputation as a skilled metallurgist whose services were solicited by the Spanish crown.[193] Lettered men like Luis Berrio de Montalvo had suggested that Spain's experience as a mining colony of imperial Rome prepared the country to mine American silver, and father José de Acosta had argued that Inca imperial precedent helped to establish the infrastructure to support industrial-scale mining and minting of silver, even if they focused their extractive and refining technologies on bermellon (*llimpi* in Quechua) rather than mercury. For Acosta, the ability of mercury to invert imperial paradigms – to replace the Roman mining of Spain and the Inca mining of America with the Spanish mining of America – is part of the mineral's nature and the plan of the Author of the Book of Nature: "Cierta transmutación inmediata de cosa tan pesada en cosa tan liviana y al revés, por cosa rara se puede tener en naturaleza. Y en todas estas y otras extrañezas que tiene este metal, es digno el autor de su naturaleza de ser glorificado, pues a sus leyes ocultas obedece tan prontamente toda natualeza creada."[194] But Barba inverted the naturalization of conquest in this rhetorical imagining of a westward translation of mining and empire by returning to Spain at the end of his career. At the request of royal officials, the nearly 80-year old priest-metallurgist boarded a ship from Argentina and returned to his native country to improve production by applying American and German mining practices to the silver operations of the Iberian peninsula.[195] On the question of his financial remuneration, however, a brief digression is necessary, for there is some debate as to whether a religious man like Barba owned or could own mines and refineries.

The preeminent mining historian Modesto Bargalló identifies Barba as an owner of refineries (*hacienda de minas*), but does not provide documentary evidence to support the claim. The renowned Andean historian Joseph María Barnadas, Barba's biographer, concurs that Barba was a "señor de minas y dueño de ingenios" (mine and refinery owner), but the only citation provided is from Bargalló. The more recent and equally well-informed scholarship of Carmen Salazar Soler also upholds Barba's status as "señor de minas y dueño de ingenios," but she cites Barnadas.[196] According to the historian Pablo Quisbert, priestly ownership of the sites of mineralogical production was not often recorded in official documents; the archival silence on Barba's land holdings should not imply that he did not own mines and refineries, for "estas cosas no se dicen" (these things are not said).[197] Quisbert and his collaborator, the historian and anthropologist Tristan Platt, are right to note that the absence of extant documentation does not mean that the evidence did not exist, and that perhaps it would be more helpful to consider the information as "not yet found."[198] But because there are so many records of individual priests and nuns, as well as religious institutions like monasteries, schools, and confraternities that owned mines and refineries, the absence of such evidence in Barba's case is worth the taking notice of.

In the seventeenth century, there was not a conflict between religious profession and mine ownership, as the income from the mines and refineries underwrote local church missions and contributed to the treasury of an imperial monarchy whose rule was authorized by divine right. If not for the divine imperative to convert the Indians to Christianity, "reducing" them and "incorporating" them into the church universal like so many metallic bodies, why else would God have provided such great mineral wealth? For

priests like Barba and José de Acosta, there is only one reason why the heathen lands of Alto Perú were blessed with unimaginable stores of silver and mercury: because faith and obedience were the only routes to salvation, "en esta causa gasta el tesoro de Indias que le ha da de Potosí" (in this cause we spend the treasure of the Indies that God has given to Potosí). Barba, in like fashion, argues for the providential design of the new benefit of amalgamation: "proveyó Dios para tan excesivo gasto, del abuntantísimo mineral de Guancabélica" (God provided the most abundant mineral wealth of Huancavelica for such excessive expense).[199] Given the conviction that the Author of the Book of Nature plotted these mines in anticipation of the arrival of the Spaniards, it should not be surprising to find extensive documentary evidence of religious men and women who participated in the production of colonial silver.

Capoche, for instance, lists several religious clerics who discovered or purchased mines in the Cerro Rico of Potosí.[200] These owners included one father Cáceres, whose three indigenous laborers worked three *varas* (yards) of silver vein at a depth of 180 *estados* (1000 feet), father Yllarregui, who shared ownership in the Berrio vein with a fellow religious, two indigenous miners, and two civil figures. Part of the vein was run by the mining company of Diego Chuna, identified only as "indio" and his partner, Agustín Chara, the discoverer of the asset and a man identified by his *allyu* (family line or tribe) as "Llanquisupa del Cuzco." The rest of the vein was partitioned among the Iberian miners and investors. The priest Yllarregui owned three *varas*, Pedro de Grado owned ten *varas*, and Santiago Samalvide owned another three *varas*, while five *varas* belonged to Martin de Vergares, the cleric who collaborated with the Friar Horacio Genari in the development of a method to process silver without iron.[201] In the 180-*vara* vein

discovered by one "Huaman, indio," on the backside of the mountain at a depth of only four *estados*, the Iberian cleric Juan Sevillano and the "indio presbítero" Diego Ylla each owned 70 *varas*. Religious institutions like convents and monasteries owned mines and refineries, as well, and they were important sources of income to support church activity. The nuns of Monasterio de la Encarnación of Lima received eight indigenous workers to mine their 60 *varas* of silver at the depth of 50 *estados*, the Convento de Nuestra Señora de la Merced received six tribute workers for its 46 *varas* at a slightly deeper profundity of 60 *estados*, the Cofradía de Nuestra Señora owned 60 *varas* at 70 *estados* of depth, and, in the mine of Espiritu Santo, the Jesuits owned 5 *varas* at a depth of 30 *estados*.

So while it remains unknown whether Barba earned income from his work as a mine discoverer or as a metallurgist, it is clear that Barba, like many other men and women of the cloth, had first-hand experience with the technical and commercial conventions of colonial Iberian silver mining and metallurgy. It is also clear that Barba's work as priest of Potosí and priest of Nature allowed him to collaborate with other priest-metallurgists in the development of mining and metallurgical methods and, like the other writers of amalgamation treatises, that his experiments with silver brought him into substantial and substantive contact with skilled indigenous miners and metallurgists with whom he exchanged ideas and materials. Although they worked in different professions, as physicians, priests, and civil administrators all of these writers would have studied the same natural philosophical and humanist traditions during the first years of university or through a program of self-directed study. Barba and Cárdenas would have shared a similar intellectual inheritance, but the former's calling as a priest and the latter's practice as a medical physician seems not to explain why it is that they would both convert the

metallic terms of friendly sameness into an act of erotic embrace, especially because other mineralogical writers who shared their learned backgrounds and colonial experiences did not.[202]

One factor that links Barba and Cárdenas, and separates the two writers from Capoche and Berrio de Montalvo, however, is mine ownership. Barba and Cárdenas did not own the sites of production where indigenous, African, and European miners and metallurgists collaborated and competed to invent and improve technologies like the amalgamation method, while Capoche and Berrio de Montalvo were financially invested in the science of sameness. The economics of ownership – rather than geography, chronology, or profession – seems to explain the different natural vocabularies of these amalgamation treatises. By tracing the word "abrazar" in the texts of Capoche and Berrio de Montalvo, we can identify the moments in which mine-owning authors employ affective language and where they do not.

I have chosen the key word "abrazar," which finds its way into English in 1657 through the posthumous publication of Francis Bacon's "True Report of the Detestable Treason Intended by Doctor Roderigo Lopez," because it is one of the more commonly-invoked terms in silver metallurgy in the early modern era, and it is one whose deeply emotional resonance, "to embrace," exists alongside an equally technical definition, "to structurally reinforce."[203] For authors like Barba and Cárdenas, whose metallurgical treatises delight in literary play and theoretical speculation, "abrazar" as alchemical vocabulary nicely voices the overlapping languages of emotional affect and metallurgical technology. But for other writers, the term's technical definition could stand independently of its affective reading. García de Llanos, who worked as an overseer

(*veedor*) in Potosí from 1599-1604, is one such writer. He defines "abrazar" in exclusively technical terms as the raising of "dry stone walls with a firm base that extends upward to the opening of the shaft, where it situates itself [*donde acomodado está*] and embraces the opening [*abrazarlos con ellas*]." The subterranean masonry provided structural support for rocks that seemed to float mid-air at the tight intersection of mineral veins or adits ("que parece a veces están en el aire").[204] Although the term "abrazar" could be used to describe engineering or construction projects like those designed to reinforce worn-out mine shafts, the term was more commonly invoked to describe metallurgical processes associated with mixture and combination. All of the writers studied in this book treat the verb "abrazar" as synonymous with "mix," "join," "unite," or "incorporate," but the term's dual significance on affective and technical registers makes it a useful site of comparison within and across amalgamation treatises. Because its emotional and technical qualities were equally available to these writers, "abrazar" represents a key node of authorial command.

Capoche and Berrio de Montalvo were familiar with the affective language preferred by Barba and Cárdenas, and they employed the natural vocabulary of terms like "abrazar" to describe a range of cosmological reactions throughout their texts. Minerals "embraced" other matter just as root elements like earth "embraced" other essences like water and humidity. But unlike Barba and Cárdenas, Capoche and Berrio de Montalvo studiously avoid using affective language to describe the method of amalgamation. In his explanations of the union of mercury and silver, Berrio de Montalvo prefers terms like "coger" (to gather: "hasta coxer la plata," "en coxer la plata del metal tanto mas," "el azogue reciba calor, y obre, en coxer la plata," "coxiendo luego puntas de plata"),

“juntar” (to join: “le ennegrece, y azuela, y se junta con ceniza, para hecharlo luego a labar”), “recibir” (receive: “y ella reciba su humedad, sin gasta ni consumir la del azogue”), “tomar” (take: “vuelve acabando de tomar su plata”), and “incorporar” (incorporate: “después de incorporado,” “antes de incorporarle en el metal”, “le incorpora en el metal,” “por incorporar del metal,” “se les incorpora azogue y laba de las arenas, con que no causa liga cobriça en el cuerpo de la demás pella”). Berrio de Montalvo uses almost every canonical verb that is not “abrazar” to categorize mineral mixture and to explain the new method of amalgamation.[205]

The only overlap between Berrio de Montalvo’s technical description of mixtures in the mineral and human kingdoms arrives in his use of military language. Just as minerals do battle when they are mixed together, the one striving to defeat the other (“con animo de ve[n]cer el azufre”), so too will the new benefit of amalgamation “defeat” the enemies of the Spanish empire: financial ruin and intellectual complacency (18). The first was precipitated by excessive mercury costs and the second by a lack of innovation with the mercury method. Berrio de Montalvo proposes his team’s heat-based adaptations in response to the production problems that plagued the mid-seventeenth century silver industry of New Spain, for some eighty years had passed since the development of amalgamating silver and mercury (“con su humor, el qual beneficio truxo a esta Nueva España avrá ochenta años, Bartolomé de Medina”), and the conditions had changed since the time of Medina: “no solo para vencer la poca diferencia que en esto pudo aver, sino también para aumentarla a vno y otro beneficio, y vencer el consumido del azogue, que tan considerable es” (19, 19v). Meanwhile, the New Spanish mine administrator reserves affective terms like “embrace” for “truly harmonious” mixtures of earth and water (“la

armonia de su verdad, que consiste, en que assi como el agua busca la mezcla, y junta de la tierra, y ella la recibe y abraça con tanta vnion") and arsenic and earth ("quema y abrasa los cuerpos"). The elemental embrace is why, Berrio de Montalvo explains, herbs grow in gardens ("como se ve en las hortaliças") and metals can be refined in clay ovens ("los hornos de barro"). For in the interaction of heat and earthy elements, each body exhales its fertile saltishness "en que abraça siempre en si las humedades del nitro, y todas las otras, dandoles mayor calor, templado a la orden natural: inadjustible, segun y como la natureleza necesita" (in which it always embraces the humidities of nitric salt and all other salts, giving the mixture more heat and tempering it to its natural order: resolute, according to the needs of nature).[206] Berrio de Montalvo found the affective vocabulary perfectly compatible with a philosophy of correspondence, and he drew from the discursive frameworks of analogical thinking to describe a range of cosmological interactions below ground and on the surface of the earth, both to explain plant growth and to outline metallurgical treatments. But he resisted the application of terms like "embrace" to describe the material work of amalgamation.

Capoche, too, recognized the conceptual availability of the affective language inherited from natural philosophical doctrines of analogical thinking, but like Berrio de Montalvo the Potosí mine owner opted for a more neutral vocabulary in almost every description of amalgamation in his late-sixteenth century treatise. This is not to say that the technical work of amalgamation is separated from the imaginative or literary work of the method, for amalgamation is quite literally at the center of Capoche's *Relación.* The manuscript is divided into two sections, the first of which describes the state of mining and metallurgy before the introduction of the new benefit, while the second part narrates

the social and scientific developments produced by the chemical technology. Amalgamation is the structural core of the text and the dividing line between Capoche's detailed accounts of indigenous smelting technologies (part 1) and Iberian chemical mixtures (part 2).

Capoche's *Relación* transmits quantifiable details like precise measurements of mine shaft heights and depths, dimensions of refining equipment like tanks and ovens, lists of reagents and materials for amalgamating silver, and census counts of the mine owners and laborers who fund and perform the work. But these classificatory modes of organizing the raw agents of amalgamation and the people whose natural knowledge and technical practices give value to the materials are not the only voice of the text. The *Relación* also provides a deeply emotional enactment of the dehumanizing labor conditions suffered by miners and refiners, suggesting that Capoche's deep observations of life and labor in the mines and his way of organizing the people and things around him through language shares some of the same affective vocabularies as other mineralogical treatises. Many indigenous women and men, he notes, have used their mineralogical knowledge, technical skills, and commercial savvy to profit from their work in the mines, refineries, and metal markets where indigenous women concentrated in particular ("son muchas las que en esto se ocupan"), but not all groups have shared or shared equally in this prosperity. Capoche condemns in no uncertain terms the three distinct groups that take advantage of indigenous tribute workers: Iberians, members of rival *ayllus*, and indigenous elites. With equal force he denounces the "poco celo" of the Spaniards "movidas de sus particulares intereses" (motivated by their particular interests) and the warringAndean tribes ("parecen de otra nación") that use the Iberian silver industry as an

excuse to force their "malicia" upon their rivals. However, he reserves his greatest criticism for the indigenous elites, noting that "es cosa averiguada que el mayor tirano que han tenido han sido sus caciques y gobernadores, por haberlos fatigados con el rigor en que los tenía el Inca" (it is well-known that the greatest tyranny that they have had is that of their caciques and governors, who have exhausted the workers as rigorously as when they were under the rule of the Inca).[207]

The same "poco ingenio y faltos de imaginativo" (little wit and lack of imagination) that prohibited indigenous miners from inventing a technique like amalgamation ("para inventar los instrumentos necesarios y convenientes a las obras que hacían") almost makes the Andeans non-native residents, for so little do they know about the land and its capacity: "y así vivían con una grande ignorancia de lo que había en el mundo como si no nacieran en él" (109). While many Iberian writers would naturalize their own colonial presence in America by analogizing the translation of mining knowledge and practice from imperial Rome to colonial Spain, and in turn from imperial Spain to colonial America, here Capoche invokes the natural vocabulary of mining and metallurgy to denaturalize the originary inhabitants of Spanish America – and to signal the exploitative conditions in which some Europeans forced them to labor. The Andean miners' lack of intellectual capacity, Capoche argues in impassioned prose, makes the abuse precipitated by the Spaniards all the more reprehensible, since they are not dealing with equally-matched wits. The degree of technical detail in his manuscript is matched by the deeply emotive accounts of exploitative conditions in the mines, and it is worth quoting at length to compare the lack of affective language used in Capoche's explanations of the amalgamation process. Loaded with two *arrobas* (50 pounds) of

material, the Indians proceed with their blankets

> atada por los pechos y el metal a las espaldas, y suben de tres en tres; y el delantero en una mano lleva una vela para que vean por donde suben y descienden, por estar las minas oscuras sin ninguna claridad, y la vela de poca luz y las más veces se le apaga con el viento, y con entrambas manos lo mejor que pueden se vienen asiendo y ayudando, y subiendo con harto trabajo ciento y cincuenta estados y otros tantos de descendida; y en minas que son [de] cuatrocientos [estados]--que por tierra llana era distancia para cansarse un hombre yendo cargado, cuanto más descendiendo y subiendo con tanto trabajo y riesgo--allegan los indios sudando y sin aliento, y robada la calor, y el refrigerio que suelen hallar para consuelo de su fatiga es decirle que es un perro, y darle una vuelta sobre que trae poco metal o que se tarda mucho, o que es tierra lo que saca o que lo ha hurtado. Y menos ha de cuatro meses que sucedió que un minero queriendo dar a un indio sobre esto, temeroso del palo con que le quería herir, se fué a guarecer a la propia mina y con la turbación cayó y se hizo cien mil pedazos.[208]

Capoche condemns with full force this type of exploitative relationship, and the emotionally-fraught language and imagery indicate his willingness to move between technical and affective registers. But unlike other writers, Capoche does not apply this affective language to his accounts of amalgamation. He keeps separate the passionate account of the explosive reactions between Iberians and indigenous people in the mines and the generative interaction of silver and mercury in the refineries. The language of friendship and desire is nowhere to be found in his *Relación*, for it is the fundamental

difference in the intellectual capacity (*ingenio*) of indigenous and Iberian practitioners that separates their work in mines (*minas*) and refineries (*ingenios*).

Instead of affective terms like "embrace," Capoche explains the technical process of amalgamation with neutral verbs like "take" and "incorporate," for he does not analogize the mixture of silver and mercury to human friendships or describe them in terms of cosmic principles of sympathy and sameness. Rather, he likens the relationship between the minerals to a sponge that absorbs water and pulls it away from contaminants, and he describes the process with straightforward language: "Como iba diciendo, el azogue la junta y embebe en si como la esponja al agua, incorporandola consigo apartándola de la tierra y cobre y plomo…" (As I was saying, mercury joins and soaks up silver like a sponge does to wáter, incorporating it into itself and separating it from the dirt and copper and lead, 122). Here, analogy is not a discursive formation through which to identify points of continuity in human and non-human interactions; it is as a convenient framework through which to translate an unfamiliar concept into a more accessible image, a useful method of making known -- in the natural vocabulary of a sponge -- the unknown result of incorporating silver and mercury.

Capoche's matter-of-fact description of amalgamation suggests a more restricted form of affective analogical thinking than that exercised by Barba or Cárdenas. The only overlap in Capoche's account of mixture in human and non-human bodies clusters around the verb "acudir" (converge), a term with an established technical and neutral register. According to the *Diccionario de Autoridades*, early modern writers like Cervantes, Lazarillo, and father Luis de Granada drew from the term's multiple valences to describe a timely or favorable convergence, particularly in the arrival of help or support. In the

context of agricultural production, the term carried a particular connotation of abundance, as when the Jesuit priest Alonso de Ovalle (1601-1651) praised the lands of eastern Chile (present-day Mendoza, Argentina) for their fertility: "es tan fertile como hemos visto, porque las cosechas acuden a más las frutas son mayores."[209] This rich multiplicity of meaning – the fortuitous arrival of an abundant source of natural aid – is precisely what Capoche wants to ascribe to the technical and cultural work of amalgamation. In the union of silver and mercury, there is no friendship between the minerals or among the humans who process them; there is, instead, a felicitous convergence of raw materials and new technologies with the indigenous, African, and European miners and metallurgists who will perform the work of amalgamation – and who will benefit, some more than others, from the *nuevo beneficio*.

Just as silver and mercury became the "remedio de este pueblo" when they "acudieron bien," so too did voluntary wage laborers "converge" in their migration to the interior regions of Potosí: "acudieron muchos indios yanaconas de todos los distritos de las ciudades principales a la labor de sus minas."[210] In its semasiological collapse Capoche's preferred verb at once indexes the incorporation of silver to mercury and measures the flows of indigenous silver miners and metallurgists: "por no tener indios para acudir a todo y la gran falta de azogue que ha habido y hoy hay," "acuden los indios a quien más amistad quieren hacer y con facilidad se acuestan a donde los inclinan," "porque todos acudiesen a ocuparsen en el beneficio de metales" (177, 179, 180). When the silver wealth of the Cerro Rico was discovered in 1545 by Diego Gualpa, large flows of indigenous contract laborers arrived in the city, and when the work became less profitable, they left. When the amalgamation method was established on an industrial and

commercially-viable scale in the 1570s, the *yanaconas* returned and took advantage of the opportunity to work with smelting or amalgamation operations, depending on the grade of silver they had extracted from a particular site.

The migration patterns of the wage laborers in the late-sixteenth century may have been indebted to established traditions of apprenticeship in mining and metallurgy. According to the historian of science Julio Sánchez Gómez, by 1573 each parish of Potosí had its own school in which master metallurgists passed their traditions to generations of younger practitioners, and by 1574, as we learn from Iberian metallurgists like Álvaro Alonso Barba, the new method of amalgamation had been established in the region, occasioning the eyes of the world to cast their approving admiration upon the imperial city of Potosí, and inviting large flows of miners and metallurgists to the provinces of Alto Perú.[211] This "convergence" of skilled indigenous laborers and intracolonial Iberian amalgamation techniques enabled the improvement of civil life ("buen gobierno") and technical innovation throughout the region: "Y como fuese creciendo el número de los artificios y cada día se entendiese más el provecho que del nuevo beneficio se seguía, íbanse extendiendo por la tierra" (And because the number of devices was growing and every day the fruitfulness of the new benefit extended further, and it continued to spread throughout the land, 117).

In provinces like Chuquisaca and Los Lipes, indigenous and Iberian women and men took advantage of the technologies and commercial networks cemented by the introduction of the new benefit of amalgamation. The convergence in the high mountains of Potosí radiated to the provinces where indigenous female mine discoverers like Catalina Arupo "sacó metal que acudió por el beneficio de azogue" and male Iberians

amalgamated silver that, alternately, “no le acudió bien” or “acudió bien.” The case of Araupo is discussed in more detail in chapter four, while the different results of the two Iberian assays in Oslloque are worth mentioning here because it is precisely in this passage where Capoche’s first and only use of “abrazar” emerges. As the passage demonstrates, Capoche uses the term to describe a failed set of mining and metallurgical practices. In the province of Los Lipez, where Barba would later administer the sacrament and assay silver for more than 30 years and Antonio López de Quiroga would become one of the wealthiest miners in the history of Potosí, some ten or twelve Spaniards, having discovered a westward-sloping silver vein in the Cerro of Oslloque, populated the mining seat located fifteen leagues outside of Colcha. Their silver production was limited by the region’s unique mineralogies and by their mineralogical knowledge; the Iberian miners were unfamiliar with what Capoche calls “nuestra usanza” (our use), or the amalgamation method. Around 1581, one miner tried to amalgamate silver with mercury, but “no le acudió bien” (it didn’t take well) because the silver was so humid that “no puede abrazar el azogue a la plata” (mercury cannot embrace the silver). Instead, they were forced to contract skilled indigenous workers whose “aprovechamientos de metales” (knowledge of metals) allowed them to command a wage of two and a half reales. The Iberian group’s lack of knowledge of amalgamation makes them dependent upon indigenous mineralogical knowledge and practice; they are also the only group whose work is described with an affective verb, and the only group to produce less than favorable returns on their labor.[212]

The neighboring mines owned by Martín García de Loyola, Domingo de Basurto, and Cristóbal Flores, meanwhile, used a combination of indigenous smelting ovens and

Iberian amalgamation methods. The *capitán* García de Loyola smelts in *guayra* ovens the silver that is extracted from a site "donde se halló una cata antigua tapaca a manos" (where he found an old test vein worked by hand), but he experimented with mercury amalgamation in another site and determined that "acudió bien" (it took well). The military leader-cum-mine owner probably used the *guayra* oven because, like other Iberians had discovered, the European-designed furnaces (*fuelles*) did not allow them to extract as much high-grade silver as the indigenous heating systems. Basurto and Flores also used the new benefit of amalgamation, here glossed in the neutral vocabulary of profitable success rather than the affective language of Barba, Cárdenas, or the underproductive Ibeerians of Oslloque. In neutral terms, Capoche notes simply that "sacó plata por azogue" (he extracted silver with mercury).[213]

"Acudir" is at once a technical term of amalgamation and a discursive record of population and demographics, an overlapping term of silver metallurgy and peopling. For the refinery owner Capoche, the "new benefit" of human and mineral reaction and interaction meet in Potosí and radiate to the provinces; the overlap of mineral amalgamation and new demographics of human mixture – and the language in which they are narrated – is not a question of friendship or similarity, but rather of convergence, a happy harbinger of prosperity. As we saw in chapter one, "abrazar" had been used by some writers, like the attorney general Sebastián Sandoval y Guzmán, as an overlapping term of metallurgical technology and population management. Certainly, the mutually constitutive technical and cultural registers of colonial American scientific discourse contain many such examples of these terms, like "casta" and "metal mulato," or, in the case of the English, the appeal to "planting" as a political process of naturalization and a

material practice that could be improved with empirically-tested scientific knowledge. But as Capoche's *Relación* and its appeal to an idea of "convergence" suggest, relative to the emotional translation of friendship into desire in authors like Barba and Cárdenas, writers who owned the sites of mineral production preferred other, less affective natural vocabularies.

Just as the language of metallurgical writing reveals within-group differences that are as substantial as those without, so too are there important points of rupture within English agricultural writing. These differences partly reflect the types of individual experiences and orientations that I have traced in the lives and letters of Barba and Cárdenas, relative to the economics of mine ownership for Capoche and Berrio de Montalvo, but they also channel the different material practices of plant and animal husbandry that were conceptually available to English agricultural writers as they searched for the metaphorical terms of colonial settlement. Some practices of crop science, most notably grafting, depended upon an identification of sameness and sympathy, while others, like planting (either setting or sowing), emphasized the productive value of difference and antipathy. Animal husbandry, especially shepherding, presented another complex set of metaphors for seventeenth-century colonial apologists, one that was at once sanctified by the religious terms of pastoral labor and vexed by the political, social, and economic legacy of enclosure in England. What convergence of scientific innovations, faith relationships, and cultural frameworks made the language of planting into the central metaphor of colonization in Anglo America?

IV. "thou hast cast out the heathen and planted it; thou preparedst room before it, and didst cause it to take deep root, and it filled the land": The Deep Roots of Difference and the Guise of Friendly Grafting in Colonial English Agricultural Letters[214]

That agricultural scientific discourse performed the cultural work of the English colonial enterprise is confirmed by the overlapping languages of agricultural improvement, spiritual cultivation, and colonial planting in plurigeneric texts like Walter Blith's *The English Improver* (1649), the expanded edition of 1652, *The English Improver Improved*, or captain John Smith's (fl. 1633-1673) *England's Improvement Reviv'd* (1670), instruction manuals that intersperse political commentary and recommendations for public policy. John White's *Planters Plea* (1630) and John Cotton's *God's Promise to His Plantations* (1630), promotional pamphlets that position the propagation of the faith as the rationale for the planting of English bodies in the New World, channel the language and metaphor of improvement as material practice and spiritual metaphor. These foundational images of planting and peopling were given greater purchase and wider circulation by imaginative works like Shakespeare's *Tempest* (1623) and Milton's *Paradise Lost* (1669/1674), as well as the religioscientific treatises that drew from elements of all these genres, such as John Dury's *Reformed Spiritual Husbandman* (1651) and John Flavel's *Husbandry Spiritualized* (1661). At once a richly symbolic and culturally satisfying way of framing the English colonial project in the New World, the language of English planting and the English idea of peopling stem from equal parts religious sensibility and material cultivation.

The physical practices of planting engage an appealing and conceptually available religioscientific root paradigm through which the English could promote their colonization of America in the terms that allowed them to see themselves as they wanted to be seen. This idea of a religioscientific root paradigm unites three disciplinary studies, from history, anthropology, and the history of science, to offer a new way of reading the

colonial English agricultural scientific archive. The English idea of planting is equal parts religioscientific, because, as the historian Walter Woodward has shown, its projects of agricultural reform were inspired by a millenarian spirit that sought to bring about Edenic restoration; root, because, as the anthropologist Victor Turner put it, metaphors that frame human experiences in terms of natural processes like plant growth or animal lifecycles symbolically raise the terms of individual lived realities to a collective level; paradigm, because, as the historian of science Thomas Kuhn famously defined the term, agricultural scientific discourse served as the model from which a coherent narrative of English scientific experiment and agricultural reform originated.[215]

By framing their work in America in these religioscientific terms of planting and possessing, English colonists naturalized their settlements in the New World as so many nurseries dedicated to the propagation of the gospel and the improvement of the English state. Like "the rootes that issue out from the Truncke of the Tree, though they be dispersed, yet they are not severed." As White insisted from the earliest years of the English colonial project, these planters were to form "part of our owne body," to be known as "our owne flesh and bones," and in England's foreign plantations they would "but doe good offices, by drawing nourishment to the main body, and the tree is not weakened but strengthened the more they spread, of which wee have a clear instance in the Romane State." Borne out by England's experience as a feeder of agricultural products to imperial Rome, White could argue with the authorizing precedent of antiquity that although the soil was different, the body politic would remain the same; in the eyes of the state, "a Colony is a part and member of her owne body; and such in whose good her selfe hath a peculiar interest."[216] In sum, so long as the seed was English, so too

would be the fruit; in John White's model of colonial planting, as in so many of his contemporaries' proposals and practices, the matter of the soil mattered little.

This understanding of the relationship between English stock and colonial roots may stem in part from received traditions or Roman imperial frameworks and also from the particular experiences and attitudes that governed seventeenth-century English agricultural practices. As the agrarian historian Joan Thirsk points out, English farmers of different regions had long exchanged material samples of soils with other husbandmen, and they tried especially to find lower-quality soils than those of their native seats. By planting the choicest seeds in the worst, non-native soils, they believed they could root out from the mismatched earth and seeds more of the contrary energies necessary to generate plant and cereal growth; the greater the contrast and Strife between soil and seed, English crop science suggested, the more productive the sprouting and the more bountiful the harvest. Farmers from North and South Staffordshire purchased seeds from each other, Cambridgeshire farmers sold their wheat and barley seeds to the husbandmen of West Suffolk, and everyone sought to purchase imported hempseed from the Low Countries.[217] The material practices of settlement, namely the planting of English bodies, religious institutions, and political frameworks in the foreign soils of America and Ireland, follows the preferences and practices of husbandmen in England.

While technical manuals instructed farmers in the methods of selecting seed and explained the benefits of sowing rather than setting, what gave this language of planting its political purchase in the circum-Atlantic economy was its spiritual and cultural register. Seventeenth-century agricultural science recommended the types of labor relationships between planter and planted that accorded nicely with the cultivation of

early modern religious appeals to industry. That the New English soil was worse than English varieties, White argued in accordance with both the agricultural philosophy and spiritual husbandry of the seventeenth century, meant that the region was particularly well-suited for planting English: "if men desire to have a people degenerate speedily, and to corrupt their minds and bodies too, and besides to take-in theeves and spoilers from abroad; let them leeke a rich soile, that brings in much with little labor; but if they desire that Piety and godlinesse should prosper; accompanied with sobriety, justice and love, let them choose a Countrey such as this is." Unlike the West Indian islands or Ireland, both of which "offer a richer soyle," the poor soils of New England made available to Protestant planters the particular conditions that their natural philosophy and religious ethos suggested as the way to wealth.[218]

English apologists like John White sanctified their agricultural production and the reproduction of English bodies by drawing broadly upon the language of planting. At times they analogized the colonists to plants, as in the examples of colonial roots and naturally migrating sets of fruit trees, while at other times they equated the entirety of the English colonial settlement to the labor of rooting out noxious weeds and planting virtuously in their stead. Cotton Mather, for example, put this trope to memorable use in his refashioning of Psalm 80 in the *Magnalia Christi Americana*, what Perry Miller called Mather's "monumental piece of ancestral veneration." In reading of the ways in which the faithful flowering of ancient Israel at once typified the experience of the planters of New England and allowed the Puritans to exceed the scriptural precedent, Mather suggested

The colony might fetch its own description from the dispensations of the great

> God, unto his ancient Israel, and say, 'O, God of Hosts, thou hast brought a vine out of *England*; thou hast cast out the heathen and planted it; thou preparedst room before it, and didst cause it to take deep root, and it filled the land; the hills were covered with the shadow of it, and the boughs thereof were like the goodly cedars; she sent out her boughs unto the sea.' But still there was one stroak wanting for the complete accommodations of the description; to wit, 'She sent forth her branches unto the river;' and this therefore is to be next attended. The fame of Connecticut river, a long, fresh, rich river, (as indeed the name *Connecticut* is Indian for a long river,) had made a little *Nilus*, of it in the expectations of the good people about the Massachuset-bay: whereupon many of the planters belonging especially to the towns of Cambridge, Dorchester, Watertown and Roxbury, took up resolutions to travel an hundred miles westward from those towns, for a further settlement upon this famous river.

In replacing the vine transplanted from Egypt to Israel in Psalm 80.8 with one that delivers the English to New England, Mather grounds the Puritan project in orthodox terms of divine favor coupled with the image of natural migration. The rooting out of heathen sin in New England ("thou hast cast out the heathen") likewise takes as its authorizing precedent the richly metaphorical terms of agricultural labor and the example of sacred scripture. But while the Song of David concludes with an appeal for divine intercession – a prayer that that "Lord God of hosts" might "behold, and visit this vine" and "cause thy face to shine, and we shall be saved" – Mather's reading ends with an endless westward progression "for a further settlement." The great waters of Egypt become here the "little *Nilus*," the Connecticut River along which rising generations of

English planters plot their new settlements. The land has been emptied so that it may be filled with the deep roots of planting English.[219]

In the powerfully cohesive tradition of analogical thinking, agricultural processes were available both to prefigure the planting of colonial society, as in the case of Mather, and to typify the faith relationships of individual planters as well. For the reverend John Flavell, the preparatory work of plowing the ground, the careful insertion of seed into the newly opened soil, the watchful monitoring of desired and undesired botanical growth, and the rush to harvest crops that came to fruition in ways predictable and less so all served as a "similitude" for the propagation of the gospel in the plantations of the New World and in the hearts of the planters. "What are ye," Flavell asks, "but a field, or a plot of ground, to be manured and cultivated for God? And what are Paul, Apollos and Cephas, but so many workmen and laborers, employed by God, the great husbandman, to plant and water you all?" The resemblance in the outer world and the inner essence enables Flavell to bind together agricultural labor and spiritual work, making the macrocosmic plantation and the microcosmic heart into equally fertile ground for the planting of the seeds of faith.[220] The material practices of labor and the cosmological elements of husbandry, its seeds and soils, are used as points of departure for the religious processes and spiritual patterns that interest Flavell; however, the annotations and marginalia left by readers suggest that Flavell's spiritual conception of husbandry held special resonance in practical application.[221] The conceptual availability of planting as a metaphor for individual habits and communal life, as material and spiritual practice and process, is what gives this religioscientific root paradigm its central place in English colonial discourse. These are the multigeneric nodes that allow agricultural scientific

theories to circulate beyond their immediate range of application by farmers and husbandmen, and to instead enjoy wider purchase in the discourse of planting empire in America.

At once grounded in the traditions of the past, the authorizing logic of colonial planting also threw into sharp relief, and indeed depended upon, important advances in English agricultural science. Literary scholars and historians have studied the cultural and symbolic valences of spiritual planting, many of whom, like Alexandra Walsham and Jorge Cañizares Esguerra, find points of continuity among the spiritual gardening of the British Isles and the Americas following Protestant and Catholic Reformations, while agrarian and economic historians like Joan Thirsk and Craig Muldrew have attended more to the technical innovations of plant science and their economic consequences.[222] This section aims to unite these two modes of study by situating the technical advancements of English agricultural science – new methods of setting seed, the introduction of clover to convert staple crops into marketable specialties, and the draining of fenlands – as part of a larger colonialist discourse on the right way to people and plant.

There was no shortage of other conceptually available farming practices in which plant or animal husbandry might be taken as what Flavell identifies as one of the many "lively similitudes" with which "the Scriptures abound with parables," like grafting, breeding, or shepherding. Indeed, many books of agriculture oriented husbandmen toward the best practices in the *Art of Planting, Graffing, and Gardening*, also positioned by Thomas Barker (fl. 1651) as the three parts of *The Country-Man's Recreation*, and Flavell, whose volume was catalogued and sold alongside these technical manuals, argues that "there is nothing in nature that shadows forth this great gospel-mystery" as

aptly as grafting emblematizes adult faith relationships because "no soul [is] united with Christ without a cutting sense of sin and misery."[223] But the English described their colonization of Ireland and the New World as planting, not grafting or shepherding. To graft a plant is to bind like to like, to generate from a common root new life but not a new life form; both the stock and the scion, the part grafted to the root, retain their core characteristics as the plant experiences growth without creation. The decision to graft rather than plant is often made in response to environmental conditions, like the need for a better soil or else access to or protection from the elements. To shepherd is to apply the practices of good husbandry and environmental stewardship to the tending and protection of an innocent but aimless flock. These material practices both require and occasion different relationships between planter and planted, cultivator and cultivated. In contrast, the art and science of planting contained an *apriori* element of accommodation. If the idea of grafting was to replicate the nature of the scion in more favorable conditions, to quite literally re-produce the original model, the idea of planting from seed allowed for adaptation to new conditions.

As a metaphor for colonial settlement, the language of planting provided an especially attractive way of positioning the English project in the New World. Dr. Robert Child, one of the more active contributors to the "international spiritual brotherhood" of the Hartlib circle, intervened in the transnational debate about the relationship between local conditions and universal husbandry as the determinants of fruitful harvests. Namely, Hartlib circle correspondents throughout the circum-Atlantic republic of letters exchanged theories and shared their experiments with sowing, setting, and grafting to identify whether agricultural success was determined by deep knowledge of the

particulars of the local or whether best practices in husbandry could be universally applied throughout the terrestrial globe, so long as the climatological and botanical conditions were similar enough. Grounded in his observations about English planting in New England, Virginia, and Ireland, Child, a universalist, argues that planting from seed allows for the widest degree of adaptation to a new environment. "Divers Plants though at first they difficultly thrive," Child begins, "yet when they are habituated to the Countrey, and to cast their seed there, thrive well: This I have observed that *Virginia* Wheat at first difficultly thrived in *New-England*, but the seed that matured there the next year, flourished very well: the same I observed of Wheat brought from *England*, of water *Melon* seed brought from the Western Islands: the like I observe in *Ireland* of Oats and Barley sown before *December*…." The material benefits of setting from seed, like increased adaptability, accustomation, and habituation, were easily analogized to the benefits of learning to adapt, acculturate, and familiarize oneself with a new colonial habit and habitat.

As spiritual metaphor, however, planting, grafting, and shepherding could be used interchangeably to epitomize the work of the church and to instruct the faithful on their roles therein. The late-seventeenth century catechism of Chelmsford, Massachusetts minister John Fiske (1601-1677), written as an extensive dialogue, translates the church's complex definitions of sacraments and faith relationships into terms that will help young Puritans and their literate parents ("you and yours") to reap the "spirituall fruit" of church teaching. Baptism, for instance, is performed "in order of nature, our planting or ingrafting into Christ, and our begetting, breeding & bringing forth of the womb of the Church, do precede our nourishment and growth therein." Fiske's richly symbolic terms

of the soul's exaltation in the sacrament of baptism equate the material practices of planting and grafting. Here equally generative methods of preparing the infant soul to become the fruitful womb of adult faith relationships, a language widely circulated in the writings of Puritan minister Thomas Hooker (1586-1647).[224] For Hooker, grafting was akin to the process of humbling oneself before God. For adult sinners who sought to prepare their hearts for Christ's entry, they had to carve out physical and metaphorical space. Once "pared," the sinner would find that "hee is wholly pluckt from the first *Adam*, (for here is the maine lift) So that now the second *Adam* Christ Iesus, may take possession of him."[225] For John Flavell, the language of grafting complemented that of planting, allowing him to analogize the grafting of good trees into better soil as a type of spiritual migration and adult salvation. Were a stock of "unregenerate men" to "be removed into good soil, and graffed with a better kind," Flavell argued, "it may become a good tree, and yield store of choice and pleasant fruit." Imagining the possibilities for spiritual gardening, Flavell continues, "If such a stock were removed into a better soil, and graffed with a better kind, it might bring forth fruit pleasant and grateful to the husbandman; and if such persons, before described, were but regenerated and changed in their sights and principles, what excellent and useful persons would be sweet and acceptable to him."[226]

But in terms of the material work of settlement, the practices and language of grafting would have suggested a fundamentally different relationship between the English and the people and places they colonized. The science of planting, unlike grafting, is informed by difference: by inserting a seed into a soil whose essence was unlike its own, like planting seeds of apples, "cold and moist in the first degree," in dry, warm, sandy

lands, planters could "occasion Quarrells and Contention" between these warring opposites. It is worth pointing out that apples were at once one of the most important segments in the emerging industry of market gardening, perfected in the late sixteenth century by Dutch immigrants who settled in the outskirts of London and improved by the grafting practices that Henry VIII's royal gardener adapted from the French, and, in the imaginative spaces of print culture and visual arts, the fruit responsible for the downfall of humanity having been plucked by the similarly cold and moist Eve in the garden.[227] The generative force of Strife would enable the botanical growth to feed local populations with cereals, fruits, and vegetables and, by virtue of seventeenth-century improvements in transportation, knowledge of non-native species, and the development of commercial networks, to sell surplus crops beyond the pale of market towns.

Neither grafting nor shepherding gave rise to the types of technological innovations that revolutionized seventeenth-century agriculture in England or the colonies. Fifteenth-century policies of enclosure had already dramatically reorganized the social and economic landscape of pastoral English lands, while the technologies of grafting remained largely unchanged until the eighteenth and nineteenth centuries. Seventeenth-century agricultural manuals, following the precedent of antiquity and the medieval era, suggested that by grafting scion to root one could produce a perfectly mixed specimen. Neither entirely new nor wholly old, similarly-sized botanical elements like white and red roses, apples and pears, or lemons sweet and sour, could bring forth equally matched matter: Kircher's ''flower both red and white," Markham's "half apple and half pear," and Giambattista della Porta's figs "halfe white and half black" or pomegranates "sweet on the one side and sowre on the other."[228] These combinations

circulated broadly in print but were impossible to practice, according to horticultural scientists, perhaps explaining why – unlike in the case of sowing and setting – there had been no known innovations in the methods or theories of grafting from antiquity through the seventeenth century. Markham offered a few such "novelties," but even such a great self-promoter as he could not describe these techniques without qualifying the limits of their practical utility: "Although for certainty, use and commodity, the manner of grafting already prescribed is of sufficiency enough to satisfie any constant or reasonable understanding, yet for novelty sake, to which our Nation is infinitly addicted, and to satisfie the curious," Markham offers a section on new methods that are "not altogether unnecessary, having both certainty in the worke, pleasure in the use, and benefit in the serious imploying of those howers which else might challenge the title of idlenesse, besides they are very well agreeing with the soyles and fruites of this Empire of *Great Britaine*, and the understandings of the people, for whose service or benefit, I onely undergoe my travel." Even commercial authors who had every reason to celebrate seventeenth-century innovations in grafting found, in fact, that they could not. In the eighteenth-century, however, there were improvements to champion, as botanists began to reconsider the nature of graft transfers of scion and root, while nineteenth-century practitioners adapted grafting methods to a commercially-viable industrial scale.

If in the seventeenth century it was entirely conventional for writers like Jane Sharp to assert in *The Midwives Book* that a grafted plant would produce fruit like its scion, but a seed planted from the grafted plant would "bring fruit like the stock it was grafted on," by the eighteenth century what the historian Jenny Davidson calls these "reversions to nature" would become untenable claims unsubstantiated by experiment. As

an agricultural node of improvement in the seventeenth century, grafting as material practice and metaphor for joining was not nearly as compelling as was the discourse of planting, setting, and sowing. What passed as knowledge of grafting often failed in practice, and the relationship of scion and graft was poorly understood at best. As a metaphor, grafting suggested a process of correction rather than origin – a perfectly good root was to be saved from bad soil. If colonial apologists wanted to frame the mismatch of seed and soil in productive terms, they had to invoke the discourse of planting. It was planting, after all, where contrariety was generative; in grafting, difference is undesirable.[229]

Shepherding, or animal husbandry more broadly, represents another possible frame through which English colonists might have justified their religioscientific essays into the circum-Atlantic theater of nature. As recent studies of human-animal relationships and analogies of sameness have suggested, early modern writers were deeply invested in exploring the limits of human subjectivity by way of non-human interaction.[230] But while technical treatises and instruction manuals often treat plant and animal husbandry in the same terms, crop science offered a much more palatable set of conceptually available metaphors for colonial settlement than animal stewardship. In the case of seventeenth-century English agricultural letters, the metaphors of shepherding and pastoral work were complicated especially by the legacy of enclosure. Earlier policies of enclosure had radically reworked the economic and social landscape of England, but reform-minded writers were divided over whether these innovations were to be celebrated or reworked once more. For Hartlib circle contributor Gabriel Plattes, the enclosing of land in private hands led to wasteful mismanagement of fixed resources; the

remedy for the present state of England, he argued, would be easily performed so long as farmers embraced the possibility of new "perfection" in agricultural knowledge rather than acting like "Plebeans [who] are like those in *Ireland* who will not lay aside their old custom." Plattes therefore proposed in all seriousness the creation of a centralized Council of Husbandry to regulate land use and ensure, for instance, that no one occupied as pastureland a space better suited to arable regimes or tillage, and that no water was wasted to fertilize land that was more apt for grazing. He concluded, in at least partial jest, that the act of enclosing land and sheep denied English farmers their humanity and made them more sheep than men, a less than faithful shepherding of the English public writ large in public ledgers and church records: "A friend of mine did search divers Register books in several Parishes in *England*, he also searched the Parsons books of Tythes, and found that where Arable land was turned into Pasture there were fewer Christnings, and many more tyth Lambs and tyth Calves, whereby he discovered a kinde of Witchcraft, which is to turn men into beasts."[231] Walter Blith disagreed with much of Thomas Tusser's "prayse" of "The Countrey Inclosed," vowing to "sope the Black-more no more" in the debate over open and enclosed lands, but he ultimately if cautiously endorsed the system of enclosure as one that might provide incentives for individual farmers and bind them at the same time into communal necessity, "what Right, or Interest, he hath in Common."[232] Enclosed tracts held by landowners and leased to freeholders and tenants was still ajacent to champion lands, and poor and unpoor farmers alike still depended upon each other to exchange soil and seed samples that would maximize food production for their families, their parrish tyths, and the markets.

If the writers of the period like Plattes, Tusser, and Blith were actively debating in

terms of racialized language and public obligation to the poor and middling sorts whether enclosure produced technical efficiencies and social improvements, the scholarly historiography is even more divided and divisive. The historian Brian Donahue, summarizing the last thrity years of this debate, finds that the system of land held in common was not as resistant to commercialization as some agrarian historians had suggested, but that in the long term, the "new farming methods, new crops, increased production, and adaptation to market demands" allowed under the commons system proved less commercially viable than the more direct turn to privatization and market production enabled by enclosure.[233] Despite the rich traditions of spiritual shepherding, and the technical improvements of seventeenth-century pastoral labor, the vexed question of enclosure could have helped to make plant rather than animal husbandry a more appealing metaphor for the work of colonization.

Pastoral terms were more famously applied to indigenous populations rather than to creole settlements. In his chronicle of the abuses waged by the Spaniards in New Spain, for example, the Dominican friar Bartolomé de las Casas suggests that Spanish soldiers purposely misinterpret scriptural passages like Zechariah 11:4-8, where the responsibilities of shepherd to sheep and Lord to shepherd are explained, as an authorizing precedent for murder performed in the name of providence. When las Casas was translated into English in 1583 and 1656, the *Brevíssima relación de la destrucción de las Indias* was first sold under the title *The Spanish Colonie* and then as *Tears of the Indians*. As Thomas Scanlan has shown convincingly, the prefatory materials and framing devices of these two versions help to set up a larger argument about the shifting stakes of English colonialism. In the late-sixteenth century edition, the text throws into sharp relief

the European nature of the conflict between an emerging Anglo program and a firmly-established Iberian model by underscoring the unstable place of the Dutch, then part of the Holy Roman Empire presided over by Felipe II. The mid-seventeenth century volume, by contrast, seems to follow the model of John Eliot (1604-1690) and his narrative of missionary conversion in North America, *Tears of Repentance: Or, a Further Narrative of the Progress of the Gospel Amongst the Indians in New-England* (London, 1653). "What these early translations show," Scanlan argues, "is that Spanish colonization or, more precisely, the Spanish treatment of the native populations in the colonial setting –could be made to signify something about the Spanish as a nation." [234] The debate about peopling in English colonial policy was always, then, both a real material practice and an artfully crafted discursive form.

In a more explicit argument for colonization of foreign lands as the remedy for the choking English state, John White, for example, was adamant that shepherding would not solve England's economic woes. As long as other regions enjoyed a competitive advantage in the cloth industry, relieving England of its "overflowing multitudes" would provide the only real form of economic security both for the landed in England and the landless farmers and artisan laborers transplanted abroad. If the spiritually rich image of shepherding was an uncomfortable agricultural frame for the English colonial project, and if grafting suggested that something was rotten in the home soil, then the discourse of planting seemed to strike the right note of metaphor and practice. The planting of English abroad would not only remedy the problem of population, but it would also allow for "the propagation of Religion," or what White calls "the most eminent and desirable end of planting Colonies" to which "this Nation is in a sort singled out unto that worke."[235] New

planting technologies and new spaces in which to plant gave the language of English colonization a way to show both continuity with the past and communion with new, innovative theories that had been tested and reformed in the fields of experience. The advances of crop science helped to provide empirical grounding for the authorizing logic of English colonization, and the productive work of difference articulated by theories of planting – rather than the framework of similarity and sameness that governed theories and practices of grafting – converged to make planting the foundational discourse of English colonization. The science of botanical planting advocated the logic of difference, and in the tradition of analogical thinking the terms of difference offered to English planters an appealing way of understanding their human relationships.

The language of friendship and desire was conceptually available for all of the writers whose amalgamation treatises remain extant, as suggested by the moments when even mine and refinery owners like Berrio de Montalvo and Capoche incorporate these terms into their accounts. But only some authors used the intimate terms of human relationships and experiences to explain the technical processes of amalgamation, and those writers tended to be the men who did not to own the sites of silver extraction and production. For example, Barba and Cárdenas, writers for whom affective language is the preeminent discourse of amalgamation, invoke these natural vocabularies in the moments when the material work of incorporation is performed in the embodied labor of indigenous, African, and European miners. In Capoche's account, meanwhile, the material process of amalgamation coincides with human experience on matters of demographic mixture and population management, a convergence that the final chapter of this book takes up by way of comparison with English agricultural ideas of peopling.

These introductory chapters, meanwhile, have examined the scientific theories of planting and refining, and they have underscored the ways in which the same concepts and traditions received from the natural philosophy were applied in different theoretical formulations and material practices within colonial Anglo- and Iberian-American sciences. The remaining chapters of this book – indeed, the bulk of this story – studies the people who put these seventeenth-century theories into practice, and the writers who explained the technologies of agricultural and mineralogical science in terms that naturalized and justified their colonial settlements. The next two chapters concentrate on individual agents of science, and they throw into sharp relief some of what has been suggested in this chapter: namely, that individuals from some of the most marginalized groups in the Americas – African and indigenous women and men – made substantial contributions for better and worse to the development of the scientific fields that underwrote colonial settlement, and that by tracing the often overlooked language of technical treatises we can appreciate the deep epistemological and experiential participation of these agents of science. Chapter three examines the shifting gender pronouns in English agricultural manuals to show how they register larger shifts in cultural ideas of gender and reveal the specific contributions of female practitioners to the development of in the colonial silkworm industry in Virginia. Chapter four recovers from the colonial archive the broad participation of Andean and Iberian women in every operation of the silver industry: the discovery of mines and extraction of ore, the refining of metal, and the distribution of processed silver in commercial markets. Chapter five synthesizes the localized case studies of chapters three and four with the planetary view of colonial scientific theories and practices outlined in chapters one and two by

comparing the colonial scientific paradigms of Anglo- and Iberian-America with their respective strategies of peopling and population management. The structure of the book therefore builds from the theories of colonial planting and amalgamating to what communities of natural scientists did and said, and it concludes with an analysis of how those discursive forms were incorporated into biopolitical paradigms that organized these nodes of botanical and mineralogical flows and explain and regulate the problem of population.

The Gendered Language of English Colonial Agriculture

On 28 November, 1653, some three years after his failed attempt to sell some 200 homebound copies of the *Eikon basilike* in the colony of Virginia, John Ferrar (c. 1588-1657), the former Virginia Company treasurer, sent to Samuel Hartlib an account of his daughter's successful experiments with silkworm cultivation. If the colonial readers were unresponsive to the beautifully-bound but politically unpalatable celebration of the life of the Stuart monarch printed so soon after his beheading, perhaps, Ferrar figured, the planters would give greater purchase to the monarchy's colonial designs in the emerging luxury market of silks. As the letter explains, Virginia Ferrar (1627?-1688), so named for the colony, had fed the same mulberry leaves to two groups of worms, one housed in the family garden and one that lived in cabinets inside the house. She compared the sizes and survival rates of the two groups and concluded "in triall and experiment" that the outdoor worms delivered the best outcomes for silk. The tale of these trials, a story spun as artfully and with wider circulation than the homebound books, formed part of a transatlantic exchange of natural knowledge that belied the more restricted geography of the garden plot and the intimate corners of Virginia Ferrar's bedroom in Little Gidding, Cambridgeshire, England. The treatises threw into sharp relief the explicitly feminized program of silkworm cultivation and silk production around which mid-seventeenth century English colonial apologists fashioned their reformist proposals. Two years after receiving the report, Puritan reformer and Polish émigré Samuel Hartlib (c. 1600-1662)

appended it to correspondence from Germany, England, and Ireland and assembled a transnational dialogue that was published in London, in 1655, as *The Reformed Virginian Silkworm; or A rare and new discovery of a speedy way, and easy means, found out by a young Lady in England, she having made full proof thereof in May, anno 1652*.[236] Why, at the height of the Protectorate, might an international community of Puritan readers and reformers endorse the Stuart monarchy's program of a colonial silk industry? And why would they frame their proposals around the labor of a female sericulturalist and feminized silkworms?

Although literary scholars have focused their studies of gender and seventeenth-century science on single-author texts that fall largely within the purview of natural philosophical theory or medicine, agricultural treatises like the Ferrars' represent an important genre whose gender-inclusive, transnational, and commercialized modes of practice and production of knowledge puts pressure upon some of the longest-held theories of gender and early modern science.[237] Agricultural historians, for their part, have either concentrated more on technical innovations like new plows, the introduction of new species, or new methods of setting seed, or else on the large-scale reordering of the landscape produced by engineering works like enclosure or the draining of the fens. While these new crops and technologies are essential parts of English agrarian history, a focus on measurable outcomes has overshadowed a more careful attention to the language in which these important new devices and methods were explained and justified.[238]

By concentrating on the subset of silkworm treatises within the larger body of agricultural texts, I attempt in this article to bring together these two approaches: an

appreciation of the epistemological and practical contributions and an analysis of the cultural work performed by rich language and images of seventeenth-century English agricultural scientific discourse. This study applies the methods of close reading – a rooting out of the nitty-gritty details and play of language – to a literary corpus that falls somewhere between history and literature: instructional manuals, scientific treatises, and epistolary exchanges in which the reformation of agricultural labor establishes the boundaries of English natural knowledge and helps to produce a definitive English identity in an era of colonial planting. This shift in genre helps to throw into sharp relief the substantial contributions of women to colonial science throughout the circum-Atlantic world, and to situate their work within the experientially-oriented, commercialized, religioscientific conventions that historians of early modern science like Margaret C. Jacob, Margaret J. Osler, Steven Shapin, Londa Schiebinger, Jorge Cañizares Esguerra, Antonio Barrera Osorio, Katharine Park and Lorraine Daston have identified.[239] Female and male contributors to English agricultural science are the subject of this chapter, while chapter four discusses the broad participation of Andean women in colonial Iberian mineralogical science.

Equal parts political framework of naturalization, religioscientific essay into agricultural improvement, and the symbolic applications of the language and imagery of planting, became the preeminent colonialist discourse of the British Atlantic world and the authorizing logic of those settlements. Often, in the mid-seventeenth century, these terms were invoked by writers who turned one eye toward Iberian and Dutch models, while at the same time strenuously protested the differences in Anglo, Dutch, and Iberian American colonialisms.[240] The literary roots of planting as agricultural practice and

political naturalization spread through the placelessness of Thomas More's *Utopia* (1516) and grounded proposals for the domestication of racialized moorlands and "heathen" heathlands in England, and they anchor the conclusion of minister John White (1575-1648) that English planters who settle the marshlands of Naraganset Bay, perhaps borrowing the Dutch technologies of fenland drainage perfected in England in the years preceding the publication of White's *Planters Plea* (London, 1630), "need not feare a clear title to the soyle" where the native population has recently been decimated by disease.[241]

After the English civil war (1642-1646; 1648-1660) the overlapping discourse of agricultural science and religiopolitical possession became increasingly codified in English colonial expression and it was enlisted by Puritan reformers and royalist administrators alike. Two months before the appointment of Oliver Cromwell as Lord Protector, the English and Welsh Parliament passed acts to ensure *The Speedy and Effectual Satisfaction of the Adventurers for Lands in Ireland: And for the Encouragement of Protestants to Plant and Inhabit Ireland* (London, 1653), while after the Restoration of Charles II the Irish parliament called *For incouraging Protestant-strangers and others to inhabit and plant in the kingdom of Ireland* (Dublin, 1662).[242] Individuals like Sir Hugh Platt and Edward Maxey debated the values of sowing over setting, terms that were channeled by later writers like William Loddington (1626-1711) in their positioning of *Plantation Work* as *The Work of This Generation: Written in True-Love to all such as are weightily inclined to Transplant themselves and Families to any of the English Plantations in America* (1682). Throughout the seventeenth century, and especially after the English civil war, private writers and public bodies endorsed the

language of planting and possessing as agricultural scientific discourse and religiopolitical paradigm.[243] Against the radical changes of the mid-seventeenth century political landscape, the authorizing logic of planting appealed to the colonialist sensibilities of loyalists and dissenters alike. Sericulture, and the silkworm treatises that describe the methods thereof, represents a searching strand of continuity amid these moments of rupture in human and heavenly time. Hartlib circle correspondents like John and Virginia Ferrar connected Stuart-era investment in silk colonies to at once establish continuity with the past and to open a space for their own interventions in the present, phrased in gendered terms of agricultural improvement that was designed to enable the economic, cultural, and religious reform of colonial Virginia.

By shifting Virginia's economic center from tobacco harvesting to silk cultivation, reformers like the Ferrars hoped to diversity the colonial economy with a new crop. Such a change would also decentralize production from large-scale monoculture plantations to small-scale silkworm houses. This political and economic repositioning invited a remaking of England's imperial image as an enterprise built on the nothingness of tobacco smoke to the expanding market in textiles, then dominated by rival Dutch, Spanish, French, and Italian industries, and it shifted the grounds of English colonists' relationships with native Virginians. As Virginia Ferrar suggested, the natural knowledge of indigenous sericulturalists could be profitably incorporated into her own program of experimentation, while her father celebrated the possibility of spiritual and economic redemption of native souls and silkworm bottoms. This large-scale shift in the material and spiritual terms of English colonial practice and policy was carried out in the small-scale shift registered in the language of silkworm treatises, a discursive node whose fluid

gender pronouns translated the center of colonial labor from naturally fertile soil to the feminized and *Reformed Virginian Silkworm*. The sexed silkworms did not displace the canonical image of a feminized earth, but they made labor – rather than land – central in the way to wealth in the already feminized colony. In their gendered language, the discursive forms of the silkworm treatises complemented the call for an economic shift from land- and labor-intensive tobacco cultivation to land-poor but labor-rich industries in sericulture and apiculture, itself the seat of *Feminine Monarchy* and a "natural" model of what Karen Ordhal Kupperman has called "colonial design."[244]

Like the hidden mines that represent South America's "mucha dote" (great dowry) and the material transformations performed in the New Spanish method of amalgamating silver (*la plata*) with mercury (*el azogue*), the language of English agricultural is decidedly gendered.[245] But unlike in the case of the Spanish or Portuguese, English does not require grammatical gender for nouns, pronouns, or adjectives. The gendered language of English agricultural texts acts instead as a complex marking system that codes physical properties like soil conditions and silkworm ages.[246] These properties in turn signal the relationship between planter and planted by determining the amount of labor required to make the land bear fruit, or revealing whether the sericulturalist should be constructing silkworm houses or preparing to mate the insects. At least, this is what happens in agricultural experiments performed by men and related in male-authored accounts. The pronouns that refer to soils, seeds, and silkworms shift between neuter, male, female, and hermaphroditic positions as shorthand for natural knowledge in the works of writers like Sir Hugh Platt, Gervas Markham, and Edward Williams. But in the trials of Virginia Ferrar, the material retains a consistently feminine gender that accords

with her identity. The question of identity is particularly important in silkworm treatises because identity is the only fruitful result of the experiments: silk from colonial Virginia never developed as a viable alternative to Iberian silver in global markets and it never replaced tobacco in the British mercantile economy.[247]

This chapter, then, has three parts. The first part explains the collapse of linguistic and cultural gender in early modern English and argues that this gender shift in the history of the English language makes seventeenth-century English a particularly poor choice upon which to position the whole of what philosopher of science Pierre Hadot calls, in response to Carolyn Merchant's powerful thesis, a "highly interesting" argument about gender and science. I agree with Hadot that Merchant's work is invaluable to the field, but I also follow him in suggesting other approaches to the question of gender and early modern science.[248] By putting English scientific writing and its shifting linguistic gender in dialogue with the unchanged obligatory gender in Spanish scientific letters, I argue that a comparative, multilingual approach will help us to better make sense of colonial scientific discourse. As the linguistic and scientific channels through which new people, botanical elements, and knowledges flowed into the two largest transatlantic empires of the seventeenth century, English and Spanish colonial scientific discourse share an important historical trait. But they also share an important grammatical difference, and one that can help to clarify the role of gender in seventeenth century scientific letters. Unlike in English, the obligatory grammatical gender of nouns and adjectives in Spanish helps to distinguish its linguistic gender from its ideas of cultural gender.

The second part applies this expanded frame in a close reading of the shifting gender pronouns of four English agricultural texts, Platt's *Jewell House of Art and Nature* (1594), Markham's *Booke of the English Husbandman* (1635), Williams's *Virginia's Discovery of Silke-vvormes* (1650), and the Ferrars' *Reformed Virginian Silkworm* (1653), to demonstrate the complex marking role that feminine and masculine referents play in the genre. The third part of the chapter analyzes the ways in which these different models of gendered agricultural science are employed in the hemispheric production of English colonial identity. English agricultural writers position their work against the extractive precedent of Spanish American mining and metallurgy, and in close imitation of the commodity-driven model of agricultural development advocated by Portuguese apologists like Ambrósio Fernandes Brandão (b. 1555?). But unlike Brandao, who argues for even growth in the sugar, tobacco, cotton, and brasilwood industries, the English hope that their methodically-tested silkworm experiments will allow for the large-scale cultivation of a product that can displace what John Ferrar calls "that contemptible, beggerly *Indian* Weed" from the colonial economy (27). Tobacco, concludes this "publique spirited Patriot," blinds the planters to "that slavery" and "poverty" in whose "toyl" "you wear out your selves with," while silk, he argues, is the material good that will improve the common good. In Ferrar's mercantile vision, the raw material of Virginia will refined and given value in England, where it can be spun from the knowledge and practice of exiled French Huguenots, enlisted in commercial competition against Dutch and Italian industries, and used to counter the hegemony of Spanish silver in global trade.[249]

I. "aut ex confuses rerum seminibus": Resiliency and Change in The Gender Shift in Early Modern English

Since the publication of Carolyn Merchant's *The Death of Nature* (1980), a powerfully cogent account of the feminization of Nature in some of the most formative scientific texts of the seventeenth century, the debate about gender and early modern science has been framed in terms of a single-author and largely Anglocentric tradition. (Francis Bacon may have written in Latin, but he was also a native speaker of English. When he published his work, he did so in London for a largely Anglophone readership.) The range of responses to Merchant's work, from historians and philosophers of science who uphold her findings, like Evenlyn Fox Keller, Sandra Harding, and Katherine Park, to those who disagree with her thesis, like Alan Soble, Peter Pesic, and Brian Vickers, have based their support and objections on the highly literary questions of metaphor, translation, and publication circumstances.[250] Although historians have long recognized that the material facts of American encounter helped to shape the development of seventeenth-century science, especially in providing the capital, raw materials, and occasion for reformulating the existing beliefs of the geography of the known world,[251] what Francis Bacon called an opening of the "intellectual globe," much of the debate about gender continues to revolve around one of two theoretically-oriented texts written in England by Bacon: the printed tract *De augmentis scientarum* ("The Advancement of Learning," 1623/1638) and the manuscript treatise *Temporis Partus Masculus* ("The Masculine Birth of Time, or, The Great Instauration of the Empire of Man Over the Universe," 1603/1653).[252] The thorny question of gender in Bacon's Latin or Englished Latin remains unresolved because, as Margaret J. Osler writes, it is fundamentally unclear "whether speakers of languages that have gendered nouns ascribe social and psychological meaning to those genders."[253] This confusion between linguistic and

cultural gender in English stems from their collapse in the gender shift that began in the Middle Ages and culminated in the seventeenth century.

As historical linguist Ann Curzan has shown, grammatical gender in early modern English is not the rule but rather the exception among Old and early middle Germanic languages, all of which lost their inflectional endings around the same time. But among these languages, only English was accompanied by a shift in linguistic gender. After the emergence of the pronoun "she" in the textual record of Middle English, and on the cusp of the widespread use of the neuter pronoun "its" in the late seventeenth century, early modern English works slowly through a complex and contextually-defined process in which linguistic or grammatical gender (a formal set of grammatical principles wherein parts of speech are classified and declined by masculine or feminine gender) was folded into cultural gender (definitions, values, and normative and counternormative expressions of masculinity and femininity in a particular social context). This grammatical shift in English was tied to changing ideas of animacy and personhood, such that early modern distinctions between human and non-human bodies allowed the masculine pronouns "his" and "he" to take on universal meaning for all of "mankind." As Curzan argues, "the distinctive masculine forms continue to refer to both inanimate and animate nouns after the masculine-neuter pronouns come to refer almost exclusively to animate antecedents," which suggests that these nouns might be "culturally gendered."[254]

The cultural ascription of gendered markings to cosmological elements like soils and seeds was reinforced by their shifting grammatical referents. In the late-tenth century *Aelfric's De Temporibus Anni*, for example, the sun was marked with a feminine pronoun some 59 times. But within the next hundred years the grammatical pronoun for the sun

would be fixed in Middle English as “he” or “his.” According to Curzan, non-canonical texts like agricultural manuals, herbals, and natural histories do not reveal larger principles of grammatical gender because they so heavily repeat the same “inanimate” nouns like earth, river, and names of plants and animals. However, because these nouns were considered animate in the early modern era, as Curzan points out throughout her book, I would like to suggest that non-canonical texts and their shifting grammatical terms do illustrate larger patterns in linguistic and cultural gender.[255]

Given the transitional state of its grammatical gender, seventeenth-century English is a particularly poor choice upon which to hinge a large, important, and, in the words of philosopher of science Pierre Hadot “highly interesting” argument about gender and institutionalized natural inquiry. According to Hadot, this argument gained traction when scholars used the striking frontispiece images to map an explicitly feminized model of Nature onto otherwise ambiguous texts. But, as Jorge Cañizares Esguerra, following José Antonio Maravall, revealed in his study of Bacon’s *Instauratio Magna* (London, 1620), these frontispieces were often extracted from books published for and circulated among other linguistic, cultural, and epistemological contexts. In the case of Bacon, scholars who only looked at the English-language edition emphasized the modernity of Bacon’s work without realizing that he had borrowed the symbolic images of a ship navigating beyond the pillars of Hercules, the limits of the known world and of human knowledge, from the *Regimiento de navigación* (Madrid, 1606) of Andrés de García y Céspedes (1560?-1611). Might the study of gender and Baconian science follow a similar pattern? In their arguments about gender and seventeenth-century science, historians and literary scholars have tended to examine the images of a feminized and subordinated

Nature in the theoretical terms of a Baconian literary tradition, rather than the imperial contexts in which natural knowledge was applied for human benefit – or, perhaps more accurately, for the benefit of some humans and the "natural" justification of the enslavement of others.[256] Baconian science, of course, foregrounds the role of natural knowledge in improving human life, the goal of the priests of Soloman's House and Spaniards shipwrecked from Peru who wage inquiries into nature in the *The New Atlantis* (1623). And it does so in often explicitly imperial contexts, as the "Empire of Man" would suggest in "The Masculine Birth of Time," although these two dimensions have been largely overlooked in the study of gender and natural science. As I argue in this chapter, examining the literatures of applied sciences like agriculture and mining, situated in the context of empire, or what Bacon calls "a thing rare and hard to keep" because of its impossible reconciliation of opposites ("it is one thing to mingle contraries, another to interchange them") will better explain the complex marking role of linguistic and cultural gender in seventeenth-century scientific letters.[257] The similarities and differences of English and Spanish colonial scientific discourse help to clarify this question.

Two depictions of the landscape of colonial Iberian American mining regions nicely demonstrate the differences in cultural and linguistic gender. The first comes from Book IV of father José de Acosta's *Historia natural y moral de las Indias*, where Acosta analogizes South American mineral wealth to a great dowry that a father must offer for a particularly ugly daughter. The second, a feminization of the mines of Chaqui, is from the priest and metallurgist Alvaro Alonso Barba's *Arte de los metales* (Madrid, 1640). Barba's text lacks any culturally gendered marking, underscoring in comparison with Acosta the role of grammatically obligatory gender. That these texts have not been

included in the study of gender and science owes more to the marginalization of Iberian science within history of science than to their ability to help us to appreciate the differences between the two forms of gender that circulate within colonial scientific literatures. Both texts engage with the inherited traditions of Aritsotelian natural philosophy and work through contentiously unresolved questions about the nature of the Americas, from the subterranean generation of metals to the effects of humidity upon the human body. For reasons owing more to the marginalization of colonial Iberian science than to the literary content, authors like Acosta have been read more for their ethnographic depictions and historical value instead of their contributions to Renaissance astronomy, geography, or mineralogical science. Meanwhile, Barba is widely read and cited by Latin American and Spanish historians of science for his foundational role in the development of the large-scale and commercially-viable method of amalgamating silver with mercury, while North American and European scholars tend to credit sixteenth-century European metallurgists like Vanoccio Biringuccio, Georgus Agricola, Lazarus Ercker, or even the eighteenth-century naturalist Ignatius Van Born with the invention. Fortunately, this is changing as historians of science now take seriously the mutually-constitutive scientific and cultural value of texts like the *Historia natural y moral de las Indias* and the *Arte de los metales*.[258]

Anthropologists and historians have noted the pervasive identification of mines in South America with an eroticized female body that is "deflowered" by male laborers who "hope to seduce the mountain in order to be desired by her." The feminized mine, a gendered ascription that is characteristic of "most traditional cultures," according to Carolyn Merchant, is understood as both a virgin, feminine space awaiting the male touch

and as a symbolic maternal womb that brings metals to term. This belief and practice would have been shared by seventeenth-century Spanish and indigenous miners and metallurgists, as Carmen Salazer-Soler has suggested in her reading of European embryology theory and Inca cosmology of the Pachamama.[259]

In the opening pages of Book IV of the *Historia natural y moral de las Indias*, Acosta analogizes the mineral deposits to "plantas encubiertas en las entrañas de la tierra" (plants concealed in the entrails of the earth). As their veins course through subterranean mines "se ven también sus ramos y como tronco de donde salen, que son las vetas mayores y menores, que entre si tienen notable trabazón y concierto" (one sees as well their branches and trunk-like points of origin, which are the principal and subordinate veins, which have notable joints and concert among themselves). The heat of the sun and the planetary forces, meanwhile, work in concert to create metallic and plant bodies. Against this intermixed embriological and arboreal analogy, Acosta imports the gendered potential of the mining landscape into a Christian framework and signals its geographically-marked providential blessings:

> "Por donde vemos que las tierras de Indias más copiosas de minas y riqueza han sido las más cultivadas en la Religión Cristiana en nuestros tiempos, aprovechándose el Señor para sus fines soberanos de nuestras pretensions. Cerca de esto decía un hombre sabio, que lo [que] hace un padre con una hija fea para casarla, que es darle mucha dote, eso había hecho Dios con aquellas tierra tan trabajosa, de dale mucha riqueza de minas para que con este medio hallase quien la quisiese. Hay pues en las Indias Occidentales, gran copia de minas y haylas de todos metales: de cobre, de hierro, de plomo, de estaño, de azogue, de plata, de oro. Y entre todas las partes de Indias los reinos del Pirú son los que más abundan de metales, especialmente de plata y oro y azogue; y es en tanta manera, que cada día se descubren nuevas minas; y según es la cualidad de la tierra, es cosa sin duda que son sin comparación muchas más las que están por descubrir que las descubiertas, y aun parece que toda la tierra está como sembrada de estos metales, más que ninguna otra que se sepa al presente en el mundo, ni que en lo pasado se haya escrito."

[From whence we see that the lands of the Indies most abounding in mines and wealth have also been the most cultivated in the Christian Religion in our own day, as the Lord takes advantage of our pretensions for his sovereign ends. Along these lines a wise man said, that what a father does to marry an ugly daughter, namely to give her a large dowry, is what God has done with these mines in this hard-wrought land. That is, he gave these lands such mineral wealth so that they would find someone who would want them, and love them. And so there are in the Indies and the West Indies a great amount of mines, and there are all types of metals: of copper, of iron, of lead, of tin, of mercury, of silver, of gold. And among all of the parts of the Indies, the kingdoms of Peru are the most abundant in metals, especially in silver and gold and mercury. And it is in this way that everyday new mines are discovered, and in accordance with the quality of the land, it is without doubt and beyond compare that there are many more mines to be discovered than have been discovered. And it even seems that this land is almost sown, as it were, with metals, more so than any other region that is presently known in the world, or any other region that has been written about in the past.][260]

The metales "sown" into the landscape form the cosmological complement to the spiritually rich harvest of souls "cultivated" in Christian faith. In Acosta's formulation, the mineral wealth is analogized to a particular – and particularly gendered – set of human and divine relationships organized by hierarchy. Both the wealthy father who gives a large dowry to his ugly daughter, and the wise God who gives mines to Peru so that the land would be desired by the Spaniards, are authorized by the spiritual order of the Catholic missions in South America.

While Acosta's natural history imports the gendered "minas" into a culturally-specific analogy of the father of the family and God the Father, Barba's metallurgical treatise shows how the availability of linguistic gender does not necessitate a culturally gendered reading of the natural world or the study of nature. Barba, the priest and metallurgist who worked for some thirty years in the silver deposits in Yampárez and Los Lipez province, and the copper mines in La Paz, Pacajes province, describes the "hidden" mines of Chaqui. Some four leagues outside of Potosí, this mine is characterized by what his fellow Spaniards perceive as its secrecy:

> "que su mina está oculta, no lo dudo, pues todos los minerales que en aquella provincia se han poblado, han sido hallados y estrenados por los españoles, sin haberse encontrado hast ahoy con labor ninguna Antigua de plata de los indios; constando, por otra parte, que las tuvieron riquísimas, pues además de las corpas o piedras de metales de plata muy escogidas, que los indios me daban de minerals no conocidos, estaban las calles de los pueblos, cuando yo fuí a ser cura, casi veinte años há, llenas de grandeza menuda de metal muy rico, que yo recogí y aproveché."
> [that the mine is hidden I do not doubt, for all of the minerals in that province, which is now settled, have been found and revealed by the Spaniards, who despite their great labor have discovered no existing sign of Indian silver; recall, meanwhile, that they had great stocks of the richest silver, for in addition to the raw lumps or metallic stones of the well-hidden silver that the Indians gave to me from unknown minerals, when I went to serve as the priest of the town, almost twenty years now, its streets were full of great deposits of very rich metal that I gathered and benefited].[261]

Here, and unlike in the case of Acosta, the gender of nature, either as cosmological whole or as discrete mines, metals, and mineral bodies, does not interest Barba. Despite the conceptual availability of the trope of nature's secrets, and the grammatically obligatory gender of "mina," Barba does not feminize or subordinate the mine site. Unlike Acosta's linguistically and culturally-gendered reading of the mining landscape, Barba's discussion of the mines serves largely as the backdrop against which he frames his real interest – displaying his privileged relationship to the indigenous people, as suggested by the prevalence of first-person phrases ("me daban de minerales," "que yo recogí y aproveché"). As priest of the town and priest of nature, Barba enacts his special relationship to an Andean community that cloaks itself in secrecy to protect nature's secrets from other Spaniards, but willingly offers him access to the region's natural resources: "Ha costado su busca vidas de indios que se han muerto con sus propias manos por no verse obligados a descubrirla" (This search has cost the lives of Indians who have killed themselves with their own hands because they would not see themselves forced to discover the mine). Barba's image of nature is feminine because of grammatical

principles rather than cultural resonances. Unlike Acosta's elaborate analogy, grammatically feminine spaces like the "minas" of Alto Perú do not perform any particularly cultured work in Barba's metallurgical treatise.

Because of the collapse of linguistic and cultural in early modern English, however, this distinction would be left to the discretion of a translator. It would be wholly possible to use the grammatical gender of the term "minas" to describe the space in culturally feminine terms, and such a reading would be supported by both Iberian and Andean conventions. This question of translation and mistranslation is one of the problems that has so far marked the debate of Anglophone scholars in their study of Francis Bacon's Latin. As Alan Soble has pointed out, Sandra Harding, one of the most-frequently cited scholars in the debate, cites Carolyn Merchant's translations of Francis Bacon rather than another version of the text. Soble suggests that Harding prefers Merchant's translation, which emphasizes the grammatical feminizations of Latin terms like *Naturae*, because it accords with her argument and allows for the framing of verbs like *vexatio* as aggressively sexualized acts of rape and torture.[262] As Soble points out in the case of the Latin, the markings of grammatical gender authorize such a translation of Bacon's work, although there are certainly other ways of rendering the terms in English. The colonial scientific texts of Iberian America, and their translation into English, offer one such example.

In the seventeenth-century English-language translation of Barba's treatise, the translator Edward Montagu, the Earl of Sandwich (1625-72), prefers gender-neutral nouns like "Nature" and "mines" instead of obligatorily gendered pronouns. Montagu, the English ambassador to Spain, "Englishes" the obligatory gender of "hidden" (*oculta*)

of the Spanish phrase "que su mina está oculta, no lo dudo" in gender-neutral terms. In this way, Montagu's translation maintains the most important feature of the passage, Barba's first-person perspective: "although at present that Mine remains undiscovered, which I do not at all wonder at …."[263] The grammatically gendered mine permits its feminization in English, as in the earlier example "por no verse obligados a descubrirla" (to not see themselves obliged to discover her/it), but the choice of pronoun reveals more about the translator's interpretation of the passage than it does about the gendered work of Barba's mining landscape. It would not be inaccurate to feminize the mine with a pronoun like "her," but such a translation would be more appropriate for the passage from Acosta rather than the example from Barba. Acosta's "great dowry" makes little sense without the cultural ascriptions of gender, while Barba's "hidden" mines do not perform any culturally gendered work in the original Spanish.

The question of grammatical and cultural gender has figured prominently in the debate about gender and seventeenth-century science, as feminist historians of science have rightly signaled the feminine gender of "Nature" and its important role in Francis Bacon's foundational scientific texts. However, these historians have missed the distinction between grammatical and cultural gender because the two are collapsed in early modern English. By comparing seventeenth-century English scientific works with those of the country's imperial rival, Spain, we can better appreciate how gender is used and not used in the scientific service of empire. This multilingual mode of comparison not only shifts the debate away from the exclusive purview of theoretically-oriented Baconian texts and into the colonial scientific practices of the Americas, but it also juxtaposes two colonizing languages that use grammatical gender in different ways. The

next section of the chapter builds from this comparative frame to examine the complex marking role of grammatical gender in early modern English agricultural texts.

II. "whereby the earth being robd of her salt, can bring forth no more fruit, vntill it be dunged againe": Gendered Pronouns in Science and Gendered Bodies of Scientists

Like the soil whose gender shifts in accordance with its relationship to the husbandman's knowledge and labor, the gendered pronouns of Edward Williams's silkworm treatises also register different states of natural knowledge and practical requirements. They begin as male insects that index a natural accord with their colonial cultivator, but they become female after the silkworm "master" undergoes a purification ritual that prepares him to mate the worms. In the Ferrar report, however, the silkworms retain their feminine identity throughout their life cycle, revealing less about the science of silkworms than about the female sericulturalist who studies them. The linguistic markings do not express cultural ideas of gender, as Williams's male silkworm is represented as an "innocent Artist" who must be treated with delicacy and protected from the extremes of environmental variation, while the female is praised for "her vigour and hardness."[264] In early-seventeenth century accounts, largely translated from the French or written by native speakers of French, silkworms tend to be gender neutral, suggesting that the gendered markings of mid-century manuals are not inherited via translation from treatises written in Latin or Romance languages.[265] The gender of the silkworm in Williams's treatise is particularly striking because, as he states in his prefatory address to the reader, "there is little of mine in this, but the Language." The "Substance" instead comes entirely from the relation of John Ferrar, supplemented by what Williams, the colonial planter, identifies as "my own experience of the place." A comparison of Edward Williams's account of silkworm cultivation, based on John Ferrar's ideas but authored by

Williams, and John Ferrar's account of silkworm cultivation, based on the work of Virginia Ferrar but authored by John Ferrar, underscores the central role of gendered language in marking the limits of English natural knowledge and its place in England's colonial designs. To understand how English authors sexed their labor and larvae with linguistic gender, a few notes about silkworm lifecycles, rearing techniques, and colonial distribution networks are necessary.

As colonial observers noted, silkworms (*Bombyx mori*) move through four distinct stages in their lifecycles, or what seventeenth-century sericulturalists referred to as "shifts" or "sicknesses" when the insects advanced from one state of maturity to the next. In all of their shifting states of development – from metamorphosis to adulthood, caterpillarhood, and, if they survive, pupation – silkworms require little land. But, as colonial observers like William Bullock suggested, and others like John Ferrar vehemently denied, silkworms demand significant amounts of labor and care. Bullock found that the labor demands of sericulture made the commodity poorly-suited to the land-rich and labor-poor colony of Virginia, but Ferrar insisted that the presence of native mulberry trees revealed the region's natural disposition for silk. Not for nothing had the Author of the Book of Nature had inscribed these "woods of Mulberry" in which silkworms were "Naturally found / to live, Feede and spinn." Other promoters of colonial sericulture agreed with Ferrar's assessment. According to Edward Williams, because the mulberry tree grew "aboriginally" in Virginia and Carolina, these were lands naturally suited for silkworm cultivation.

But while English colonial apologists correctly identified the presence of the mulberry tree, they did not properly identify its species. White mulberries (*Morus Alba*)

had long been agreed upon as the best source of silkworm food, and even late-nineteenth century silk promoters like the Women's Silk Culture Association declared that "The silk which it produces is of the finest quality." But the American mulberry upon which colonial promoters naturalized their designs produced red berries. Seventeenth-century sericulturalists concluded that the varieties of the Americas were red berry-producing versions of the white mulberry tree, but in fact they were red mulberry trees proper (*Morus rubra*). Misidentifying the color properties of the tree led colonial promoters to endorse a program of silkworm cultivation that the colony would never be able to support, for red mulberries are suited for human consumption and livestock feed, but silkworms do not eat the leaves. Colonial informants could not have known that they were incorrectly categorizing the tree, but theor misreading of red berries as signs of a white tree allowed English promoters to see these fruits as evidence that the region was naturally suited to silk. natural designs for silk. For those who were inclined endorse sericulture over other agricultural commodities like tobacco, the mulberry trees were proof positive of providential design.[266]

Hartlib circle correspondents like Edward Williams, Virginia Ferrar, and John Ferrar were especially inclined to identify a product that could diversify the colonial economy of Virginia and answer the dominance of Spanish silver in global markets. Williams begins his assessment of the potential of silk to fill this gap in the English mercantile economy by establishing the natural accord of colonial sericulturalists and the silkworms of Virginia. The former was removed from England and the latter was "aboriginally native" to the Carolinas ("the South of Virginia") and "transplanted" to the colony (17). The two non-native bodies share a particular kind of correspondence:

“Whatever we naturally desire and abhore, does this Creature by the prosperity or infelicity of his labour show a most experimentall refinement” (10). Either in its artful industry, which enables the generation of luxury goods, or its resistance to work, what Williams calls the “infelicity of his labour,” the silkworm’s production or lack thereof makes known to the world the innermost sentiments of the worm – and registers its relationship to the governor.

The silkworm’s outward manifestation of the “natural desire” of the planter is complemented by the way in which the two transplants make their homes in the colony, as both are drawn to Virginia’s “Spaciousness, pleasure, healthfulnesse, distance from offensive vapours, damps and humidities, warmth in the extremes of colds, coolnesse in the extremes of warmth” (10). Because the feminized Virginia landscape has been furnished with the very materials necessary “to invite all who have the desire,” the silkworms, like the planters responsible for their cultivation, find ideal homes in the colony (A3). This question of home is paramount to silk production, for like “the noblest of Creatures, Man,” the silkworm will not thrive “if wee sort him not with a lodging proper and agreeable to his nature” (10). The “Governour” therefore draws upon his “particular affinity” with the silkworm to monitor “his disposition and safety” and accommodate “his station” so as to maximize “the benefit of his labours” (10, 19, 26, 22). The gendered accord between the transplants allows for the felicitous early stages of the silkworm life cycle, “the beginning of his apprentissage” (12). But once the master performs a self-purifying ritual that enables him to mate the silkworms, the worms take a feminine pronoun. This grammatical change signals the new and newly productive relationship between cultivator and cultivated.

Earlier silkworm cultivators like Olivier de Serres (1539-1616), translated into English by Nicholas Geffe (fl. 1589-1607), had recommended that "the governour shall not forget to drinke a little wine earlie in the morning before he goes to worke" so as to remedy what Geffe renders in English as "the naughtie breath of folkes."[267] When the practice is translated into the colonial context, Williams ascribes this "naughtiness" exclusively to "deadly smell of Tobacco," an offensive offering in the master's natural courtship of Virginia. "No Countrey under the Sunne is lesse ingratefull then Virginia," Williams proposes, "if she be but justly courted, but to Complement a Virgin for her affection by breathing smoake in her nostrils, to expresse our Civilities by vapour; and for all that vast Dowry of Spaciousness, wealth, bounty of aire, and plenty of provisions, to proffer her a joynture of Tobacco, is a complement indistinguishable from incivil rudeness" (A3-A3v). Like other early moderns, Williams frames his essay into natural knowledge as a kind of courtship in which luxury goods like silk form part of an elaborate exchange of gifts and services. But unlike Ulisse Aldrovandi (1522-1605) or Paolo Boccone (1633-1704), men who "courted nature" in Peru and Florence, Williams's courtship includes a purification ritual designed to counter the pernicious effects of tobacco smoke. So in Williams's account, the coloniality of the silkworm master so thoroughly infuses him with the stench of tobacco that he must "purifie the ranknesse of his own breath (when fasting) with good Wine ere he approach them, with the odour whereof the worme is highly cherished" (21).[268]

After purifying the inner temple of his physical body, the silkworm governor must then attend to the outer temple, the physical home of the silkworm colony; he sweeps the floor, coats it in vinegar, and, lastly, "straws" it with lavender, spike, rosemary, thyme,

and other such "quickening aromatics" like frankincense, benzoin, and storax. This fully sensory and quasi-religious rite of fasting, taking wine, and introducing aromatic herbs and incense before entering the silkworm house serves as the prepatory work for the next stages in silkworm cultivation, vivification of the seed and propagation for the next year's harvest. In becoming "master of an exact purity," the silkworm master protects the silkworm, "chast and magnificent Creatures," from the "ill breathings" that "make this innocently noble Creature expresse her resentment by her own deathe, or sicknesse" (21). The process of purification changes the silkworm cultivator, and therefore it changes his relationship to the silkworm, now marked with a feminine pronoun.

The natural accord of the governor and his colonial subject during the early years of the silkworm life cycle transforms into a generative relationship appropriate to the mating stage. The sexed silkworm's productive and reproductive value is signaled in the shift from male to female pronouns. For although reproduction is natural, and "nature her selfe infuses in them disposed applications to finde out their opposite Sexes," the silkworm master plays a decidedly embodied hand in the mating ritual. Finding it "necessary to couple such as are yet disjoyned," he sews together the male and female worms and hangs the pairs from nails over a fine, close-woven fabric like old velvet or a worsted blend of heavy wool and sensuous silk (27). The "coupled Butterflies" will emerge from their cods (cocoons) the next day, "in the morning about eight of the clock," and by rubbing the fabric gently between his hands the silkworm master can gather the extirpated seed "with great facility." By preserving the seed for the next year's harvest, he assures his continued good fortune in cultivation and good profit in silk production. Likewise, by transforming the sexual economy of purity and the sex of the silkworms, the

silkworm master changes the silk industry of colonial Virginia from natural possibility to commercial viability.

The shared grammatical gender of Williams's infant male silkworm and adult master at once registered their sympathetic statuses as non-native transplants and their different states of purity in the same virgin colony whose rivers in "every way glide in deepe and Navigable channels, betwixt the breasts of this uberous Countrey, and contribute to its conveniency beauty and fertility." To harvest in "this excellent Virgin" the profitable "disposition ingrafted by Nature to be Mother of all those excellencies," these states of purity had to be reconciled through ceremonial performance that catalyzed shifts in matter and master – the one, from male to female, and the other, from unclean to clean.[269] This new mark of linguistic gender and the changed biological sex of natural matter makes possible a productive and reproductive coupling. Remaking sexual purity and gendered positions in the silkworm order is akin to remaking the silk industry in the virgin colony; the way to wealth was not just the planting of tobacco in the type of fertile soil that in other colonial climes easily yielded a "ten for one profit," or a return on investment of six:one by the time the goods were brought to market by the British East India Company (21). Instead, planters in Virginia would harvest the reproductive labor of silkworms whose grammatical shift from male to female registered a new colonial economic program.

In the male-authored texts that describe the work of explicitly masculine agricultural practitioners – husbandmen, masters, and governors – the pronouns used to describe soils, seeds, and silkworms fluctuate to reflect the author's understanding of the fertility of the material and to signal the labor relationship occasioned by its nature. But

in a multivocal account like that of the Ferrars, an account in which the silkworm is cultivated by a woman who exchanges botanical samples and hypotheses with male and female correspondents, the material is described with gender pronouns that are firmly rooted to the identity of the experimenter.

This linguistic marking not only distinguishes the Ferrar treatise from other practically-oriented agricultural manuals, but also from the marvelous transformations that characterize the silkworm itself, a characteristic for which the insect is praised in the densely self-analytical readings of the Book of Nature offered by Sir Thomas Browne (1605-1682). In Browne's sweeping "cosmography of myself" that delights as much in metaphor as in the "general beauty in the works of God" with which he finds complete sympathy, the physical metamorphosis of the silkworm inspires truly metaphysical awe. The "strange and mystical transmigrations that I have observed in Silk-worms" recalls the metamorphic nature of human life, tried in the "three distinct worlds" of macrocosmic existence: the "obscure World and womb of our mother," the "scene of the World" upon the surface of the earth, and the spiritual plane, "that ineffable place of *Paul*, that proper *ubi* of spirits."[270] The fixedly feminine pronouns used to describe silkworms and scientists in the Ferrar treatise, however, defy both the generic conventions of agricultural treatises and the fluid nature of the silkworm itself. The sympathetic masculinity of silkworm and master in Edward Williams's account needed to be transformed into a gendered relationship that would admit generative harvesting in colonial Virginia. But the silkworms studied and mated by Virginia Ferrar in England needed no such reformative resexing; they were, are, and will be feminized nodes of silk production improved by female-directed experimentation.

Virginia Ferrar spent "many a year" raising silkworms "by the Book-rules" in order to become the "Mistris of Silkworms" who experimented with different methods of cultivation. In anticipation of her experiments, she assembled silkworm houses, selected two different food sources (mulberry leaves and lettuce), and moved all of the silkworms indoors for the winter. In addition to experimenting with food sources, she determined to test indoor cultivation against outdoor cultivation. In the spring of 1652, when the mulberry leaves and silkworm eggs began to hatch in the garden, she introduced half of the worms to the mulberry trees and allowed them to feed normally. The other half of the worms remained in their winter cabinets. At the end of the 45-day cycle, she found that the garden silkworms had grown to be much larger and more productive than the house silkworms.

John Ferrar's letter of 1653 to colonial Virginia's "beloved planters" narrates each step of Virginia Ferrar's silkworm experiments and suggests that her results could be profitably employed in the development of a large-scale, commercially-viable English silk industry. If the economic role of her work is clear in John Ferrar's vision of England's answer to Spain's silver, his account of that work is decidedly less so. In a series of confused feminine pronouns, John Ferrar's letter establishes the full interchangeability of the female experimenter and the feminized silkworm: "when her young Mulberry-tree in her Garden began to put out its buds, then her Silkworm-eggs began to hatch, as the nature of this wise creature is, when her food begins once to appear, she comes forth of her shell: she presently laying a Mulberry-leafe upon these little crawling creatures, they came upon it instantly; then she carried the leafe and them upon it to the tree, upon whose leaves they made hast to be … they grew and thrived

wonderfully, and surpassed in largeness of body those other worms she kept in her chamber" (9-10). The blooming mulberry trees of Virginia Ferrar's garden plot attract the feminized subjects of her fruitful experiment and lead her to conclude that what is most natural is also most profitable. Gone are the manmade houses and elaborate rites of preparation that figured so largely in Williams's account. Both John and Virginia Ferrar, the latter now "crowned with an excess of happiness," immediately seek to apply the findings to the nascent silk industry in what John Ferrar calls "her dearly beloved *Virginia* (for so you must give her leave to call it), for she concluded, and so must all you, that this being thus effected in *England*, how much more with the assured confidence will the wormes live, feed, and spin in *Virginia*?" (10). The real fruits of the trials, "such a gallant sight" that had thoroughly "ravished the Spectators," then, are their implications for an exchange of natural knowledge and colonial commodities among the English who husband England and those who plant in Virginia, and between the indigenous people of Virginia and the English there planted.[271]

Against Williams's model of luxurious courtship signaled in fine fabrics and aromatic herbs, the Ferrars argue that "very poor and slight houses in Virginia will do the deed." This endorsement of minimal human intervention into the feminine silkworm order comes in part from Virginia Ferrar's findings and in part from English reports on the practices of native Virginians, whose houses consisted of reed or cane poles topped with mat roofs. In valuaing the empirical trials of Virginia Ferrar in England and the methods of indigenous practitioners in Virginia, the Ferrar treatise articulates a model of colonial development that takes seriously the value of both native and non-native knowledges. Although they encourage the planters to make their own experiments, as

"rare and strange things have upon triall often been found out," they insist that collaborative partnerships represent the most effective way to colonial wealth: "and if you would but shew the Savages samples of all kinde of things, you should soon by them know more in a moneth what is in that Countrey to be had then you had done these 40 yeares; and for reward they would bring in of all kindes unto you, what they have and you desire to know, so a sudden discovery may be made of all things in that land to your infinite gain" (16). For Williams, the insects produce silk in exchange for a colony well-tended by a purified governor, but for the Ferrars, the most important contractual relationship is that of colonial planters and native Virginians. For each pound of silkworm bottoms that they deliver to the planters, the indigenous cultivators should be paid the equivalent of five shillings "worth in any Commodity they desire. And thus by the blessing of Almighty God, there may be good hope of their civilizing and conversion; so that they may be likewise great gainers, in body and soul" (11). But this fixed rate of material redemption – English goods measured in hard currency in exchange for natural resources measured in weight – is complemented, and cut against, by the redemptive work of religioscientific cultivation. Indigenous people are at once recognized as valuable contributors of natural knowledge and practice, and as the unredeemed souls whose incorporation into the English spiritual economy will enable the full realization of the reformist ends of *The Reformed Virginian Silkworm*.

Colonial planters are not the only subjects who might benefit from native knowledge of silkworms and indigenous people's participation in the English economy, "as all men that have their eyes in their heads, and English hearts in their bodies, see and apparently know" (13). Indigenous natural knowledge can also be profitably redeemed in

England, as Virginia Ferrar suggests when she asks for a report of "what by any *English* or *Savage* hath bin any way observed in her: when her eggs first hatch, then how long time she is feeding before she spins, upon what part of the tree she fastens her Bottom; How long she continues in her Bottom before she comes out a Fly, then when they couple, where they lay their eggs, upon what part of the trees? How long they live after that time? For these in the old World never eat after they once begin to spin" (22). This general solicitation of knowledge of silkworm size, color, and role in the food chain, expressed as a "Loving Advertisement to all the Ingenious Gentlemen-Planters in Virginia" that is submitted by "V.F." but written in the third-person figure of "the Lady," concludes with a specific request for native knowledge: "what do the *Savages* call them, or know any use of them?" (23). The confused gender pronouns that texture John Ferrar's account of his daughter's garden-plot experiments appropriately bookend the section with the promise "that she is not a nice curious kinde of *Silkworme*; but stout and robustous." Unlike the particular demands asserted by the delicate male silkworms of Edward Williams's account, the hearty labor of the female silkworms and scientist are provided at "small cost unto you." The former requires only leaves and a simple lodge, "and pays you ten-thousand fold what you bestow onto her," while the latter shares her experientially-proven results, and supplies the colony with material samples ("a store of Silkworm-eggs" so "that none of you may want a stock to begin your Silk-work") in exchange for what can only be provided by the people in Virginia, natural knowledge of the region.

Virginia Ferrar's solicitations rare rather detailed. First, she requests that the planters send her a general and comprehensive natural history of Virginia's soil composition, water sources, dyes, and mineral wealth, for which she has outlined the

procedures of mineral assay and botanical dissection. Second, she solicits specific materials to further her study of silkworms: "That you please send of her Bottoms to satisfie all men, who are like the Queen of *Sheba*, much better trust their eyes than ears" (23, 10). The assemblage of indigenous and colonial knowledge of silkworms, and a supply of materials, will allow her to test her methods on new varieties and to refine her conclusions accordingly. This experientially-driven approach to silkworm cultivation – one of steps and missteps performed through trial, error, and repetition – is informed by an always commercialized religioscientific sensibility, expressed in John Ferrar's request on Virginia Ferrar's behalf that the planters "inform her what be the things, the wayes, the means to advance *Virginia's Prosperity*, if they may be procured and effected" (24). In developing a careful set of procedures for testing ideas, recording each step, measuring its outcome, sharing theories and materials with other practitioners, and using the results to increase operational profitability, Virginia Ferrar's silkworm experiments fall squarely within what historians of science identity as the experiential and commercial conventions of seventeenth-century science in England and the Continent.[272]

But her attitude toward native knowledge, visible in the moments when her father signals her by name or pronoun, differs from that of her collaborators in an important way. Like other Hartlib circle contributors, Virginia Ferrar solicits native knowledge out of a two-pronged scientific curiosity and commercialized approach to agricultural improvement. But, unlike her father, she believes that the indigenous sericulturalists of Virginia possess natural knowledge and practices that could be valuably applied in the reformation and improvement of silkworm cultivation in England. John Ferrar had pointedly dismissed the potential of native knowledge, suggesting that although colonial

Virginia possessed the natural resources for a profitable silk industry, its people lacked the intellectual capacity to properly cultivate the way to wealth: "where Worms and Food abound naturally, and the Inhabitants are born with Brains, the advancement of the Silk Trade must needs be proportionable: upon which double score *Virginia* hath the advantage of any place in the yet discovered World; I mean for Worms and Food, which may be thus severally demonstrated" (25). The "Brains," as this clarification lays bare, are lacking. But while Virginia Ferrar found the empirical study of silkworms crucial to the improvement of the industry, John Ferrar did not believe natural knowledge or technical competencies to be necessary for the colonial industry. In a heavily-annotated response to William Bullock's (b. 1617?) *Virginia Impartially Examined, and Left to Publick View* (London, 1649), John Ferrar responded at length to Bullock's suggestion that the silkworm industry would fail because of a lack of specialized laborers. According to the historian Peter Thompson, Ferrar responded with passionate detail that filled the margins of the page: "Truly he still runs one / in his Error in this / thing Espetially in that / of Silke so proper for the / Land soe hopefull soe / Easy of soe littell charge / and time that I cannot / but wonder soe wise a man thus to over shute / him selfe and the Mis / tery all men know it / but an Egg sett in Salte / donn by women and / Children with noe labour / in a house in six weeks / time hinder noe other / Commodity / to plant or tend gaine nothing like / it…" John and Virginia Ferrar seem, then, to value differently the extent of native knowledge and the ability of indigenous practitioners – and women – to contribute to a transatlantic dialogue on the science of silkworms and to translate that conversation into a commercially viable industry. Even as he acknowledges in his letter Virginia Ferrar's substantial and deeply informed work in designing and executing an empirical

study of silkworms, John Ferrar's marginal comments lump adult women with children in terms of their scientific knowledge and skilled labor.[273]

In addition to this important question of the role of native science and female practitioners in the colonial English knowledge economy, the gendering of silkworms and scientists reveals an important difference in the practice of female and male practitioners who study, cultivate, and improve silkworms for the good of the colonial English enterprise. The gendered pronouns ascribed to the silkworms in treatises like Williams's and the Ferrars reveal different relationships between cultivator and cultivated. The masculine silkworms tended by the master-governor demand an elegantly adorned home and a pure practitioner before they will produce their valuable silk, while the feminine silkworms require very little material comforts to bear fruit: "you will abundantly content and satisfie this, though noble, yet most humble creature even with any habitation to do her work in" (16). Although Carolyn Merchant has formatively suggested that the gendering of nature seventeenth-century scientific writing served to displace female naturalists with a feminized model of the natural world, the gendered markings of natural bodies in these agricultural treatises underscore the substantial contributions of a female sericulturalist. As these Hartlib Circle exchanges make clear, the gendered pronouns ascribed to botanical matter help to distinguish men's and women's work on and in relationship to natural materials. By translating the study of gender and science from London-centric, single-author texts that formulate the theories and methods of science to multivocal documents like those read and applied by Hartlib circle correspondents throughout the Atlantic world, we can appreciate more fully the complex marking role of gendered language in seveneenth-century scientific discourse.

This shift in gender and genre unearths important subtleties of language, like gendered pronouns, as well as material realities, like exchanges of soils, seeds, and silkworm eggs. United by their commitment to the religious and socioeconomic reforms enabled by the development of a commercially-viable silk market in colonial Virginia, female and male silkworm experimenters shared material goods whose circulation cemented community ties between and within linguistic communities. In addition to the transatlantic traffic in natural knowledge and commodities, these cosmological essays into nature connected English, Irish, and German correspondents to form a multivocal, transnational dialogue that unfolded between 1651 and 1654. Virginia Ferrar exchanged material samples of silkworms with local cultivators, like her cousin Mary Ward, Mr. Lawrence Ward, her kinsman Esquire Ferrar, one Mr. Wright and one Dr. Russel. By trading in botanical specimens, ideas, and accounts of their trials with silkworms, Virginia Ferrar and her collaborators confirmed the reports of colonial planters who found that silkworms would live, feed, and spin silk in a variety of trees, including shrubs, bushes, oak, poplar, plum, apple, and crabapple varieties (22, 26). After a contributor from Dublin suggested that lettuce worked as well as mulberry leaves as a primary source of food for silkworms, and that "the heard called *Dantedelyon*" might prove equally fit, Virginia Ferrar convinced a local English gentleman to try a combination of lettuce and mulberry leaves. In her own trials, she had found that silkworms thrived equally until it came time to harvest their silk, at which point the lettuce-fed worms died. But in light of the report from Dublin, she vowed to conduct another trial and to compare her results with "a Gentleman near her." He used lettuce for the first 25 days of the harvest cycle before switching to mulberry leaves; this

combination, they found, produced silkworms that "did very well and spun as good Bottoms as those wholly kept with Mulberry leaves" (31-32). Other Hartlib circle correspondents exchanged ideas at a purely immaterial level, writing, as in the case of a Dublin-based contributor, in support of the theories that informed Virginia Ferrar's work. "The Experiment is most Natural to my apprehensions," the contributor declares in analogical fashion, because silkworms, like caterpillars, have traditionally lived and reproduced in trees. They were only moved to manmade houses "in expediency," or for human convenience, rather than the benefit of the silkworm or silk production (30). Virginia Ferrar's finding, in sum, comports with the contributor's beliefs about the relationship between nature and art.

But not all readers agreed with this assessment, as another Dublin-based correspondent wrote to extol the benefits of art over nature. "I like not the Gentlemans Reason why he likes the Proposition concerning feeding of Silk-worms upon the Trees," this reader answers, because "almost all Plants" are known to be "improved to such a degree of excellency to the eyes, nose or palat by industry and home-helps and contrivances." Three forms of human engagement with plant bodies – "industry," "home-helps," and "contrivances" – produce three fully sensory improvements in sight, smell, and taste. It is important to point out that this reader does not object to the results of Virginia Ferrar's experiments, but rather to another reader's theoretical explanation of those results. In its circulation within Hartlib circle discursive networks and material channels, Virginia Ferrar's study of silkworm lodgings and food sources becomes part of a larger debate about the relationship between art and nature, or the capacities and limits of human agency in the making, testing, and application of natural knowledge. The

relationship between cultivated and cultivator, expressed through gendered pronouns that connect the female silkworm and the female scientist, and the male silkworm with the male scientist, shape the results of the experiments in Virginia and Little Gidding and reveal the multivocal, transnational exchanges of natural knowledge and practices in which these complex gendered markings were played out.

Natural knowledge and its gendered soils, silkworms, and scientists serves as the platform for multilingual exchanges of experientially-grounded projects of religious, economic, and agricultural reform. The gendered pronouns that are used to classify natural elements like soils, seeds, and silkworms at times signal important characteristics about the material, as in the case of fertile or barren soils. But more often, they highlight the relationship of the agricultural practitioner to the material that she or he works with. As such, they index the state of natural knowledge and mark the practices appropriate to the material, like the degree of industry required of the husbandman or the preparatory work required to mate silkworms. As measures of human relationships to natural bodies, the gendered pronouns of English agricultural scientific literatures tell us more about the human than they do about the natural or the scientific. The thoroughly subjective, contextually specific nature of scientific thought and practice has been well-established by philosophers of science like Donna Haraway.[274] This chapter contributes to that "cultural turn" in analyzing, by way of conclusion, the role of gendered language in English agricultural discourse as it is enlisted in the formation and dissemination of colonial English identity.[275] English apologists naturalized their colonial plantings in the language of agriculture, cultivating an ethos of industriousness and improvement that was at once indebted to and also fashioned against Iberian colonialisms in the Americas.

III. "¡No 'milagro, milagro' sino industria, industria!": The Hemispheric Nature of English Colonial Identity

I begin this section with a deliberately provocative quotation from Cervantes's *Don Quijote* (1615, part II, chapter 21): "Not a miracle, a miracle, but industry, industry!" The phrase is Basilio's, uttered when the gallant townsman secures the hand of his beloved, Quiteria, with what she believes to be his dying word. By outwitting the priests who attend him, the impoverished Basilio prevents Quiteria from marrying the wealthy lord Camacho and attributes his "impossible" turn of fortune to his own "industry" (*industria*), performed "with my own hands" ("yo por mis manos"), rather than to orthodox forces of miraculous intercession or divine apparition. For the historian Juan Villar, these moments of individual bootstrapping, connected explicitly to the failure of traditional institutions, mark the turn from the first half of the novel to the second, whose opening lines find Don Quijote's housekeeper instructing Sancho to "go govern your own house and work your own small plots of land (*pegujares*), and stop your fantasies of islands and islanders" (*dejaos de pretender ínsulas ni ínsulos*). There is indeed an important timeline from the first part of the novel, published in 1605, to the second, published in 1615, along what Villar identifies as "the decisive crisis of Spanish power, and, with even greater certainty, the first great crisis of doubt of the Spanish people." By connecting individual industry with clever tricksterism, Basilio's memorable turn of phrase in part II suggests one of the ways in which the same terms of seventeenth-century letters could be applied to different ends in Anglo and Iberian discourse.[276]

Basilio is one of many early modern Iberian literary figures to align the performance of industry with deception. The New Spanish playwright Juan Ruiz de Alarcón's (1580-1639) *Industria y la suerte* (Madrid, 1628), for instance, cultivates a

model of industry made of equal parts preparation and trickery, both precisely executed. Industry, and its close cousin, wit (*ingenio*), was at once the sign of an agile agent who could accommodate himself or herself to challenging situations, and a mark of clever deceit. That *ingenio* is also the term for a mill or refinery adds to the uneven development of the same terms in Anglo and Iberian letters, both social and scientific.[277]

In the historiography of modernity, and scientific modernity in particular, "industry" has been one of the most important markers of difference between seventeenth-century Iberian and Anglo scientific enterprises. The English economic historian Craig Muldrew locates the origins of industriousness in turn-of-the seventeenth-century England, where the coincidence of Protestant culture and material hardship, namely population increases that outpaced food production, created "an entire attitude towards the improvement of both goods and effort, aimed at superior production and the increase of profit and wealth for both individuals and the nation." In an argument supported by English archival documents like household inventories and probate registers, Muldrew cites Polish émigré Samuel Hartlib as the foundational example of an agricultural reformer whose "idea of industriousness here is not simply one involving harder work, or working more hours, motivated by the desire for more goods. It is rather a response to falling real wages and labour market competition in the first half of the seventeenth century, which eventually resulted in greater earnings." Muldrew is responding to the work of Jan De Vries, who has famously situated the "industrious revolution" of the seventeenth century in Dutch household units that began to work longer and more intensely in order to purchase an increasing variety and amount of luxury and consumer goods. To this engaging debate about the agricultural and Northern

European origins of industriousness, I offer only the above lines from Cervantes's (1547-1616) *Quijote*, a passage so well known that it is featured on the Wikipedia entry for the history of science and technology in Spain.[278]

The enduring images of Spanish miner and English planter were given powerfully cohesive and artistically stunning expression by some of the finest writers of the early modern era. The native silver that Francisco de Quevedo's (1580-1645) imagined miner brazenly steals from Indian ground ("le hurtas riqueza al indio suelo") and the deceptively precious metal ("Oro llamas al que es dulce desvelo") that he pillages before returning to Spain as soon as he looted the Indies ("al instante / que el Occidente dejas saqueado") is anything but refined in the hellishly "endlesse work" of Mammon's smithery in Edmund Spenser's (1552-1559) *Faerie Queene* (1590), wherein "seruile sclaue[s]" labor before "an hundred raunges weren pight / And hundred fornaces all burning bright."[279] Spenser's vision of natural conquest courses through the river bodies of book 4, where a "fishy fruitful" union of Irish, Scottish, Welsh, American, and Indian subcontinent rivers all feed into one common English head, but in his land-based encounters he is careful to mark the presence of Spain in the demonic work of mining and metallurgy of book 2.[280] Spenser's forging of imperial Spanish identity in the interstices of mining, metallurgy, and Catholicism is answered in the honest labor of the prelapsarian Adam and Eve who cultivate the honeyed lands of Eden in book 4 of Milton's (1608-1674) *Paradise Lost* (1669/1674).

In these imaginative works, the images of English planter and Spanish miner enjoyed wider circulation and carried more memorable expression than the era's technical manuals, scientific treatises, and epistolary correspondence. But it was those colonial

scientific discursive forms that produced the foundational language of setting and settling, mining and mixing, and it was those scientific texts, like their more widely-studied and widely-enjoyed imaginative counterparts, that helped to shape the central identities of Anglo- and Iberian-American colonialisms. The humble origins of the gendered bodies of insects, soils, and seeds naturalized English colonial expansion and framed English colonial designs as opposite of and superior to the policies and practices of imperial Spain: opposite, because theirs was a material practice of cultivation rather than extraction, and superior, because it demanded a more analytical perspective, or what Hartlib circle writer Gabriel Plattes (1600-1644) calls "intellectual eyes."[281]

If the Virginia planters will "follow but with good courage your cheerful leader," John Ferrar argues in terms that echo the Iberian command to *seguid vuestro jefe*, Virginia Ferrar's "Silken-Mine will be to you of more benefit then a Mine of Silver" and colonial Virginia will "rival *Peru* for wealth" (9, 26).[282] The successful silver mining and metallurgy industry of South America was enabled by the triple convergence of the silver mines of Potosí (the provinces of Charcas, Chayanta, and Los Lipez in present-day Bolivia), the mercury mine of Huancavélica (southwest of Lima), and the perfection of a new method of amalgamation that made Huancavélica's proximity to Potosí "el casamiento de más importancia del mundo" (the most important marriage in the world).[283] These natural resources would mean very little without human knowledge of their benefit, as Ferrar had noted in the case of sericulture but seemed to overlook in the case of Iberian mining and metallurgical science, like most English colonial apologists in their references to Spanish science. A brief explanation of the technical advances of colonial Iberian mineralogical science will help to situate these English colonial appeals.

In the mid-sixteenth century, collaborative teams of indigenous, African, and European miners, metallurgists, and merchants worked in various degrees of freedom and unfreedom in the mining post of Pachuca, in New Spain, to perfect the method of amalgamation. The existing theories of natural philosophy suggested that the silver and mercury were too similar to deliver a generative outcome, but the results of the experiments were clear. The New Spanish team, led by the Sevilla-born Bartolomé de Medina, who left his hometown and profitable business to test an idea that he heard through "pláticas con un alemán" (conversations with a German), developed a large-scale and commercially-viable method of refining silver with mercury. Their ten-step *patio* method was adapted into a heat-based treatment better suited for the colder ambient temperatures and higher mineral weights of Alto Perú. European and indigenous methods of smelting only worked on the highest-grade silver ores (Ag), but the new chemically-based method of amalgamation allowed the full range of silver mineralogies to be profitably treated and minted, including the most common mixtures of silver, ferrous, and sulfuric particles, called *metales mulatos* and *negrillos* in the racialized terms of colonial science. The science of amalgamation, developed in New Spain and introduced to Peru in 1571, incorporated the mineralogical knowledge and embodied labor of New and Old World practitioners, performing the very types of generative mixtures contained in its theoretical formations.[284]

But it was not just the intellectual labor that made the method so profitable, for without the embodied work of indigenous, African, and European women and men in the mines and refineries, the technique of amalgamation would have little value. The challenging topography of the central Mexican highlands inspired a constellation of

innovative transportation networks, while chronic water shortages in Potosí led to the development of efficient water-powered *ingenios* (mills or refineries), irrigation channels, and water management systems like *lagunas* for mineral washing. In South America, Spanish, Portuguese, Italian, Dutch, and English miners capitalized upon indigenous smelting techniques and the Inca *mita* system that organized non-Inca or low-status Inca into bands of tribute laborers who extracted and refined silver into a standardized currency. That currency, the *reales de ocho* that found their way into Robinson Crusoe's hands and the mouth of Long John Silver's parrot, facilitated trade in local indigenous markets (*gatu*), intracolonial markets of the Americas, and the global markets that, after the establishment of the Spanish post in Manila, also in 1571, connected Europe, Africa, and Asia. Following the collapse of China's system of paper money, the country moved to a silver bullion standard that enabled the Spaniards to trade at extremely favorable rates relative to Europe. In China and Japan, they traded gold and silver at ratios of nearly 2:1; in China they traded silver at 1:6, compared to the ratios of 1:12 in Europe, 1:10 in Persia, and 1:8 in India. In addition to direct trade through its port in Manila, the Spaniards sold American silver to Portuguese, Dutch, and English trading companies for transport, diversifying the circulation of silver and hedging against the collapse of a single market.[285]

In comparison with the global economic order enabled by the technical advances in Iberian science and the human and natural resources of Spanish America, colonial Virginia relied upon tobacco as a medium of exchange, putting the English at what John Huxtable Elliott calls "an obvious disadvantage," as British American colonies competed for access to hard currency and the metropolitan center used what little it had to subsidize

its own imports.[286] It was for good reason, then, that John Ferrar dismissed the tobacco plant as all "smoak and vapour" and convinced himself that his daughter's experientially-proven results with silkworms would help the colony to cultivate "a real-royall-solid-rich-staple Commodity" (10). The silkworm industry would stabilize "all liberall Virginia" by diversifying its economy and providing the English with a material response to counter the dominant position of Iberian silver in global commerce.

But in ways immaterial, too, John Ferrar positioned his daughter's methodologies and results of silkworm cultivation against Iberian silver. While Iberian America developed in accordance with high-value commodities like precious metals, British America, marked by an absence of mineral wealth that was much bemoaned by adventurers like Ralph Lane (1530?-1603), was forced to rely upon other strategies of colonial development.[287] For many natural scientists within the Hartlib circle, this necessity occasioned the enactment of an imperial identity that was grounded in the nobly humble agriculture order that, they argued, only less capable minds dismissed as a "ridiculous" way to wealth. Dr. Robert Child (1613-1654), between his trips to John Winthrop, Jr.'s Ironworks site in New London, Connecticut, and his surveys of Ireland, later published by Hartlib as *Ireland's Natural History* (London, 1652), insisted that the better husbanding of silkworms could improve England and its colonies alike.[288] Child writes, "And though it may seem ridiculous to many, to affirm that *Magots*, *Butterflies*, should be of any importance; I desire them to consider, that we have our Honey, the sweetest of foods from *Bees*, which are Cattel of this kind: also, our *Silks*, *Sattins*, *Plushes*, and bravery from the poor *Silk-worm*, which may be called a *Magot*, *Caterpillar*, or *Butter-fly*, &c."[289] In other words, agricultural improvers whose "eyes

corporeal" are fooled by superficial conditions, like the small size or ugly body of an insect, would do well to consider the matter with Plattes's "intellectual eyes beholden of all good mens understanding." These synechdotic "intellectual eyes" afford the English planter an especially informed perspective; mining may have been the material practice that burrowed into the depths of the earth for mineral wealth, but agricultural fruits would be harvested with more profound – and profoundly – intellectual labor.

In these charged projects of agricultural reform, Spanish silver mining was understood at once as an enviable commodity-driven model of colonial development, and as an extractive material practice that was as "poisonous" to the English as tobacco had been to the silkworms. Instead, mining and metallurgical work, as foundational practices of settlement and authorizing settler ideologies, would be replaced with what Ferrar calls the "honest employment" of planting and possessing. The economically profitable and spiritually rewarding work of cultivation would advance human knowledge in the name of collective social improvement. Like Spanish mineralogical writers, English agricultural authors claimed that their labor was part of providential design for universal good.[290] But unlike Spanish authors, such as father José de Acosta, who argued in his *Historia natural y moral de las Indias* that God had made Spain an important source of mineral wealth for imperial Rome in fulfillment of the foreordained westward translation of empire and mining in the Americas, the English insisted that their agricultural work would bring about the restoration of Adamic empire.[291] For Acosta and writers like him, the colonial past was precedent for a colonizing future. But for agricultural writers like Ferrar, Child, and other Hartlib circle correspondents, the colonial present would speed their heavenly reunion with "the Great Husbandman," or what John Flavel (1630-1691)

calls in his *Husbandry Spiritualized* "the day of re-espousals."[292] The stakes of English agriculture were quite high, then, and the state of natural knowledge in need of improvement.

The possibility of a large-scale, commercially-viable silk industry had long intrigued English colonial promoters as a way of positioning themselves against the Spanish in America and ensuring that their enterprise was one of right Christianity, true commerce, and accurate cosmography. Richard Hakluyt (1551?-1616), who frames his *Principal Navigations* (1589-1600) with that tripartite focus, was also one of the earliest speculators in silkworms and their potential to counter Spanish hegemony in the global economy. In his *Discourse Concerning Western Planting* (1584), Hakluyt lists silkworms as one of the key natural resources of the regions whose peopling with English bodies and Protestant culture would prove most advantageous to "us of England" who "bethincke ourselves, howe wee may abate and pull down their hygh myndes." Spanish America naturally abounded in goods like honey, wax, and silkworms "in marvelous nombre, a great deale fairer and better than be our silkworms."[293] Like other English colonial apologists looking to answer Iberian silver, English writers like Hakluyt include silkworms among any number of possible goods. He cites (in English) the accounts of the French explorers Jean Ribault and Jacques Cartier, the Italian Giovanni Verrazano, and the Spanish physician Nicolás Monardes, and (via Oviedo's Italian) the Spaniard Stefano Gómez to demonstrate the range of New World commodities: spices and timber, fish, fowl, furs, and fruits like plums, oranges, almonds, plus corn, wine, and oil "apte for any kind of husbandrye" (20-25; 24). In his pages-long accounting, Hakluyt treats equally these abundant natural resources; they are cataloged at a dizzying pace and listed without

detail or qualification such that they appear as a richly disordered array of equally fertile natural potential. For Hakluyt, unlike Sir Thomas Browne, there was nothing special about the silkworm – until its masculine and feminine bodies emerged as the key nodes of English colonial bounty.[294]

Hakluyt naturalizes English designs for America by rooting the English to New World agricultural goods and identifying in this approach an important precedent – and an importantly non-Spanish model – in the Portuguese empire. For Hakluyt, the Portuguese represent the antithesis of the Spanish in the New World, both in their policies of good governance and their agricultural-inspired development throughout their colonies in Africa and the New World. In his recommendation American plantations relieve England of its prisoners and idle poor, the latter a surplus pool of laborers created by the mechanization of English agricultural "art and science," Hakluyt borrows from a variety of commoditiy-driven imperial models, two of which are explicitly linked to Portuguese precedent. The southern Americas, once peopled by the English, will be the productive sites of labor in all sorts of natural resources sectors: "in settinge them to worke in mynes of golde, silver, copper, leade, and yron; in dragginge for perles and currall; in in plantinge of suger canes, as the Portingales have done in Madera; in mayneteynaunce and increasinge of silke wormes for silke, and in dressinge the same; in gatheringe of cotten whereof there is plentie; in tillinge of the soile there for graine; in dressinge of vines whereof there is great aboundaunce for wyne; olyves whereof the soile ys capable, for oyle; trees for oranges, lymons, almondes, figges, and other frutes, all which are founde to growe there already; in sowinge of woade and madder for diers, as the Portingales have don in the Azores ..." [295]

Early modern English writers may have demonized colonial Spanish mining and metallurgy and positioned their agricultural labor as more sanitized and sanctified, but Portuguese accounts like Ambrósio Fernandes Brandão's *Os diâlogos das grandeças do Brasil* (1618) provide a different image of commodity-driven agricultural development. Like the English apologists, Brandão argues that agricultural industry can be just as profitable as the mining and metallurgical sectors of Spanish America. But unlike English writers, Brandão locates colonial agriculture in an explicit and unapologetic context of slave labor rather than a glorified ethos of cultivation. These key points reinforce Lisa Voight's call to attend to the important similarities and differences of Anglo and Iberian colonialisms by treating fully the two crowns of the Iberian union.[296]

Colonial agriculture, Brandão affirms, is a practical and practiceable commodity-driven model of development that takes advantage of American natural resources and European natural knowledge and dominance in the transatlantic slave trade. Written during Brandão's nearly 25-year stay in Olinda, the coastal city that neighbors the sugar-producing department of Paraíba, the text begins when Alviano, recently arrived from Portugal and keen to copy the Spanish model of colonization, eagerly identifies a found object as a precious stone. He is soon corrected by the trinket's owner, Brandônio, resident in Brasil and supporter of commodity agriculture, who shows his compatriot that even seemingly low-value natural goods like the trinket "se podia applicar para muitas cousas" (can be applied for many uses).[297] As the dialogue unfolds, Alvino's initial disappointment gives way to a more cautiously enthusiastic support for agriculturally-driven development, and by the end of the text the two interlocutors have outlined a general plan for the development of the sugar, brasilwood, cotton, and timber industries.

These four key commodities will be transported from inland Brasil to Rio de Janeiro, where they can be produced with the lowest costs ("por alli se achar mais barata"), and sent to Angola for "a troco de escravos e de marfim que de lá trazem em muita cantidade" (an exchange of slaves and marble that will be brought from there in great amount) (156). This intracolonial and translantic traffic will make Brasil the esteemed "praça do mundo … e juntamente academia publica" (the marketplace of the world and also a public academy) whose primary students are Brasil's indigenous people: "E então, como neste Brasil concorren de todas as partes diversas condições de gente a commerciar, e este commercio o tratam com os naturaes da terra, que geralmente são dotados de muita habilidade, ou por natureza do clima ou do dom céo, de que gozam, tomam dos extrangeiros tudo o que acham bom, de que fazem excellente conserva pera a seu tempo usarem della."[298] The benefit of becoming the seat of the global economy, the imagined geocultural center of the exchange of monoculture plantation commodities is, for Brandão, the best way to improve the indigenous populations in the Americas. For John Ferrar and Edward Williams, tobacco was the plague of Virginia's colonial landscape and economic community. But for Brandão, it allows the native people of Brasil to traffic in the civilizing influence of worldwide trade.

Given the much-bemoaned absence of mineral wealth in Virginia, it is perhaps not surprising that colonial promoters like John Ferrar and other Hartlib circle correspondents would turn to the Portuguese model to argue that what brasilwood did for Brasil, so too might silkworms do for Virginia. Ferrar asks pointedly, "What is *Brasil*, *Fustick*, *Logwood*, and many more kinde of Dies, but Woods? what Coucheneal the rich Scarlet die, but a Fly, or the excrements of the *Indian* Fig-tree? what is the new-found rich dying

stuff of 25 l. a Tun, but of a tree that is brought from the Island of *Liberty*, neer Cape *Florida* where Captain *Sailes* plants? And shall *Virginia* not yield a drop of good Liquor or Colour? It cannot be; if but a triall thus easie were made" (24). For Hartlib circle correspondent William Potter, who proposed the introduction of paper money into the English economy, these trials would lead to greater investment in English plantations "in *Ireland*, and other new Plantations throughout the whole Globe." The plantation commodities would, in turn, become the new products that made England an attractive market for global commerce: "if there were such vent here in England, even Forraign Nations would dispatch their commodities hither as to the quickest Market, and by meeting here (as in a center) might furnish each other with returns, so as *England* would become as it were a general Market or Faire to other Nations, to the great enriching thereof."[299]

Like Brandão's call for Brasil to become "the center of the world," Potter's vision of agricultural development invites a geoeconomic recentering of the known world, although tobacco has no place in the Hartlib circle model. Instead, their vision of English colonialism is based on the lowly silkworm that is wrongly dismissed by short-sighted investors whose "intellectual eyes" have been clouded by "the pernicious blinding smoak of Tobacco." In his call for foreign investment in colonial sectors to move beyond the established market for precious metals, Ferrar locates the silkworm at the heart of his three-part plan for the reform of Virginia: the economic reform of tax laws and currency policy to allow silk its position as a medium of exchange, the spiritual reform of the indigenous people who will benefit from the civilizing influence of English planters, and the cultural reform produced by replacing with silk the plant "that thus hath dimmed and

obscured your better intellectuals" (20). Although it is enacted upon the surface of the earth, the material and intellectual processes of agricultural labor are anything but superficial. The improvements in silkworm cultivation, tried in the Little Gidding garden plot by Virginia Ferrar and celebrated in Hartlib circle correspondence by John Ferrar, enable Ferrar's vision of the wholesale reformation of the English colonial enterprise in Virginia. The economic, spiritual, and cultural development of indigenous Virginians revolves around an equally important reformation of planterly identity as one whose study of nature and application of experientially-proven practices allow for the improved husbanding of colonial commodities.

This ethic of industriousness, a model of methodically-organized religioscientific labor, reforms the English planter from one who relies upon the nothingness of smoke to one who cultivates silk, the kind of luxury good that could potentially rival Iberian silver as a generator of material wealth and a rich symbol of colonial identity.[300] The English colonial identity of sanctified planter is produced from French sericultural knowledge, solicited in rivalry with Italian and Dutch strengths in the silk market, and positioned against the Spanish hegemony in the New World. But to overtake their rivals, the English would need to remedy what Child identifies as the country's "deficiencies" in natural knowledge, especially on questions of fertility. The fluid gender pronouns of agricultural materials reveal the muddled English understandings of "the true causes of Fertility," of which Child claims "we are very ignorant" (30). Child's remedy was for "Ingenious Gentlemen" and "Merchants, who travel beyond Sea" to study the "many excellent things both for Husbandry, Physick, Mechanicks" in the West Indies, Russia, "*France, Spain, Italy, Holland, Poland, Germany, &*" and to report back to the English on the uses

"manifest and very beneficial to us" (68). These foreign missions will underwrite the better husbanding of an England that learns to incorporate nodes of botanical flows from "divers things in our Plantations worth the taking notice of," such as "the Silk-gras of *Virginia*" and, from New England, "*Indian Corn*" and cranberries, "so called by the Indians, but the *English, Bearberries*." This corn can be profitably sown alongside English wheat, and the New World fruits, "accounted very good against the Scurvy," can be made into sweet English tarts, where they would be found "very pleasant" (69-70). While Potter had suggested that agricultural commodities would make England into the heart of the global marketplace, Child sees England as the meeting place for global currents of both natural knowledges and new, non-native crops.

In all of these cases, the global visions of English glory that were so rooted to the language and imagery of agricultural improvement would be for naught unless reformers like John Ferrar, Virginia Ferrar, and Edward Williams could perfect their practice of agricultural science. This was especially true for the science of silkworms. The silkworm industry, as we know today, never produced the kind of wealth and noble occupation that its promoters had hoped for. Instead, it produced something else: an English colonial identity grounded in equal parts of agricultural science – the collaborative testing of ideas, recording of processes, and measuring of results – and the faith that this physical and intellectual labor would not only deliver colonial wealth, but also ensure the restoration of Adamic empire. In signaling what English agricultural practitioners and colonial planters knew and did not know about fertility, growth, and increase, the gendered language of agricultural scientific discourse marked the epistemological boundaries of English agricultural knowledge and the limits of its spiritual aims.

What makes these flexibly gendered cosmological bodies so interesting within the context of early modern English agricultural science, is, first, that they are not grammatically obligatory, and, second, that they fluctuate so freely between female, male, and gender-neutral properties. As these multivocal, collaborative treatises suggest, the natural world and its botanical elements are not consistently feminized in the whole of English scientific writing. In some cases, they do not even retain their gendered positions for a complete sentence. This is not to say that these works do not cast Nature as feminine – indeed, Nature appears throughout agricultural letters as the "most perfect worke Mistris," "a loving Nurse," "the True Mother, in whose Bowells is more wealth than ever will be drawne forth, and enough to satisfie … all other mens desires." But the gendering of Nature is far more complex than a consistently feminized and subordinated reading would suggest, as cosmological elements like soils, seeds, and silkworms take on different grammatical genders to register their physical compositions and labor relationships between planter and planted. Even the explicitly masculinized bodies of English husbandmen occupy different gendered subjectivities in the paradoxical frame of Christian inversion, a topsy-turvy world turned inside out by the intervention of the "Great Husbandman" who, as the minister John Flavel writes, converts planters into planted (143). In the *Husbandry Spiritualized*, Flavel draws upon analogical thinking and richly metaphorical "similitudes" or "resemblances" to explain how divine agency converts manly husbandmen into metaphorical fields "weak in heart" who await God's love to fructify their spiritual hearts with the richly "double sweetness" of the inseminatory word.[301] At once masculine sowers of seed "clean and pure" and the recipients of "nature sanctified in the bud," the earthly husbandman implores the

"mystical Husbandman" to "send forth his word and spirit to plough up my hard and stony heart" with "the seeds of grace sown in the renewed soul" (94, 95). Awaiting the "true pleasures and delights" contained "seminally in grace … which are glory in the bud," the husbandman, a third Adam whose very name foregrounds his explicitly masculine identity, threatens to become one whose soul is "a miscarrying womb, or dry breasts" if the "Great Husbandman" does not "Disseminate this seed within my heart" (94, 282, 283). As feminist historians have rightly noted, there is a pervasive ascription of feminine identities to cosmological bodies in early modern nature writing. But the gendering of Nature does not just consist of a feminization of material elements: gender acts as a fluid literary device that plays a complex marking role that makes possible the ascription of a range of subjectivities – male, female, neuter, and hermaphroditic – for human and non-human natural bodies in an era of colonial planting.

In the eighteenth century, when the gender shift in English had stabilized, historians of language and imperial apologists celebrated the "simplification" of the grammatical gender of English. Having covered the Latin, Irish, German, Danish, and Norman origins of English and the proper methods of second language acquisition, the eighteenth-century historian of language V.J. Peyton begins his encomium on the "excellence and superiority" of English "over all other European languages" by identifying four key features that mark the language's superiority: clarity, simplicity, comprehension, and "sweetness."[302] Peyton, who offers his study on the origins of the English language and traces it, as the title goes, *through Its Different Stages and Revolutions: Being Very Interesting for Persons Ignorant of the Infant State of Their Own Country and Those Revolutions; and for the Benefit of Those Who Aspire to the Perfect*

Knowledge of Their Mother Tongue, concludes that "The Italian is pleasant, but without sinews, like a still fleeting water: the French delicate, but even nice as a woman, scarce daring to open her lips for fear of spoiling her countenance: the Spanish is majestical, but runs too much on the o, and therefore is very guttural, and not very pleasant: the Dutch manlike, but withal very harsh, as one reader at every word to pick a quarrel" (29). What makes the Spanish language unappealing or "unpleasant" for the English apologist is the linguistic and aesthetic complement to what mining historian Peter J. Bakewell calls the "aggressive Iberian colonizing energy combined with America's relative geographical, political and biological openness" – the excessively masculine enterprise of the Spanish, either in material practices like mining or in the grammatical manhood of the language, its too "guttural" use of the letter "o," the masculine marker for nouns and adjectives. Nature may have been understood in subordinated and feminized terms in early modern scientific writing, but the masculinization of language and natural scientific inquiry, for English writers like Peyton, was no more desirable.

And the feminization of language did not necessarily imply subordination or undesirability. Creole etymologists in the Americas, like the mine owner Diego Dávalos y Figueroa and his cowriter doña Francisca de Briviesca, his older and much wealthier wife, argued in the *Miscelánea austral* (Lima, 1603) that the excessive femininity of Spanish caused it to absorb foreign terms and to incorporate them "como si fueran naturales nuestros" (as if they were natural to us). In some cases, as with the adoption of the Quechua term "cocha" to refer to any pool of water, distinguished in Spanish as "charco, laguna, estanque, y alberca" (puddle, lagoon, pond, reservoir), the feminine openness of American Spanish is "improprio" because it leads to imprecision. But in

other cases, as when Quechua and Aymara terms could be located within Greek or French origins, as in the word "mama" for "mother," the practices of creole "ethimologia" root the Spaniards to the cultural and physical landscape of Peru and identify a glorified classical precedent through which native languages and their speakers are recuperated into Spanish. These terms were used to distinguish the peninsular and American forms of the Spanish language and to celebrate the latter over the former.[303]

The ideal linguistic position was, like the seat of the global marketplace for Brandão or Potter, in the center of an imaginatively reworked geographic landscape: neither too masculine, nor too feminine. As Peyton argues through a natural colonial analogy: "Now we, in borrowing from them, give the strength of consonants to the Italian, the full sound of words to the French, the variety of terminations to the Spanish, and the mollifying of more vowels to the Dutch; and so, like bees, we gather the honey of their good properties, and leave the dregs to themselves" (29). In drawing from one of the most common early modern tropes invoked in the naturalization of conquest, Peyton's comparison of industrious English speakers and organized bee colonies (rather than silkworm colonies) fuses key elements of linguistic nationalism with Kupperman's well-studied "model of colonial design." This naturalized model of the sweet rewards of industry was intimately bound up with gender as a grammatical and cultural principle in English. The language, and what its apologists understood as "the English mind believed to have molded it," had learned from the Romance and Germanic languages of Europe to simplify its gendered systems into three grammatical categories: male, female, and neuter, an "improvement" that emerged from the rhetorical tropes of improvement and industry in the colonial agricultural archive.[304] Early modern agricultural writers like Sir

Hugh Platt urged readers to "neither enuie Spaine for hir riches, nor flatter her for her commodities," because, as Walter Blith argues, "the Improvement, or Advancement of the fruits and profits of the Earth by ingenuity, is little less then an addition of a new world."[305] In Spanish letters, the *industria* of minds like Cervantes's Basilio is the subject of praise and suspicion, while in English agricultural writing the industry and "ingenuity" of husbandmen is enlisted to efface Spain from the western hemisphere. For with the proper planting, and scientifically-driven reforms of agricultural labor, the English husbandman might be rewarded with another America ("little less then a new world").

By separating English and Spanish colonial scientific discourse in contemporary scholarship, historians and literary critics repeat the tendencies popularized by early modern English apologists who subordinate digging to planting and Spanish to English. (And, for that matter, Italian, Dutch, and French to English.) Such a separation obscures not only the very real rivalries that inspired the Spanish and the English to fashion their colonial enterprises against each other, but also the broad similarities that categorize their writing about scientific knowledge and application in the circum-Atlantic theater of nature. Gender is a fundamental category of human cultural identity and, in many languages, a grammatical principle. It should not be surprising that Iberian and Anglo scientific writers understood their material practices in gendered terms, nor should it be surprising that those terms were remarkably fluid – that some writers of agricultural and mineralogical texts chose to emphasize the cultural resonance of gendered images, while others preferred to ignore them, that some authors used gendered language as a way of marginalizing women, while others, as I hope to have shown, used it as a marking system for natural knowledge and practices that reveal the collaboration and competition of

women and men in agricultural experiments and, as the next chapter shows, mineralogical practice.

Colonial Scientific Literacies and Capacities: The Mining Women and Men of Alto Perú

In 1641, an indigenous woman named Bartola Sisa moved from her home in Oruro, Alto Perú, to the mining seat of Carangas some 120 miles to the southwest; there, three years later, she discovered a silver vein while prospecting between the mountains of La Candelaria and La Asención.[306] Sisa then enacted the forms of possession recognized by the Spanish government: she named the site (Espíritu Santo), assayed the ore, and contracted miners, all indigenous men, to extract the material after proving its high *ley* (weight). The Spaniard Cristóbal Cotes eagerly watched this process and appeared one day with a proposal. Claiming that the colonial government would not permit Sisa to register the site in her own name "por ser muger," or in the name of her son, a 9-year old minor, Cotes offered to register the vein in exchange for a share of the profits (1, 4v-5). Bartola Sisa reluctantly accepted, but when Cotes violated the terms of their agreement by preventing her from returning to the site, she sued him for unlawful occupation of the asset that she had discovered.

As the case unfolded over the next three months, it revealed the ways in which Bartola Sisa's claims of possession depended upon her technical skills in mineral detection, extraction, and assay. But equally important were her organizational skills in supervising laborers, recruiting indigenous witnesses in her new home to testify against a powerful male colonist, and working with her court-appointed attorney to make her case in a culturally meaningful way to the colonial administration. This case, in conjunction with the others that are presented in this article, not only suggests that women's

participation in colonial mining and metallurgy was more substantial than has been acknowledged, but also that the nature of seventeenth-century mining and metallurgy in Alto Perú created opportunities for women and men who could combine technical, commercial, and organizational competencies.

When Cotes enlisted the local corregidor Capitan don Lopes Ruiz de Samboa to declare that Sisa's "mal modo de bibir" had corrupted the indigenous people of Carangas, Sisa called upon the protector of the Indians, don Diego Benítez de Maqueda y Villalón, and three of her "yndios mingados," wage-earning *barreteros* (drillers) from Potosí, two of whom testified through a court-appointed interpreter (2, 4).[307] On 22-23 July, 1644, Francisco de Questo, Francisco Quispe, and Pedro Achatta affirmed that Sisa had followed the established protocols of discovery by performing the drill-hole extraction, assay, and registration in accordance with the colonial order (3-4). Most of the witnesses' testimony explained the nature of their work for Sisa, although Achatta, a "natural de Tauaya" (some 130 miles west of Potosí as the crow flies) and resident of San Bernando de Potosí, thrashed Cotes's opportunism with particular intensity: "sin hauer gastado ninguna el dho xproual de cotes y saue la labrado sin hauer querido dar nada de ella a la dha yndia ni tampoco ningun dinero y que aun que sea quexado no adelantado justicia por ser yndia por miserable pobre y de balda del dho xproual de cotes al contrario rico con dha mina espanol poderosso" (5v).[308] This forceful critique of the coloniality of power is registered within the legal frameworks of the colonial mining administration and embedded in a rich case that challenges the long-standing image of colonial mining as mysogynistic, violent, backwards, corrupt or corrupting, and dehumanizing.[309] Instead, Bartola Sisa's case against Cristóbal Cotes describes gender-inclusive material practices

and administrative frameworks that take seriously the voices of skilled indigenous miners. Moreover, the critique waged by the miner Pedro Achatta was reinforced by the institutional support of the court; three days after Achatta's testimony, the Real Audiencia ordered Cristóbal Cotes to leave the mine site and concede full privileges of discovery and ownership to Bartola Sisa.[310]

As this mid-seventeenth century case between the female indigenous miner and the male Spaniard suggests, the arts and sciences of colonial mining and metallurgy were situated within a complexly overlapping web of legal policies, commercial calculations, and intercultural negotiations. For some historians of science, these mutually constitutive technical and organizational dimensions reflect what Bertha M. Gutiérrez Rodilla calls the "peculiar bilingüismo" that was developed in the science of Greek and Roman antiquity and inherited by Renaissance scientists. As Greek was absorbed into Roman learning, so too was the Greek language made the primary vehicle for scientific and philosophical transmission and cultural exchange, while Latin retained its position as the language of law and commerce. For Renaissance scientists, the already complex bilingual inheritance of a scientific language whose theoretical concepts came from Greek and practical guidelines from Latin was compounded by the influence of Arabic. [311] While historians once posited a clear division between the new science of the seventeenth century and earlier, artisanal practices, since the publication of Paolo Rossi's *Philosophy, Technology, and the Arts in the Early Modern Era* in 1970, scholars have consistently demonstrated that the relationship between the arts and sciences was one in which the latter systematically and profitably disciplined the former without fully replacing its knowledges or methods.[312] The scientific theories and methods that emerged from these

artisanal modes were produced by and rooted in the historical moments and places whose political, cultural, and economic conditions circumscribed the range of conceptually available and commercially-practiceable possibilities.[313] Although legal documents like the case of Bartola Sisa have not often been considered in histories of science, they contain important details about technical practices, labor relationships between indigenous and Iberian practitioners, and accommodations of colonial administrative policies.[314] This is particularly the case in Spanish America, where legal scholars have shown that political frameworks like the *ordenanzas* were more concerned with protecting mineralogical output than disciplining gender relations.[315] These details can help us to place Andean women's mining and metallurgical work within the broader context of what historians like Antonio Barrera Osorio, Ursula Klein and Emma Sparry, Harold Cook, William R. Newmann, Jorge Cañizares Esguerra, Londa Schiebinger, Paula Findlen and Pamela H. Smith, Pamela O. Long, Margaret J. Osler, and Manuel Castillo Martos have identified as the experientially-based and commercially-oriented nature of seventeenth-century science.[316]

By contrast, manuscript sources circulated within the Spanish empire, like Luis de Capoche's *Relación general de la Villa Imperial de Potosí* (1585), only summarize the results of these kinds of mine discoveries. Through Capoche we know that indigenous women like Catalina Arupo, "india natural del Cuzco," discovered and was granted legal possession of a silver vein in the Copacoya mountain, three leagues northeast of Potosí. We also know that she discovered three veins in the Patipati mountain, also three leagues outside of Potosí, one vein in the Chqauil mountain, five leagues outside of Potosí toward the Guariguari mountain range, and another one in the Parini mountain, near the Chaquil

mountain. At each of these sites she ran a test line ("dio una cata"), registered the property, and "sacó metal que acudió por el beneficio de azogue" (removed metal that was amalgamated).[317] This three-part process of geological detection, legal registration, and mineral refining indicates not only that she had identified the types of low-grade silver more suited for the new method of amalgamation rather than the smelting methods in the traditional *guayra* ovens, but also that she had access to the Iberian-controlled mercury markets.[318] Her technical skills in the discovery of silver mines would have meant very little without the corresponding social and commercial networks through which to buy mercury and sell the finished product.

In the popular imagination, mining and metallurgy are associated with misogynistic attitudes, widespread womanizing, and environments that are fundamentally hostile to women, both in the colonial era and in our own time. And while it is true that colonial mining and metallurgy were then, as they are now, physically taxing professions that demand precise technical competencies, it is also true that seventeenth-century Andean and Iberian women participated widely in these industries. In the colonial era, female and male miners identified geological formations and assayed ore to determine mineral weights (*ley*), while metallurgists used those findings to mix reagents in the proportions best suited to the particular mineralogical conditions of each sample. This was skilled but dangerous work, performed in hazardous conditions by women and men who, through the trials and errors of first-hand experience (and, in rare cases, formal study), learned the methods of their craft, supported their families and themselves, and contributed handsomely to the royal coffers.[319]

And yet women like Catalina Arupo and Bartola Sisa have not often been studied

for their contributions to and practice of colonial Iberian mining and metallurgical sciences. While historians have documented that women played important roles in large-scale engineering projects in seventeenth-century Europe and that women participated broadly in the colonial Iberian economy, women's work in the commercially-oriented mining and metallurgical industries of the region has not received the same consideration.[320] Following the larger pattern in histories of science, which tended to cluster around scientific institutions or heroic geniuses whose single authorship of highly-stylized theoretical treatises lends itself to text-based scholarly analysis,[321] histories of mining and metallurgy in Spanish America have revolved around individual figures like the priest and metallurgist Álvaro Alonso Barba.[322] This is not without reason, as Barba's modification of the New Spanish *patio* method of amalgamation into a heat-based treatment better suited to the colder ambient temperatures and higher mineral weights of Alto Perú made it possible and profitable to benefit a wider variety of silver mineralogies.[323] This chapter, then, begins by reviewing the conditions in which colonial mining and metallurgy were practiced by women and men, lettered and unlettered, in Alto Perú. In the second part, I turn to the stories of the Andean women whose broad contributions to the practice of mineralogical science in the region have been overlooked. That their work has not been more broadly appreciated reflects their marginalization within the historical record and the marginalization of Iberian science within the history of science. If colonial Iberian science did not count as "science," proper, then the indigenous and Iberian women who discovered mine sites, assayed ore, and mixed reagents to fit the specific mineralogical conditions of a sample certainly were not going to count as agents of science, either. The chapter concludes with a discussion of the larger

consequences of marginalizing Iberian science not just in the historical record of the colonial Americas, but in the lived realities of the people of what is now called Bolivia.

I. "Porque con letras son verdaderamente hombres, y de la plata no se aprovechaban mucho ni todos" [Because with letters they are true men, and with silver they never benefited much or many]: Literacy, Personhood, and the Historiography of Colonial Iberian Silver[324]

It is not just women whose contributions to colonial mining and metallurgy have been understudied, then, but also the men who, unlike Barba, did not elaborate their theories in the richly literary language that lends itself to scholarly study. According to the historian of science Julio Sánchez Gómez, the majority of mining and metallurgical practitioners of colonial Spanish American remain anonymous because they left little or fragmentary written evidence of their work.[325] Mining and metallurgical work was hands-on, practically- and experientially-oriented, and yet mining and metallurgical historiography necessarily privileges the written accounts of literate practitioners who could explain the theories that informed their work and document their trials in a format that could be preserved for later study. But these lettered accounts often reveal the substantial contributions of unlettered practitioners.

The most widely studied metallurgical practitioner in Alto Perú, the priest-metallurgist Álvaro Alonso Barba, is quick to recognize his collaboration with indigenous miners and Iberian priests who contributed their knowledge and practice to the development of amalgamation. For example, in one memorable scene the priest-metallurgist describes how his christening of a new mine site in Los Lipez province was indebted to the indigenous miner who recognized a unique geological formation, extracted a test sample, and shared it with him. Spanish miners had tried to amalgamate silver from the mine of Xauquegua with mercury, but the results were so poor that they

abandoned the site.[326] An indigenous miner noticed the unique mineralogy of the silver in this vein, relative to other silver bodies that he knew, so he extracted a sample and delivered a portion of it to Barba, who then experimented with smelting methods to see if they would deliver better results. While Barba not specify how he got the idea to smelt the silver, it is possible that the miner suggested tried treating the ore with traditional heat-based methods rather than the Iberian method of amalgamation. (It is also possible that Barba determined to try the metal with heat based on the poor results of the other Spaniards.) This collaboration, which Barba documented at the material level and may have left undocumented at the level of knowledge, proved successful. Barba soon thereafter christened this productive new site, "puse por nombre Nuestra Señora de Begoña," and it became a node of economic development in the region, pulling migratory workers from throughout Alto Perú: "Hízose luego ingenio junto a ella, y concurrieron mineros, que hallaron y trabajaron otras muchas, de que se ha sacado muy grande suma de plata" (Then a refinery was made next to the mine, and miners poured in who found and worked many other mines, from which a great sum of silver has been extracted). Barba's larger point in the chapter is that a metallurgist must scrutinize the material and respond appropriately to its conditions. No one method will work universally on the diverse silver mineralogies of the region, so miners and refiners must understand the new technologies of amalgamation and earlier methods of smelting. But there is another point, too: without the collaborative work of the unnamed indigenous miner who identified the sample and shared it with Barba, the site would not have developed.

These collaborative relationships help to produce new methods and technologies that incorporate Iberian and indigenous knowledges and practices, as in the development

of the *Tintin* process for mixed metals. In addition to working with indigenous practitioners, Barba exchanged material samples and ideas with people he considered peers, as well. Though they also remain unnamed, he refers to them as friends whose ideas and materials course through the religioscientific networks of Alto Perú's metallurgical practitioners. These men include one "amigo mío, sacerdote" (my friend, a priest) who sent material from Cerro de Santa Juana, in Berenguela de Pacajes, or another "amigo mío, minero entonces y religioso hoy de la familia del seráfico Padre San Francisco" (friend of mine, then a miner and today a religious of Our Seraphic Father St. Francis of Asisi).[327] Barba declines to name this second priest-metallurgist, but he describes at length his colleague's process of developing *Tintin*, a four-step treatment for amalgamating the precious metals that are commonly found intermixed with stones in Turco, province of Carangas.

The mixed origins of *machacado*, the name for the intermingled rocks and precious metals, made the metals difficult to smelt or treat with the new method of amalgamation, "porque si ha de ser por azogue, ni puede molerse bien, ni el azogue abrazar el oro o plata tan gruesa; y si por fuego, la mezcla de la piedra seca y sin jugo que los acompaña, es de estorbo gradísimo para la fundición, en cualquier modo que se haga, y no puede apartarse lo uno de lo otro sin riesgo de mucha pérdida" (because if you use mercury, you will not be able to grind the mixture finely, nor will the mercury embrace such thick gold or silver, and if you use fire, the mixture of dry stones that accompanies the precious metals is such a nuisance in smelting that no matter what you do you cannot separate the one from the other without the risk of great losses, 119). To put these complicated mineralogies to human benefit ultimately demanding nothing short of

"brújula" (sorcery), until the invention of his friend. This method, which consists of creating a pyramid-shaped hole in a hard stone, filling the concavity with the *machacado* and reagents, crushing them with a mortar and washing the mixture, allows miners and metallurgists to profit from previously unusable materials. Because of the washing in the third step, they could also produce mineral bodies suitable for later treatment with mercury. In the process of mineral washing, water entered the hole through a fat, high tube and mixed with a soft film ("lama sutil") that was produced by the reagents. This film contained low-grade particles that could be amalgamated with mercury to deliver a kind of double benefit or "muy considerable provecho" to the treatment (119). Barba's passage does not contain any details that would help historians to identify the inventor of the method, nor does he indicate whether his friend continued to experiment with mining and metallurgical technologies after he professed to the church. Instead, the example of the miner-cum-religious gestures to a broad context of mineralogical experimentation that developed in response to localized problems like impure silver bodies.

We can place religious men, civil figures, Iberian women, and female and male indigenous miners and metallurgists within this context because of the brief details provided in lengthy treatises and the extensive details provided in fragmentary archival documents. These two literary corpora offer different types of details, but taken together they can help to more fully situate women's and men's participation in and contributions to colonial Iberian mineralogical science. I begin with cases of men to show that it was not just women's voices that have been overlooked in the study of colonial mineralogical science, but any number of mineralogical practitioners whose fragmentary documentary records and language make it impossible for their stories to become part of "the alchemy

of modernity," or enlightened national narratives of progress. As the historian Tristan Platt suggests, it took a lettered man who worked within a recognized scientific institution to introduce a vocabulary that resonated with a European audience: "Only when [Ignatius von] Born, Director of the Museum of Natural History in Vienna, reinvented American techniques within a German theoretico-practical discourse, was enlightened Europe convinced that industrial silver-refining by amalgamation could be profitable."[328]

Archival records testify to the widespread involvement of secular and religious metallurgical practitioners from Spain, Italy, Germany, and the Netherlands. In some cases, their work was recognized in extrajudicial fashion, as in the naming of the rich mineral vein in the Cerro of Potosí "la veta de los flamencos" after the Dutch miners who organized the site's mining and minting of silver, but more often foreign miners used Iberian judicial frameworks to protect their work. These archival texts document the substantial legal activity of the Flemish miners and metallurgists who registered property, recorded bills of sale, and used Iberian legal structures like powers of attorney to solidify their collaboration in mining centers like Potosí and Porco. These miners, some of whom are given Hispanicized names like Adrián Enríquez and others of whom are marked with ethnic Flemish identities like Juan de Bruselas or Dionisio de Holanda, bought mineral rights from Spaniards, sold them to other Dutch miners, and used their own networks of metallurgists (*ensayadores*) to refine the ore and mint it for market. At times, they collaborated to invest in mineral extraction and processing, as when Adrián Enríquez purchased five *varas* (yards) owned by Juan Pérez de Lizárraga, and sold them to Levin de Enveres for 100 *pesos corrientes*, allowing Enveres, with the support of Guillermo de

Diste as the underwriter, to join the 100-vara rich Flemish mining company of Bruselas, Holanda, Pedro Panus and Andrés de Lovaina, or when Lovaina gave to Diste one-sixth of the mine that he shared with Bruselas in the Rosario vein of the Cerro Rico.[329] At other times they competed against each other, as suggested by the power of attorney drafted by Bruselas, Dyste, Enveres, and Lovaina for the lawyer Juan de Ferández to represent them and their interests against Pedro Panus regarding the group's share of the property left by the deceased Dionysio de Holanda.[330] As these documents from the earliest years of Iberian control of Potosí suggest, Flemish miners and metallurgists were actively involved in the extraction, refining, and selling of silver in Potosí and the surrounding mining regions. Their formation of mining companies and negotiations of Iberian legal frameworks helped to shape the commercial conventions of colonial mining and metallurgy some seven years after the site was revealed to the Spaniards by Diego Gualpa.

After the introduction of the amalgamation method to the region, in the early 1570s, these patterns of technical and economic collaboration and competition would figure into formal appeals for patronage in the support of new mining technologies and equipment. Some of these inventors preferred to frame their appeals in individual petitions, such as those submitted by Juan Fernández Montaño, Gaspar Ortiz Picón, Domingo Gallegos, the Genovese Juan Agustín Rojo, Gabriel Treviño, the Friar Gonzalo de Vargas Carrillo, the Captain Juan del Corro y Segarra, and don Pedro de Mendoza.[331] Other metallurgists preferred to collaborate in their experiments and the presentation of their results, revealing the collective nature of colonial science and colonial law.[332] Some of the most prominent metallurgical teams included the Corsican Carlos Corzo de Leca

and Francisco Sande, and Juan Muñoz de Córdova and Hernando de la Concha; these pairs worked together for years and submitted a number of petitions jointly. Other individuals moved between partners, as in the case of the miner Garci Sánchez, who worked alternately with the Friar Horacio Genari and the *clérigo presbítero* Martín de Vergaraesse.[333] The widely collaborative networks in which these miners and metallurgists exchanged ideas and material samples are documented in two main sets of archival documents that reveal the overlapping technical and commercial nature of colonial mineralogy: formal appeals for recognition by the crown (*relación de méritos y servicios*) and account books (*libros de cuentas*).

In their appeals for patronage, these largely unstudied metallurgists proposed with or without credit a series of new devices and methods designed to increase silver production in seventeenth-century Alto Perú. This technical equipment ranged from all-purpose *tinas* (bins) that would retain more mercury during the washing stage, as Juan Agustín Rojo suggested in his appeal, to the oval-shaped, open-hood ovens designed especially for *negrillos* (iron sulphides infused with silver antimonides found below the ground-water level).[334] These racialized ore bodies, so-named because their dark color rendered them "metales de malesa" (undesirable; literally, "metals of weeds") had proved nearly impossible to benefit. Neither the traditional smelting method nor the new method of amalgamation could respond adequately – or profitably – to their complex mineralogies. Part of the problem was the imprecise naming of the ore, for, as Álvaro Alonso Barba pointed out, "no todos los metales negros se comprenden debajo de nombre de Negrillos" (not all black metals are included under the name of *Negrillos*). By ignoring some of the differences among these black silver bodies ("ignorado

generalmente su fundamento") metallurgists had proceeded "tan acaso y sin ciencia" (so haphazardly and without reason) in insisting unsuccessfully upon one treatment over the other. The costs of amalgamating *negrillos* with mercury outweighed the silver yields produced by the treatment, and the longer the ores were left in the fire with the goal of being cleaned and purified ("se limpiaran y purificaran") the more vile and impure they became: "pues al paso que dura más la quema, se aumenta y aviva la maleza."[335] The solution, as Barba explains in prose and engineers like Simon de Corona y Orihuela and the physician Lope Saavedra Barba revealed in their design of new ovens (see figure 1), was to combine elements of the Iberian method of amalgamation with indigenous heat-based applications; *negrillos*, these metallurgists discovered through trial and error, needed to be heated before they could be amalgamated. The open-top ovens designed by Corona y Orihuela and Saavedra Barba allowed more sulfurous particles to burn off as the mixture was exposed to heat. This led to greater yields of silver because more of the precious matter was retained.[336] In collaborative experiments and exchanges of ideas, then, colonial mineralogical science performed in real material terms the kinds of generative amalgamations of New World and Old World knowledges and practices contained in its theoretical formations. Iberian and indigenous theories of mineral composition and structure were combined to identify a method of refining the most common silver mineralogy of the Americas, the mixture of silver and sulfur called, in the racialized discourse of colonial science, *negrillos* or "little black ones."

Figure 1: The design of Corona y Orihuela's open-top oven for negrillos (ABNB CPLA 20 1635).

These innovative combinations of indigenous and Iberian methods and technologies resulted in proposals to treat all kinds of silver mineralogies and to improve upon the amalgamation method imported from New Spain and the practices native to Peru. One such proposal came from Juan Fernández Montaño, who suggested two ways to modify the Iberian amalgamation method with native knowledges and materials.[337] First, he suggested adding 20 -22 ounces of "piedra azul de los Lipes" (a blue stone from los Lipes) that has no name in Spanish but "que en lengua de los yndios se llama copaquiri" (in the language of the Indians is called copaquiri) to the 50-quintal piles of silver, mercury, and salmuera. Second, he called for miners to add to their mineral washing piles three Indian blankets' worth of manure ("como puede lleuarse en tres mantales de yndios") and six or seven *arrobas* of powder ground from the tailings of the indigenous *guayra* smelting ovens. With these two practices, Fernández Montaño claimed, the miners of Alto Perú could greatly increase their silver production and decrease their mercury costs ("se aumenta mucho en venta y diminuye mucho la perdida

del azogue pues esto es tan tan notable benefficio"). The scraps of indigenous metallurgy, the "cisco que ay oy en las guiaras desta V[ill]a de Potosi que bea basura que de secyan los yndios guaradores" (that today in the *guayra* ovens of this Villa of Potosi are seen as trash removed by the Indian smelters), in combination with animal scraps, are literally incorporated into the Iberian method of amalgamation in a profitable combination of hybridized metallurgical practices and materials. Just by using blue stone or with the *cisco* alone miners can achieve higher silver yields and better conservation of mercury, Fernández Montaño argues. But by incorporating new materials (the stone) and repurposing indigenous methods (scraps from the *guayra* ovens) jointly into the Iberian method of amalgamation, "sera el beneficio bueno y demuchas prouechos" (the benefit will be good and very fruitful). The Spaniard who is willing to draw from native materials and practices, in other words, will reap the greatest advantages in improving the new amalgamation method.

This new benefit of amalgamation inspired no small number of technical inventions and innovations from metallurgists throughout Alto Perú. They collaborated in the development and modification of the amalgamation method by experimenting with combinations of pure silver, *pacos* (surface-level silver chlorides), *negrillos*, and the equally racialized *metales mulatos* (silver sulphides) that Barba calls "un medio entre Pacos y Negrillos, y así lo crió la naturaleza entre los dos" (a metal halfway between *pacos* and *negrillos*, and so nature created it between the two).[338] They tried treating these mixed ores with different catalysts like salt, reagents like *salmuera* (NaCl) or *magistral* (distilled copper and iron sulfates), or other metals like lead, tin, and copper. Some practitioners focused on ways to make the large-scale method more cost-efficient, as with

Juan del Corro y Segarra's idea to recycle the amalgams from one batch to decrease mercury expenditures, or Juan Agustín Rojo's suggestion that iron could be eliminated from the process without decreasing silver yields. Rojo was originally dismissed as "loco o charlatán" by the viceroy Marqués de Cañete but was later well-received in Potosí, while the initial enthusiasm for del Corro y Segarra's work faded after a few years of less than encouraging results, as María Luisa Rodríguez Sala has shown.[339] The theoretical or intellectual traditions, as well as the initial rounds of institutional frameworks, supported del Corro y Segarra, but the practical results of Rojo's method earned him the support of his peers and, eventually, that of the royal officials.[340]

In addition to these formal petitions for recognition of their service to the crown, miners and metallurgists like the refinery administrator Antonio Hurtado and the accountant Gaspar Ruiz left fragmentary accounts of their experiments in documents like libros de cuentas. Between 23 February and 12 April, 1630, Hurtado and Ruiz chronicled their trials with the new method of amalgamation. In a series of five-column charts organized chronologically, they carefully recorded the amounts of silver, mercury, and reagents that they used in each batch of silver processed at the ingenio of Mateo de Torres Naranjo (see figure two).[341] They also cataloged the results of their steps and missteps, showing which ratios of materials produced the most pella (amalgam) and the most valuable silver (in marcos), and which combinations led to the greatest losses of mercury or the least valuable piña. Their practice was marked by trial, error, and repetition based on a careful accounting of the amount and value of each material used in every step of the amalgamation process. But the experiments abruptly stop after four months of trials. Because they left only fragmentary documentary evidence of their work, and because

they did not explain the nature of their experiments – whether motivated by necessity, financial incentives, or sheer curiosity – these men, like the mining women of the region, have remained largely unstudied in the history of colonial Iberian mining and metallurgy even though their work helped to produce the large flows of bullion that made possible the religiopolitical and economic hegemony of imperial Spain. Some of their experiments produced measurable improvements in time or cost, while other suggestions were fanciful speculations at best and knowingly fraudulent claims at worst. But the collective practices and the competition of these miners, metallurgists, and merchants helped to solidify the experiential and commercial conventions in which men and women sought new mines, extracted ore, and processed metals for minting. By taking seriously the scientific value of these experiments – by contextualizing mining and metallurgical work within the hands-on, market-oriented conventions of seventeenth-century applied sciences – we can better understand the development of the silver industry in colonial Alto Perú.

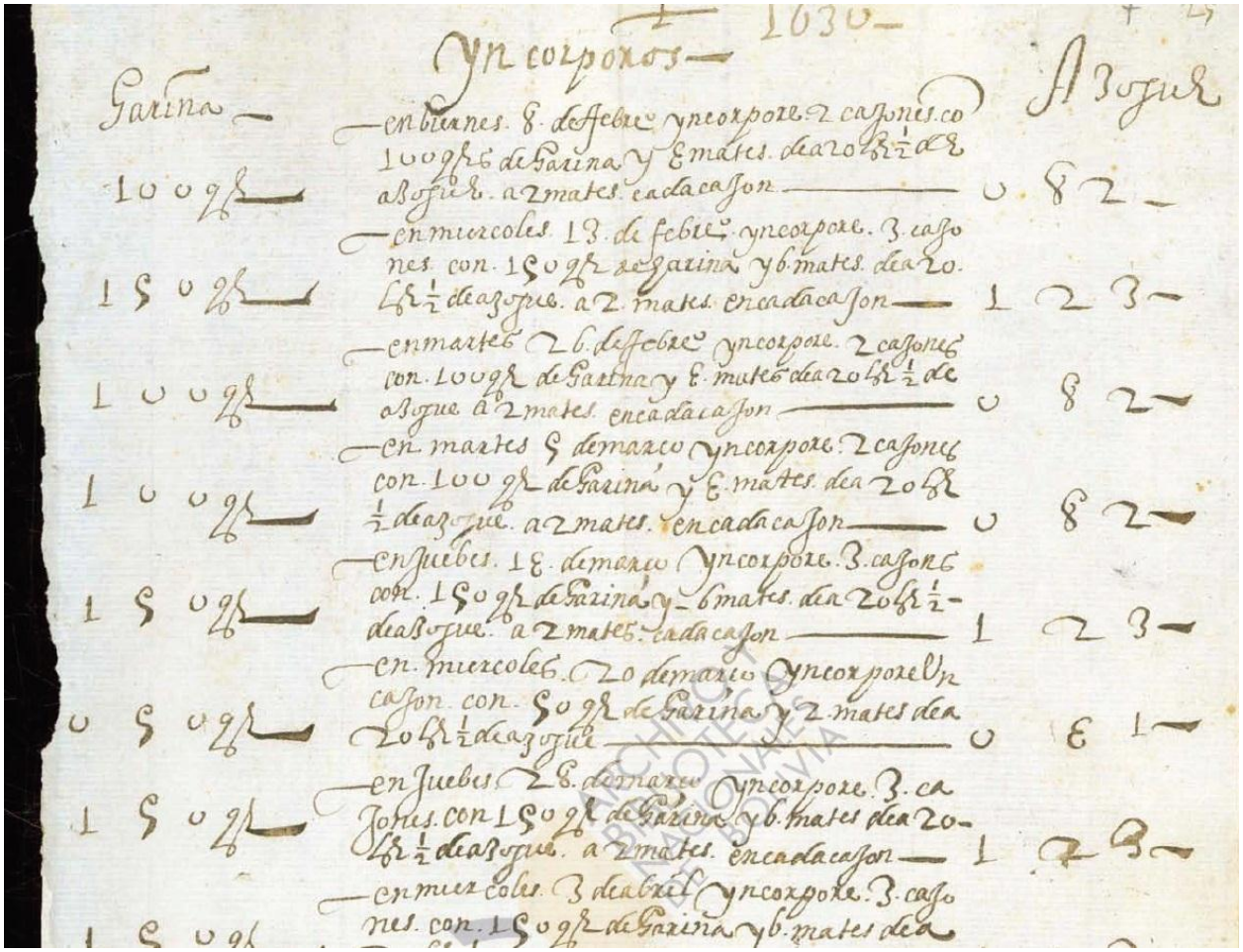

Figure 2: Log of silver amalgamated with mercury, 8 February - 3 April 1630. The left-hand column lists the amount of ground silver and the right-hand column catalogs the amount of mercury used in the initial mixing. ABNB Minas 8.1 1630.

Because so much of life in the region revolved around that industry, we can read a variety of textual sources to appreciate the scope of the developments of mining and metallurgical technologies. Learned treatises like Barba's and fragmentary archival documents both reveal broad patterns of experiential and commercially-oriented collaborative modes of practice. While accounts like Barba's *Arte de los metales* have been more widely studied, legal cases also reveal important details about the production of mineralogical knowledge and the practice of mineralogical science in seventeenth-century Alto Perú. This is because, as legal historians like Matthew C. Mirrow have shown, Spanish law was designed to maximize mineral extraction and the minting of

silver. Royal officials cared less about regulating gender relations in the silver industry and more about the production of silver. Although important studies of gender and seventeenth-century science have suggested that the increasingly commercialized and mechanistic modes of seventeenth-century science were prejudicial to women,[342] the opposite seems to have been the case in the colonial Americas, as historians like April Lee Hatfield and Kimberly Gauderman have shown in their studies of agriculture in North America and textiles in Ecuador.[343] In Alto Perú in particular, the commercialized nature of mining and metallurgical work created opportunities for Iberian and indigenous women alike; if they earned a profit and contributed their royal *quinto*, these women, like their male colleagues and competitors, could receive institutional support from the colonial government when they took their rivals to court for practices that were prejudicial to their own. If they were too successful, mining women were sued by Iberian and indigenous men who argued that the women had encroached upon their own mines and refineries. If they failed to contribute to the royal treasury, the Spanish government pursued action against them. As these legal cases demonstrate, mining women sued and were sued in large number. The economics of mining and metallurgical work – its *raison d'etre* – emerged within a broadly litigious culture that left behind a rich legal archive. By expanding the definition of seventeenth-century science to focus on the application of its hands-on, market-oriented nature, these archives help us to better understand the contours of colonial science. I turn now to some of the stories of indigenous and Iberian women whose substantial participation in and contributions to colonial mining and metallurgy have been largely underappreciated.

II. "hallandome como me hallo yndefensa": Mining Women in Seventeenth-Century Alto Perú

In addition to their first-hand experience as miners and refiners, women in seventeenth-century Alto Perú also took advantage of the commercial and organizational nature of the silver industry to take on roles as mine managers or investors. While the commercial dynamic of Renaissance-era mining and metallurgy has been well-documented by historians like Erik Ash in cases of European investors, as in the case of the uneasy partnership that was formed in 1556 between Thomas Thurland and the joint-stock Company of Mines Royal and the Ausburg-based bankers of Haug, Langhauer, and Company to benefit the copper assets of northwest England, women's involvement as managers of and investors in colonial Iberian mining and metallurgy has not received the same attention.[344] In some cases, women like the silver miner doña Isabel de Rojas, who lived and worked in the mining seat of San Luis de Alba, province of Paucarcolla, used their gendered identities to argue for their right to manage mine sites. Doña Isabel had inherited from her late husband Alonso Ramírez a vein that he discovered in the Laicacota mine, located on the shores of the Lake Titicaca. When Juan de Tamayo, the owner of the adjacent vein, prevented Ramírez from registering the site and extracting ore, doña Isabel sued Tamayo in 1661. In her capacity as mine owner and manager, she sought 14,000 pesos of back compensation for "el desfruto que me hizo en dos sitios de minas que tengo" (the profit he enjoyed from two mine sites that I have). While there is no evidence in the case that doña Isabel worked directly in the excavation or benefit of silver, she clearly identified herself as the owner-manager who was responsible for negotiating colonial legal frameworks to ensure that the profitable asset remained productive. For example, Ramírez's former coworkers, the brothers Pedro and Joan Cabezas, refused to testify "por respetos vmanos" (worldly fears), but doña Isabel

successfully petitioned for an *aguacil mayor* to record their statements. With the presentation of this testimony, the Real Audiencia ruled in her favor.[345]

While women like doña Isabel used their organizational skills to negotiate mining policies and legal frameworks, other mining wives used their marriages to male miners and refiners as a way to invest their dowries in the capital-generating mineralogical sector. One such example is the widow doña Beatriz de la Roca y Merlo, who argued to be named as the sole heir of her husband's refineries because her dowry had provided the seed money for the expansion of the couple's estate in the mining seat of San Baltasar de Astria de Tomahavi. When their marriage began, her husband, the miner and refiner Juan de Carriaso, was so poor that "no tenia mas que vn ttrapiche" (he had nothing but a mill). But the couple went on to thrive with her "ayuda, trauajo [y] solicitud" (assistance, labor, and solicitude) as well as the capital represented by her 8,000-peso dowry of hard currency and chattel property, or "eslauos" and "platta labrada y en rreales" (slaves and silver minted in pieces of eight). According to doña Beatriz's claim, these financial and non-financial contributions to the marriage justified her sole possession of the mining and refining operations; although her brother-in-law filed to be recognized as a joint inheritor she argued that he did not deserve to enjoy the fruits of an estate to which he had made no contribution, financial or otherwise. Because Carriaso had died before he could record his last will and testament in writing, doña Beatriz relied upon the testimony of her 17 witnesses to support her claim that her husband wanted to name her, "mi muger y compañera" (my wife and companion), as the sole heir. All of the witnesses, who included male and female Iberian mine owners and indigenous miners and metallurgists, testified to Juan de Carriaso's poverty before his marriage and to his improved

circumstances thereafter. One witness, the 39-year old miner Pedro Puma, "yndio ladino en lengua española y de mucha razon" (an Indian who speaks Spanish and has reason), provided exceptional detail on Carriaso's poverty before his marriage. According to Puma, Carriaso was so poor that Puma himself "le buscaua platta para poder pagar los jornales a ottros yndios por el amor que le tenia y ser su compadre" (looked for silver for him to be able to pay the wages of other Indians, for the love that he had and because he was his *compadre*). Another witness, the 30-year old Hernando Mateos, who knew Carriaso as a mine-owning boss rather than as a friend and *compadre*, corroborates Puma's assessment by recalling the dramatic difference in worker compensation after Carriaso married doña Beatriz: "anttes que se cassase le vio muy pobre y que no podria pagar los yndios de su trapiche y despues que casso con la susso dha le vio con hazendia y que pagaua lo que deuia" (before he was married he was seen to be very poor and he could not pay the Indians who worked at his mill, and after he was married to the aforementioned woman he was seen with a hacienda and he paid what he owed). While the indigenous witnesses like Puma and Mateos emphasized Carriaso's poverty in the context of silver production, Iberians like the 70-year old Manuel Álvarez highlighted the ways in which doña Beatriz's financial capital enabled Carriaso to pay off his debts to private lenders, like Álvarez, and to the royal coffers alike. Absent a written account of Juan Carriaso's intent, this testimony about doña Beatriz's substantial contributions to the marriage led both the local *corregidor* and the colonial officials in La Plata to name her as the sole heir to the estate.[346]

Outside of their investments in assets that they owned with their husbands, female investors in Alto Perú also financed projects that had been designed by third parties or

independent contractors, male and female alike. These women made the types of financial investments in mine exploration, refining equipment, and metallurgical methods that facilitated the development of mineralogical science and practice throughout the region. Female lenders like doña Catalina de Sandoval and doña Magdalena Yanguas, both of whom had grown up as citizens and propertyholders (*vecinas*) of the mining regions, invested in specific projects of mineral excavation or refining. Doña Magdalena, of Potosí, made a substantial loan of 2,300 pesos to the mercurysmith, refiner, and mine owner Don Martin de Vela Reinaga, of Porco, but her appeal dragged on in court because of the competing claims of don Martin's other debt collectors, including minor officials like the other party named in the suit, maestro de campo Don Luis Domínguez de Monroy. Don Luis had resolved his case to his own satisfaction, with don Martin going to debtor's prison in June of 1672 to repay the 330 pesos that he owed the male colonist, but doña Magdalena petitioned colonial administrators to find a way for both parties to collect on their debts. On 14 December, 1672, the court instructed both parties to be repaid. If doña Magdalena's case reveals few of the technical or managerial competencies displayed by other mining women, it nevertheless shows how a propertied Iberian woman negotiated multiple jurisdictional frameworks in the provinces of Potosí and the colonial metropole of La Plata.[347]

Other female lenders assumed much more hands-on roles in their investments, however. For example, doña Catalina de Sandoval and her husband, don Bernardo Pérez de Villaro, both propertyholders in San Antonio del Nuevo Mundo, lent 2,150 pesos to the capitán Don Fernando de Ximenez of Tarija. When Pérez de Villaro was called back to Argentina, he granted his wife an extensive power of attorney to negotiate the buying

and selling of human, mineral, and commercial property, dated on 4 November 1557 and signed before three witnesses, Gonzálo Gutierrez Guerrero, Baltazar de Castro, and their servant (*criado*) Alvaro Pérez. Acting in her husband's absence, doña Catalina continued to run the Esmourco refinery in the province of Los Lipez, and she also initiated legal action against the couple's debtors, including powerful colonial officials like Fernando de Jiménez, mayor (*alcalde*) of the Province of Lauicla, Tarija. According to doña Catalina's statement, the couple had many times earlier solicited payment from Jiménez, who had thus far avoided collections ("aunq-e se le an pedido barias beces no los paga"). But once her husband left the area, doña Catalina cascaded the complaint to administrative officials in La Plata, calling on 7 February, 1661, for a formal censure of Jiménez and a full payment of the debt. The extant documentation, delivered to officials in La Plata by "el castellano Don Pedro Flores" and seen by the court on 30 December, 1661, does not indicate what happened to her case after it was received in Sucre. Nevertheless, the timeline allows us to see that doña Catalina aggressively litigated for repayment only after she had the legal authority to make decisions independently, or at least without consulting her husband.[348]

For elite Iberian women like doña Catalina, the institution of marriage provided crucial investment opportunities that she could share in as a partner – and pursue with greater force once her partner had disappeared. Other elite women had long found themselves in similar situations following the deaths of their husbands, rather than their departures. In the mid-sixteenth-century, one doña Juana de los Ríos of Potosí owned mines in the Veta Rica and the Veta de Estaño of the Cerro Rico. After the passing of her husband, Martín de Robles, doña Juana assumed sole ownership of the mining companies

that worked the couple's property in Potosí and Porco, and six years of account registers (1562-1568) chronicle her place in the day-to-day operations, in litigating against debtors like mine overseerer Pedro de Leycegui, and her role as a slaveowner who leased out individual laborers to other mine owners and refiners to generate additional capital.[349]

While these documents suggest that many women took on increasingly active roles after they were widowed, important numbers of mining women also maintained collaborative partnerships with their husbands during both spouses' lifetimes. On 7 October, 1572, for example, one doña Petronila de Castro of Potosí joined the mining company of don Gerónimo Osorio and his wife doña Isabel de Quintanilla. For nearly eight years the couple had organized lucrative companies to extract silver from the assets owned by doña Isabel, but with the filing of the new article of incorporation the company would divide its risks and opportunities equally into three parts. The central role of doña Isabel was signaled in her designation, with her husband, as a *capitán*, a title that she receives three times in the course of the two-page document: "los señores capitanes G[uiller]rmo Osorio justicia mayor de la villa de oropesa e doña ysabel de quintalla su muger," "esta es la mina que los dhos capitanes geronimo osorio y dona ysabel de quintanilla tienen," " aprouaria e rratificaria la dicha compania que aya entre los dichos capitanes geronimo osorio e dona ysabel de quintanilla." I do not know whether it was conventional for female mine owners to be called *capitanes*, but the designation as such in a formulaic legal document suggests that it was common enough to pass without a special mention or justification by the notary.[350]

Ownership of a mining company does not necessarily imply any knowledge of the technical elements of mining and metallurgy, of course, but legal and commercial

documents like powers of attorney and articles of incorporation suggest that mining women did contribute their knowledge and practice to their mining companies, often in ways that have gone underappreciated. In one case, an indigenous woman named Mari Flores formed a mining company with her husband, Hernán García, mulato, Juan de Vallejo, mestizo, and one Blas García, to unearth the precious metals buried in the *guaca* of Manducalla, between the mountains of Sicasica and Churuquella, and the other burial sites surrounding the city of La Plata.[351]

While this case does not suggest that any of the investors had developed technical competencies in mine site detection, it evidences some of the ways – here, the quite disturbing ways – in which indigenous women's knowledge could be profitably applied by the colonial government in its complex negotiations of the mineral wealth stored in *guacas*. These spaces could be recognized as religious sites that were legally protected from excavation, but at the same time they could also described as idolatrous storehouses whose extirpation was necessary for the moral health of the region. The ambiguous cultural status of this mineral wealth was reflected in contradictory colonial jurisprudence. On the one hand, the rich stores of precious metals excavated from the sites were considered royal property to be taxed *(quintado*) accordingly, as documented in seventeenth-century legal compilations like the *Gazophilativm regivm prevbicvm* (1675) of Gaspar Escalona y Agüero. But these excavations were to be licensed and carefully supervised so that, as the Viceroy don Luis de Toledo put it, "no sean defraudados los indios" (the Indians will not be deceived). When colonial officials excavated sites without a license, they were sent to prison assessed heavy fines, as in the case of the 1687 ruling in La Paz against that city's *corregidor*, don Bernabé Felipe de

Aragón, and treasurer, don Francisco Arias Maldonado. [352]

So when the indigenous Mari Flores and her husband, Hernan García, mulato, filed their article of incorporation on 27 March, 1569, for a company that would specialize in the excavation of *guacas*, the crown seemed to have found a convenient solution to its problem. A mixed-race mining company of an indigenous woman, a mulato man, and a mestizo investor, the artisan Juan Vallejos, was offering to unearth valuable materials that colonial administrators could profitably tax without the appearance of fraud. Mari Flores knew the location of the buried treasure, Hernán García found investors for the project, and Juan Vallejos, like the other investors, would contribute the capital necessary to finance the initial rounds of excavation. According to the terms established in the six-year contract, the major costs of operations – indigenous laborers and materials ("las c[o]s[t]as y gastos que se an de hazer asi d yndios como otras las an di pagar") – would be shared by each of the seven investors according to her or his share in the company. After subtracting their expenses, the profits were to be divided among twelve parts: one part for charity, five parts for Hernán García and Mari Flores jointly, two parts for Blas García, a chairmaker, one-and-a-half part for Vallejos, and the remaining investors whose professions and identities are not mentioned: Juan Bernal (one share), Juan Nyrlas (one share), and Miguel Lopez Pregonero (half a share).

If this was the only article of incorporation that I found – or know of – for a *guaca* site, it is one of many cases that document racially-inclusive patterns of mine ownership in colonial Alto Perú. One year after the Flores-García company was registered in Potosí, Alonso de Valenzuela, a free mulato mine owner living outside of Cochabamba, bequeathed his agricultural holdings in the valley of los Yungas de Chuquimona and

everything except his mining property to his indigenous wife, Beatriz Hernández, and his oldest son, Juan. In his last will and testament, Valenzuela, identified as "de color moreno," left his wife, identified as a member of the *guanca* tribe, in charge of the assets that he had acquired during their marriage, including the house, farmland, and 60 containers of (contraband?) cards ("sesenta barachas de naypes"). While these goods were itemized in the account books held by his son Juan, the fate of his mining property was left unclear. Three years earlier, Valenzuela had paid 120 pesos to purchase from mine owner Pedro de Arrieta Ceujano some 70 *varas* in a vein named Carmen in the mining seat of Berenguela, Cochabamba. With one Pedro Vélez he had established a mining company to extract ore from the site, but they seem not to have performed any work, yet, as Valenzuela notes that even the preliminary stages of excavation were not undertaken ("no denos a de meter en la labor della vna barreta"). This document suggests a very different relationship between mining husband and wife than those that we have seen in other contexts, including partnerships that cross racial and cultural lines. Valenzuela, as a free man, could own and bequeath property, but he curiously elects not to leave his share in the mining company to any of his heirs. No further mention is made either of his partner Pedro Vélez or of the seller Pedro de Arrieta Ceujano, as the remainder of the will itemizes Valenzuela's debts to other men in the region, primarily coca farmers and traders. Although much remains unknown about the mining company, and about the roles that Beatriz Hernández or her children may have played in silver production following the death of Alonso de Valenzuela, the fragmentary documentary evidence nevertheless helps to establish a pattern of mine ownership by mixed-race individuals in seventeenth-century Alto Perú. Farter east, in what she identifies as the

"multiple ecological zones" of the Mizque region, historian Lolita Gutiérrez Brockington has documented extensive participation of African, mulato, and indigenous mine owners in the silver industry outside of Potosí.[353]

In addition to their investments in the mining and metallurgical sector, women throughout Alto Perú worked in the refining of metals, learning through first-hand experience rather than formal study the most effective methods of mixing reagents and raw silver and the most cost-efficient heat sources for a range of silver ores. Like their male counterparts, female refiners amalgamated or smelted several different types of silver mineralogies, including pure silver, *pacos*, *negrillos* and *metales mulatos*. The cases of women like doña María Michel and doña Leonor López Maldonado situate colonial Iberian science in the interstices of technical procedures, experiential modes of knowing, market-oriented interests, and colonial legal frameworks. In 1625 in the mining seat of Turco, doña María Michel was cited alongside "demas culpados" for failing to contribute her mandatory *quinto*; that she was a woman operating a refinery was far less important to colonial authorities than was her rate of silver production.[354] It is unclear what happened after this citation, as there are no extant documents of her response.

The case of doña Leonor, however, is much more extensive, as it unfolded over several months and referenced a series of earlier cases.[355] Because Juan de Zebada and Jacinto Carvajal, two local Iberian refiners, had been found guilty in 1623 and 1651 of the same land rights violations and compensation failures that doña Leonor was charged with, her case allows us to analyze the cultural work of her gendered appeals in a specific colonial scientific context. Carvajal argued that in the nine years that he had refined silver on the land, he had worked to the satisfaction of the local indigenous community and the

Iberian administration alike; his neighbors in Pocoata had never opposed his presence, and he had productively contributed to the royal coffers. This case was instigated, he argued, by other Spaniards who owned adjacent or nearby mines and wanted to take advantage of the commercially-viable "nuevo beneficio" without having to compete with established refiners like him. Because they had no grounds for expelling him from the region, Carvajal insisted, these refiners instead convinced indigenous communities to use their claims to native lands against him. Carvajal's claim is not supported by documentary evidence, as Don Francisco's family had a long history of positioning itself within and benefiting from Iberian legal frameworks. In 1640, for example, one don Fernando Ayra de Arriutu, the *cacique general* (tribal leader) of the misnamed "Copoata" (in the same partiality, Hurinsaya, and province, Chayanta, as the town of Pocoata), petitioned for and received a coat of arms of blue, red, and gold in recognition of his family's substantial service to the crown, from its revelation of mineral wealth ("el descubrimiento de dicha provincia con mucha suma de oro y plata") and mita contributions in human labor ("redujisteis mucha suma de indios a vuestra costa sacándolos de partes remotas, con que se enteró la dicha mita") and animal power (*carneros*), to its silencing the rebellious uprisings of indigenous peoples and ensuring the compliance of other tribal leaders ("la obediencia de los demás caciques"). Two animal symbols, a tiger in the bottom right-hand corner and a bird in the top left-hand corner, plus, in the bottom left-hand corner, a military tower atop a steep crag and, in the top right, a group of three white lilies in a green planter, formed the base of the crest, while an Indian with a gold-feathered headdress, meant to represent the family's ancestral roots "from the time of the Incas Yupanqui and Huayna Capaj," suggested how one noble line

might recognize the "kings that were in those provinces."[356] With extensive documentary and iconographic evidence of this elite family's command of Iberian legal networks, it is not surprising that the court dismissed the silver miner Jacinto Carvajal's allegations about Iberian rivals who had incited the community leaders to litigate against him. Although he lost in his case in 1651, Carvajal's pleas about the unjust claims of indigenous elites like don Francisco continued to resonate with individual Iberian refiners, if not with the crown. In her deposition of 1676, some twenty-five years after Carvajal's case had been decided, doña Leonor claimed that the experience with Carvajal had given the indigenous leaders of Pocoata a taste for litigation and inspired the people of Pocoata to challenge the territorial expanses of her estate (*hacienda*) and refinery (*ingenio*) "como lo hisieron con Jacinto Carabajal difunto" (as they did with Jacinto Carvajal, deceased, 16v).[357]

For its part the indigenous community of San Juan Bautista de Pocoata, province of Chayanta, alleged in its petition of 1676 against doña Leonor that the widowed Iberian refiner was illegally occupying its land on two counts. First, the cacique and governor don Francisco Ayna de Airunto claimed, Iberian law only allowed Spaniards to build refineries on indigenous lands as long as the refiners contributed their royal *quinto*. Therefore, doña Leonor was in violation of the law because her refinery was "despoblado arruynado sin minas" (abandoned, ruined and without mines, 6). Second, he argued, she could not legally possess the estate, "aunque fuera dote" (even if it were a dowry), because of her late husband's outstanding debts; the mine discoverer Santiago de Palacios had never paid the workers who built the refinery "desde los cimientos personalmente" (with their own hands and from its very foundation, 23, 6v). Doña Leonor, then, had to

prove that she had processed enough silver to justify her use of the land, and that her right to the property was independent of her husband's debts. The court ordered an inventory to resolve the first question, and upon determining that doña Leonor was only processing one of the two types of metals produced by the mine, the local *corregidor* awarded possession of the land and $4,000 pesos in back compensation to don Francisco. He led the indigenous community to the refinery, where they "arrancaron yerdos y hisieron otros actos de posesion" (ripped up grases and made other acts of possession, 28v).

In a survey that was ostensibly commissioned to determine legal possession, it is surprising that the surveyer, Francisco González de Mendoza, did not ask doña Leonor about the land that she had not previously declared, or about the *rancherías* surrounding her property. Instead, she was required to testify under the sign of the cross about three mallets that were housed in a shed without hammers. At this point, Gonzales de Mendoza seemed more concerned with documenting doña Leonor's metallurgical capacity rather than determining the territorial extension of her operations or her right to use the land, perhaps because the new method of refining enabled metallurgists to recover silver from the *negrillos* instead of discarding it as slag, generating a new source of profit for the crown.[358]

At the time of the inventory, doña Leonor had "tres cedasos los dos con sus telas nueuas de negrillo" and "dos montones de relabes de metales negrillos," but no *pacos.* The *pacos* would have been treated with mercury, but doña Leonor's amalgamation materials, like the "Galpon que fue desazogadera" and the "orno de desazogar pinas" had been converted into agricultural uses ("al presente sirve de enserrar Ganado de Cerda"). That she stopped treating *pacos* after her husband's death suggests that it was more

advantageous to focus on *negrillos* and agricultural production than the mercury-intensive process of amalgamation.

While the case does not say when her husband died, we know from the work of economic historians like Héctor Omar Noejovich that mercury supplies were tremendously unpredictable in the mid-seventeenth century. As Noejovich demonstrates, mercury supplies spiked in the 1630s following the introduction of the physician Lope de Saavedra Barba's new closed *horno de aludeles*, which, unlike the older open-form *jabeca* ovens, captured and recirculated the mercury vapors that burned off during the heating process. This new invention saved fuel and increased the production of mercury, but it also encouraged miners to extract more mercury, according to Julio Sánchez Gómez. By 1642, miners at Huancavélica had to search for mercury at greater depths and with greater health risks. The mercurysmith's guild (*gremio de azogueros*), faced with a shortage of *mita* laborers, had to hire wage laborers to perform this increasingly undesirable and unsafe work; the higher labor costs, along with the more time-intensive process of excavation, increased the price of mercury for refiners throughout the region. None of these details are presented in doña Leonor's case, but the broader context of mercury supplies and prices might help to explain why doña Leonor stopped treating *pacos* and focused instead on *negrillos*.[359]

Her decision to shift silver production from *pacos* to *negrillos* might make economic sense, but it would not have been enough to justify her possession of the land amid the competing land rights claims of the indigenous community. But unlike the male refiners before her, doña Leonor's position as a widow allowed her to appeal to the sacred institution of marriage to protect her earthly property. After losing the first evidentiary

round in the case, doña Leonor began to make gendered arguments. She appealed for the case to be heard in La Plata, where she might find a lawyer to more vigorously defend her, invoking the explicitly gendered language that introduces this section of the chapter: "hallandome como he hallo yndefensa por no tener letrado de quien balerme ni poderlo tener en este paraje" (finding myself as I find myself a defenseless woman because I do not have a lettered man who can show my worth, nor can I find one in this parish, 33). The city was home not only to these legal resources ("los ynstromentos que asen en mi fabor") but also to the demographics that were more favorable to her interests, for the urban space was characterized by densely overlapping nodes of social, economic, and political power concentrated in her Iberian compatriots.[360]

Unlike the provincial administrator, the Real Audiencia did not respond to don Francisco's arguments about the illegitimacy of doña Leonor's marriage or her dowry. Instead, the court revoked the earlier ruling, affirmed the sanctity of doña Leonor's marriage, and awarded her possession of the land with the stipulation that she "tenga reparado corriente Y moliente El Ingenio dentro de vn año" (have the refinery repaired and running within one year, 90v). While the provincial Spanish authorities had recognized don Francisco's claims of land possession, the administrators in La Plata rejected his appeal to Catholic doctrine; they found no fault in the transfer of property from husband to wife. When these mining and metallurgical disputes were waged over civil questions of possession, as in the cases of the male refiners, the court sided with the indigenous communities, but when the cases turned upon religious institutions that regulated gender systems, the court upheld the Iberian frameworks.

Mining men like Carvajal and Zebada grounded their land rights claims with

cartographic appeals that indigenous communities could refute by presenting their own maps. In Carvajal's case, the town of Pocoata submitted a map whose superior geographic precision and topographic knowledge enabled the community to prove that the Spanish miner had encroached upon communal lands (see figures three and four). Cartography represented an important form of evidence that framed competing land claims in the same terms. The visual enactment of the same natural landmarks – rivers, lagoons, hills, mountains, mines, and pastures – as well as signs of human intervention -- the towns of Pocoata and Macha, the annexed valley of Chayala and the annexed property of Carvajal, houses, mills, cultivated fields, fruit orchards, and properties assigned to specific owners, such as Carvajal's mines and don Fernando's livestock pastures – allowed royal administrators to appreciate the differences in the two parties' knowledge of the land and to evaluate the competing claims in a non-linguistic framework. Like the witness testimonies and inventories submitted in the evidentiary phases of the case, the maps represented material realities that were framed in accordance with the particular arguments advanced by the people of Pocoata and the Spanish miner Carvajal. But unlike the Spanish-language evidence, map making did not require a third-party translator or interpreter for the indigenous community.

The collective knowledge of the natural features of landscape – in addition to the boundaries of one person's mine relative to another's mill, the distinctions in fields designated for the cultivation of wheat, potatoes, and corn – could be projected onto paper and shaped as evidence in something closer to their own terms. The assemblage of labeling practices suggest that the topographical elements were drawn first and given more importance than the words used to mark them; the labels on the Pocoata town map

alternately run left-right (facing the reader), left-right (upside down), and top-bottom, while Carvajal's labels run clockwise around the page. The text of the Pocoata map is much more detailed than Carvajal's, but the direction of the text requires a constant repositioning to be able to read it. The use of maps to authenticate claims of possession in the trial of the town of Pocoata and a male refiner reveals one of the key contrasts with the town's later suit against a female refiner. Instead of grounding its land rights claims in its knowledge of the landscape, the town contested doña Leonor's rights of possession by arguing that her marriage was invalid. Map making at the localized level of the township put the indigenous people of Pocoata on more equal footing with their male Iberian opponent, but there was no comparable form of evidence that could support their claims against the authority of transnational church frameworks or the sanctity of an institution like marriage. Doña Leonor drew upon her gendered position as a woman and, more specifically, her legal-sacramental status as wife (now widow).[361]

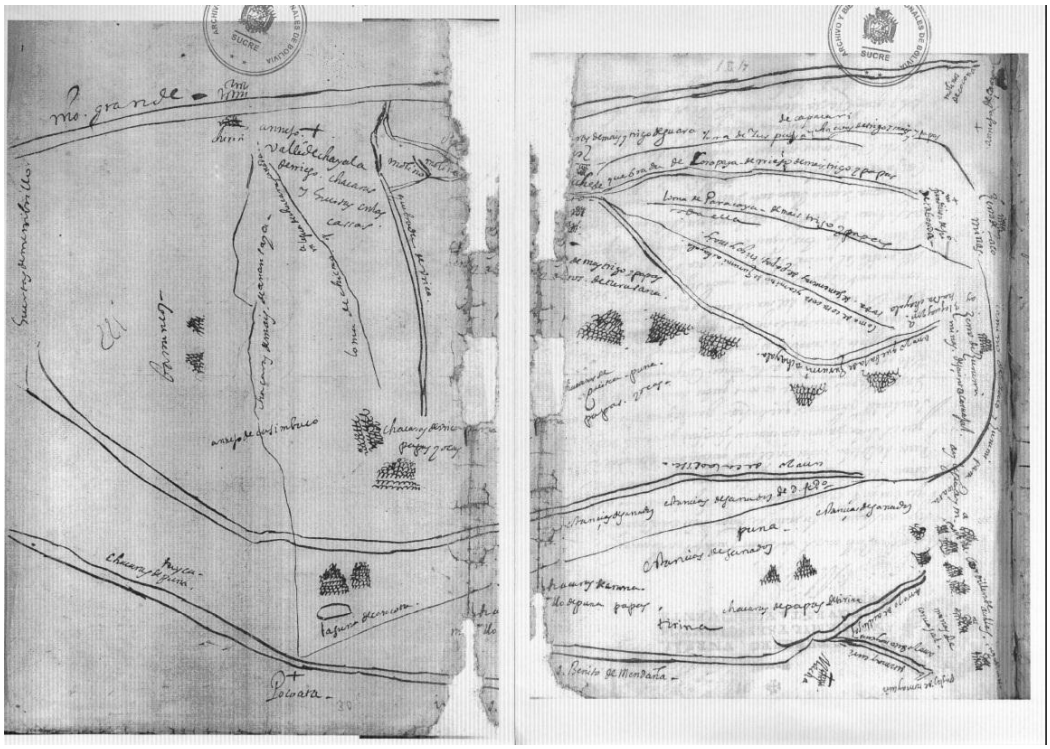

Figure 3: Pocoata Community Map, 1651. In the town's vision of the landscape, Carvajal's mines between the dry river beds (arroyos) in the bottom, right-hand corner of the page, and fields are clearly marked for the cultivation of specific crops or as pasture lands. ANBN Minas 63.14, f. 30.

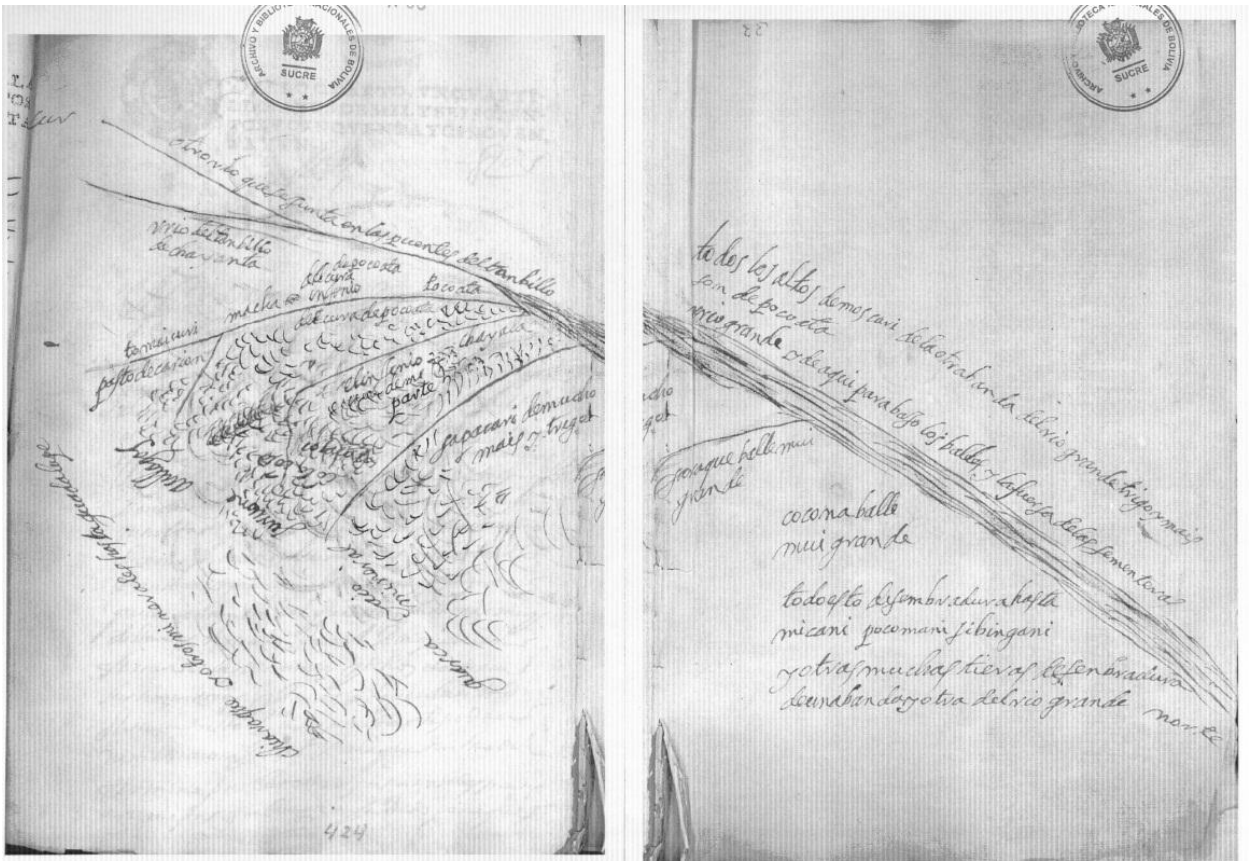

Figure 4: Carvajal's map, 1651. Carvajal classifies the landscape features with terms like "mucho trigo," "muchas tierras," and "muy grande" to signal his knowledge of the disputed area. ANBN Minas 63.14 f. 33.

Amid the decentralized nature of Spanish law, doña Leonor positioned her case within overlapping layers of colonial power to pit one administrative body against another.[362] The details contained in her case, from the inventory to the testimonies of indigenous miners who represented five different townships and two *ayllus*, revealed the ways in which gendered and ethnic identities intersected with the commercial practices, ecclesiastical frameworks, and legal policies that governed metallurgical work. Colonial Iberian mineralogical science, like all seventeenth-century sciences, was embedded in the economic, civil, and religious interstices of the institutional patterns and local practices

that sought to bring order to richly disordered human life.

Because seventeenth-century marriage was both a physical and spiritual union sanctified by the church and fundamentally economic relationship, it is not surprising to find married couples who collaborated in mining and metallurgical operations.[363] Archival records testify that these operations continued after the death of the husband or wife. For example, at the time of his death in 1684 in the mining seat of San Salvador de Vara, province of Chayanta, the *capitán* José de Zárate Treviño left substantial debts on the couple's mines and refineries. But over the course of the next four years, his widow, doña Juana de Ávila, successfully paid off his debts and provided for herself by assuming control of the Santa Rosa refinery and one "yngenio de hilaces."[364] The three priests and one *capitán* who testified in her case all supported her right to possess the refinery because of her faithful marriage and, more importantly, her equally faithful continuation of the metallurgical work, which they had seen her perform first-hand when they visited the refinery ("y la a bisto trabajando en dho su yngenio").[365] Doña Juana certainly did not have any formal education in natural philosophy or elemental root theory, but her years of collaborative work as a mining wife prepared her with the technical skills that she needed to treat silver, and the organizational skills required to make the operations profitable.

The same practical experience, corroborated by witness testimony from high-ranking landowners and clergy as well as indigenous miners and metallurgists, helped other seventeenth-century mining wives to justify their right to inherit mining property and equipment. This was the case with the widowed doña Isabel de Salazar, who in 1607 found herself arguing for access to the property that she had shared with her husband. In 1577, Agustín Ramírez, doña Isabel's first husband, built a series of houses for living and

for refining silver ("una casa de fundicion y de vibir en ella") along the river Palca, in the mining seat of Berenguela. Thirty years later, doña Isabel, by then well into her second marriage, had to defend her right to the land and the silver against the competing claims of Diego de Morales, who had purchased what he thought was unclaimed property. Eleven male and five female Iberians, four indigenous women, one priest, and seventeen male indigenous miners and metallurgists testified that in the years following her husband's death, doña Isabel had continued her husband's work, and that unlike Morales, or the man from whom he bought the title to the land, doña Isabel had improved the site by planting maize, wheat, and, as Maria Casima of Palca testifies, "muchos arboles frutales de Castilla" (many Spanish fruit trees) planted alongside what the *ranchería* that she owns "hasta oy dia con algunos yanaconas" (up to now with a few Indian wage laborers). Although some witnesses use the same terms to describe agricultural improvement and metallurgical work, it seems that doña Isabel's agricultural contributions licensed her possession of the land. No witness mentions her work with silver, but many, like wage laborer Fernando Mamani ("yndio que se minga [y] va con la dicha doña ysabel") cite "la labor y beneficio de sus tierras cojiento mucha comida" (labor and benefit of her lands, harvesting a lot of food) alongside the "labor y beneficio" required to harvest silver.[366] When the Real Audiencia awarded doña Isabel possession of the mines and refineries, it was in recognition of her economic contributions to the estate – her work with indigenous laborers and her physical improvement of the land – as well as her legal position as a mining wife.

It was not just women who had to demonstrate that their technical knowledge and organizational competencies had improved their partners' stations, as mining husbands,

too, had to prove that their contributions to their marriages entitled them to inherit property that they had shared with their wives. One such case involves don Valeriano Diaz de Mendoza y Azpuru, a widowed *vecino* of Potosí, who in 1692 sued to be recognized as the rightful heir to the riparian refineries located in the *parroquia* of Nuestra Señora de la Concepción and owned by his wife, doña Antonia Vázquez de Ayala. His right to possess the land was challenged by Joseph de Ayala because under don Valeraino's management the site had become all but worthless: "no ay mettales en el buitron ni en el yngenio ... ni asadones con que repasen los yndios ni dhos mattherales mas que veinte quinttales de sal que valen dies pesos." The crown took these charges seriously, and it dispatched a series of local administrators to survey the property and evaluate its productive capacities. Don Valeriano was eventually granted possession of the refineries, but only in exchange for his promise "como dueño" to "adelantar las haciendas y ponerlas corrientes."[367]

Ten years earlier, in the mining seat of Aullagas, province of Chayanta, Jacinto de Espínola Ortiz Melgarejo had filed a similar petition seeking recognition as the rightful owner and inheritor of the silver mines left by his late wife, doña Antonia María de Montalban. Only in his capacity as "marido y conjunta persona" could he hope to be recognized as one of the "dueños de minas." But because the mines of San Dimas and Santa Rosa had been left "despobladas," the crown was reluctant to remove the present occupant, Andres de Queres Cano, from the site. In 1687, five years after he had filed his first claim, Jacinto de Espínola Ortiz Melgarejo was still seeking recognition as the owner of the mines.[368] Clearly, it was not enough to inherit a mine or refinery through a deceased husband or wife in seventeenth-century Alto Perú; instead, men and women

alike had to legitimate their ownership through their production of silver. In some cases, they made their claims through witnesses who certified that they had seen the widow or widower working in the mines or refineries; in other cases, mining husbands and wives invoked the standardized conventions of documents like the *poder* to show the range of their technical and commercial involvement.

This was the strategy employed by doña Margarita Velásquez de Camargo, born in Lima and resident in the mining seat of San Luis de Alba, province of Paucarcolla, in a dispute with her cousin, the Potosí-based mine owner Bernardo Enríquez de Camargo, over the ownership of Antonio, a black slave who was alternately identified as "de casta congo" and "de casta angola," in the overlapping terms of the physical human body ("casta") and mineral classification, what Barba calls the "casta de metal" whose mixtures are "más rebeldes en la quema" (this caste of metal that is most rebellious in the fire).[369] In the middle of some 165 folio pages that represent an 11-year dispute, this is not where one might expect to find a demonstration of the wide range of technical and managerial responsibilities executed by a mining wife. In his *poder* of 9 July 1678, the mine owner don Joseph Ruiz de Villareal, the second husband of doña Margarita and a native of Madrid, granted her full power to represent him in any civil or ecclesiastical legal dispute, and he afforded her full access to all of his chattel goods and liquid assets, like gold, silver, slaves male and female, and "mercadurias de castilla y de la tierra" (merchandise from Spain and America, 83v). But he also extended to doña Margarita the right "para que rrija gouierne y administre las minas e yngenio que corre por mi quenta" (to command, govern, and administer the mines and refinery listed under my account) in the Provinces of Paucarcolla and Chuquito, and any other regions in which he might

invest in the future (84).

Because she was responsible not only for maintaining the mining and refining operations, but also with expanding them ("las defienda y ampare"), doña Margarita was charged with determining which new or abandoned sites to exploit, how much to borrow in raw materials and hard currency ("rreales Piñas de Platta varras") to finance the expansion, and how many liquid assets, human and material, to purchase in support of the growing operations ("cassas solares chacaras esclauos minas e yngenios trapiches y otras moliendas de methales de Plata como de asucar," 85, 87). On more technical matters, she was to decide how much mercury to purchase from the colonial government "como le Paressiere para el venefficio de los methales" (according to what she determines in the benefit of metals) and how much to leave as a *quinto* contribution (85). Lastly, she enjoyed particular control over personnel decisions, evaluating how many workers to hire, from "mineros veneficiadores mayordomos yndios" (miners, refiners, overseers [and] Indians) to all other employees who are or may become necessary ("otras Perssonas que sean necesarias"), moving workers around as she saw fit ("paresiendo le combiere quite vnos y ponga otros"), and determining what to pay them "por los ttiempos y pressios que le paressiere" (for the hours and wages that she determines, 84v). The *poder* is, by definition, a formulaic legal document. I have cited the details of one power of attorney in detail, but the standardized legal conventions of the document suggest that there are many more such records that evidence the wide range of commercial and technical responsibilities shared by married couples in the mining regions of colonial Alto Perú.

These technical and commercial decisions, from the assessments of mine site

expansions and the amount of mercury needed to treat the silver harvested from the mines, to the management of relationships with government officials and workers, threw into sharp relief the extent to which doña Margarita's judgment determines the viability of the mining and refining operations. In just three pages, don Joseph referred six times to doña Margarita's discretion, or what "le paressiere" in questions of mine management. This *poder* not only revealed the commercialized nature of seventeenth-century metallurgical science in Alto Perú, but it also gestured to the substantial contributions of mining wives to the colonial mining and metallurgical industry. That their contributions were scattered among seemingly unrelated cases, such as an intrafamilial dispute over the ownership of an African slave, might explain why mining wives, or mining women in general, have not been more widely appreciated in studies of colonial mineralogical science. Unlike the official proceedings of proto-scientific societies, or the single-author metallurgical manuals that are more widely cited in histories of colonial science, women's participation in mining and metallurgy was recorded in legal cases about tangible property, like mine sites, refineries, chattel slaves, and capital investments, as well as less quantifiable contributions, like industriousness and emotional support.

Mining marriages of this sort enabled indigenous men who married mining women to petition for legal recognition of their privileged status in the seventeenth century,[370] and they continued throughout the eighteenth century, when a man who contracted marriage with a mining woman might then the professional opportunities and social privileges associated with guild membership. Although guilds existed in the seventeenth century, they became part of a more institutionalized social and scientific community throughout eighteenth-century Europe and Spanish America.[371] Such was the

case of don Josef Zamar, who in 1787 applied for and received membership in the *gremio de azogueros* of Lima based on "las resultas de mi destino, y ocupacion de Mineria" (the results of my destiny and profession of mining). Within one year of his marriage to doña María Delgar, don Josef had assumed responsibility for her family's mining operations and processed some 20,000 *marcos* of silver with their corresponding *quinto* contributions. Because he had expanded the operations by having "adquirido y descubierto" (acquired and discovered) new assets "por mi mismo" and "por mi diligencia" (on my own and through my diligence), by marrying into the mining family of doña María, don Josef, who had no formal education or experience in mining and metallurgy before the marriage, could faithfully say that "En su virtud soy Minero de exercicio" (in truth I am a practicing miner). His marriage to doña María made possible a financially-profitable occupation and a socially-respected position as a member of a professional guild.[372] Only three years after his acceptance into the guild, however, don Josef's wife, doña María, assumed control of the family's extensive estate along the Ribera de Oyoni, province of Cajatambo, because her husband's inexperience and barbarous mismanagement ("como de la varbarie") had ruined and "destruido las Minas mas opulentas, capaces de enrriquecer un Reyno" (destroyed the most opulent mines, capable of enriching a kingdom).[373]

Throughout her petition, doña María's knowledge of the mining and metallurgical operations was revealed in her command of technical language and her abilities to negotiate with the skilled workers who abandoned the site's unsafe conditions. In his haste to extract as much *negrillo* ore as possible, don Josef had removed all of the bridges and support beams ("Puentes y Estrios") from the underground mine of San Juan, leading

to a tunnel collapse that killed two miners. In the nearby Nazareno, he had "tajeado la Mina, imposibilitandola de tal suerte, que solo a costa de un immenso caudal puede reparse el daño" (mined downward, making the mine so impassable that only at an immense cost could the damage be repaired, 6). By engaging in such sharply underhand stoping or downward mining (*tajea*) and removing the tailings (*caudal*) without leaving any other structural supports, don Josef had destroyed the mine that had for many years proved "tan rica y abundante" (4). Doña María, apparently more concerned with the financial ruin than with the loss of human life, left her home in Lima to manage the mines and refineries: "En este estado, y considerando q[u]e los daños me ha ocasionado en las Hac[iend]as solo podrian en alg[u]ns modos remediarse con mi presencia, tomé la determinaz[io]n de ponerme en camino para ellos" (In this state, and considering that the damages that he has caused to my estate can only be remedied with my presence, I made the determination to set out for them, 6).

She first attended to the physical work of constructing new bridges and abutments "q[u]e a fuerza de sudor, industria, y dispendio hi logrado avisitar los comedios de la Mina de S[a]n Juan y ponerla en un estado ventajoso" (that with the force of sweat, industry, and great cost I have managed to visit the core of the Mine of San Juan and put it in a favorable state, 6v). With these repairs "he logrado algunos progresos favorables," she claimed, "pues por una parte tengo espedito y corriente en caños de comedios de la Mina de S[a]n Juan para penetrar por el a la profundiad, y seguridad y seguir con comttancia la veta metalica" (I have achieved some favorable advances, because for one part I have the core of the Mine of San Juan up and supported by beams that allow us to penetrate to its depths and follow the metallic vein with safety and security, 26v). But

beyond the physical repairs that improved the mine safety, she also noted her efforts to repair the relationships with the mine and refinery workers who had abandoned the site in favor of better working conditions at other estates: "y por otra he conseguido restabliser la paz, y union de mis operarios que se hallavan dispersos y estraviados" (for another part I have managed to reestablish the peace and harmony among my operators that had dispersed and fled). Doña María's eighteenth-century account of her work at the mining and refining operations demonstrates the continuation of two important aspects of seventeenth-century mineralogical work. First, technical competencies, like knowledge and execution of mine safety protocol for particularly deep excavations, and organizational skills, like negotiating contracts with wage laborers, were equally important parts of mining and metallurgical work. Second, the economic aspects of the institution of marriage created opportunities – and necessities – for men and women to participate in the technical and commercial management of mines and refineries. Other elements of seventeenth-century practice, such as the involvement of mining women like Manuela Miranda, "minera y asoguera" who discovered mines in the Cerro de Santa Barbara de Rupache, in the town of San Miguel, province of Guarochiri, also continued into the eighteenth century.[374]

The examples from these legal cases tell us little about the technical methods required to identify mineral deposits or assay samples, the kinds of details explained at length in well-studied printed books of mining and metallurgy, like Agricola's *De re metallica* (Basil, 1556). Nor do they provide the types of theoretical or practical explanations needed to appreciate the different silver mineralogies that female and male metallurgists learned through experimentation and experience how to benefit with

maximum economy. Those types of passages are found largely in single-author treatises like Barba's *Arte de los metales*.

However, the multivocal nature of these legal documents reveals other types of details that help us to more fully understand the nature of colonial Iberian mining and metallurgy, and to situate women's participation in the silver industry more specifically. For example, these archival materials reveal how colonial officials responded to the assertions and complaints of male and female miners and refiners who worked throughout Alto Perú. They also underscore the ways in which mining women commanded the mutually dependent legal skills that licensed their scientific practice, the commercial skills that ensured their profitability, and the social skills with which they negotiated with laborers and government officials. As these cases of seventeenth-century women of Alto Perú suggest, indigenous and Spanish women actively prosecuted the men who failed to acknowledge their legitimate claims of ownership and they defended themselves against charges of negligence. That they were aided by court-appointed interpreters and changes of location to facilitate communication with their lawyers suggests that they enjoyed more full access to institutional resources than has typically been acknowledged in histories of gender and seventeenth-century science.

This brief outline of cases is not designed as an exhaustive list, but rather a suggestion of the range of ways in which women practiced colonial science in Alto Perú, an already transnational space home to Quechua, Aymara, African, and Spanish men and women. As this archival evidence indicates, indigenous and Spanish women made key contributions to the discovery of mines and the refining of metals, and they negotiated complex institutional legal frameworks to protect their work. This work is not recorded in

the published proceedings of scientific societies, but rather in the archival records of the institutions that supervised the day-to-day practice of colonial science: the legal institutions in which questions of science, commerce, and gender intersected. This is not to say that women had full access to legal institutions or equal participation with men in mining and refining operations, but rather to suggest that the considerable presence of women – particularly in the mineralogical archive of Alto Perú – encourages revisiting the way that we write and think about the gendered nature of science in the colonial Americas.

III. The Black Legend of Spanish America and the Copper Mines of Atacama

Although the popular history of Potosí pegs it as what one former governor memorably called in 1786 a "Pueblo levantado tumltuariamente por la codicia al pie de la riqueza que descubrió una casualidad" (a town raised in tumult by jealousy at the foot of wealth discovered by accident), the archival documents presented in the first two sections of this chapter show how in the seventeenth century, this city, one of the largest in the world, was also home to a remarkable amount of scientific innovation and an equally important continuation of successful practices.[375] Some miners and metallurgists, along with no small number of fraudulent opportunists, capitalized upon the Iberian legal frameworks that rewarded new inventions in mining and metallurgical techniques, while others, women and men alike, applied the best practices of silver extraction and processing to make a living and raise their families without any fanfare. Women, then, were not just the tragic emblems of a corrupt society, the prostitutes, refiners who murder their own daughters, and fallen women like the "liviana Margarita" whose snow-white body ("la nieve de su cuerpo") belies the violent underbelly of a mining city "salpicada

en partes de bellísimo carmín," as Arzáns de Orsúa y Vela so formatively cast them (II: 77, 179). As in any major city, the highest expressions of cultural values and aspirations – cathedrals with ornately decorated communion plates and chalices of precious metals, filigree frames that commemorated the lives of saints, and intricately-wrought pendants and sconces to light the spaces, and shops that sold silks and perfumes imported from Africa and the Middle East, spices, jewels, and porcelains trafficked from Asia, and all kinds of luxury goods manufactured in Europe: clothing, furniture, household wares.[376] These spiritual spaces and consumer goods – refined symbols of achievement and aspiration both – existed in uncomfortably close proximity to the culturally undesirable elements that are chronicled with what Bakewell calls "a pleasurable *frisson*, a certain furtive celebration" in histories of Potosí: dimly-light taverns whose patrons stumbled into the frigid nighttime temperatures, crumbling gambling halls and squalid brothels where bad hands and wandering eyes led miners to lose their fortunes hand over fist.[377]

This narrative has been reinforced by twentieth-century historians who marginalize colonial Iberian mineralogy, a scientific practice in which Andean and Iberian women played important roles in the colonial era and continue to work in a variety of capacities,[378] and by feminist historians of science who have argued that the language of seventeenth-century science authorized the displacement of women from mechanistic and commercialized industries like mining and metalworking. I do not deny the exploitative conditions inherent in mining and metallurgical work – the cramped spaces and poor air quality of tunnel mines, the harsh chemicals used to blast in open pit mines and those that are inhaled in the refineries, and the long hours logged in both facilities by women and men who, for the most part, never see the types of profits

enjoyed by mine owners. Hundreds of thousands of indigenous, African, and European miners and metallurgists labored in hazardous conditions tht produced serious injuries, destroyed workers' health, and ultimately caused premature death. But these exploitative conditions exist alongside tremendous opportunities for hearty financial compensation and rich intellectual exercise – an inventiveness and entrepreneurism often sprung of necessity and met with capacity. To dismiss the value of mineralogical work is to misunderstand why mining women and men sought positions as contract laborers in the colonial era and continue to choose this profession today.

Mining and metallurgy were then, as they are now, taxing positions that require women and men to master precise technical competencies and to execute them in hazardous conditions. The devastating consequences of these conditions for ecological and human health, two sides of the same minted coin, are well-documented, although scholars disagree about the extent of the destruction of colonial Iberian mining and postcolonial operations performed by nation states and global corporations. Shawn William Miller, for instance, has argued that important technological improvements and advances in worker safety in the nineteenth and twentieth centuries were more than offset by the dramatically expanded scale of mining and metallurgical industries after Bolivia, Peru, and Chile became independent nation states.[379] But less well-studied are the epistemological sophistications and technical advances that make possible the work of mining and metallurgy – the types of advances for which mining women and men are professionally and financially rewarded, and the reasons why they continue to perform their work and exercise their crafts. Alto Perú was a richly demographically-mixed center of mineralogical innovation – its large-scale refineries, modification of the New Spanish

amalgamation method to accommodate the region's colder ambient temperatures and mineralogical variations, and intricate water management systems of interconnected dams, canals, and tunnels to store and deliver water to the refineries represent important technical and epistemological advances in seventeenth-century mining and metallurgy.[380]

This story of innovative engineering and creative reworking of natural philosophical theories is not the dominant account of the region. The marginalization of Iberian science by Anglo-Saxon Europe and Anglo America has been well-documented by historians like Tristan Platt and historians of science like Modesto Bargalló, but the consequences of this marginalization extend beyond the relatively small circle of scholars who read academic histories and histories of science.[381] I conclude this chapter, and set up the conclusion of the book, with an example of one of those consequences.

In 1912, the geologist Lou Henry Hoover and the mining engineer Herbert Hoover, the man who would take office as the thirty-first president of the United States some sixteen years later, the first English-language edition of the German metallurgist Georgus Agricola's *De re metallica*. The early modern text and its nearly 300 woodcuts was first printed in a Latin-language edition in Basil (1556) and was soon thereafter translated into German, Italian, and Spanish. The Hoovers' translation is remarkable for its clarity and naturalness in English – no small feat in moving from early modern Latin to contemporary English – its amazingly detailed notes and appendices, and its reproduction of all of the woodcut images. The English-language edition was first published in London and supported by the subscribers of the *Mining Magazine*, but a hardcover edition issued by Dover Publications in New York (1950) and a subsequent paperback version has facilitated scholarly and popular access to a text that occupies an

important place in two historical moments in mining history – the early modern era and our own time. According to the Dover website, the translation is one of the publication house's best-selling texts.[382] That the Hoovers' translation and research has been as important to the field as the text proper is indicated by the remarks of scholars like historical geographer Alan K. Craig, who rightly credits this "classic contribution" with encouraging historians to "enthusiastically search for new insights into the significance of mining, particularly within the New World Spanish colonial empire."[383]

The Hoovers' work with Agricola's metallurgical treatise has been rightly and deservedly praised. However, their reading of colonial Spanish American mining, relative to European traditions, is far less sanguine, and the ramifications of Herbert Hoover's beliefs about the capacities of Andean science in particular became quite severe after his election as president of the United States. In a three-page footnote explaining the development of amalgamation, the translators explain why it is impossible for their "good neighbors" to the south to have developed a refining method as innovative as the large-scale amalgamation technique that was developed in Spanish America and remained in practice through the late-nineteenth century mines and refineries of Australia, New Zealand, and the western United States.[384] Hoover and Hoover conclude that there is no "direct evidence" that the technology was developed in Europe or "re-invented" in America, but "the presumption is in favour of the former."[385] 'Presumably' this is because Hoover, hailed by twentieth-century historians like Alexander DeConde as one of the "important architects" of modern US policy in Latin America, subscribes to what political scientist Lars Schoultz identifies as widespread and long-held North American beliefs about the inferiority and degeneracy of Latin America relative to the United States.[386] As

Schoultz puts it, the policies that emerge from this attitude of "paternalistic hegemony" are punctuated by infantilizing metaphors of "underdeveloped" or childlike faculties and "hysterically" irrational effeminacy that begs to be ordered by a logical, masculine North America (8, 98, 243, 248, 254, 257, 279, 294).

In his more technical writing, and long before president-elect Hoover would resolve the border disputes between Chile, Peru, and Bolivia some 50 years after the conclusion of the Guerra del Pacífico (1879-83), Hoover had described in detail the importance of capacity and mining intelligence in determining the commercial viability of a mine site. Based on a series of lectures delivered at Stanford University and Columbia University, Hoover published his *Principles of mining: Valuation, organization, and administration; Copper, gold, lead, silver, tin, and zinc* in 1909. The market-driven nature of mineralogical science is evidence in the book's composition, as the final five chapters are dedicated to cost/benefit analysis of equipment upgrades, labor policies, and site exploration; Hoover identifies "the vast preponderance of the commercial over the technical" as the "most dominant characteristic of the mining engineering profession" and one that is "largely of American development."[387]

Hoover's acute sensitivity to the commercial demands of industrialized mining are revealed in his discussion of the efficiencies and cost advantages produced by the different capacities, skills, and intelligence levels of European, Asian, and African miners. According to Hoover, the "results obtained from working labor of a low mental order, such as Asiatics and negroes, with those achieved by American or Australian miners," prove that "it may be stated with confidence that the white miners above mentioned can, under the same physical conditions, and with from five to ten times the

wage, produce the same economic result, -- that is, an equal or lower cost per unit of production" (162). He concludes that "one white man equals from two to three of the colored races, even in the simplest forms of mine work such as shoveling or tramming," and he supports this finding with statistical analysis based on data gathered from "much observation and experience" in four mines of the Indian subcontinent, six in West Australia, three in Africa, and five in the western United States. The results are organized into a 4-column table that shows a 2:1 cost advantage for U.S. mining operations staffed by white men relative to Indian mines that use primarily Indian miners, even factoring in the different wage rates of $3.50 a day in the US and $.20 a day in India. According to Hoover, the productivity and efficiency of "the higher intelligence" delivered this considerable cost advantage for white miners relative to the Indian mining operations (164).

However, Herbert Hoover was not just a mining engineer who used his broad technical background to inform his comparative analysis of the commercial viability of mining practices or what he calls "'good-will,' that is, the earning capacity" (183). As president elect on the "Goodwill Tour" of Latin America in 1928, Hoover also helped to draw the present-day territorial boundaries of his "good neighbors," Chile, Peru, and Bolivia, effectively allocating the mineral-rich lands of the *norte grande* to Chile, backed by the well-documented efficiencies and advances of British industry, and leaving Bolivia as a landlocked country. The geopolitical ramifications of this act of border making continue to factor into contemporary debates over land rights and mining royalties, energy sources like natural gas and lithium, and in questions of cultural patrimony. This last question has intensified amid Bolivian political movements that define the natural

world as a constitutional subject with nationally-recognized rights and agencies.[388] Is it possible that Hoover's beliefs about mining intelligence and scientific capacity, culled from his first-hand experience as a mining engineer and his study of early modern metallurgical treatises like Agricola's *De re metallica*, influenced his decision to privilege Chilean/British interests over Bolivian land claims?

It is worth remembering that the "interested" material practices of mining and metallurgy have long been understood as proxies for Iberian culture in the Americas. For example, the foremost mining historian of Latin America, Peter J. Bakewell notes with what he calls a "crudely psychoanalytical" point that the physical work of mining parallels the cultural and demographic work of mixture: "...it is nonetheless true that the Iberians' success in mining in America and the unparalleled miscegenation that they set in motion in the sixteenth century have common origins in aggressive Iberian colonizing energy combined with America's relative geographical, political, and biological openness compared with most of the non-European world."[389] In other words, the material practices of mining and metallurgy have long been mapped onto the cultural landscape of South America.

Given the traditional definition of "science," Herbert Hoover probably did not consider colonial Iberian mineralogical science to be "science" proper. And that is part of the problem, for histories of science, histories of the Americas, and the women and men whose stories these fields try to tell with accuracy and objectivity. According to feminist philosopher of science Elizabeth Potter, a reader unfamiliar with key feminist conceptual frameworks will nevertheless be at home within their recognizable "underpinnings" of "Anglo-American and continental epistemology and philosophy of science." Based on

the content of Potter's well-studied synthesis of feminist epistemology of science, this "continent" includes England but stops at the Pyrenees.[390] By marginalizing Iberian science, a 30-year debate about the gender of nature and the nature of gender has been defined within largely monolingual, mononationalist paradigms that, by definition, are poorly-equipped to handle fundamentally transnational questions of gendered systems and science. By employing a multilingual, comparative methodology, I have tried to show how the collapse of linguistic and cultural gender in English misleads scholars into interpreting the work of gender in seventeenth-century scientific writing. And by presenting archival cases from colonial Alto Perú, I have applied an important theory from feminist histories of science to a new group of texts. The cases of women and men who collaborated and competed in the silver industry of Alto Perú confirm the experiential and commercial orientations of seventeenth-century science, an expanded definition of science that is largely indebted largely to the work of the feminist philosophers and historians of science. But their more-situated account of scientific thought and more careful contextualization of scientific practices has not been mapped back onto some of the foundational arguments in feminist histories of science.

My archival diggings in colonial Iberian science suggest that increasingly mechanized and commercial fields like the mineralogical sciences of the Americas provided women and men with a platform through which they developed mutually dependent technological and social skills. As historians and literary scholars have demonstrated in their studies of colonial Quito, the Anglo-Dutch Caribbean, and the circum-Atlantic British world, agricultural sciences applied in textiles and food production followed a similar pattern. Just because early modern mineralogical and

agricultural practitioners did not have access to literacy or did not publish their work in formats that are easily accessible or recognizable to present-day scholars does not mean that we cannot appreciate the broad nature of their contributions to the development of colonial scientific knowledge and practice, or the ways in which these contributions enabled some people and disabled others. The fields of agriculture and mining are more than just bodies of scientific theories and models of best practices: they were, in the seventeenth century, the preeminent discourses that performed the cultural work of the two largest empires of the Americas, England and Spain. And they are, as the example of Herbert Hoover, la Guerra del Pacífico, and the Guerra del Gas suggest in our own time, important sites of political and economic power whose resources can be used to further subordinate the most marginalized human and non-human beings, or, as I hope I have also shown, to offer opportunities for women and men to develop epistemologically sophisticated theories and to invent new technologies that can be applied for human and non-human benefit.

To People and Possess:
Settlement Patterns and Colonial Science in Iberian and Anglo America

In the haunted spaces of what the Algerian-born spirit Ariel calls the "the still-vexed Bermudas," the island's airy apparitions and mysterious movements convince the once-rational Sebastian to now "believe / That there are unicorns; that in Arabia / There is one tree."[391] But Caliban, native to the island by virtue of his matrilineal inheritance ("This island's mine, by Sycorax my mother"), had warned him not to take seriously the strange happenings of the island. Counseling the displaced Europeans in their own language, he implores them to

> Be not afeard. The isle is full of noises,
> Sounds, and sweet airs, that give delight and hurt not.
> Sometimes a thousand twangling instruments
> Will hum about mine ears, and sometimes voices
> That if I then had waked after long sleep
> Will make me sleep again; and then in dreaming
> The clouds methought would open and show riches
> Ready to drop upon me, that when I waked
> I cried to dream again.[392]

This "devil, a born devil, on whose nature / Nurture can never stick" (4.1.188-189) longs for the salubrious music of the island, the sweet sound of nature's flows that refuse to be incorporated into the human language that greets him upon his emergence from the dream-like state.

As Caliban sees it, his brutish existence under Prospero's rule stems from his displacement from his native seat and native language, the fertile material and cultural grounds from which he will beget other Calibans. Having revealed the island's

agricultural secrets to Prospero, Caliban is "rewarded" by Prospero with three overlapping colonial enactments of power: physical removal from the choicest lands ("and here you sty me / In this hard rock, whiles you do keep from me / The rest o'th' island"), linguistic removal from his native language ("The red plague rid you / for learning me your language!"), and sexual separation from women ("Thou disdst prevent me; I had peopled else / This isle with Calibans"). In one of the most widely-discussed passages in Shakespeare's *Tempest*, Caliban frames his inability to plant, to people, and to profess in his own tongue as equal signifiers of his subjugated status.[393] For historians and literary scholars of the colonial era, and especially, as Peter Hulme and William H. Sherman note, for postcolonial critics working in countries that once belonged to the British empire, these lines solidify the play's engagement with the question of colonization and its enlistment, in different times and places, in support of and in opposition to colonial designs.[394] The first two vectors of colonial power – land and language – have been used by historians like Bernard Bailyn and Patricia Seed to argue that the third – peopling – represents what Seed calls a "specifically English colonial desire." Among historians and literary scholars of the circum-Atlantic Anglophone world, the idea that peopling is policy is firmly established. But the biopolitical move to align population management with colonial scientific discourses of land rights and usage is a strategy employed by colonial apologists throughout the Americas.

In recent scholarship, peopling as state policy has perhaps been popularized perhaps most famously by Michel Foucault, for whom the sixteenth-century convergence of state centralization and religious dissonance – the coming together of nation-based models of government and the falling apart of the holy, Catholic, and universal church –

made population, by the eighteenth-century, "a new subject." That is, the problem of population became both a body politic and a disciplinary mode. This turn to public counting, developed over the course of the seventeenth century, revealed, as Foucault puts it,

> that population has its own regularities, its own rate of deaths and diseases, its cycles of scarcity, etc.; statistics shows also that the domain of population involves a range of intrinsic, aggregate effects, phenomena that are irreducible to those of the family, such as epidemics, endemic levels of mortality, ascending spirals of labour and wealth; lastly, it shows that, through its shifts, customs, activities, etc., population has specific economic effects: statistics, by making it possible to quantify these specific phenomena of population, also shows that this specificity is irreducible to the dimension of the family. The latter now disappears as the model of government, except for a certain number of residual themes of a religious or moral nature. What, on the other hand, now emerges into prominence is the family considered as an element internal to population, as a fundamental instrument in its government.

These lived realities were not recorded in individual family histories, but rather in the statistical assemblages of census reports and demographic studies. What had been a singular model of government, that is, a union of church and state analogized in the human body and the biological unit of the family, became instead a three-part field that encompassed, explained, and regulated its population through the art of self-governance ("morality"), the art of governing a family ("economy"), and "the science of ruling the state" ("politics").[395]

But what Foucault leaves out of this compelling account of the rise of state science, and the science of the state, is, among other things, the discovery of the New World and the role of colonial American science in the development of these instruments and tactics of government. An empire needs people, after all, to reproduce itself in a New World. Following the seminal influence of Foucault, literary critics and historians like Nancy Armstrong, Leonard Tennenhouse, and Joyce Chaplin have applied the biopolitical

problem of population to early American studies. But even as they make a case for what Armstrong and Tennenhouse call "the transportation of bodies and information across regional and national borders," their definitions of early America seem more consistent with the linguistic and territorial boundaries of the nineteenth century rather than the fluid borders of the early Americas.[396]

Patricia Seed, however, has analyzed the question of peopling and population management in English, Dutch, French, Spanish, and Portuguese colonial literatures, and there is much to recommend her work, which manages to attend to the particulars of local experience and hold together a broadly comparative frame all at once. But in the heart of her excellent reading of the coloniality of power in Shakespeare's *Tempest*, a power forged in the interstices of Prospero's alchemical literacy, Caliban's matrilineal land rights claims, and the supposed designs of that earthy "foot-licker" upon Miranda's virginity, Seed makes a bold claim about what she calls "the specifically English colonial desire for 'peopling.'"[397] To support her reading of English biopower she turns also to the empiricism of counting, observing that "'peopling' is the most frequently occurring word in histories of the English conquest of the New World,"[398] and she references Bernard Bailyn's foundational work in demographic studies of the colonial era and the early republic. Bailyn's work is illuminating and recalls the request of Virginia governor Thomas Dale (d. 1619) in 1611 that the British crown send its convicts and felons to remedy the colony's chronic labor shortages, for, Dale writes, "'so do the Spaniards people the Indies.'"[399] As Bailyn's example suggests, the story of *The Peopling of British North America* is incomplete without understanding the Iberian population management strategies that informed English colonial habits of thought. But Patricia Seed's insistence

on the exclusively Englishness of peopling continues through the end of her reading of colonial law, land rights, and Shakespeare's *Tempest*, and her compelling argument is worth quoting in full: "Only rarely does peopling emerge as an important ambition in Spanish and Portuguese colonial literatures. Not until after independence from Spain did the idea of 'peopling' with Europeans gain support in Ibero-America--and even then only in three South American nations. Thus the intent to 'people' with Europeans is a uniquely English colonial ambition in the Americas." The three exceptions to this finding, Seed adds in a footnote, are the population management policies that developed alongside export-based agricultural industries in what she calls "the ABC countries (Argentina, Brazil, Chile)."[400]

Agriculture also informs Seed's distinction between English and Spanish attitudes toward land rights and possession, as the English marked their possession on the surface of the land and denied native peoples' right to it, while the Spanish granted topsoil rights to indigenous people but claimed ownership of subterranean resources. Seed's identification of the vectors of colonial power in the *Tempest* are not coincidental – the discourses of colonial science, gendered understandings of land rights, and the trope of purity in real or perceived sexual relations between brown men and white women are thoroughly intermingled in the historical and literary archive of the colonial Americas. But her insistence on an agriculturally-inspired English idea of peopling, in opposition to the population management strategies and designs of Spanish America, emerges from a long historiographical tradition of oppositional thinking. As I hope to show in this chapter, there are substantial differences in English and Spanish ideas of colonial peopling, but they are far more similar than they are different. Both colonial enterprises

frame their population management practices in colonial scientific terms: planting and possessing in British America, and founding and amalgamating in Spanish America. The differences in their definitions and cultural understandings of peopling reflect the differences in the material practices of English agriculture and Iberian metallurgy; agricultural science draws out the warring contrarieties of soils and seeds to generate botanical growth, while the chemical-based method of amalgamation developed in New Spain employs the concept of sympathetic affinity to draw different particles into one body. By investigating the literary roots of these colonial scientific discourses, we can appreciate the large and important similarities in Anglo and Iberian ideas of peopling and we can tease out their smaller but telling differences.

By reading the English colonization of America in agricultural metaphors and material practices, and by defining the act or desire to "people" in the agricultural terms of rootedness and planting, historians and literary scholars have made a sound case for peopling as the preeminent population management strategy of the English. But the preeminent place of planting-as-peopling and peopling-as-planting in English colonial letters should not suggest that peopling was not an equally important element of Iberian colonization; an empire needs people, after all, to reproduce itself in a new world. Both colonizing enterprises looked to natural scientific discourse to explain and justify their presences in the Americas, but English and Spanish colonists took recourse to different scientific fields that contained different sets of terms. In British America, to people was to plant, but in Spanish America, the rhetoric of peopling echoed the technologies of mining and metallurgy: to mix together diverse bodies, to purify them, and to incorporate them into the uniform molds of the church universal. This idea of peopling did not depend on

the physical body, but rather on one's inner essence: the souls (*almas*) that were counted and quantified in so many population surveys and census records. This broadly spiritual platform of peopling underwrote Iberian population management strategies and informed resistance to those strategies.

In chapters one and two, we saw how the scientific theories of amalgamation developed from a profitable mineralogical technique of refining sameness into an overlapping discourse of mining technology and social accounting. Key terms like "abrazar" and "amar" signed the sympathetic affinity of silver and mercury, especially in treatises written by men (and they are all written by men) who did not own the sites of production. In the third chapter in particular, we saw how the idea of "convergence" (*acudir*) textured the refinery owner Luis Capoche's analogical account of mineral and human mixture in the emerging economies of the inland mining regions. This chapter continues to investigate the overlap between the material technologies of mining and metallurgy and the rich terms of human experience, building from the scientific theories of mineral amalgamation into a study of the amalgamated body politics of Iberian America.

As in the case of the term "acudir" in silver metallurgical treatises from the Andes and New Spain, terms like "ley" and "fundir/fundar" in the copper metallurgical archives of eastern Cuba and the Aroa River Valley of northwest Venezuela occupy mutually constitutive technological and social registers. But silver and copper metallurgy required different material treatments, so they inspired different sorts of metaphors. The chemical process of amalgamation produced one set of terms, while the smelting techniques of copper metallurgy offered writers an alternative natural vocabulary. Both processes reveal

the biopolitics of colonial science, and the ways in which the discourses of planting and mining participate in an integrative imperial dialogue. It was the language of amalgamation and incorporation, rather than planting or grafting, that Anglophone authors like Thomas Jefferson used to discuss the questions of race and interracial union so central to the early republic.

I. "needed hands to check / Fruitless embraces": The Root Paradigms of Planting English [401]

The spiritually-rich language of physical planting and peopling is writ large upon the English colonial archive and throughout the circum-Atlantic republic of letters. Authors like William Loddington (1626-1711) positioned *Plantation Work* as *The Work of This Generation: Written in True-Love to all such as are weightily inclined to Transplant themselves and Families to any of the English Plantations in America* (1682), while public-spirited individuals proposed in their letter to Robert Molesworth, first Viscount (1656-1725), *The true way to render Ireland happy and secure, or, A discourse wherein tis shewn, that tis the interest both of England and Ireland, to encourage foreign Protestants to plant in Ireland* (Dublin, 1697).[402] While that letter attempts to distinguish the sanctified work of planting Protestants from the adventurerly traditions of conquest, for other authors, like the Count of Merveilles, Blaise François de Pagan (1604-1655), the border between planting and conquering had long been transgressed by texts like those that narrated the exploits of Sir Walter Raleigh (1554-1616) in Guinea and the Orinoco river basin. In William Harrison's Englishing of Pagan's *Historical and Geographical Description of the Great Country and River of the Amazones in America*, the book presented to Charles II in 1660 explains to the newly-restored monarch the physical and human nature of "that place which Sr Walter Rawleigh intended to conquer and plant."

Pagan, Harrison is keen to point out to his royal readers in the prefatory epistle, was so named in recognition of his service to Christian empire: the family name represents "the badge of their great exploits in mating and killing the Pagans, or Infidels."[403] Whether or not the agricultural terms of planting and possessing were linked to the models of conquest that English authors more often associated with the Spanish, all of these texts drew from and came to reinforce the same definition of planting. To plant was to people, to transport into a new soil the seeds of English culture that would take root in the plantations of Ireland and the Americas and so produce and reproduce the paradigms of English lives and letters. Equal parts political framework of naturalization, imaginative metaphor of colonialist designs that take their cues from natural vocabularies, and religioscientific essays into crop science and agricultural improvement, the language and practice of planting-as-peopling became the preeminent colonialist discourse of the British Atlantic world and the authorizing logic of settlement.

Following the devastation of the English civil war (1642-1646; 1648-1660) and the "Intestine Troubles" that had so much "despoiled and wasted" the royal kingdom, civil administrators in England, Wales, and Ireland sought ways to restore the land to its profitably fruitful state. In a series of wide-ranging reforms, magistrates throughout the British Isles formulated new tax exemptions, land rights entitlements, inheritance policies, and professional privileges like guild memberships to entice large numbers of English Protestants, merchants, and skilled artisans to migrate with their families to less populated regions. These population management strategies were expressed in the explicit language of planting-as-peopling, a political framework that naturalized foreign-born subjects in the natural vocabulary of agricultural roots. The English and Welsh

Parliament passed acts to ensure *The Speedy and Effectual Satisfaction of the Adventurers for Lands in Ireland: And for the Encouragement of Protestants to Plant and Inhabit Ireland* (London, 1653), while the Irish parliament called *For incouraging Protestant-strangers and others to inhabit and plant in the kingdom of Ireland* (Dublin, 1662).[404] In Ireland, these political, economic, and professional privileges were extended to any professor of the "Protestant Religion, and also Merchants, Traders and Dealers in any Goods, Wares or Merchandizes, Artizans, Artificers or others working or manufacturing any Goods or Commodities, or any Mariners or Seamen," especially those whose work led them to the "Materials and Commodities" that could most encourage "the growth of this Kingdom, as Wool, flax, hemp, Wollen and Linen yarn, Iron, and sundry others the like" (3, 2). These parliamentary acts sanctioned vocational work, almost all of it in agricultural sectors, as a political process that naturalized the planters in political and rhetorical fashion. The naturalizing power of agricultural discourse helped to create the language through which an international body of Protestants could take root in England or its circum-Atlantic plantations. In exchange for their harvesting of agricultural commodities and their founding of iron, foreign-born Hugenots, for example, could now receive the same privileges as native-born subjects. Their transplantation from France, like the rerouting of English Protestants to Irish soil, was explained in the natural vocabulary of rooted agricultural pathways.

The official endorsements of the English, Welsh, and Irish Parliaments had, in turn, followed early-seventeenth century proposals put forth by individual planters or the proponents thereof. One such plan to politically naturalize and rhetorically sanctify non-native planting was that advanced by Somerset parson Richard Eburne, whom in 1624

articulated a *Plaine path-vvay to plantations that is, a discourse in generall, concerning the plantation of our English people in other countries*. Eburne naturalizes English colonization by arguing that the flows of English bodies from overpopulated to supposedly empty lands parallel the migration patterns of bees from hives "ouerfull" and seeds from orchards "ouergrowne with young sets." Both the colonies of bees and the plots of cultivated fruit trees send forth their excess members to be "transplanted into some other soile" for the good of the individual specimen and the good of the larger ecological community. By invoking the natural vocabulary of colonization, Eburne's appeal to what Karen Kupperman calls "the model of colonial design" finds its home in the politically authorizing language of natural settlement. Just as the insects abandon their overcrowded hives "by swarming to seek a new habitation elsewhere," so too "it is as lawful for men to remove from one country to another."[405] At once the language of nature and culture, agricultural metaphors of planting – like the metallurgical terms of amalgamating and refining in the colonial Iberian scientific archive – take their cues from natural nodes of botanical flows that are wedded to enactments of human industry and ingenious cultivation. But unlike in the Iberian case, the English agricultural metaphors of planting-as-peopling define Anglo-Atlantic population management strategies and settlement patterns as a common body rooted to a new soil. By this logic, the same Protestant seed planted in Ireland or America would beget the same stock as in England; the fruits of English planting could be harvested equally in the homeland or in England's foreign plantations.

The natural justification of transatlantic migration would be framed in the explicit terms of peopling and possessing when English colonization was analogized to botanical

processes rather than insect orders. In John White's *The Planters Plea*, for example, the planting of colonies, akin to the making of families ("Now what are new families, but pettie colonies?"), is defined in terms of humanity's covenant with God. Following, like Eburne, the terms of Genesis 1.28 and Psalm 115.16, White suggests that "the gift of the earth to the sonnes of man necessarily inforceth their duty to people it." God's gift of the earth is not given freely, but with a moral imperative for certain groups of humans to plant and possess: "If it were then the minde of God, that man should possesse all parts of the earth, it must be encouraged that we neglect our duty, and crosse his will, if we do it not." Taking their cue from the Book of Scripture and the Book of Nature, English apologists like White (1575-1648), minister of Dorchester, Derby, and supporter of the Dorchester Company's first mission in Massachusetts, analogized planters to plants as a way of naturalizing the act of planting English. Just as orchard trees could not grow without sufficient space, neither could the faithful grow in fruitful wise unless the planters, like their plants, could put down their roots in "a more plentiful supply in a larger scope of ground." By "building upon a principle that nature suggests," White's language of planting, peopling, and possessing yokes together colonial scientific theories of plant generation, religiously powerful metaphors of cultivation and Edenic recovery, and politically authorizing logic of natural settlement.[406] Grounded in the traditions of analogical thinking, seventeenth-century English writers likened the localized work of husbandry in the English midlands to the productive planting of the English in colonial plantations throughout the Atlantic world.

Planting as a colonial policy of peopling integrated the practical orientation of agrarian improvement and the naturalization of political subjecthood into a coherent and

compelling narrative of so many spiritual harvests in a transplanted body politic. But the language of planting and transplanting was not the only biopolitical discourse enlisted in the service of American settlement. Iberian-American settlement patterns were also expressed in religiotechnical terms of colonial science, but rather than the root metaphors of English planting, the authorizing discourse of colonization in Spanish America, and the source of material production that underlay those imperial pretensions, were mining and metallurgical sciences. As in the case of Anglo America, natural science provided the vocabulary of technical improvement and biopolitical management of the subjects who productively mined and refined such impressive quantities of ore.

But unlike the agricultural language of British American settlements, the biopolitical roots of Iberian peopling and population management course through mineralogical science, which contains different theories about the roles of similarity and difference. And also unlike English crop science, which advocated a mismatching of seed and soil to ensure that the best English stock would rise up and into full bloom, colonial Iberian metallurgy perfected the science of purification. The outer impurities were rigorously cleared away in successive administrations of heat and chemical reagents, an innovative treatment developed in the sixteenth-century highlands of central Mexico and adapted in the seventeenth century for the environmental, labor, and cultural conditions of Alto Perú. In the eighteenth century, mining and metallurgy would also perform the cultural and commercial work of opening up the inland regions of Minas Gerais to new demographic mixtures and new technologies in gold extraction and refining. But in the seventeenth century, it was in Spanish America that innovative technical practices and new theories of mineral science brought into being the amalgamated body publics of the

mining regions. Spanish American ideas of peopling, too, came to depend less on the physical body and more on the inner essences of indigenous peoples and Africans that could be incorporated into the church universal.

While the bulk of this study has explored the overlapping scientific and social registers of amalgamation as epistemological framework, technical practice, political principle, and cultural metaphor for new communities in the silver mining regions, this chapter concentrates on copper metallurgy. Silver was by far the larger industry, one whose "external consequences" or impact on settlement patterns, demographics, artistic productions, and cultural architecture are, as Peter J. Bakewell puts it, "almost beyond measure." But copper metallurgy, because it required different knowledges and technical competencies, was localized in different geographic nodes, and was explained in different natural vocabularies, offers a helpful point of comparison with the more widely-studied literatures of colonial silver. Precious metals like silver and base metals like copper require different techniques of mining, refining, and minting, and these knowledges were in turn held by different demographic groups that put different pressures on the same problem of population: indigenous Americans in the silver mines of Alto Perú and central Mexico, and Africans and their descendants in the copper mines of northwest Venezuela and eastern Cuba.[407]

II. "y ser forçoso para poner en perfeccio[n] las minas y fundiciones del cobre, poblar, y fundar de nueuo tres lugares" [and to bring the copper mines and refineries to perfect order, it will be necessary to populate and resettle three places]: Copper Metallurgy and Population Management [408]

Today, by virtue of the borders drawn by mining engineer, Secretary of Commerce, and US President Herbert Hoover, Chile is one of the largest suppliers of copper in the global economy.[409] But in the colonial era, the most important sites of

copper production were eastern Cuba and the Aroa River Valley of Venezuela. Here, more than in the case of the silver industries of Alto Perú and New Spain, African miners and metallurgists possessed the knowledge and practices required for optimal copper extraction and processing. The cultural and demographic composition of the copper mining regions was transformed by the flows of laborers wrought from their ancestral Africa and forced into sites like El Cobre, Cuba, and Guacara, Venezuela. As such, these regions contain rich mineralogical narratives of peopling and population that can help to situate Iberian policies within the broader context of American settlement, and to reveal some of the important distinctions within the colonial Iberian copper and silver mineralogical archives.

This chapter explores those regions by putting in dialogue two very different accounts of seventeenth-century copper mining and colonial management of *cobreros*, enslaved Africans who mined and refined copper. The *Relación y vista de ojos* (1620) by don Manuel Gaytan de Torres, whose survey of the Aroa River Valley uses the material processes of copper metallurgy, a three-part process of crushing, purifying, and casting into uniform molds, to explain the three-part process of "reducing to our holy Catholic Faith" the Indians of the discovered lands, discovering more of the Indies, and "poblarlas de Christianos." The second example comes from the town of El Cobre, Cuba, in the easternmost province of Santiago, where a community of some 300 royal slaves resisted the crown's attempts to be removed from their families and relocated on the island. These are very different texts – the one, a single-author treatise written by a royally-appointed surveyor and trained metallurgist from Jerez de la Frontera, the other a fragmentary set of documents assembled between 1687 and 1800 describing events from 1604 and 1673 in a

community of royal slaves in provincial Cuba. However, the two sites also share linguistic, cultural, and economic similarities, as both places were organized around imported and exported free and unfree laborers and spiritually supervised by virgin saints: La Virgen de la Caridad del Cobre (Our Lady of Charity) and La Virgen de Guía de Caracas (Our Lady of Guidance), a "coincidence" about which the Cuban anthropologist Fernando Ortiz asked, "¿no es curiosa?" (isn't that curious?)[410] As this spiritual framework indicates, the dominant metaphor of peopling or population management strategies is not one of replicating the physical body, but rather the soul's path to salvation. For don Manuel, copper metallurgy provides a framework through which to understand the work of peopling, importing and incorporating free and unfree laborers in northwestern Venezuela. And for the royal slaves of El Cobre, Cuba, the language of spiritual peopling provides the terms of resistance to the types of population management strategies promoted by don Manuel. The slaves who were torn from their ancestral Africa, transported across the Atlantic in tightly-packed ships sick with the stench of humans whose humanity was never acknowledged, and put to work in privately-held and, later, royal copper mines and refineries in Cuba resisted the king's order to relocate to Havana by arguing that the intercession of the Virgen de la Caridad is proof positive that their true home is El Cobre. If the Venezuelan case demonstrates how the technical terms of copper metallurgy informed religiopolitical processes of population management – who would be brought to the region, how many people would arrive, and how they would live once they got there – the second case demonstrates how those processes also provided the terms of resistance for the people they were designed to relocate and regulate. The overlapping language of metallurgical science and

demographic mixture, what I am calling the language of "spiritual peopling" in the state-sponsored survey of Venezuela, suggests the types of population management strategies that were employed by the crown, while the case of the royal slaves of the copper mines of eastern Cuba suggests the forms of resistance available to the subjects of population control when they appropriated the terms of spiritual peopling for their own use.

Unlike metallurgical treatises that describe the "nuevo beneficio" of amalgamating silver with mercury, texts like Barba's *Arte de los metales* (Madrid, 1640) or Cárdenas's *Problemas y secretos maravillosos de las Indias* (México, 1591), whose most interesting metaphors involve the relationship of sameness and difference between the primary reagents of silver and *azogue* (mercury), copper metallurgy is a different material process that produces a different set of imaginative metaphors. As don Manuel explains, copper is refined in a three-part process of crushing or reduction, purification and softening, and, finally, casting the adhesively soft matter into the internationally uniform mold of the square sheet. These steps take place in three continuously-running facilities whose precise dimensions don Manuel spells out in the second of his seven articles. The first is a 180-foot long crushing house with twenty-two pairs of bellows, eleven on each side. The second, a 72-foot long "casa" with twelve pairs of bellows, six on each side, where "se ha de afinar, y adulçar con otro ingenio" (it must be purified, and made soft by another refinery). The last facility is a 50-foot long cluster of five refineries that weigh the copper and cut each piece into a uniformly square cathode sheet "like that which comes from Hungary" (3). Together, they would produce somewhere between 66 and 75 pounds of copper a day, but this number could be increased by "regulating the amount of Africans applied in the mines" (4v).

The disturbing cataloguing practices that list miners and metals together as if they shared the same states of personhood demonstrate the organizational and commercial calculations that inform the settlement plans for the region. But the language of this report is just as revelatory as these quantifiable nodes, and the overlapping terms of metallurgical technology and population management suggest that colonial science and settlement went hand in hand. By carefully attending to three keywords in particular, *adulzar* (to soften or sweeten), *ley* (mineral weight/religious salvation), and the minimal pair *fundición/fundación* (smelting/founding), we can better understand the problem of population and the governance of demographically-mixed settlements in the colonial Americas.

The first step in copper processing is crushing or reduction, identified by don Manuel as "the lightest task" and the kind of work that could be performed by African women or men. The second step was purification, or where "se ha de afinar, y adulçar" the newly reduced ore. Silver metallurgists also use "afinar" or "afinación" as a synonym for purification, but the term "adulzar" is rare. It does not appear in any of the major mineralogical literatures from Potosí or New Spain, as metallurgical writers like Luis Capoche, Álvaro Alonso Barba, and Luis de Berrio y Montalvo all use terms like "afinación" or "purificación" to describe the methods of purification, whether by administering heat or washing with reagents.[411] According to the *Diccionario de Autoridades*, "adulzar" is a less-commonly used synonym of "endulzar," defined as "metaphorically to soften, make tolerable and agreeable one's work, hardships, life, etc." For don Manuel's contemporary Sebastian de Covarrubias Horrozco (fl. 1611), "adulzar" meant "to make something sweet, not being its original condition." Noting that the term

is “not often used,” Covarrubias cites Antonio Nebrija’s *Grammar*, the volume published in 1492 whose opening lines gave one of the clearest expressions to the coeval rise and fall of empire and language: “que siempre la lengua fue compañera del imperio; y de tal manera lo siguió, que juntamente començaron, crecieron y florecieron, y después junta fue la caida de entrambos.”[412] In both dictionaries, this non-canonical term appears directly above the word *adultero*, one who commits adultery, providing a linguistic closeness that positions don Manuel’s technical description of copper metallurgy within the sexualized economy of colonial settlement. The operational capacity of the site will never reach its “perfection” without human laborers to put it to work.

The houses of purification that represent the core of the new settlement’s physical infrastructure threaten to become both impure and unproductive spaces so long as they are marked by a dramatic imbalance of men and women. To remedy the problem of population among the enslaved Africans, “to keep them in safety, and so that they attend to their work with joy, and so that they might not neglect their duties or fall in sin,” don Manuel explains, the slaves “must be married, and therefore it is necessary to purchase other such quantities of black women” (8v). The original ratio of 3 ½ adult Africans for every Spaniard now becomes 6 ½:1, and the demographic composition of Africans to Spaniards will become increasingly asymmetrical with each generation or the length of time, “specified in the account that was given to Your Majesty,” that black men and women, and their children, would be required to serve (8v). Throughout the colonial Americas, the policies of enslavement suggested that children followed the condition of their mothers regardless of racial phenotype.[413] A child born to an enslaved mother, then, would also be considered a slave. But the curious phrase in don Manuel’s plan, “que ellos

y ellas, y los hijos que tuuieren seruiran el tiempo que está dicho en el memorial que dio a V.M.," (that the men and women, and the children that they have will serve the time that is said in the account that was given to Y.M.") suggests that a different policy may have been intended for the copper mining regions of the Aroa River Valley. Because no *memorial* remains extant with the present-day copies of don Manuel's *Relación*, we do not know what the conditions of enslavement for the children were to be. It is possible that the *memorial* merely repeats the standard policy of hereditary slavery, and that the phrase from the *Relación* delights in a circular referentiality characteristic of baroque aesthetics. However, it is also possible that the well-documented capacities of African miners and metallurgists in the extraction and processing of a base metal like copper, rather than precious metals like gold and silver, led the crown to endorse a non-inheritable form of enslavement for the children of enslaved Africans in Venezuela. Rather uncharacteristic forms of slavery, like royal slavery in El Cobre, Cuba, and "divine enslavement" in Venezuela, were to be found throughout the copper mining regions of colonial Spanish America.[414]

Whether they were enslaved for life or not, the conditions of slavery were brutally violent, and the early years of slave life in the copper regions of northwestern Venezuela would look remarkably like the patterns of the extended Caribbean. Denied their recognition of personhood, slaves would be trafficked across the Atlantic and sold in the same markets as mining equipment and refined metallic bodies. The number of unfree and free black, indigenous, and white laborers that the crown would need to bring to the site was determined by the estimated production capacity of the Aroa River Valley. Based on the samples that he assayed with the factor at the Casa de Contratación in Seville, don

Manuel estimates in his fifth article that the site will produce 100 *quintales* (pounds) of copper each day, and that the port city of Borburata can be built up to handle the shipping and distribution of people and products. Assigning groups of indigenous, African, and Spanish laborers to specific tasks, he estimates that the port will require eight indigenous dockhands, plus a significant number of cattle ranchers to supply animal protein. This group had been conveniently made available by the crown's recent confiscation of the 100 *indios encomendados* of the householder Francisco de Vera "for the crimes that he committed" (7v). Although they would not be directly involved in the extraction or processing of copper, the indigenous people would provide key support in shipping the products and sustaining the population of miners and metallurgists. Without the transportation networks that connected the Aroa River Valley to the priority ports of the Caribbean basin, and without organized, large-scale foodways to support the workers in the inland mining region, there would be no site to speak of. The one-hundred and eight indigenous people enlisted in the founding of the copper mines would be physically outside of the community, but their labor and contributions would underwrite its very settlement.

The majority of the labor needs on the site proper would be fulfilled by free and unfree people from the Old World. Although the site's maximum production capacity could reach 100 pounds of copper per day, don Manuel estimated that it would probably produce something between 66 and 75 pounds of copper per day. This more realistic estimation could be increased, he added, by "regulating the amount of Africans applied in the mines" (4v). The key to managing the production of copper was also to manage the population of black laborers, and from there to determine how many white and

indigenous workers would need to support the enslaved population.[415]

After a careful reckoning of natural and human resources, don Manuel concluded that the settlement needed a ratio one Spaniard for every three Africans "que para el manejo y beneficio de los ingenios y fundiciones se han de agregar" (who for the management and benefit of the refineries and casting irons/smelting ovens must be united, 10v). His final tally calls for 355 Africans to work primarily as miners, metallurgical practitioners, woodcutters, and porters, and 110 Spaniards to serve variously as administrative officials, master miners and metallurgists, military captains and soldiers. The number of Spaniards itemized in the list was almost identical to the number of indigenous laborers whom don Manuel had recommended "reducing" to the site, the one inside the community and the other ensuring its continuity but remaining outside its physical foundations. Artisanal positions like carpenters, smiths, foresters, locksmiths, bellowmakers, brickmakers, tanners and agricultural specialists in staples like maiz, yuca, and plantains, "todas comidas que vsan los negros," were to be occupied by Spaniards during the initial years of operation with the idea that rising generations of Africans would learn the skills to replace the Europeans (9). Although the accompanying *memorial* is no longer extant, a passage like this one from the *Relación* may help to explain the settlement patterns that don Manuel envisioned. In the paragraph that introduces his six-page catalogue of people and products, for example, don Manuel suggests that the operational costs will decrease after the first few years because African miners and metallurgists can replace Spaniards in skilled positions: "que no yrá a mas la costa, sino a menos, passados algunos años, porque los negros estaran despiertos en los oficios, y ocuparan algunos, que oy es fuerça los hagan Españoles" (after a few years the

cost will not go up, but instead down, because the blacks will be awakened to the offices and they will occupy some that today we find necessary for Spaniards to do, 5v). The recognition that in time African laborers could replace Spaniards in some positions suggests that the crown intended to employ creole Africans as miners, metallurgists, and artisans rather than to continue its transatlantic traffic in human beings. It also suggests a relationship between African and Spanish laborers that was different from the hereditary, fixed binary of slave and master that developed in monoculture plantation economies or mines and mints of precious metals. The interchangeability of black and white workers over time suggests more of a temporary servitude, with training or apprenticing, rather than a permanent enslavement. This is not to suggest that enslavement in the copper mines was somehow less brutal in terms of working conditions, or less painful in terms of separation from family, language, and ancestral home. Rather, what this case suggests is that the policies of peopling in the copper mining regions of Venezuela looked different than those of the more widely-studied Anglo- and Iberian-American plantations of sugar, cotton, and tobacco, or the mines of silver and gold in Spanish and Portuguese America. Treatises of copper mining and metallurgy therefore allow us to appreciate the similarities and differences among and between agricultural and metallurgical discourse communities in the colonial Americas with respect to their treatment of the problem of population.

So far, don Manuel's problem of population might be less about the uneasy demographic mixture of indigenous, black, and white laborers than it is about gender imbalance. In his six-page tally of imported and incorporated free and unfree laborers, the only black women included in the register are the four *negras* who will work as crushers, "the lightest task" (6). But in his conclusion don Manuel is more explicit about the

relationship between copper production and slave reproduction: "And to have them in safety, and so that they assist in their work with joy, and so that they might not neglect their duties or fall in sin, they must be married, and therefore it is necessary to purchase other such quantities of black women" (8v). For this traffic in black women he recommends that the crown source from the Lisbon markets where the slaves are more easily acculturated to Iberian ways ("having taken the land and found themselves somewhat *ladinos*") and therefore given to "multiplication," "as is seen throughout the Indies … because the work will be tolerable, and the land where they populate very healthy" (9). Familiarity with the language and the land begets a more generative coupling of male and female slaves, in don Manuel's cruel assessment put rather matter-of-factly. By contrast, he argues, the slaves at Cartagena "no son negros de tanto trabajo, ni tan buena ley" (they are not given to as much work, nor such good religion). The historian Stuart Schwartz has recently studied the meaning of "ley" as religious salvation and principle of tolerance, but it is also important to note that "ley" is the technical term for "mineral weight" or "quality."[416] The same word, then, could gesture toward the quality of one's soul and its possibility for salvation, and the quality of a metallic body its potential to be purified. This fittingly commodified term appears in a list of the "tools" that "with the help of God must be kept alive and increased, which are the blacks and cattle." Copper of "alta ley," or high weight or grade, and slaves of "buena ley" were both productive and reproductive in the spiritual economy of colonial Iberian mining and metallurgy.

In this cataloguing of people amid so many things, and the classification of people as things, we see don Manuel equate spiritual salvation with and material redemption. In

his reading of the salvation of the soul in the same terms as the production of mineral wealth, don Manuel's plan for the exploitation of copper and the peopling of the region is informed by a peculiar religious sensibility. The overlapping discourses of metallurgical technology and spiritual peopling become more pronounced as don Manuel explains how to lay down the physical and communal foundations of the copper mining settlement. "Y ser forçoso para poner en perfeccion las minas y fundiciones del cobre poblar, y fundar de nueuo tres lugares": (it is necessary to populate and found again three places to complete the mines and refineries): two in Nigura province and the port city of Borburata, which had been burned to the ground by the English (10v).[417] "Fundar," like "poner en perfección," the term used by Saint John of the Cross (1542-1591) to gloss the three powers of the soul, carries an explicitly religious connotation in addition to its mineralogical resonance. According to the *Diccionario de Autoridades*, the physical work of founding, "to lay the foundation of a house or temple," also implies spiritual edification, signifying "likewise to establish a Religion or Community, joining men ("compañeros") and signaling to them the institution and rules that they should observe." The word "fundición," likewise, signals a material process of ordering with the aim of improvement: of softening metals such that one can "hacer de ellos lo que se pretende," (make of them what is fit) setting them "in corresponding molds."

The work of the copper fundiciones and the work of the fundaciones of the Catholic church in the Indies, the casting irons, smelting ovens, and the pillars of the church, are mutually constitutive material processes in the three-part plan for the region. The first stage, in the known regions of the New World, would see the "reduction" of the Indians, identified as "el mejor fruto de las Indias." Reduction is both a political

framework inherited from the Roman Empire, and the first step in copper metallurgy. The second stage of settlement would see the discovery of new regions that would, thirdly, be peopled with Christians (10). Don Manuel's plan, then, is to people the Indies not with phenotypical copies of Europeans, as peopling had been defined in the context of other European empires that planted their roots in the New World, but rather with spiritual copies. The plan that the royal metallurgist outlines for the settlement of the Aroa River Valley becomes one in which the rich copper deposits and African families, both "de buena ley," provide the material support for the work of populating the region. This material work, in turn, underwrites the true work of the mission: to convert the indigenous people who are to be reduced and incorporated into the mineralogical production and religious community. Just like the copper ores that are made soft and receptive, poured into molds whose uniformity enables their circulation as global goods, so too are the people of the Aroa River Valley, black, white, and copper-red, cast into the universal molds of the Catholic Church.

In the overlapping language of colonial science and biopolitical programs, black families, white supervisors, and indigenous laborers converge to underwrite the new settlement of the region whose copper cathodes and saved souls will play equally important roles in the two, always overlapping empires to which they belong: the economic order of the Spanish empire and the spiritual order of the Holy Roman Empire. That don Manuel had both of these religious and economic empires in mind is revealed by his comparison of the copper from the Aroa River Valley with that of the copper from Hasburg-controlled Eastern Europe and from Cuba, finding the Venezuelan ore "as good as the Hungarian sort and better than that of Havana" (13). Just like the copper ores that

are made soft and receptive, poured into molds whose uniformity enables their circulation along the global networks of a Spanish empire that stretches from Manila to Madrid and connects Hungary and Havana, so too are the people of the Aroa River Valley cast into the molds of the Catholic Church and the Holy Roman Empire whose work it performed.

In seventeenth-century terms, the soul was at once immaterial essence and countable matter. In census records and population surveys of the Andes, for instance, priests like Luis de Vega of the silver mining town of Tomave, southwest of Potosí in the province of Porco, describe the "32 animas" (souls) that the parish contributed to the mita, while Jesuit missionaries in Brasil, like José de Anchieta (1534-1597), drew an imaginative line between the pursuit of spiritual generation and mineral harvests in the Amazon. In his letter to Saint Ignatius of Loyola, composed in Piratininga, São Paulo, in June of 1554, Anchieta aligns the twelve men dispatched by the governor Tomé de Sousa (1503-1579) to the Brasilian interior (sertão) to search for gold with the sole Jesuit priest who accompanied them in this "discovery of many generations" (para descobrir muitas gerações). "Eles vão buscar ouro," Anchieta writes, "e ele vai buscar tesouro de almas, que naqueles partes ha mui copioso e por aquelas partes cremos se entra até ao Amazonas" [they seek gold and he seeks the treasure of souls, which in those parts is copiously found and where we believe one can reach the Amazons].[418] The conventional surveying of souls in census reports, population studies, and letters to church superiors offered a method through which colonial administrators and missionaries could make countable the immaterial. If Michel Foucault is correct that statistics represent "the science of the state," then we must understand who counts – and how – if we are to understand the problem of the population in the colonial Americas. For seventeenth-

century Iberian writers like don Manuel and José de Ancheita, peopling was not just defined in terms of the physical body, but also in terms of the human soul. Put otherwise, bodies mattered, but souls, too, were matter – at once a spiritual matter of state and a physical matter to be counted and managed by instruments of the church and state.

If these population management strategies developed to control the demographically-mixed settlements of Spanish and Portuguese America outlined the crown's theories and practices of spiritual peopling, the religious framework also provided the terms through which the most marginalized subjects could resist those strategies. This is what happened in eastern Cuba, when in the late-seventeenth century a community of royal copper mining slaves invoked conventional Iberian ideas of spiritual peopling to resist being moved from their homes in El Cobre to the capital city of Havana. They aligned their appeal with orthodox Catholic values like family and the veneration of the saints to petition for – and win – recognition of their land rights and kinship networks from the same institution that denied their humanity. The assemblage of their multivocal legal documents, recorded in 1687 by notaries dispatched to take the testimony of *cobrero* slaves about the miraculous events of 1604 and the uprising of 1670, differs from the single-author Venezuelan treatise in terms of language, genre, and political power. As such, these cases taken together reveal the two sides of Iberian American practices of peopling: the religioscientific terms of mining metallurgy through which population management strategies and policies were framed, and the resistance to those strategies.

The organized resistance of *cobrero* slaves in the late-seventeenth century is all the more remarkable because of the colonial Iberian population management strategies

that we have seen in early-seventeenth century Venezuela, and in light of the crown's response to the problem of population in eastern Cuba proper. Following large-scale slave revolts in 1735, 1736, and 1737, for example, the crown expelled to New Spain and Peru the thirty-six "most rebellious and bold" (más revoltosos y atrevidos) of the 108 slaves who had "manifested their rebellion in their application to work," including the women who had urged the revolt ("que le alborotaban"). The Governor and Capitan General of Cuba, Pedro Roca de Borja, argued that the removal, punishment, and redistribution of black slaves was the only way to ensure the successful extraction of "considerable portions of copper" and the continued obedience of both "the blacks who so far have not shown signs of uprising" and the "free population of whites, mulattos, and some families from the Canary Islands" whose proximity to the slave leaders led Borja to pronounce that "we are certain to see in the future the just suspicion that the aforementioned slaves have provoked."[419] The primary conditions for the relocation of the "ynquietos y sediziosos" were that the host communities be "sufficient in their number of Population and citizenry to keep them [the slaves] subjected and subordinated," that no slaves be relocated to a coastal site where they might flee or "have any communication with the English of Jamaica, or any other foreign nation," and that enough slaves be kept in Santiago to serve in the military.[420]

At the same time that it expelled female and male black slaves, the crown enticed families from the Canary Islands to relocate to eastern Cuba. In exchange for their transatlantic voyage, the state offered land grants ("con asignazion de tierras realengas") that were designed most immediately for some forty or fifty families to provide their own sustenance and produce food for the Cuban public. But the reward of land was also

extended to these white families with an eye toward the general "improvement" (fomento) of Santiago, an improvement understood as a demographic rebalancing of the number of black slaves and white families who lived side by side on an island far removed from the imperial metropolis (1). The number of Canary Island families selected to receive land was to be determined based on a population survey of the black slaves, male and female, of the region, suggesting that the production of copper and the reproduction of enslaved black copper miners and metallurgists would again determine how many Spaniards would arrive in a particular copper mining region and under what type of conditions they would disembark (5).

By 1740, the crown found the transatlantic relocation of Canary Island families impractical ("no siendo practicable"), and it turned its population management tactics to groups of professional miners and metallurgists already in the Americas. To these "Mineros de profesion, y fundidores de arte" of Mexico City and the state of Michoacán, the crown proposed offering "more advantageous and favorable conditions" to support their work. Should they relocate from New Spain, where they had experience with copper ("donde hay Minas del propio metal"), the mining professionals would be rewarded with mines teeming with potential and a mining landscape void of competition. The royal decree suggested that local officials entice New Spanish miners with a combination of financial promise and professional flattery. The mines of Cuba had once been "very abundant and lucrative," local officials were instructed to say, but the sites lacked "personas inteligentes, y practicas" (people of intelligence and experience) to use the resources properly and profitably.[421] These policies of repeopling, the exportation of black slaves to other American regions and the importation of white families and creole

metallurgists, represented the crown's attempt to remedy the high rates of social conflict that underwrote low rates of copper production.

To determine the effectiveness of this top-down population management, local officials were dispatched to survey the region and quantify the demographic composition of the population, specifically determining "si son naturales de la Tierra Negros o Mulatos con Expresion del nu[mer]o de cada clase, y de si estos bastaran a contener y hazer que este[n] su[j]etos y subordinados los Negros (if they are natives of the Land, Blacks or Mulattos with an Expression of the number of each class, and if these will be enough to contain them and make sure that the Blacks are subjected and subordinated)."[422] The state outlined its population management practices in two parts, formulating policies to redistribute and measure the populations of black and white subjects alike, and classifying the white population into groups of family units and mineralogical professionals. The extensive detail with which these policies were articulated, and the controls created to quantify their effectiveness, leave us with the curious question. How could a community of royal slaves resist the population management instruments of a state that so successfully moved free and unfree people across the Atlantic and within the Americas?

What makes the case of the *cobrero* slaves even more interesting is that when they were held in private hands, the slaves complied with an order to remove to Havana. Following the English attack of 1662, some 275 *cobrero* slaves were sent to Havana to rebuild the wall that had been destroyed. The slaveholder don Francisco Salazar y Acuña charged the crown some 12,000 pesos for having lent out his slaves for the work, but the crown did not respond well to the bill, given that Salazar y Acuña's family had neglected

its *quinto* contributions for nearly forty years.[423] In 1670, the cobrero slaves became the property of the state, and under their condition of royal slaves they resisted the order of removal. In their petition of July 13, 1673, they argued that they could not be separated from their land or families. This is a complex story whose fragmentary archival documents have been collapsed and retold in folkloric traditions that are punctuated by tales of miracle and faith and invoked in different times and places in support of or in opposition to changing ideas about the island of Cuba. As the anthropologist Fernando Ortiz has rightly pointed out, these moments serve as testaments of veracity for believers but they are more difficult for academically-trained literary scholars, historians, and anthropologists to use in their formulations of comprehensive interpretative frameworks that rightly read and explain the remains and folklores of the past.

As it happened, around the same time that the mining regions were made known to the Spanish and first consolidated into state ownership, a Marian virgin appeared in 1604 to a group of three slaves. This group, consisting of the ten-year old Juan Moreno (the same man who would later negotiate on behalf of the community in its petition against the crown) and Rodrigo and Juan de Joyos, "hermanos y yndios naturales," had left the copper mines to collect salt from seaside deposits. In the bay, the boys saw a white object with a sign that read "yo soy la Virgen de la Charidad" (I am the Virgin of Charity). They celebrated the miracle "full of joy and happiness" and cut short their work, returning home immediately to share the relic with Miguel Galan, the overseer of the *hato* of Barajagua. Galan dispatched one Antonio Angola to inform the mine administrator Capitan Don Francisco Sánchez de Moya, who insisted that the virgin be housed upon an altar, a temporary one in Barajagua and a permanent one on a hilltop, and

that she be accompanied by a constant flame maintained by the Joyos brothers. Through a series of signs, including nocturnal wanderings and flashing lights, the Virgin registered her displeasure with the location selected by Sánchez de Moya and indicated her preferred home adjacent to the mines and slave quarters. There, a hermitage and holy shrine were immediately constructed.[424]

The Virgin, according to Moreno's notarized testimony of April 1, 1687, had laid claim to a specific site and she had made her will known to a specific community of enslaved African and indigenous copper miners. By relating his experience to the Virgin, Moreno's narrative reconfigured the relationship of the mining population both to the spatial realities of the copper regions and the spiritual values of the dominant culture. By positioning themselves within orthodox ecclesiastical and civil frameworks, namely the gendered codes of Marian devotion and royal slavery on an island far beyond the imperial pale, the royal slaves successfully petitioned for the same state that held them in slavery to recognize their land and family rights. The ambiguous status of royal slavery and the nuanced role of gendered spirituality converged in the slaves' petition, and the crown agreed that the *cobreros* could not be removed to Havana. The same state that proposed race-based population rebalancing policies for Cuba, Mexico, Peru, and the Canary Islands also endorsed the supreme infallibility of providential intercession in matters of geography. That is, the appearance of the Virgin de la Caridad del Cobre determined, for the crown, which people should live and worship in particular places. The spiritual framework of peopling and populating, then, also provided the terms of its resistance.

As in the case of British America, Iberian ideas of peopling and population management were tied in part to the physical body – to the importing and exporting of

voluntary and coerced laborers, to the "reduction" of native communities and the amalgamation of non-native peoples. But the definition of peopling in Spanish America did not call for the re-production of a white European body or the planting of a rising generation. Instead, seventeenth-century Spanish instruments of population control were informed by religioscientific paradigms of reduction and incorporation, the overlapping language of metallurgical technology and missionary conversion. The two largest empires of the Atlantic drew from the material practices of colonial science to authorize and explain their settlement in the Americas, but these naturalizations of colonial designs took their cues from different scientific theories and practices.

As this chapter seeks to show, the comparative framework of colonial science allows us to appreciate the broad pull of similarity in Anglo and Iberian American lives and letters and to better understand their differences. The privileged place of planting in the colonial English archive should not suggest that peopling was not an equally important element of Iberian colonization. This chapter joins a growing body of scholars like Katherine C. Little, Ralph Bauer, and John Huxtable Elliot, all of whom have shown that the lines between Protestant paradigms and Catholic convictions, English models of planting and Spanish frames of conquest, were never so clearly drawn as nineteenth- and twentieth-century bipolar theorists would have us believe.[425] Though the English professed their difference from the Spanish, and the Spanish emphasized their difference from the English, both groups framed their work and justified their presence in the Americas in terms of colonial science, and both groups used the terms of colonial science to organize their policies of peopling and to articulate their practices of population management. By attending closely to the keywords expressed in their original languages,

terms like "heath" and "moor" and "ley" and "fundir/fundar," we can appreciate the ways in which colonial science shapes and is shaped by the settlement patterns of demographically mixed and culturally rich communities in the Americas and the circum-Atlantic world more broadly. Colonial science offers a frame through which we might read the remains of past not just as material culture, but as cultures that matter.

III. "The Moorefields are the best instruction": Natural Blackness and Colonial Science

If not quite the hard and styming rock of Caliban's native island, in the seventeenth century the moorlands of the British Isles were considered only slightly more habitable and hospitable to English ways. As environmental historian Ian Simmons glosses the pre-Romantic interpretation of "the moors," these upland regions were "waste places and better avoided, not least because of the kinds of people who might be found there."[426] In rich traditions of imaginative art and writing, the townspeople of *Beowulf*, as modernized brilliantly by Seamus Heaney, repeat whispered tales of monstrous male and female forms seen "prowling the moors … beyond the pale" untethered to family roots or ancestral homes, instead haunting always the "frost-stiffened wood" where "the heather-stepper halts" atop

> windswept crags
> and treacherous keshes, where cold streams
> pour down the mountain and disappear
> under mist and moorland.[427]

The darkened dreamlike landscape of the moorfields of *Beowulf* is the only apt home for the "unnatural" figures who exist out of time ("their whole ancestry is hidden in a past / of demons and ghosts") and in a placeless place of erasure "under mist and moorland."

The inner essences of moorbound monsters from the medieval era is writ large upon the windswept environment, a symbolic space translated into the early modern

imagination in works like Shakespeare's *Macbeth*. There, the three witches so famously "wither'd and so wild in their attire, / That look not like the inhabitants o' the earth" plot upon the same "blasted heath" of the heathen uplands before vanishing "Into the air; and what seem'd corporal melted / As breath into the wind."[428] In these imaginative fashionings of the moorlands and heathlands, the physical properties of moorish, heathen blackness reveals to the world the types of inner darknesses that could only be explained by way of a supernatural order. The "prophetic greeting" of the witches and the folkloric traditions of peoples past rush into contact and dissolve just as quickly into the furied winds of the windswept moors, an environmental landscape well-suited to the transitory "supernatural soliciting" begotten by false-speaking "instruments of darkness."

And yet for early modern agricultural writers, these blackened spaces offered tremendous possibility for natural instruction and learned cultivation. Sir Hugh Platt, for instance, argues for the primacy of experience rooted in explorations of the English blacklands rather than essays into the received books of natural science. In his *Jewell House of Art and Nature* (London, 1594), Platt affirms unequivocally that "the best naturall phylosophie that euer I coulde learne in this point, was neither out of Aristotles physicks, nor Velcuries naturall philosophy, nor *Garsceus* meteors, nor out of any of the olde philosophicall Fathers, that writ so many hundred yeares past; but that little which I haue, I gathered it on the backside of Moorefields."[429] The instructive value of the English moors was signaled in the late-seventeenth century emergence of the professional category of "mooreman," or a husbandman who specializes in the cultivation and profitable improvement of blackness. Platt's passage in celebration of the acquisition of first-hand knowledge in the moorlands and the term that designates professional mastery

of this knowledge are separated by nearly one-hundred years. In that span of time, agricultural writers actively debated the scientific properties of the moors and heaths, and they speculated about the "transmutative" borders of blackness as a natural principle. The circum-Atlantic correspondence of Hartlib circle contributors reveals how one transnational readership community engaged in this debate over the nature of blackness.

Hartlib circle commentators like Dr. Robert Child and Dr. Arnold Boate found each other's "Philosophy concerning Moor-logs" to be "no ways receivable," while contributors like Gabriel Plattes drew from both of their readings to recuperate the moorlands as a site of botanical transmutation and national transformation. The reform of the land and the body public is achieved, in Plattes's vision, through interrelated policies of husbanding and peopling. What Child and Boate dispute is the very matter of the relationship between the spiritual and the physical, the same principles distinguished Iberian-American and Anglo-American definitions of peopling. As Child sees it, the blackness of the moorlog is inherited from the "sooty fume, or *evaporation* of the black *turf*, (which endeavoreth, as all earths do) to reduce all things into its own nature." Though the soil cannot force the perfect decomposition of the log, or fully convert the matter from tree to earth, through the nothingness of smoke "it introduceth divers dispositions, and qualities, as blackness in the Wood." Boates disagrees with Child that blackness can be "communicated" into the tree "by the blackness of the earth or turf," but he declines to provide an alternate explanation of the origins of blackness in moorlogs relative to other evergreen trees of the region, like cedars and firs, or more resinous varieties like pines. Instead, he turns quickly from the moors to intervene in the debate over the origins of syphilis, namely whether the germ vectors were translated from

Europe to America or from America to Europe, and what role agricultural labor may have had in the transmission of the disease. (He ardently refutes Van Helmont's claim that "smutty corn" caused the debilitating affliction that the English called the French Pox, the French called "the disease of Naples; the Dutch the disease of the Spaniards (who then held the Low Countries); the Turks called it the Frank *i.e.*, Christian disease; and the Persians the Turkish disease."[430] While Boate was more interested in the matter of syphilis, Child pressed him on his reading of the moorfields, returning his somewhat reluctant interlocutor to a dialogue about the nature of vapors in the moors.

Child's response expands the more restricted frame of his original theory to insist more broadly upon a physical and spiritual explanation of the origins of blackness. Like all soils, he argues, the moors have "an innate power to transmute other extraneous things into their own nature," but unlike sandy earths, clayish turfs, or mixtures of marle, none of which received as much color-focused attention in Hartlib's *Husbandry*, "this earth hath a peculiar and more manifest faculty of multiplying." The "peculiar" fertility of the moorlands springs from its immaterial essence, the "Vapors, Fumes, or *Effluvia*, call them what you will; for *I* think all multiplicative Acts to proceed from such spiritual things, and not from bodies; and of this earth, doth this alteration or blacknesse of wood proceed." The generative power of blackness, according to Child, springs not from its roots in the soil, but rather from "such spiritual things" as its vaporous essence. Blackness, then, was both an observable physical property whose natural fertility, once it was more fully comprehended, could profitably be harvested, and it was also an intangible ethereal fume that disintegrated into airy vapors and eluded human observation and understanding.[431]

If Hartlib circle contributors disagreed over the physical and spiritual properties of blackness, or the tangible matter of blackness and the immaterial blackness of exhalation, perhaps they could agree on the productive use of the fertility of the moorlands. According to Child, the people of the North of England "are altogether ignorant" of the long, black moorlogs that plant their roots "several feet deep" in the moors, but in the plantations of Virginia and New England the timbers that "grow wonderfully thick in such *Moors* or *Swamps*" are put to good and continual use (18-19). The deep concern with color seems to have been resolved by the English planted in the New World, Child suggests, for they had found a way to put the "multiplicative Acts" of the moors to profitable use.

It is difficult for modern readers not to understand these passages on color – and blackness in particular – as part of a larger, culturally-informed and always politicized discourse on mixture and purity both physical and spiritual. On this point the art historian John Gage rightly notes that "in the modern world 'black' is perhaps the most heavily freighted colour term of all," and that in the United States in particular it is "the most political of all colours."[432] But what did these readings of the moorlands and heathlands mean in seventeenth-century English agricultural letters and the transnational communities of readers in which they circulated? Does it make any sense to read colonial scientific accounts of color in racial or ethnic terms, given the unstable nature of early modern definitions of race?

This book answers with a resounding "yes," for the fluid ideas of race, color, and ethnicity that circulate in seventeenth-century scientific treatises are precisely the sorts of questions that early modern writers sought to pin down. In other words, these are the

problems and the terms that the writers of the period were most concerned with, so these are the terms through which modern literary scholars and historians should approach the colonial archive. Some writers, like Sir Hugh Platt, sought to better understand the "transmutative" properties of blackness with first-hand experiments performed upon moorlogs, heaths, and black turfs, while others, like Child and Boates, citing Platt, debated the generative nature of blackness on more theoretical terms. Still others, like Hartlib circle correspondent Gabriel Plattes, looked to the realm of imaginative fiction as a place in which to test out competing theories of agricultural science and religioscientific readings of blackness. Plattes's fictional dialogue is an example of the types of multivocal, plurigeneric forms that circulate among the transnational readership communities of Hartlib circle agricultural reformers.

Plattes's contribution to the transnational debate about heathen heaths and too-fertile moors is his *Macaria* (London, 1641), a slim, fifteen-page quarto printed with facing pages and a brief prefatory address to Parliamentary officials. In this dialogue between a scholar, recognizable for his habits of mind and dress, and a traveler who promises to "tell you strange news, and much knowledge" brought from "over the sea without paying any Custome, though it bee worth all the merchandize in the kingdome," Plattes carves out a space in the moorlands upon which he reconciles the science of agricultural improvement and the political problem of population. By suggesting that the remedy for the English state is not to export its "surplus" population but instead to improve the husbanding of England, Plattes makes a case for domestic agrarian reform rather than foreign transplantation as the best policy of population management.[433]

In the utopian no-place of Macaria and the literary landscape of the moorlands,

English anxieties about the nature of blackness in crop science intersect with debates about the planting of English abroad. By seating his proposal for the repeopling of England in the moorlands, Platte's imagined dialogue incorporates real places in the imagined reconciliation of real debates. As the dialogue begins, the scholar, acutely aware of the problems choking the English state as Parliament attempts to "make a good reformation," and the traveler, newly returned from the utopian community of Macaria, where "the people doe live in great plenty, prosperitie, health, peace, and happinesse and have not halfe so much trouble as they have in these European Countreyes," remove to the moorfields to talk freely about the possibility of enacting Macarian agrarian and population reform in England (2). The physical space represents the first point on which they agree: the moorfield is the only site where both interlocutors believe they can converse at length about the state of England without the fear of being overheard or put under watch by swarming members of the body public. It is precisely the problem of overpopulation that sends the interlocutors "into the Moorefields" to compare the state of England with that of Macaria.

The central government of Macaria is much more restricted than the English Parliament, and its five councils – Husbandry, Fishing, Land and Maritime Commerce, and "new Plantations" – meet briefly only once a year (3). The more efficient bureaucratic framework is possible, the traveler explains to the skeptical scholar, by the more streamlined, efficient laws of the land; the problem of population is managed by two councils, Husbandry and New Plantations, which each attend to a different segment of the body public. Macarian citizens allot 1/20th of their agricultural production to public works, "by which meanes the whole Kingdome is become like to a fruitfull Garden, the

Highways are paved, and are as faire as the streets of a Citie; and as for Bridges over Rivers, they are so high, that none are ever drowned in their travels" (4). But more important than a tax policy that promotes "faire" pathways through the dark haunts like the moorlands, Edenic recovery "like to a fruitfull Garden," and the continuation of human life ("none are ever drowned"), is the law of improvement and fair use. "If any man holdeth more land than he is able to improve to the utmost, he shall be admonished," the Macarian law states, first with a loss of property and ultimately, should he consistently fail to "amend his Husbandry," with the penalty of exile (4). Unlike in the real case of the English, planting its subjects abroad is a matter of punishment in Macaria. Banishment from the land is not a political remedy for the problem of population so much as a deterrent for poor agricultural practices. But like the English, the Macarian state has also created policies to regulate its hoards of crowded subjects; they are the domain of the Council for New Plantations. Every year, the council surveys the population with "diligent notice" to determine "a certaine number" that "shall be sent out, strongly fortified, and provided for at the publike charge, till such times as they may subsist by their owne endevours" (5). The method of surveying the public is remarkably innovative, the traveler insists, and indicative of the superior education of the Macarian people.

All physicians and ministers in Macaria draw from the same grounding in the natural philosophy so that medical doctors are both "true Naturalists" and "good Divines," and, like the discoursing scholar in the dialogue, they who cure the soul also minister to the body (6). They are able to execute both functions with excellence because they outsource the making of new knowledge and the testing of new methods to the

"Societie of Experimenters," concerning themselves only with the practical matter of "the diversitie of natures, complexions, and constitutions, which they are to know, for the care of soules, as well as of bodies" (6). The problem of population is remedied in this fictional world by mapping one's inner nature onto the physical body, by reading in a person's complexion the essence that constitutes subjecthood, and by exporting to foreign plantations those members who form "the surplusage of people that may be spared" (6, 5). Both the scholar and the traveler endorse the state-sponsored program in which learned men diagnose the bodies and souls of its subjects, but they agree that the English state will require a different solution than that worked out in Macaria. Unlike in that other, ideal island community, the spiritual ministers of England do not know how to treat the physical body; "having not the skill of Physick," the "Divines of England" are therefore neither as "highly esteemed" nor as influential as their Macarian counterparts (11).

The remedy for the problem of population in England is the literary opposite of the practices of Macaria: instead of reading bodies to enact the spiritually-appropriate exportation of subjects, Parliamentary officials in England will read "a book of Husbandry" that lays bare the best practices of applied crop and animal science. This compendium of agricultural knowledge and practice will explain the most nuanced and least understood elements of natural science and foodways production, like the "transmutation of sublunary bodies" with whose mastery "prove any man may be rich that will be industrious" (11). As this "Art of Printing will so spread knowledge" to public officials and private subjects, all the literate members of the state will become "good instruments in this worke of Reformation." The real answer to the problem of

population, according to the fictional interlocutors, is not the transplantation of the English to Ireland or America so much as the better husbanding of England by the lettered English. The reduction of surplus population will only provide a short-term solution to overpopulated regions, but the doubling of a better-fed English public will create a critical mass of domestic consumers for market-ready goods like cereals, vegetables, fruits – and books. A more concentrated body politic in England will also provide the demographic power on the global stage to temper "the combustions in France, Spaine, Germanie, and other Christian Countreys," a bubbling unrest that threatens to tear asunder the bonds of Christendom and "give the Turk an advantage." For, as the traveler reminds his learned partner, "you know that a house divided against itselfe cannot stand" (12).

These are the same lines, of course, that two score and sixty-four years forward would be so powerfully articulated in Lincoln's Gettysburg Address, and they were the terms with which Augusta Jane Evans's proud heroines, the astronomer Irene Huntingdon and the aptly-named painter Electra Grey, would reject the encroachment of Union troops upon Confederate heaths and hearths with the publication of Evans's *Macaria; or, Altars of Sacrifice* in 1864. Evans (1835-1909) dedicated the plantation fiction to the "Army of the Southern Confederacy, who have delivered the South from despotism, and who have won for Generations yet unborn the precious guerdon of Constitutional Republican Liberty," and the novel was first published in Richmond, Virginia. Later that year, its dedication removed, *Macaria* was issued in a pirated edition that New York publisher Michael Doolady had received via Cuba. The movement of the text from its origins in Mobile, Alabama, to Southern and Northern publishers in the warring United States by

way of a still-colonial Spanish port reveals some of the integrative material connections of nineteenth-century Anglophone and Hispanophone literatures so nicely documented by scholars like Kirsten Silva Gruesz. But the production and circulation of *Macaria* in 1864 also suggests a broader translation from the moorfields of seventeenth-century English agricultural letters to the "blood-red heath" of Manassas, Virginia, a movement in which the blackened soils of Plattes's English moorlands are replaced with Evans's scarlet-stained heathlands of the US South. The shifting material ground from black to red underscores the violence of the Civil War in the United States and throws into sharp relief some of the continuities of colonial scientific classifications of color and composition.[434]

In the early US republic, however, it was not seventeenth-century English agricultural scientific discourse that had provided the terms of the emerging national body. Instead, late-eighteenth and early-nineteenth century Anglophone writers like Thomas Jefferson (1743-1826) and antebellum writers like Jerome Holgate (1812-1893) turned to the natural vocabularies of colonial Iberian metallurgical science to articulate their idealized and dystopian ideas about racial mixture in the new national project. The agricultural metaphors and practices of planting may have been the central religioscientific root paradigm of English colonial letters, but amalgamation and refining were the founding terms of early republican literatures. Jefferson and Holgate are two very different writers whose equally different genres enjoy very different legacies of reception: the one outlined the paradoxical terms of freedom for some and enslavement for others in foundational political frameworks of nation-statehood, while the other published an imaginative book of fiction at his own expense under the silly-sounding pseudonym "Oliver Bolokitten." And yet the canonical work of Thomas Jefferson and the

largely ignored novel of Jerome Holgate invoke the same key terms of amalgamation and incorporation to negotiate political and cultural anxieties about an interracial body public in the United States.

Colonial Iberian science developed the technology of amalgamation by reconfiguring the received epistemes of the natural philosophy, and it incorporated the new chemical benefit into an industrial-scale system of mining and minting the silver that sustained the Spanish empire throughout the seventeenth century. The remarkable epistemological sophistication of the method and its nuanced technical processes underwrote the very founding of colonial life in Latin America, and the advancements of mineralogical science were made possible by the substantial contributions of African, indigenous, and European women and men. That their seventeenth-century stories are not appreciated more broadly in the history of colonial mining, or the history of science, owes partly to these eighteenth-century Anglophone appropriation of the terms of Iberian mining and metallurgy. In the political formations of Jefferson, and the imaginative work of writers like Holgate, to say nothing of the images that circulated in nineteenth century periodicals, the colonial Iberian technology of amalgamation became the vehicle through which Anglophone readers understood in metallurgical terms what it meant to debase and to mix, to organize black, white, and red bodies into hierarchies of purified inner essences and outer complexions.[435]

The contributions of scientific agents from indigenous and African communities in colonial Iberian America were instead replaced with negative ideas about racial mixture for the white, Anglophone readers who responded eagerly to these texts and consumed these images. Colonial Iberian mineralogical science contained in its racialized

naming of *pacos*, *metales mulatos*, and *negrillos* and their sorting into "castas de metales" the antecedents to Anglophone markings of skin color as racial order, and the casting of those orders into political states of personhood and nonpersonhood, or full and partial humanity. By integrating the history and languages of seventeenth-century American arts and sciences into a broader dialogue, I have tried to show the always overlapping nature of matter in Anglo- and Iberian-American colonial discourse.

Historians of Iberian science often write against the charge that the contributions of Spanish and Portuguese technologies are less substantial than those of progressive, enlightened, Protestant traditions of Northern Europe, and scholars like Antonio Barrera Osorio, Jorge Cañizares Esguerra, and Júnia Ferreira Furtado have done much to recover the advancements of colonial Iberian scientists in an immense range of fields like medicine, botany, cartography, navigation, astronomy, and, also, mining and agriculture.[436] What this book suggests is that the accomplishments of colonial Iberian science – those that enabled advancement for some and those that ensured the dehumanization of others – have not necessarily been erased from the historical record. Instead, some of these principles were translated for a new community of readers, creating in the process a multilingual, comparative palimpsest of scientific and cultural thoughts and practices that emerged from a seventeenth-century archive and took on new resonance in their eighteenth- and nineteenth-century reception and reconstruction. In the translation of the colonial Iberian metallurgical technology of amalgamation into a political platform of the Anglophone enlightenment, the racialized terms of colonial science were preserved, but the intellectual sophistication and technical accomplishments of Iberian science were written over with racist anxieties and fears. I hope that a more

nuanced understanding of this process of colonial scientific translation will help scholars of the early Americas to appreciate and read the shared languages and histories of the colonial past.

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Azogue, cuyo secreto y nuevo agente que obra con tanta eficacia descubrió y redujo a práctica en el Cerro de Potosí y toda su Ribera, Don Juan del Corro y Segarra por el año de 1676 con asistencia del Licenciado Don Bartolomé González Poveda, Presidente de Charcas, que en carta de 3 junio de dicho año participó los admirables efectos experimentados al Señor Virrey del Perú y remitió testimonio de autos y tanto de la instrucción que es la siguiente: forma del nuevo beneficio de metales de plata por el Capitán Juan del Corro (Lima: s.n., 1676).

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Zulawski, Ann. “Wages, Ore Sharing, and Peasant Agriculture: Labour in Oruro’s Silver Mines, 1607-1720,” in Bakewell, ed., pp. 199-224.

---. “Social Differentiation, Gender, and Ethnicity: Urban Indian Women in Bolivia, 1640-1725.” *Latin American Research Review* 25.2 (1990): 93-114.

Zwierlein, Anne-Julia. *Majestick Milton: British Imperial Expansion and Transformations of Paradise Lost, 1667-1837* (Münster and New Brunswick, N.J.: Lit Verlag and Transaction Publishers for Rutgers University, 2001).

[1] Bakewell, *Silver and Entrepreneurship in Seventeenth-Century Potosí: The Life and Times of Anthony López de Quiroga* (Albuquerque: University of New Mexico Press, 1988), pp. 23-24, and *Mines of Silver and Gold in the Americas* (Aldershot, Hampshire, Great Britain and Brookfield, V.T.: Variorum, 1997), p. xvii. On the tradition of misogynistic thought and language in commercialized and artisanal mining, see Kuntala Lahiri-Dutt and Martha MacIntyre, *Women Miners in Developing Countries: Pit Women and Others* (Aldershot, England and Burlington, VT: Ashgate, 2006). On the tradition of reading colonial Latin American mining and metallurgy as backwards, exploitative, and resistant to technological progress, see Alan K. Craig, "Spanish Colonial Silver Beneficiation at Potosí," in *In Quest of Mineral Wealth: Aboriginal and Colonial Mining and Metallurgy in Spanish America*, ed. Craig and Robert C. West (Baton Rouge: Geoscience Publications Dept. of Geography and Anthropology Louisiana State University, 1994), pp. 271-285, Margaret Rich Greer, Walter Mignolo and Maureen Quilligan, eds., *Rereading the Black Legend: The Discourses of Religious and Racial Difference in the Renaissance Empire* (Chicago: University of Chicago Press, 2007), and Bakewell, *Silver and Entrepreneurship*.

[2] Consider for example Jefferson's response to Antonio de Ulloa (1716-1795), in a foonoted passage in Query VI of the *Notes on the State of Virginia* (1782): "In so judicious an author as Don Ulloa, and one to whom we are indebted for the most precise information we have of South America, I did not expect to find such assertions as the following. 'Los Indios vencidos son los mas cobardes y pusilanimes que se pueden vér—se hacen inocentes, se humillan hasta el desprecio, disculpan su inconsiderado arrojo, y con las súplicas y los ruegos dán seguras pruebas de su pusilanimidad.—ó lo que refieren las historias de la Conquista, sobre sus grandes acciones, es en un sentido figurado, ó el carácter de estas gentes no es ahora según era entonces; pero lo que no tiene duda es, que las Naciones de la carácter de la parte Septentrional subsisten en la misma libertad que siempre han tenido, sin haber sido sojuzgados por algún Principe extraño, y que viven según su régimen y costumbres de toda la vida, sin que haya habido motivo para que muden de carácter; y en estos se vé lo mismo, que sucede en los del Peru, y de toda la América Meridional, reducidos, y que nunca lo han estado.' Noticias Americanas. Entretenimiento XVIII.'" Jefferson translates the extensive quotation for his Anglophone readers, glossing the main threads of the passage and contextualizing Ulloa's summary against his own reading of the native communities of North America. "Don Ulloa here admits, that the authors who have described the Indians of South Americ, before they were enslaved, had represented them as a brave people, and therefore seems to have suspected that the cowardice which he had observed in those of the present race might be the effect of subjugation. But, supposing the Indians of North America to be cowards also, he concludes the ancestors of those of South America to have been so too and therefore, that those authors have given fictions for truth. He was probably not acquainted himself with the Indians of North America, and had formed his opinion of them from hearsay. Great numbers of French, of English, and of Americans, are perfectly acquainted with these people. Had he had an opportunity of enquiring of any of these, they would have told him, that there never was an instance known of an Indian begging his life when in the power of his enemies: on the contrary, that he courts death by every possible insult and provocation. His reasoning would have been reversed thus." Jefferson concludes his own passage by imagining a conversation with Ulloa in which the Spanish surveyer is exposed to Francophone and Anglophone reports of North American Indians: "'Since the present Indian of North America is is brave and authors tell us, that the ancestors of those of South America were brave also; it must follow, that the cowardice of their descendants is the effect of subjugation and ill treatment.' For he observes, ib. 27. that 'los obrages los ariquilan por la inhumanidad con que se les trata.'" The rest of the footnote goes on to compare the findings of Ulloa with those of William Byrd II. In *The Essential Jefferson*, ed. Jean M. Yarbrough (Indianapolis, I.N.: Hackett Publishing, 2006), pp. 81-2.

[3] On the "leyenda blanca" see Olga Portuondo Zúñiga, *La Virgen de la Caridad del Cobre: Símbolo de la cubanía* (Santiago de Cuba: Editorial Oriente, 1995). On the black legend, see Greer, Mignolo, and Quilligan, *Rereading the Black Legend*.

[4] Lane, "An account of the particularities of the imployments of the English men left in Virginia by Sir Richard Greenevill under the charge of Master Ralph Lane Generall of the same, from the 17 of August 1585 until the 18 of June 1586 at which time they departed the Countrey: sent and directed to Sir Walter Raleigh" in *The Principal Navigations, Voyages, Traffiques & Discoveries of the English Nation, Made by Sea or Overland to the Remote and Farthest Distant Quarters of the Earth at Any Time Within the Compass of These 1600 Years*, ed. Richard Hakluyt (London and Toronto: J. M. Dent and Sons, [1599-

1600] 1927-28), pp. 141-162, p. 147.

[5] The hemispheric and circum-Atlantic methods of literary study and historical analysis are now well-established in both fields and have helped to create a vibrant interdisciplinary discussion. From this vast and exciting body of work, I highlight only a few contributions. For excellent discussions of the theoretical frames that inform circum-Atlantic studies of the broad landscape of early modern British arts and sciences, see Bernard Bailyn, *Atlantic History: Concept and Contours* (Cambridge, M.A.: Harvard University Press, 2005), David Armitage and Michael J. Braddick, eds., *The British Atlantic world, 1500-1800* (New York: Palgrave Macmillan, 2002), especially Armitage's model of "Three Concepts of Atlantic History," pp. 11-27, and Joseph R. Roach, *Cities of the Dead: Circum-Atlantic Performance* (New York: Columbia University Press, 1996). For studies that situate colonial science within hemispheric and circum-Atlantic networks, see Daniela Bleichmar and Peter C. Mancall, eds., *Collecting Across Cultures: Material Exchanges in the Early Modern Atlantic World* (Philadelphia: University of Pennsylvania Press, 2011), James Delbourgo and Nicholas Dew, *Science and Empire in the Atlantic World* (New York: Routledge, 2008), Jorge Cañizares-Esguerra, *Nature, Empire, and Nation: Explorations of the History of Science in the Iberian World* (Stanford, C.A.: Stanford University Press, 2006), Antonio Barrera Osorio, *Experiencing Nature: The Spanish American Empire and the Early Scientific Revolution* (Austin, TX: University of Texas Press, 2006), Londa L. Schiebinger and Claudia Swan, eds., *Colonial Botany: Science, Commerce, and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2005), Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, M.A.: Harvard University Press, 2004), Parrish, *American Curiosity: Cultures of Natural History in the Colonial British Atlantic World* (Chapel Hill: Published for the Omohundro Institute of Early American History and Culture Williamsburg Virginia by the University of North Carolina Press, 2006), and Ralph Bauer, *The Cultural Geography of Colonial American Literatures: Empire, Travel, Modernity* (Cambridge and New York: Cambridge University Press, 2003).

[6] Fernando Lims, *Brasil 500 anos: a construção do Brasil e da América Latina pela mineração* (Rio de Janeiro: CETEM, 2000). See also Kathleen Higgins's study of Minas Gerais, *"Licentious liberty" in a Brazilian Gold-Mining Region: Slavery, Gender, and Social Control in Eighteenth-Century Sabará, Minas Gerais* (University Park: Pennsylvania State University Press, 1999), A.J.R. Russell-Wood's classic contribution on gold mining, slavery, and the development of Brasil, *The Black Man in Slavery and Freedom in Colonial Brazil* (New York: St. Martin's Press, 1982).

[7] Bakewell, *Mines of Silver and Gold in the Americas*, p. xiii.

[8] Sunkel and Paz, *El subdesarrollo latinoamericano y la teoría del desarrollo* (2nd ed, México: Siglo Veintiuno, 1971); Flynn and Giráldez, "Born with a 'Silver Spoon': The Origin of World Trade in 1571" in the *Journal of World History* 6.2 (1995): 201-221.

[9] Medina's statement is transcribed in Bargalló, *La minería y la metalurgía en la américa española durante la época colonial* (México, D.F.: Fundo de Cultura Económica, 1955), pp. 117-119.

[10] Bakewell, *Miners of the Red Mountain: Indian Labor in Potosi, 1545-1650* (Albuquerque: University of New Mexico Press, 1984) and *Silver Mining and Society in Colonial Mexico: Zacatecas, 1546-1700* (Cambridge: Cambridge University Press, 1971); Bargalló *La minería y la metalurgia* and *La amalgamación de los minerales de plata en hispanoamérica colonial* (México, D.F.: Compañía Fundidora de Fierro y Acero de Monterrey, 1969); Manuel Castillo Martos, *Minería y metalurgia: intercambio tecnológico y cultural entre América y Europa durante el período colonial español* (Sevilla: Muñoz Moya y Montraveta Editores, 1994), *Bartolomé de Medina y el siglo XVI* (Santander: Servicio de Publicaciones de la Universidad de Cantabria, 2006); Julio Sánchez Gómez *De minería, metalúrgica y comercio de metales: la minería no férrica en el Reino de Castilla, 1450-1610, vol. I* (Salamanca: Universidad de Salamanca, 1989) and *Minería y metalurgia en la edad moderna*. Madrid: Ediciones Akal, 1997.

[11] Menard, "Colonial America's Mestizo Agriculture" in *The Economy of Early America*, ed. Cathy Matson (University Park, P.A.: Pennsylvania State University Press, 2006), pp. 107-123 and Walsh, "Peopling, Producing, and Consuming in Early British America," in Matson, pp. 124-145.

[12] On New England, see White, *The Planters Plea, or The Grounds of Plantations Examined and the Usual Objections Answered, Together with a manifestation of the causes mooving such as have lately undertaken a Plantation in New-England: For the satisfaction of those that question the lawfulnesse of the Action* (London: William Jones, M. Flesher, and J. Dawson, 1630), and Brian Donahue, *The Great Meadow: Farmers and the Land in Colonial Concord* (New Haven, C.T.: Yale University Press, 2004). On rice cultivation in South Carolina, see Joyce Chaplin, *An Anxious Pursuit: Agricultural Innovation and*

Modernity in the Lower South, 1730-1815 (Chapel Hill, University of North Carolina Press, 1993). On the Chesapeake, see Walsh, Menard, and Lois Green Carr, *Robert Cole's World: Agriculture and Society in Early Colonial Maryland* (Chapel Hill, University of North Carolina Press, 1991).

[13] Platt, *The Jewell House of Art and Nature. Conteining diuers rare and profitable Inuentions, together with sundry new experimentes in the Art of Husbandry, Distillation, and Moulding. Faithfully and familiarly set downe, according to the Authors owne experience, by Hugh Platte, of Lincolnes Inne Gentleman* (Amsterdam [London]: Theatrum Orbis Terrarum and W. J. Johnson [Peter Short], 1979 [1594]); Markham, *The Booke of the English Husbandman. Contayning the Ordering of the Kitchen-garden, and the Planting of Strange Flowers: The Breeding of All Manner of Cattell. Together with the Cures, the Feeding of Cattell, the Ordering Both of Pastures, and Meddow-ground: With the Use Both of High Wood, and Underwood. Whereunto Is Added a Treatise, Called Good Mens Recreation: Contayning a Discourse of the Generall Art of Fishing, Together with the Choyce, Ordering, Breeding, and Dyeting of the Fighting-cocke* (London: John Norton for William Sheares, 1635). Carolyn Merchant's intervention in feminist history of science, *Death of Nature*, made this argument in a way that dramatically shaped the field.

[14] Hartlib, *Reformed Virginian Silkworm; or A rare and new discovery of a speedy way, and easy means, found out by a young Lady in England, she having made full proof thereof in May, anno 1652* (London: John Streater for Giles Calvert, 1655), p. 24 and 25.

[15] The historiography is aptly summarized by Stepanie Merrim in *Early Modern Women's Writing and Sor Juana Inés De La Cruz* (Nashville: Vanderbilt University Press, 1999), which also writes against the exceptionalist vein by situating Sor Juana's work within the broader context of seventeenth-century Francophone, Hispanophone, and Anglophone women's writing throughout the circum-Atlantic world. Sor Juana, *The answer/La Respuesta: Including a Selection of Poems*, ed. Electa Arenal and Amanda Powell (New York: Feminist Press at the City University of New York, [1691] 1994), par. 28, ll.713-726.

[16] The meticulous work of Rosa Perelmuter represents one such entry into this project. See for instance her *Los limites de la femineidad en Sor Juana Inés de la Cruz: Estrategias retóricas y recepción literario* (Pamplona y Madrid: Universidad de Navarra e Iberoamericana, 2004), especially chapter three, "Filosofías de cocina." Bradstreet, *The Tenth Muse Lately Sprung up in America, or, Severall Poems Compiled with Great Variety of Wit and Learning, Full of Delight: Wherein Especially Is Contained a Compleat Discourse and Description of the Four Elements, Constitutions, Ages of Man, Seasons of the Year: Together with an Exact Epitomie of the Four Monarchies, Viz., the Assyrian, Persian, Grecian, Roman: Also a Dialogue Between Old England and New Concerning the Late Troubles: with Divers Other Pleasant and Serious Poems* (London: Stephen Bowtell, 1650), EEBO; Taylor, "Meditation II.72," *Edward Taylor's Gods Determinations and Preparatory Meditations: A Critical Edition*, ed. Daniel Patterson (Kent, O.H.: Kent State University Press, 2003), l. 1.

[17] Hanke, Lewis, ed., *Do the Americas Have a Common History: A Critique of the Bolton Theory* (New York: Knopf, 1964) and Gustavo Pérez Firmat, ed., *Do the Americas Have a Common Literature?* (Durham, N.C.: Duke University Press, 1990). The comparative hemispheric approach to early American history began, perhaps, with Herbert Eugene Bolton's teaching and research at Stanford University, reproduced in *History of the Americas; a Syllabus with Maps* (Boston: Ginn, 1928). The place of Bolton in comparative early American scholarship is traced in Russell M. Magnaghi's edited volume, *Herbert E. Bolton and the Historiography of the Americas* (Westport, C.T.: Greenwood Publishing Group, 1998).

[18] Little, "Transforming Work: Protestantism and the Piers Plowman Tradition" in *Journal of Medieval and Early Modern Studies* 40.3 (2010): 497 -526, p. 499; Elliott, *Empires of the Atlantic World: Britain and Spain in America, 1492-1830* (New Haven, C.T.: Yale University Press, 2006), p. 9-10. In his discussion of tobacco, monoculture plantation economies, and slavery, Elliott provides another helpful comparison of English and Spanish ideas of colonial planting (106).

[19] Seed, *American Pentimento: The Invention of Indians and the Pursuit of Riches* (Minneapolis: University of Minnesota Press, 2001); Benton, *Law and Colonial Cultures: Legal Regimes in World History, 1400-1900* (Cambridge: Cambridge University Press, 2002); Watson, *Slave Law in the Americas* (Athens: University of Georgia Press, 1989).

[20] Escalona y Agüero, *Gazophilativm regivm prevbicvm* (Sevilla: Antonio Gonzalez Reyes, sumptibus Gabrielis de Leon, 1675), p. 197.

[21] For comparative sociological and historical studies that emphasize the differences within the early Americas, see James Lang, *Conquest and Commerce: Spain and England in the Americas* (New York:

Academic Press, 1975) and Patricia Seed, *Ceremonies of Possession in Europe's Conquest of the New World, 1492-1640* (Cambridge: Cambridge University Press, 1995). For studies that find more similarities than differences in early American colonial settlements, see Elliott, *Empires of the Atlantic World*, Cañizares Esguerra, *Puritan Conquistadors: Iberianizing the Atlantic, 1550-1700* (Stanford, C.A.: Stanford University Press, 2006), and Bauer, *Cultural Geography*.

[22] Luis Capoche, *Relación general de la Villa Imperial de Potosí* in *Relaciones historico-literarias de la América meridional*, ed. Lewis Hanke and Gunnar L. Mendoza (Madrid: Atlas, 1959 [1585]), 9-220, pp. 102, 106; Florian Téreygeol and Celia Castro, "La metalurgia prehispánica de la plata en Potosí" in *Mina y metalurgia en los Andes del sur: Desde la época prehispánica hasta el siglo XVII*, ed. Pablo José Cruz and Jean-Joinville Vacher (La Paz: Institut de Recherche pour le Développement e Instituto Francés de Estudios Andinos, 2008), 11-28. Modesto Bargalló, *La amalgamación de los minerales de plata en hispanoamérica colonial*, pp. 60-75; Erik Ash, *Power, Knowledge, and Expertise in Elizabethan England* (Baltimore: Johns Hopkins University Press, 2004).

[23] Mignolo, *The Darker Side of the Renaissance: Literacy, Territoriality, and Colonization* (Ann Arbor, M.I.: University of Michigan Press, 2003 [1995]); Plat, *Delights for Ladies, to adorne their Persons, Tables, Closets, and Distillatories With Beavties, Banqvets, Perfumes &* Waters, ed. and intro. G.E.Fussell and Kathleen Rosemary Fussell (London: Lockwood, 1948 [Hvmfrey Lownes, 1602]), p. 92.

[24] Carlos Prieto, *Mining in the New World* (New York: McGraw-Hill, 1973), pp. 77-80.

[25] María José Bertomeou Masía, "*Los poetas y canciones del poeta Francisco Petrarcha* de Enrique Garcés. Notas sobre el *Canzionere* de Francesco Petrarca en la América del s. XVI," *Revista de literatura* XLIX.138 (2007): 449-465, 450-454. Garcés's original verse is recorded in Meléndez y Pelayo, *Antología de poetas hispanoamericanos* (Madrid, 1928), volumen 3, and the stanza quoted above is reproduced in Patricia Alegría Uria, "Juan Sobrino o la poética de la denuncia (A próposito de la crónica de Bartolomé Arzáns)" from Josefa Salmón's edited volume, *Construcción y poética del imaginario boliviano* (La Paz: Plural Editores y Asociación de Estudios Bolivianos, 2005), pp. 75-82; 76.

[26] The literature tracing Milton's influence on eighteenth- and nineteenth-century English imperial identity is compendious and ever growing. Much of the scholarship on New English receptions of Milton is summarized in Kevin P. Van Anglen, *The New England Milton: Literary Reception and Cultural Authority in the Early Republic* (University Park, P.A.: Pennsylvania State University Press, 1993). For work on the influence of Miltonic spiritual gardening in England and India, see Anne-Julia Zwierlein, *Majestick Milton: British Imperial Expansion and Transformations of Paradise Lost, 1667-1837* (Münster and New Brunswick, N.J.: Lit Verlag and Transaction Publishers for Rutgers University, 2001), esp. "The Second British Empire: Milton in India" (pp. 107-137) and "The Empire at Home: Milton, Mercantilism, and Agriculture" (pp. 245-293). The tradition of reading mining and agriculture in oppositional economic and cultural terms in Andean historiography, and Latin American history more broadly, is discussed and refuted with new archaeological evidence from Potosí by Pablo Cruz and Pascale Absi, "Cerros ardientes y *huayras* calladas. Potosí antes y durante el contacto" in *Mina y metalurgia en los Andes del sur*, pp. 91-120.

[27] See Edward Grant, *A History of Natural Philosophy: From the Ancient World to the Nineteenth Century* (Cambridge: Cambridge University Press, 2007). See also the discussion in chapter one.

[28] On pre-Inca agricultural adaptations like grinding instruments and methods, see Téreygeol and Castro, "La metalurgia prehispánica de la plata en Potosí," pp. 13-15. On large-scale agricultural estates organized to support the industrial mining and minting of silver, see Peter J. Bakewell's study of the coeval development of agricultural production in Colima, Michoacán, Guadalajara, and the D.F. with the establishment of the silver industry in Zacatecas, "Supplies and Distribution" in *Silver Mining and Society*, pp. 58-80, esp. grains, pp. 58-64.

[29] Plattes, *A Discovery of Subterraneall Treasure Viz. of All Manner of Mines and Mineralls, from the Gold to the Coale; with Plaine Directions and Rules for the Finding of Them in All Kingdoms and Countries. And Also the Art of Melting, Refining, and Assaying of Them Is Plainly Declared, so That Every Ordinary Man, That Is Indifferently Capacious, May with Small Change Presently Try the Value of Such Oares as Shall Be Found Either by Rule or by Accident. Whereunto Is Added a Reall Experiment Whereby Every Ignorant Man May Presently Try Whether Any Peece of Gold That Shal Come to His Hands Be True or Connterfeit [sic] ... Also a Perfect Way to Try What Colour Any Berry, Leafe, Flower, Stalke, Root, Fruit, Seed, Barke, or Wood Will Give: With a Perfect Way to Make Colours That They Shall Not Stayne nor Fade Like Ordinary Colours* (London : I. Okes, for Iasper Emery, 1638), p. B4r. EEBO.

[30] Archivos y Bibliotecas Nacionales de Bolivia, Audiencia de La Plata, Minas 10.4 (24/9/1642, Potosí, 14

ff), 3, 5v.

[31] Wulf, *Founding Gardeners: The Revolutionary Generation, Nature, and the Shaping of the American Nation* (New York: Knopf, 2011), p. 4.

[32] On the popular frame of polarity or oppositional thinking, Giffin pointedly asks, "Who has not heard of English and Spanish colonization referred to in terms of polarity? The Spanish conquistadores took possession of these countries in a spirit of glory, moved by an immense greed for gold and with the conviction that they were engaged in the work of true evangelization when they subjected the New World natives and brought them, by whatever means, to the Roman Catholic religion. In contrast, the English lacked the eagerness to rule and came to America to escape economic difficulties, to build homes in the New World; or they came to practice their brand of sectarian Protestantism without being molested by the authorities of the mother country. This contrasting of motives has been utilized for various ends: to exalt the prodigious feats of the Spanish conquistadores, unequaled by their English contemporaries, and also to denigrate them, charging them with cruelty and an absence of morality, and sociability, and industry to work, the supposed characteristics of English colonists." See Griffin, "Unity and Variety in American History" in *Do the Americas Have a Common History?* pp. 250-269; p. 256, and Griffin's discussion of periodization, "Problems of the National Period," pp. 202-211 in the same volume.

[33] For primary sources, see Acosta, book IV chs. 10 and 11, *Historia natural y moral de las Indias* (Madrid: Ediciones de Cultura Hispánica y Agencia Española de Cooperación Internacional, 1998 [1590]) and Luis Berrio de Montalvo, *Informes para obtener plata del azogue* ([México: En la Imprenta del Secreto del Santo Oficio, por Francisco Robledo, 1643] New York: Yale University/Clearwater Publishing Company Microfiche, 1985), esp. pp. 11-11v. Alfred Michael Hirt provides a review of the literature in *Imperial Mines and Quarries in the Roman World: Organizational Aspects, 27 BC - AD 235* (New York: Oxford University Press, 2010). Primary sources that invoke Roman imperial precedent in English agricultural letters include John White, *The Planters Plea*, and Samuel Hartlib, *The Reformed Common-wealth of Bees, Presented in Severall Letters and Observations to Sammuel Hartlib Esq.* (London: Giles Calvert,1655), EEBO. For a comprehensive review of secondary sources in antiquity through the medieval era, see P.J. Fowler, *Farming in the First Millennium AD: British Agriculture Between Julius Caesar and William the Conqueror* (Cambridge: Cambridge University Press, 2002).

[34] Here I cite only the most well-known participants in this long and nuanced scholarly debate about large, important questions of gender and science in the seventeenth century. Much of the debate centers around the formative intervention of feminist historians like Carolyn Merchant in *The Death of Nature* (San Francisco: Harper & Row, 1980). See for instance Evelyn Fox Keller, *Reflexions on Gender and Science* (New Haven, C.T.: Yale University Press, 1985) and *Secrets of Life, Secrets of Death: Essays on Language, Gender, and Science* (New York: Routledge, 1992) and Sandra Harding, *The Science Question in Feminism* (Ithaca: Cornell University Press, 1986) and *Whose Science? Whose Knowledge? Thinking from Women's Lives* (Ithaca, N.Y.: Cornell University Press, 1991). In response to their readings, historians of science offer the following interpretations of Bacon's language and habits of thought: Peter Pesic "Wrestling with Proteus: Francis Bacon and the 'Torture' of Nature" *Isis* 90.1 (1999): 81-94; and Alan Soble, "In Defense of Bacon" in *A House Built on Sand: Exposing Postmodernist Myths About Science*. (ed. Noretta Koertge, Oxford and New York: Oxford University Press, 1998), pp. 195-215, Margaret C. Jacob, "Reflections on Bruno Latour's Version of the Seventeenth Century" in *A House Built on Sand*, pp. 240-254; Margaret J. Osler, *Rethinking the Scientific Revolution* (Cambridge and New York: Cambridge University Press, 2000), Brian Vickers, "Francis Bacon, Feminist Historiography, and the Dominion of Nature," *Journal of the History of Ideas* 69.1 (2008): 117-141, and Katherine Park's response to Vickers, "'Francis Bacon, Feminist Historiography, and the Dominion of Nature,'" *Journal of the History of Ideas* 69.1 (2008): 143-146.The frame of the debate has been expanded by feminist historians of science like Londa Schiebinger in *Plants and Empire*, and *Nature's Body: Gender in the Making of Modern Science* (New Brunswick, N.J.: Rutgers University Press, 2004 [1993]).

[35] Anne Curzan, *Gender Shifts in the History of English* (Cambridge: Cambridge University Press, 2003).

[36] Klein and Sparry eds., *Materials and Expertise in Early Modern Europe: Between Market and Laboratory* (Chicago: University of Chicago Press, 2009); Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven, C.T.: Yale University Press, 2007); Schiebinger, *Plants and Empire*; Findlen and Smith, eds., *Merchants & Marvels: Commerce, Science, and Art in Early Modern Europe* (New York: Routledge, 2002).

[37] Jorge Cañizares Esguerra, "Iberian Science in the Renaissance: Ignored how Much Longer?" in

Perspectives on Science 12.1 (2004): 86-124, and Kimberly Gauderman, *Women's Lives in Colonial Quito: Gender, Law, and Economy in Spanish America* (Austin, T.X.: University of Texas Press, 2003).

[38] Parrish, *American Curiosity*; Schiebinger, *Plants and Empire* and *Nature's Body*; Hatfield, *Atlantic Virginia: Intercolonial Relations in the Seventeenth Century* (Philadelphia: University of Pennsylvania Press, 2004).

[39] Matthew C. Mirrow, *Latin American Law: A History of Private Law and Institutions in Spanish America* (Austin, T.X.: University of Texas Press, 2004) and Ricardo Donato Salvatore, Carlos Aguirre, and Gilbert Joseph, eds., *Crime and Punishment in Latin America* (Durham, N.C.: Duke University Press, 2001).

[40] ANBN CPLA 5:321-323; 2-7-1587, Potosí**,** 3 ff; Gunnar Mendoza, *Obras Completas*, vol. 1 (Sucre, Bolivia: Fundación Cultural del Banco Central de Bolivia y Archivo y Biblioteca Nacionales de Bolivia, 2005), esp. pp. 375-400.

[41] Bailyn, *The Peopling of British North America: An Introduction* (New York: Knopf, 1986); Seed, "'This island's mine': Caliban and Native Sovereignty" in *The Tempest and Its Travels*, ed. Peter Hulme and William Sherman (Philadelphia: University of Pennsylvania Press, 2000), pp. 202-211; p. 202.

[42] Fernando Ortiz, *La Virgen de la Caridad del Cobre* (La Habana: Fundación Fernando Ortiz, 2008 [1928-9]); María Elena Díaz, *The Virgin, the King, and the Royal Slaves of El Cobre: Negotiating Freedom in Colonial Cuba, 1670-1780* (Stanford, C.A.: Stanford University Press, 2000); Olga Portuondo Zúñiga, *La Virgen de la Caridad del Cobre*.

[43] Montesinos, *Anales del Perú* [1639?/1840] ed. Víctor M. Maurtua, (Madrid, Gabriel L. y del Horno, 1906), p. 50.

[44] The memorable turn of phrase is from the governor Juan del Pino Manrique de Lara as recorded in Arzáns de Orsúa y Vela's *Historia de la villa imperial de Potosí*, ed. Lewis Hanke and Gunnar Mendoza (Providence, R.I.: Brown University Press, 1965 [1737]), 3 vols; I.cxxxi.

[45] Fray Reginaldo de Lizárraga, *Descripción breve de toda la tierra del Perú, Tucumán, Rio de la Plata y Chile* (1603), lib. I, cap. Cii; qtd in Bargalló, *La amalgamación de los minerales de plata en hispanoamérica colonial*, p. 226; Barba, *Arte de los metales*, p. 65.

[46] Chaplin, *Subject Matter: Technology, the Body, and Science on the Anglo-American Frontier, 1500-1676* (Cambridge, M.A.: Harvard University Press, 2001), p. 10.

[47] The merits of comparative treatment of the histories and literary histories of the Americas have been the subject of a large and impressively detailed body of work. Some of the earliest threads are summarized in Lewis Hanke's edited volume, *Do the Americas Have a Common History?* See also Lang, *Conquest and Commerce*, and Seed, *Ceremonies of Possession* and *American Pentimento*.

[48] See for instance Jack P. Greene, *Interpreting Early America: Historiographical Essays* (Charlottesville, V.A.: University Press of Virginia, 1996), John Huxtable Elliott, *Empires of the Atlantic World*, Bauer, *Cultural Geography*, and Cañizares Esguerra, *Puritan Conquistadors*.

[49] Cedric Errol Gregory, *A Concise History of Mining* (2nd ed. Lisse [The Netherlands]: A.A. Balkema, 2001).

[50] Gifford, "Unity and Variety in American History" in *Do the Americas Have a Common History?* pp. 250-269.

[51] These distinctions, which in turn follow the English and Spanish apologists who insisted that they were unlike their rivals, were reinforced by the binary frames of difference among Protestants and Catholics and North and South. New work in early modern religious studies has helped to show that the borders between Protestant and Catholic thought and practice were far more porous than the tradition of oppositional thinking would suggest. SeeKatherine Little, "Transforming Work." Hemispheric and circum-Atlantic studies have helped to make similar points about the integrative exchanges along political, cultural, and scientific lines. For scholarship of the Atlantic world, see Bernard Bailyn, *Atlantic History*, David Armitage and Michael J. Braddick, eds., *The British Atlantic World, 1500-1800*, especially Armitage's model of "Three Concepts of Atlantic History," pp. 11-27, and Joseph Roach, *Cities of the Dead*. For hemispheric science studies, see Daniela Bleichmar and Peter C. Mancall, eds., *Collecting Across Cultures*, James Delbourgo and Nicholas Dew, eds., *Science and Empire in the Atlantic World*, Jorge Cañizares-Esguerra, *Nature, Empire, and Nation: Explorations of the History of Science in the Iberian World* (Stanford, C.A.: Stanford University Press, 2006), Antonio Barrera Osorio, *Experiencing Nature*, Londa L. Schiebinger and Claudia Swan, eds., *Colonial Botany*, Schiebinger, *Plants and Empire*, Susan Scott Parrish, *American Curiosity*, and Ralph Bauer, *The Cultural Geography of Colonial American Literatures*.

[52] Lims, *Brasil 500 anos*, and Higgins, "*Licentious liberty.*" See also A.J.R. Russell-Wood, *The Black Man*

in Slavery and Freedom in Colonial Brazil (New York: St. Martin's Press, 1982).
[53] On the sheep industry in Spain, see Jason W. Moore, "'The Modern World-System' as Environmental History? Ecology and the Rise of Capitalism" *Theory and Society* 32.3 (2003): 307–377, esp. pp. 317-319. On English mineralogical industries at home and in colonial India, see Jaclyn J. Gier and Laurie Mercier, eds., *Mining Women: Gender in the Development of a Global Industry, 1670 to 2005* (New York: Palgrave Macmillan, 2006).
[54] Bakewell, "Introduction," *Mines of Silver and Gold in the Americas*, pp. xiii-xxiv; xxi-xxiii.
[55] For a discussion of early modern climate theory and eighteenth-century casta paintings – and the ways in which these colonial productions bear upon the role of nineteenth- and twentieth-century scientific enterprises in the formation of national mythologies of origin and identity – see Carlos López Beltran's excellent study, "Sangre y temperament: Pureza y mestizajes en las sociedades de castas americanas" the volume co-edited with Frida Gorbach, *Saberes locales: Ensayos sobre historia de la ciencia en América Latina* (Zamora, Michoacán: Centro Público de Investigación del Colegio de Michoacán, 2008), pp. 289-342. See also Marie Magali Carrera, *Imagining Identity in New Spain: Race, Lineage, and the Colonial Body in Portraiture and Casta Paintings* (Austin: University of Texas Press, 2003).
[56] Grant, *History of Natural Philosophy*, p. 324.
[57] Grant, *History of Natural Philosophy*, pp. 143-146. For a more extensive discussion of what he calls the "legal fiction of the corporation," see chapter seven, "Natural Philosophy after the Translations: Its Role and Place in the Late Middle Ages," pp. 143-178.
[58] The example is discussed by Ann Blair, "Natural History" in *The Cambridge History of Science* (ed. Katharine Park and Lorraine Datson, vol. 3, Cambridge: Cambridge University Press, 2003), pp. 365-406.
[59] On scientific and biocultural borrowing, see Cañizares Esguerra *Nature, Empire, and Nation*, Sean X. Goudie, *Creole America* (Philadelphia, P.A.: University of Pennsylvania Press, 2006), Felipe Fernández Armesto, *The Americas: A Hemispheric History* (New York: Modern Library, 2003), especially the discussion of agricultural products like tobacco, peanuts, potatoes, and tomatoes, pp. 83-97, and Alfred Crosby's classic study, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, C.T.: Greenwood, 1982). On legal codes, see Benton, *Law and Colonial Cultures.* On political and cultural borrowings, see Elliott, *Empires of the Atlantic*, and Bauer, *Cultural Geography*.
[60] Grant, *History of Natural Philosophy*; ch. 2, "Aristotle," pp. 27-51, and ch. 7, "Natural Philosophy after the Translations," pp. 153-156. See also Grant's "Aristotelianism and the Longevity of the Medieval World View" *History of Science* 16 (1978): 93-106. For the influence of Aristotelian natural philosophy through the early modern period, see G.R. Lloyd, *Aristotle: The Growth and Structure of His Thought* (Cambridge: Cambridge University Press, 1968), Don Bates (ed.), *Knowledge and the Scholarly Medical Traditions* (Cambridge: Cambridge University Press, 1995), Carmen Salazar Soler, "'Plinio historiador de entonces, profeta de ahora': La antigüedad y las ciencias de la tierra en el virreinato del Perú (Siglo XVI e inicios del XVII)" in *La formación de la cultura virreinal: La etapa inicial*, ed. Karl Kohut and Sonia V. Rose (Frankfurt am Main y Madrid: Vervuert Verlag e Iberoamericana, 2000), pp. 345-73, and Daniel Garber, "Physics and Foundations" in *Early Modern Science* (ed. Katharine Park & Lorraine Daston. Vol. 3. Cambridge: Cambridge University Press, 2006), pp. 21–69. Cambridge History of Science.
[61] Montgomery, *Science in Translation: Movements of Knowledge Through Cultures and Time* (Chicago: University of Chicago Press, 2000), p. 9, 183. On the making of natural historical and natural philosophical texts, see Adrian Johns, "Natural History as Print Culture," in *Cultures of Natural History: from Curiosity to Crisis* (ed. Nicolas Jardine, James A. Secord, and Emma Spary, Cambridge: Cambridge University Press, 1996), 106-24.
[62] Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1970), p. 10. On Empedoclean root theory, see M.R. Wright, *Empedocles: The Extant Fragments* ([New Haven, C.T.: Yale University Press, 1981] Indianapolis, I.N.: Hackett, 1995).
[63] Cook, "Medicine" in *Early Modern Science* (ed. Park and Datson), pp. 407-434; 410.
[64] Blagrave, *Ephermis*, p. 8. The full title of the book of astrological predictions reads: *Blagrave's Ephemeris for the Year 1659 with Observations on every Month, and Predictions of a great Monarch now rising, who shall, before seven years are expired, wholly subdue Antichrist, and extend his Dominions into the most considerable places of the World. Together with a Descrption of his Person, Age, and Place of Birth; with the Time when he shall begin this great Work. Likewise the Amity and Enmity of the Planets unto each other, during their Orbs or Rayes: And choice times for visiting of Friends, whether Male or Female, with success. Also the Time and manner of curing Diseases by Sympathy and Antipathy. Rules for*

Husbandry; dayly Predictions of the Weather; and many other Things beneficial for Physitians and Young Students. Calculated for the Meridian of London, by Joseph Blagrave of Reading, Gent. Student in Astrologie and Pysick (London: J.C. for the Company of Stationers, 1658). EEBO.

[65] Boate, "Annotations upon the Legacy of Husbandry" in Hartlib's *Legacy* (1655), pp. 118-132, pp. 129, 130; Child, "An Answer to the Animadversor on the Letter to Mr. Samuel Hartlib of Husbandry," pp. 132-172; pp. 159, 169. Both documents are included in *Samuel Hartlib His Legacy of Husbandry: Wherein Are Bequeathed to the Common-wealth of England, Not Onely Braband, and Flanders, but Also Many More Outlandish and Domestick Experiments and Secrets (of Gabriel Plats and Others) Never Heretofore Divulged in Reference to Universal Husbandry: With a Table Shewing the General Contents or Sections of the Several Augmentations and Enriching Enlargements in This Third Edition* (London: J.M. for Richard Wodnothe, 1655).

[66] Gender, Holyoak, and Kokinov, eds., *The Analogical Mind: Perspectives from Cognitive Science* (Cambridge, M.A.: Massachusetts Institute of Technology Press, 2001). Their discussion of the complexities of analogical thinking contrast the more dismissive reading offered by Foucault in *The Order of Things*: *An Archaeology of the Human Sciences* (London: Routledge, 2001), p. 33.

[67] Diogenes, *Lives, Opinions, and Remarkable Sayings of the Most Famous Ancient Philosophers* (London: Edward Brewster, 1688). Available from EEBO. A bilingual Greek-Latin edition of Diogenes's philosophy circulated shortly after the Restoration (London, 1664), while early-seventeenth century English readers could enjoy William Goddard's particular take on the sympathies and antipathies of husbands and wives, printed in Holland but written in English "for all such gentlewomen as are not altogeather idle nor yet well ocupyed": *A satirycall dialogue or a sharplye-invectiue conference, betweene Allexander the great, and that truelye woman-hater Diogynes* (Dordrecht, the Netherlands: George Waters, 1616?). EEBO. The publishing of Agricola's *De re metallica* was delayed nearly 20 years by the preparation and printing of its 289 woodcut images. On the Empedoclean ideas that circulated through Erasmus, see for instances *Adages*, I.ii.20, "Aequalis aequalem delectat / Everyone loves his own age," followed by I.ii.21, "Simile gaudet simili / Like rejoices in like." Interestingly, Erasmus's only examples of providential concord in I.ii.22, "Semper similem ducit deus ad similem / God always leads like to like," come from pagan rather than Christian writers. Geohumoral theories are the subject of a large and informative body of work in history and literary studies. Two of these foundational works include Antonello Gerbi, *Nature in the New World: From Christopher Columbus to Gonzalo Fernández De Oviedo* ([1972] trans. Jeremy Moyle, Pittsburgh: University of Pittsburgh Press, 1985 [1975, Italian; 1978, Spanish]), and Anthony Pagden, *The Fall of Natural Man: The American Indian and the Origin of Comparative Ethnology* (Cambridge: Cambridge University Press, 1982). More recently, the question has been applied in the study of the Shakespearian stage by Mary Floyd-Wilson, *English Ethnicity and Race in Early Modern Drama* (Cambridge: Cambridge University Press, 2003), and in comparative hemispheric context by Ralph Bauer, *Cultural Geography*.

[68] *De Generatione et Corruptione*, trans. Harold H. Joachim, in *The Works of Aristotle Translated into English* (Ed. W.D. Ross. Vol. II. Oxford: Clarendon Press, 1922), 333a: 30-31, 322b: 30-33.

[69] Bacon, *The Instauratio Magna Part II: Novum Organum and Associated Texts* (ed. Graham Rees, Oxford: Clarendon, [1620] 2004) LX/HIr, pp. 93-4.

[70] Ibid, p. 95.

[71] The quotation is from Walter Blith's *English Improver*, in which Blith argues that this "constant opposition" is the cure for low agricultural yields: "for whatever causeth Barrennesse, be sure to provide a Soyle that will stand in constant opposition to it, and so though one waste another, and both are weakened, yet the Earth is thereby bettered." *The English Improver or a New Survey of Husbandry. Discovering to the Kingdome, That some Land, both Arrable and Pasture, may be Advanced Double or Treble; Other Land to a Five or Tenfold: And some to a Twenty fold Improvement: Yea, some now not worth above One, or Two Shillings, per Acree, be made worth Thirty, or Forty, if not more. Clearly demonstrated from Principles of sound Reason, Ingenuity, and late but most certain Reall Experiences* (London: Printed for J. Wright, 1649), p. 110. EEBO.

[72] Child, "A large Letter concerning the Defects and Remedies of English Husbandry, written to Mr. Samuel Hartlib," in Hartlib, *Legacy*, p. 33; Flavell, *Husbandry Spiritualized; or, the Heavenly Use of Earthly Things. Consisting of Many Pleasant Observations, Pertinent Applications, and Serious Reflections; and Each Chapter Concluded with a Divine and Suitable Poem; Directing Husbandmen to the Most Excellent Improvements of Their Common Employments. Whereunto Are Added, by Way of Appendix, Several Choice Occasional Meditations, Upon Birds, Trees, Flowers, Rivers, and Several Other Subjects; Fitted for the*

Help of Such as Desire to Walk with God in All Their Solitudes, and Recesses from the World (Elizabeth Town, N.J.: Shepard Kollock, 1794 [1669]), p. 89.

[73] Blagrave, *Supplement* (1674), p. 29; Worlidge (1675), p. 134, qtd. in Hillman (1710), 296, glossing Tusser (1584 [1984]), "A Lesson Where and When to Plant Good Hopyard" ll. 9-12; Markham, *Book of the English Husbandman* (1635), p. 61. Worlidge, *Systema Agriculturae, the Mystery of Husbandry Discovered Treating of the Several New and Most Advantagious Ways of Tilling, Planting, Sowing, Manuring, Ordering, Improving of All Sorts of Gardens, Orchards, Meadows, Pastures, Corn-lands, Woods & Coppices, as Also of Fruits, Corn, Grain, Pulse, New-hays, Cattle, Fowl, Beasts, Bees, Silk-worms, &c. : with an Account of the Several Instruments and Engines Used in This Profession : to Which Is Added Kalendarium Rusticum, or, The Husbandmans Monthly Directions, Also the Prognosticks of Dearth, Scarcity, Plenty, Sickness, Heat, Cold, Frost, Snow, Winds, Rain, Hail, Thunder, &c. and Dictionarium Rusticum, or, The Interpretation of Rustick Terms, the Whole Work Being of Great Use and Advantage to All That Delight in That Most Noble Practice* (London : J.C. for T. Dring, 1675). EEBO; Hillman, *Tusser Redivivus* (London, 1710), in *Five Hundred Points of Good Husbandry*, ed. Gregory Grigson (Oxford and New York: Oxford University Press, 1984).

[74] Markham, *Book of the English Husbandman*, pp. 8, 9, 10, 15, 49. The humoral readings are from Elyot, *Castel of Helthe*, Book II chapters 15 and 16 (New York, Scholars' Facsimiles & Reprints, 1937 [London, 1541]), pp. 28-30. The regional characterizations are provided by Joan Thirsk, "Farming Techniques," in *The Agrarian History of England and Wales: Vol. IV: 1500-1640*, ed. H. P. R. Finberg and Joan Thirsk (London: Cambridge University Press, 1967), pp. 161-199, p. 171. 8 vols., vol. 4.

[75] John Fitzherbert, *Booke of Husbandrie* (Theatrum Orbis Terrarum and Walter J. Johnson: Amsterdam and Norwood, N.J. [London: 1598], 1979), 1.

[76] Markham, *Book of the English Husbandman*, p. 9; Smith, *England's Improvement Reviv'd*, 1670, p. 55. The full title of this Captain John Smith's work is *England's Improvement Reviv'd in a Treatise of All Manner of Husbandry and Fishing: Digested into Six Books* (The Savoy, London: Thomas Newcomb for the author, 1670).

[77] Thirsk, "Farming Techniques" and *Agricultural Regions and Agrarian History in England, 1500-1750* (Houndmills, Basingstoke, Hampshire: Macmillan Education, 1987). On the draining of the fens, see Christopher Taylor's chapter "Fenlands" in Thirsk's edited volume, *The English Rural Landscape* (Oxford and New York: Oxford University Press, 2000), pp. 167-187. On the introduction of new species like clover to convert staple crops into marketable specialties, see David Grigg, *English Agriculture: An Historical Perspective* (Oxford and New York: Basil Blackwell, 1989) and George Edwin Fussell, *Farming Technique from Prehistoric to Modern Times* (Oxford and London: Pergamon Press, 1966).

[78] Plat, *The nevv and admirable arte of setting of corne with all the necessarie tooles and other circumstances belonging to the same: the particular titles whereof, are set downe in the page following* (London: Peter Short, 1601), EEBO, and Maxey, *A nevv instuction of plowing and setting of corne, handled in manner of a dialogue betweene a ploughman and a scholler Wherein is proued plainely that plowing and setting, is much more profitable and lesse chargeable, than plowing and sowing. By Edvvard Maxey. Gent* (London: Felix Kyngston, 1601), EEBO.

[79] Blith, *English Improver*, p. 110.

[80] Markham, *English Husbandman*, p. 97, 105, 106; Blith, *English Improver*, p. 110.

[81] White, *Planters Plea*, pp. 32-33, 82.

[82] Blagrave, *Blagrave's Supplement or Enlargement to Mr. Nich[olas] Culpeppers English physitian containing a description of the form, names, place, time, coelestial government, and virtues, all such medicinal plants as grow in England, and are omitted in his book, called, The English-physitian, and supplying the additional virtues of such plants wherein he is defective: also the description, kinds, names, place, time, nature, planetary regiment, temperature, and physical virtues of all such trees, herbs, roots, flowers, fruits, excrescencies of plants, gums, ceres, and condensate juices, as are found in any part of the world, and brought to be sold in our druggist and apothecaries shops, with their dangers and corrections. By Joseph Blagrave; to which is annexed, a new tract for the cure of wounds made by gun-shot or otherways, and remedies for the help of seamen troubled with the scurvy and other distempers* (London: Printed for Obadiah Blagrave, 1674).

[83] Blith, *English Improver*, p. 10.

[84] Blagrave, *Supplement*, 2.

[85] *The Practice of Physick, in Seventeen Several Books: Wherein is plainly set forth, the Nature, Cause,*

Differences and Several Sorts of Signs; Together with the Cure of all Diseases in the Body of Man. *By Nicholas Culpepper, Physician and Astrologer. Abdiah Cole, Doctor of Physick. And William Rowland, Physitian* (London: Peter Cole, 1655). EEBO. On Culpepper and the doctrine of signatures, see Raymond Phineas Stearns, *Science in the British Colonies of America* (Urbana, I.L. and London: University of Illinois Press, 1971), p. 16.

[86] Culpepper, *Practice of Physick*, p. 417; Blagrave, *Supplement*, p. 2.

[87] John Smith, "The Generall Historie of the Bermudas, now called Summer Iles, from their beginning in the yeere of our Lord 1593, to this present 1624, with their proceedings, accidents and present estate," book 5 of the *Generall History of Virginia, the Somer Iles, and New England* (1624) in *The Complete Works of Captain John Smith (1580-1631)*, ed. Philip L. Barbour (Chapel Hill and London: University of North Carolina Press, 1986), 3 vols, vol. 2 pp. 332-393; p. 370. Cotton Mather, *Magnalia Christi Americana: or, The Ecclesiastical History of New-England, From its First Planting in the Year 1620 Unto the Year of our Lord, 1698* ([London: Thomas Parkhurst, 1702] New York: Russell & Russell, 1967), p. 45. Sir George Peckham Knight, "A true Report of the late discoveries, and possession taken in the right of the Crowne of England of the Newfound Lands, By that valiant and worthy Gentleman, Sir Humfrey Gilbert Knight" in Hakluyt's *Principal Navigations* (London: J.M. Dent [1589-1600], 1927-1928), 10 vols; vol. 4, pp. 42-78; p.74.

[88] On grafting, see Markham's *Book of the English Husbandman*, pp. 135-7. The thinly veiled political discourse of unruly apricots and untended agricultural growth dominates the garden scene of Shakespeare's *Richard II*, where the English landscape is found "full of weeds, her fairest flowers choked up, / Her fruit trees all unpruned, her hedges ruined, / Her knots disordered, and her wholesome herbs / Swarming with caterpillars" in *The Norton Shakespeare* (ed. Stephen Greenblatt, Walter Cohen, Jean E. Howard, and Katharine Eisaman Maus, New York: W.W. Norton, 1997), 3.4.30-32, 45-48. The richly seminal language of faith and agriculture are from Flavell, *Husbandry Spiritualized*, p. 143.

[89] Child, "Large Letter," in Hartlib's *Legacy* (1655), p. 19; Plat, *Jewell House of Art and Nature*, pp. 40-1.

[90] Child, "An Answer to the Animadversor on the Letter to Mr. Samuel Hartlib or Husbandry," pp. 140-1; Boate, "Annotations upon the Legacy of Husbandry" (pp. 118-132), p. 119, both in Hartlib's *Legacy* (1655).

[91] Boyle, *Experiments and Considerations Touching Colours First Occasionally Written, Among Some Other Essays to a Friend, and Now Suffer'd to Come Abroad as the Beginning of an Experimental History of Colours* (London: Henry Herringman, 1664), EEBO, pp. 121, 161, 163-5.

[92] White, *Planters Plea*, pp. 25, 20. On the substantial contributions of Dutch engineers to the draining of the fenlands and the irrigation systems of the region, see Christopher Taylor, "Fenlands," pp. 169-170, on the differences between fens and marshes. On the moorlands, see David Hey's chapter, "Moorlands," in the same volume, pp. 188-207. On the farming practices and instruments necessary to cultivate the fenlands and the moorlands, see G.E. Fussell, *Farming Techniques*, esp. pp. 106-7.

[93] Calvin, *Institutes of the Christian Religion*, Rev. ed. Trans. Ford Lewis Battles (London: Collins and W.B. Eerdmans, 1986 [1536]), Book 1.5: 1.4.1.

[94] Milton, *Paradise Lost: An Authoritative Text, Backgrounds and Sources, Criticism*, ed. Scott Elledge (New York: Norton, 1993 [1669/1674]).

[95] Flavell, *Husbandry Spiritualized*, p. 57, 59; Blith, *English Improver*, pp. 75-76, 83, 136-7.

[96] Blith, *English Improver*, pp. 75-76.

[97] Markham, *Book of the English Husbandman*, p. 92. The full quotation reads: "although some Husbandmen in our Land, hold them to be both of one temper and goodnesse, reasoning thus, that by how much the black clay is better than the white sand, by so much the red sand is better than the white sand, so that what the mixture of the one addeth, the mixture of the other taketh away and so maketh them all in one fruitfulnesse and goodnesse: but in our common experience it do not fall out" (92). The productive value of different soils and seeds was in pitting their contrary natures against each other, inspiring quarrels and Strife "in Husbandly fashion," not in tempering the "more barraine" white sand with the fatter, more fertile red sand (92, 74).

[98] Flavell, *Husbandry Spiritualized*, p. 142.

[99] The quotation is from Pablo Neruda's *Confieso que he vivido: Memorias* (Santiago de Chile: Copesa Editorial [Fundación Pablo Neruda, 1974], 2004), p. 158. I translate it into English as "In exploring the caverns of metal hidden in the secrets of the earth … a new continent arises from the most secret matter of my poetry." All of the translations from the Spanish, in the colonial and postcolonial eras, are my own. So

too are the errors.
[100] Platt, "The Alchemy of Modernity: Alonso Barba's Copper Cauldrons and the Independence of Bolivian Metallurgy, 1790–1890" in *Journal of Latin American Studies* 32.1 (2000): 1-53; Bargalló, *La minería y la metalurgía*.
[101] Sonneschmidt's *Tratado de la amalgamación de Nueva España* was published first in Schleiz in 1804 and then in another German-language edition in Gotha in 1810. The Spanish-language version was first printed in México, DF, in 1805, and thereafter in Paris in 1825 and Madrid in 1831.
[102] The innovations of colonial Iberian mining and metallurgy are taken from Bargalló, *La minería y la metalurgía*, and *La amalgamación de los minerales de plata en hispanoamérica colonial*, Peter J. Bakewell, *Silver Mining and Society*, *Miners of the Red Mountain*, *Silver and Entrepreneurship*; Julio Sánchez Gómez, *De minería, metalúrgica y comercio de metales* and *Minería y metalurgia en la edad moderna*; Manuel Castillo Martos, *Minería y metalurgia*, *Bartolomé de Medina y el siglo XVI*, and the introduction to his edition of Luis de Berrio y Montalvo's *Informes para obtener plata y azogue en el mundo hispánico* (Granada: Universidad de Granada, 2008).
[103] Salt (NaCl) and copper (Cu) contain what Berrio de Montalvo calls "potencial," that is, the ability to elicit contrariety or opposition from a given element. They are the materials that provide the chemical spark of difference in the amalgamation method, but writers of amalgamation treatises underscore the role of mercury as an agent of sameness rather than salt crystals or copper solutions as properties of difference.
[104] Bargalló, *Minería*, chapter 10, pp. 127-128; Bakewell, *Miners of the Red Mountain*, chapter one.
[105] On the rise of Iberian-owned amalgamation refineries and the contraction of the indigenous-owned networks of refiners in Alto Perú, see Bakewell's introduction to *Silver and Entrepreneurship in Seventeenth-Century Potosí*. On the *pepena* system and *naboría* workers in New Spain, see Bakewell, *Silver Mining and Society*, ch. 8.
[106] Bakewell, *Miners of the Red Mountain*, ch. 1, and Moore, "The Modern World-System' as Environmental History?", p. 336, citing Bakewell's chapter-length piece, "Mining" in *Colonial Spanish America*, ed. L. Bethell (Cambridge: Cambridge Univ. Press, 1987), pp. 203-249.
[107] Biringuccio, *The Pirotechnia* (trans. and ed. Cyril Stanley Smith and Martha Teach Gnudi, Cambridge, M.A.: Massachusetts Institute of Technology Press, 1966 [1540]), I.iv, p. 58.
[108] Agricola, *De re metallica* (trans. and ed. Herbert Hoover and Lou Henry Hoover, New York: Dover Publications, 1950 [1556/1912]), fn1p47; Biringuccio, *Pirotechnica*, II.x, p. 115).
[109] Barba, *Arte de los Metales en qve se enseña el veradero beneficio de los de oro, y plata por açogue. El modo de fvndirlos todos, y como se han de refinar, y apartar unos de otros. Compvesto por el licenciado Albaro Alonso Barba, natural de la villa de Lepe, en la Andaluzia, cura en la Imperial de Potosi, de la Parroquia de S. Bernardo* (La Paz: Impresión artística, 1939 [1640]), pp. 100-101.
[110] Barba, *Arte de los metales*, *58.*
[111] Foucault, *The Order of Things*, p. 20.
[112] Barba, *Arte de los metales*, p. 73, 84.
[113] Cárdenas, *Problemas y secretos maravillosos de las Indias* (Madrid: Alianza Editorial, 1988 [1591]), p. 117. The quotations that follow come from pp. 118-121, where a variation of the word "amistad" or "abrazar" appears in almost every sentence.
[114] Cárdenas, *Problemas y secretos maravillosos de las Indias*, p. 119.
[115] Cañizares Esguerra, "Iberian Science in the Renaissance," p. 97.
[116] Barba, *Arte de los metales*, pp. 107-8.
[117] Sandoval y Guzman, *Pretensiones de la villa imperial de Potosi, propuestas en el Real Consejo de las Indias* (Madrid: por la viuda de Juan Gonçalez, 1634), p. 43r.
[118] Bargalló, *La amalgamación*, p. 221.
[119] The memorable turn of phrase, analogized through the mineral wealth of the Indies, arrives at the end of Dorotea's impassioned monologue on the limits of friendship and the boredom that befalls long-term romantic relationships. *La Dorotea*, ed. Edwin S. Morby (Madrid: Castalia, 1968 [1632]), I.iii.
[120] *Arte de los metales*, 68-69, 73-74; A. Loman y Medina (1556) in Bargalló, *La amalgamación*, p. 86.
[121] One colonial official at the turn of the seventeenth century remarked that the lack of a sound method for treating *negrillos* was an "inconviniente muy grande … porque eran muchos e no se sabe su beneficio" (ABNB CPLA 6:112; 6/11/1592 – 8/12/1592, Potosí, 1 f).
[122] Cárdenas, *Problemas y secretos maravillosos de las Indias*, p. 122; de la Mota y Escobar, *Descripción geográfica de los reinos de Nueva Galicia, Nueva Vizcaya y Nuevo León*, ed. Joaquín Ramírez Cabañas

(México, D. F.: P. Robredo, 1940 [1602]), p. 151.
[123] Barba, *Arte de los metales*, p. 38 and 56.
[124] Barba, *Arte de los metales*, p. 68.
[125] Bakewell, *Silver Mining and Society*, p. 127.
[126] Only the eighteenth-century chronicler Bartolomé Arzáns de Orsúa y Vela made a similar claim for pacos. According to Arzáns's summary of 1699, the leading refiner of the region, Antonio López de Quiroga, extracted 800 *marcos de plata* (20 *piñas* of 40 *marcos* each) from 50 *cajones* of material extracted from the Amoladera vein in the Cerro Rico of Potosí. At a time when most refiners extracted one or two ounces of silver per hundred pounds of ore, López de Quiroga processed 128 ounces of silver, enough to form three *piñas* of silver each workday (Monday-Saturday) in his refineries in the province of Machacamarca. Arzáns de Orsúa, *Historia de la Villa Imperial de Potosí*, t. 2 (1ra parte, X.XVI, p. 395; partially quoted in Bakewell, *Silver and Entrepreneurship*, p. 63).
[127] Barba, *Arte de los metales*, pp. 68-69.
[128] Arzáns de Orsúa, *Historia de la Villa imperial de Potosí*, Parte 1ª, lib. IV, cap. XVIII, qtd. in Bargalló, pp. 103-4.
[129] Barba, *Arte de los metales*, pp. 68-69, 63.
[130] Barba, *Arte de los metales*, pp. 68-69.
[131] Berrio de Montalvo, *Informes para obtener plata del azogue* ([México, 1643] New York, 1985), pp. 11-11v.
[132] Barba, *Arte de los metales*, p. 78.
[133] Ibid, p. 55.
[134] Capoche, *Relación*; Berrio de Montalvo, *Informes*; Gómez de Cervantes, *La vida económica y social de Nueva España, al finalizar el siglo XVI* ["Memorial de Gonzalo Gómez de Cervantes para el Oidor Eugenio Salazar, Oidor del Real Consejo de las Indias" 1599] ed. Alberto María Carreño (México: Antiqua librería Robredo de J. Porrúa e hijos, 1944), p. 151.
[135] Montaigne, "Of the inequality that is between us" in *The Complete Works*: *Essays, Travel Journal, Letters* (trans. Donald Frame, New York: A.A. Knopf, 2003), p. 236.
[136] MacFaul, *Male Friends in Shakespeare and His Contemporaries* (Cambridge: Cambridge University Press, 2007); Bray, *The Friend* (Chicago: University of Chicago Press, 2003); Shannon, *Sovereign Amnity: Figures of Friendship in Shakespearean Contexts* (Chicago: University of Chicago Press, 2002); Hutson, *The Usurer's Daughter: Male Friendship and Fictions of Women in Sixteenth-Century England* (London: Routledge, 1994). Literary representations of interracial friendships in eighteenth- and nineteenth-century Anglophone letters, and the possibilities and limits of friendship to allow for new modes of affective union, have been studied in fine detail by Ivy Schweitzer, Peter Coviello, and Caleb Crain. See Schweitzer, *Perfecting Friendship: Politics and Affiliation in Early American Literature* (Chapel Hill, N.C.: University of North Carolina Press, 2006), Coviello, "Agonizing Affection: Affect and Nation in Early America" in *Early American Literature* 37.3 (2002): 439-468 and the book-length study, *Intimacy in America: Dreams of Affiliation in Antebellum Literature* (Minneapolis: University of Minnesota Press, 2005), and Crain, *American Sympathy: Men, Friendship, and Literature in the New Nation* (New Haven: Yale University Press, 2001).
[137] For anthropological studies of friendship and homosociality relevant to the interests of this chapter, see for instance Stanley Brandes, *Metaphors of Masculinity: Sex and Status in Andalusian Folklore* (Philadelphia: University of Pennsylvania Press, 1980), Lionel Tiger, *Men in Groups* (New York: Boyers, 1984), from whom we have the term "male bonding," Denise Fagundes Jardim, "Espaço social e Auto-segração Entre Homens: Gostos, Sonoridades e Masculinidade, " *Cadernos de Antropologia* 7 (1992): 29-42, Marie Sautron, "La representación de la amistad entre los antigüos mexicanos: Un análisis léxico y semántico a través del corpus poético náhuatl: *Romances de los señores de la Nueva España*," *Estudios de cultura nahuatl* 31 (2000): 291-306, Matthew Gutmann's edited volume, *Changing Men and Masculinities in Latin America* (Durham, N.C.: Duke University Press, 2003) and Gutmann's literature review, "Trafficking in Men: The Anthropology of Masculinity" in *Annual Review of Anthropology* 26 (1997): 385-409. For sociological studies, see Graham A. Allen, *A Sociology of Friendship and Kinship* (London: G. Allen & Unwin, 1979) and Allen's volume co-edited with Rebecca G. Adams, *Placing Friendships in Context* (Cambridge: Cambridge University Press, 1998).
[138] See for instance Parrish, "Diasporic African Sources of Enlightenment Knowledge" in Delbourgo and Dew, eds., pp. 281-310, and the book-length project, *American Curiosity*; Chaplin, *Subject Matter*, and

"Knowing the Ocean: Benjamin Franklin and the Circulation of Atlantic Knowledge" in Delbourgo and Dew, pp. 73-96; and Walter Woodward, *Prospero's America: John Winthrop, Jr., Alchemy, and the Creation of New England Culture, 1606-1676* (Chapel Hill: Published for the Omohundro Institute of Early American History and Culture by the University of North Carolina Press, 2010).

[139] For an account of collaborative networks in colonial Iberian sciences, see Antonio Barrera Osorio, "Empiricism in the Spanish Atlantic World" in Delbourgo and Dew, pp. 177-202 and "Experts, Nature, and the Making of Atlantic Empiricism" *Osiris* 25.1 (2010): 129-148.

[140] Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge* (London: Printed by T.R. for J. Martyn ... and J. Allestry, 1667), pp. 62-3. EEBO. The topic is quoted and discussed in more detail in Londa Schiebinger, *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, M.A.: Harvard University Press, 1989), p. 24.

[141] Sterns, *Science in the British Colonies of America* (Urbana, I.L. and London: University of Illinois Press, 1971), pp. 226. See also *Colonial Fellows of the Royal Society of London, 1661-1788.* [Brugis: Sanctae Catharinae, 1948].

[142] On island ecology, see Lawrence R. Waler and Peter Bellingham, *Island Environments in a Changing World* (Cambridge: Cambridge University Press, 2011). On the physical and cultural transformations of the landscape of Jamaica in the staggered arrivals of tribes from the Orinoco basin, Spain, and England, see for instance Sheryl Luzzadder-Beach and Tim Beach, "Wetlands as the Intersection of Soils, Water, and Indigenous Human Society in the Americas" In *Soils and Societies: Perspectives from Environmental History*, ed. John Robert McNeill and Verena Winiwarter (Isle of Harris: White Horse Press, 2006). See also Douglas V. Armstrong, James A. Delle and Mark W. Hauser, eds., *Out of Many, One People: The Historical Archaeology of Colonial Jamaica* (Tuscaloosa: University of Alabama Press, 2011). For historical scholarship that calls for a full accounting of the English and Spanish colonizations, see the recent work of Stephan Palmié and Francisco A. Scarano, eds., *The Caribbean: A History of the Region and Its Peoples* (Chicago: University of Chicago Press, 2011) and the foundational work of Ira Berlin and Philip Morgan, *Cultivation and Culture: Labor and the Shaping of Slave Life in the Americas* (Charlottesville: University Press of Virginia, 1993).

[143] Newman, *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Chicago: University of Chicago Press, 2003), *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago: University of Chicago Press, 2006), and, with Lawrence Príncipe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2002); Irving, *Natural Science and the Origins of the British Empire* (London: Pickering & Chatto, 2008); Parrish, *American Curiosity*; Bauer, *Cultural Geography*, and "A New World of Secrets: Occult Philosophy and Local Knowledge in the Sixteenth-Century Atlantic," pp. 99-126 in Delbourgo and Dew, eds.; Woodward, *Prospero's America*.

[144] On the Hartlib circle's collaborative modes of scientific collection and production, see Mark Greengrass, Michael Leslie, and Timothy Raylor, eds., *Samuel Hartlib and Universal Reformation: Studies in IntellectualCommunication* (Cambridge and New York: Cambridge University Press, 1994), especially the selections by Newman (pp. 193-210), Richard H. Popkin (118-136), Anthony Milton (95-117), and Dagmar Čapková (75-92). See also Irving, *Origins*, and Charles Webster's edited volume, *Samuel Hartlib and the Advancement of Learning* (London: Cambridge University Press, 1970) and George Henry Turnbull, *Hartlib, Dury and Comenius; Gleanings from Hartlib's Papers* (Liverpool: University Press of Liverpool, 1947). The gender-inclusive, collaborative nature of Hartlib circle correspondence is discussed in more detail in chapter three.

[145] Important exceptions include the recent work of Antonio Barrera Osorio, "Experts, Nature, and the Making of Atlantic Empiricism" and "Empiricism in the Spanish Atlantic World," in Delbourgo and Dew, pp. 177-202.

[146] Marcus Tullius Cicero, *De Amicitia* (Westminster: William Caxton, 1481). EEBO.

[147] Castiglione, *The Book of the Courtier* (London: J.M. Dent, [1928]), 119.

[148] Burton, *The Anatomy of Melancholy*, 3. vols. (London: J.M. Dent, [1932]), 3:22.

[149] Dury, *A Motion Tending to the Public Good*, 1642, from a letter to "Sir C," dated 13 January 1641, in response to Cheny Culpepper's letter of 9 January, 1641. The document is reprinted in Charles Webster, *Samuel Hartlib and the Advancement of Learning* (Cambridge: Cambridge University Press, 1970), p. 107.

[150] Montaigne, "Of friendship," in *Complete Works*, p. 167.

[151] See chapter 1, fn40.

[152] The quotation is from Potosí mine owner Juan de Solórzano Pereira's legal compilation, *Política Indiana* (Madrid: Fundación José Antonio de Castro, 1996 [1647]), vol. 1, 2 vols; Book II.XVI.41 p. 382, following his gloss of More's *Utopia* in section 17 (p. 377).
[153] Aristotle, *Ethica Nicomachea* (ed. William David Ross, London: Oxford University Press, 1931), 1169b-1171a.
[154] Aristotle, *Politics. Books I and II* (ed. Trevor J. Saunders, Oxford: Clarendon Press , 1995), 1252a26-31, 1252a34.There are many fine studies of Sepúlveda's debate with Bartolomé de las Casas (1474-1566). For a detailed discussion of the debate, and the suitability of a pagan text to stand as moral or ethical authority within a Christian imperial worldview, see Anthony Pagden, *The Fall of Natural Man*, especially ch. 3, "The Theory of Natural Slavery" and David A. Lupher, *Romans in a New World: Classical Models in Sixteenth-Century Spanish America* (Ann Arbor: University of Michigan Press, 2003), especially ch. 3, "The Model of Roman Imperialism in the Controversy of the Indies, Second Phase: Las Casas versus Sepúlveda." See also the foundational work of Lewis Hanke, *All Mankind Is One; a Study of the Disputation Between Bartolomé de Las Casas and Juan Ginés de Sepúlveda in 1550 on the Intellectual and Religious Capacity of the American Indians* (DeKalb, I.L.: Northern Illinois University Press, 1974).
[155] See for instance the argument in the *Essay for the Advancement of Husbandry*: "Thus when a man lends to another *politically* as a meer man, he requires *bills, bonds, morgages*, or the like. But if he gives, he doth not so, neither if he lend to the Poor, or to persons so just that he esteems their word sufficient" (14). The passage is included in a response to Hartlib's proposal for a college of husbandry, the second to last letter printed in the 1651 edition of the *Essay for Advancement of Husbandry-Learning: Or, Propositions for the Erecting College of Husbandry: And In order thereunto, for the taking in of Pupills or Apprentices and also Friends or Fellowes of the same Colledge or Society* (London: Henry Hills). EEBO.
[156] Aristotle, *Ethics*, 1161a.
[157] Aristotle, *Politics*, 1254b27-30 and 1255b10-13.
[158] Acosta, *Historia natural y moral de las Indias*, p. 242-3. Acosta describes his experience in the "perpetua obscuridad, sin saber poco ni mucho cuándo es día ni cuándo es noche; y como son lugares que nunca los visita el sol, no sólo hay perpetuas tinieblas, raleza humana, y así sucede marearse los que allá entran de nuevo, como a mí me acaeció, sintiendo vascas y congojas de estómago."
[159] The legacy of women's work as sorters continues in present-day Bolivian mining and metallurgy, where in addition to their work as *palliris*, women work as drillers (*perforistas*) and pre-drillers (*limpiadoras*), washers (*lameras y relaveras*), some of whom specialize in recovery from slag piles (*desmontes*) or in capturing mineral deposits from muddy water (*barranquilleras*). See *Warmi mineral y copajira: imagines y testimonies de mujeres mineras, memoria de mujeres mineras en diez cooperativas* (La Paz: Ministerio de Desarrollo Sostenible, 2005).
[160] Barba, *Arte de los metales*, p. 69.
[161] On the hazardous health conditions and environmental effects, see Kendall Brown's study of the mercury mine of Huancavélica, "Workers' Health and Colonial Mercury Mining at Huancavelica, Peru" in *The Americas* 57.4 (2001): 469-496.
[162] Capoche, *Relación*, pp.9-220, p 117; Agia, *Servidumbres personales de indios* (Sevilla [Lima]: Escuela de Estudios Hispanoamericanos [Antonio Ricardos, 1604], 1946. Based on the text of AGI Indeferente General, 428, libro #32), p. 63; Brown, "Workers' Health and Colonial Mercury Mining at Huancavelica, Peru"; Studnicki-Gizbert and Schecter. "The Environmental Dynamics of a Colonial Fuel-Rush: Silver Mining and Deforestation in New Spain, 1522 to 1810," *Environmental History* 15.1 (2010): 94 –119.
[163] Agia, *Servidumbres personales de indios*, pp. 128-129. On mines classified as "despobladas" or abandoned, and female and male miners who refer to themselves in the same terms: ANBN EP 3: 546-547 (19/6/1559, Potosí), 2ff, Minas 70.7 (12/2/1686, La Plata), 6 ff, 4v, and Minas 68.2 (20/10/1676–15/12/1676, Chayanta), 90ff, p. 6. Print sources that employ these terms include the legal compilation of Gaspar de Escalona y Agüero, *Gazophilativm regivm prevbicvm*, p. 100.
[164] Agia, *Servidumbres personales de indios*, p. 104, 63.
[165] The colonial-era citations are from Capoche, *Relación*, p. 127, and the 1676 land rights dispute between the Iberian refiner doña Leonor López Maldonado against the indigenous community of Pocoata (ANBN Min-68.2; 20/10/1676/s. XVII/Chayanta – 15/12/1676/s. XVII, 90ff), 13-14v. Scholarly sources include Crespo, *Esclavos negros en Bolivia* (La Paz: Academia Nacional de Ciencias de Bolivia, 1977); Saignes, *Caciques, Tribute and Migration in the Southern Andes: Indian Society and the 17th Century Colonial Order (Audiencia De Charcas)*, trans. Paul Garner and Tristan Platt (London: University of London

Institute of Latin American Studies, 1985) and "Indian Migration and Social Change in Seventeenth-Century Charcas" in *Ethnicity, Markets, and Migration in the Andes: At the Crossroads of History and Anthropology*, ed. Brooke Larson, Olivia Harris, and Enrique Tandeter (Durham, N.C.: Duke University Press, 1995), pp. 167-223; Ximena Medinacelli, "Los Quillacas, Potosí y la sal: formas culturales de transición de un sistema de intercambio a otro mercantil" in *Mina y metalurgia en los Andes del sur: desde la época prehispánica hasta el siglo XVII*, ed. Pablo Cruz and Jean-Joinville Vacher (La Paz: Institut de Recherche pour le Développement and Instituto Francés de Estudios Andinos, 2008), pp. 279-302, pp. 282-3. On Carangas, see Pablo Cruz and Pascale Absi's chapter, "Cerros ardientes y *huayras* calladas. Potosí antes y durante el contacto," in the same volume (pp. 91-120).

[166] The quotation is from Ayzans (qtd. in Saignes p. 183). For a helpful map of ethnic groups of Southern Potosí, see p. 166 of the volume. For a study of groups from the northern region of the Department of Potosí, see Olivia Harris,"The Sources and Meanings of Money: Beyond the Market Paradigm in an *Ayllu* of Northern Potosí," pp. 297-328. For a discussion of the meaning of *ayllu* as a system of biological kinship, ethnic identification, and ceremonial obligation, see Arij Ouweneel, "The 'Collapse' of the Peruvian *Ayllu*" in *Imaging the Andes: Shifting Margins of a Marginal World* (ed. Ton Salman & E. B Zoomers, Amsterdam: Aksant, 2003), pp. 81-98.

[167] The literature on the Basque-Spanish conflict is immense and well-summarized in Alberto R. Crespo, La *guerra entre vicuñas y vascongados, Potosí, 1622-1625* (La Paz, 1969). Perhaps the most colorful record from the colonial era remains Arzáns de Orsúa y Vela, *Historia de la villa imperial de Potosí*, tomo I, caps. XXII-XIX.

[168] Capoche, *Relación*, p. 106.

[169] Prieto, *Mining in the New World*; Lewis Hanke, "The Portuguese in Spanish America: With Special Reference to the Villa Imperial de Potosí" in *Revista de historia de América* 51 (1961): 1-48, reprinted in 1962 as a standalone text.

[170] Qtd. in Bargalló, *Minería*, p. 117.

[171] Girardin, *Leçons de chimie élémentaire appliquée aux arts industriels* (4th ed., Paris: V. Masson, 1860); Hoover and Hoover, trans. *De re metallica* (New York: Dover Publications, 1950 [1912/1556]; Grünhaldt Sisco and Smith, trans. *Treatise on Ores and Assaying* (Chicago: University of Chicago Press, 1951 [1583]); Maffei and Figueroa, *Apuntes para una biblioteca española de libros, folletos y artículos, impresos y manuscritos, relativos al conocimiento y explotación de las riquezas minerales y á las ciencias auxiliares* (Madrid: J. M. Lapuente, 1871-72), Fernández del Castillo, "Algunos documentos nuevos sobre Bartolomé de Medina" in *Memorias de la Sociedad Científica Antonio Alzate* 47 (1927): 207-251; Bargalló, *La minería y la metalurgía* and *La amalgamación*.

[172] ABNB ALP Minería 56.1 [25/10/1642 – 17/11/1642], 7 ff.

[173] Agia, *Servidumbres personales de indios*, pp. 56, 71, 76. On the two republics, see Karen Graubart, *With Our Labor and Sweat: Indigenous Women and the Formation of Colonial Society in Peru, 1550-1700* (Stanford, C.A.: Stanford University Press, 2007).

[174] de la Mota y Escobar, *Descripción geográfica*, p. 145.

[175] Agia, *Servidumbres personales de indios*, p. 64.

[176] ABNB Escritura Pública 22:156 (Potosí, 12/5/1569), 2ff; EP 24:288 (La Plata, 11/8/1573), 3ff. See also Lolita Gutiérrez Brockington, *Blacks, Indians, and Spaniards in the Eastern Andes: Reclaiming the Forgotten in Colonial Mizque, 1550-1782* (Lincoln: University of Nebraska Press, 2006).

[177] Capoche, *Relación*, pp. 150, 152.

[178] Bakewell, *Miners of the Red Mountain*, pp. 136-8, and *Silver Mining and Society*, p. 182. University Press, 1971), p

[179] de la Mota y Escobar, *Descripción geográfica*, pp. 150-1.

[180] de la Mota y Escobar, *Descripción*, p. 151.

[181] de la Mota y Escobar, *Descripción geográfica*, pp. 154, 158.

[182] See for instance Díaz, *The Virgin, the King, and the Royal Slaves of El Cobre.* See also chapter four of this book.

[183] de la Mota y Escobar, *Descripción geográfica*, p. 151, 152.

[184] Bakewell, *Silver Mining and Society*, p. 144, 126.

[185] The quotation is from the deposition of a 39-year old indigenous miner named Pedro Puma who testified in support of Beatriz de la Roca y Merlo's right to inherit the property of her deceased husband, the miner Juan de Carriazo. Carriazo was the "compadre" mentioned in Puma's testimony, which is discussed in more

detail in chapter four. ANBN Minas 145.4 (1656 – 1658, La Plata), 66 ff; 14v.

[186] On silver capitalism, mining innovations, and early modern Spanish hegemony in the global economy, see Stanley J. Stein and Barbara H Stein, *Silver, Trade, and War: Spain and America in the Making of Early Modern Europe* (Baltimore: Johns Hopkins University Press, 2000). See also the collected work of Dennis O. Flynn and Arturo Giráldez, *China and the Birth of Globalization in the 16th Century* (Farnham: Ashgate Variorum, 2010). Much of this work is informed by the archival intervention of Carlos Sempat Assadourian. See for instance *El sistema de la economía colonial: Mercado interno, regiones y espacio económico* (Lima: Instituto de Estudios Peruanos, 1982) and *Modos de producción en América Latina* (Buenos Aires: Siglo XXI, 1973).

[187] Barba and Berrio de Montalvo are perhaps the best-studied of the authors whose metallurgical writings remain extant. See the excellent work of Joseph María Barnadas, *Alvaro Alonso Barba (1569-1662): Investigaciones sobre su vida y obra* (La Paz, Bolivia: Biblioteca Minera Boliviana, 1986). On Berrio de Montalvo, the biographical introduction in Manuel Castillo Martos's facsimile edition of Berrio de Montalvo's *Informes para obtener plata y azogue en el mundo hispánico* and María Luisa Rodríguez Sala, "Tres constructores de obras científico-técnicas de minería y metalurgia en la Nueva España del siglo XVII: Luis Berrio de Montalvo, Jerónimo y Becerra y Juan del Corro" in *Anuario de estudios americanos* 57.2 (200): 631-659. The best biographical study of Capoche remains that of Lewis Hanke and Gunnar Mendoza, in their introduction to Capoche's *Relación*, pp. 9-68. On García de Llanos, see the entry in *DICTER (Diccionario de la ciencia y de la tecnología del Renaicimiento*), ed. María Jesús Mancho Duque <http://dicter.eusal.es/bios/LlanosGarcia> and the biographical introduction included in the 2009 edition of the *Diccionario y maneras de hablar que se usan en las minas y sus labores en los ingenios y beneficios de los metales* (ed. Pedro Martínez Arévalo, Madrid [Lima]: Consejo Superior de Colegios de Ingenieros de Minas, 2009 [1611]). On Cárdenas, see Carlos Viesca Treviño, "Hechos y hierbas mágicas en la obra de Juan de Cárdenas" in *Estudios de Historia Novohispana* 9 (1987): 37-50, and the introduction to Xavier Lozoya's edition of the *Problemas y secretos maravillosos de las Indias* (México: Academia Nacional de Medicina, 1980), and Emilio Uranga, "Juan de Cárdenas: sus amigos y sus enemigos." *Historia Mexicana* 16.4 (1967): 477-497. For a biographical study of Bartolomé de Medina, the inventor of the *patio* process who unfortunately left only fragmentary accounts of his work, see Modesto Bargalló, "Bartolomé de Medina: Regateo de un sitial de honor en la metalurgía universal," in *La amalgamación de los minerales de plata*, pp. 68-75, Luis Muro, "Bartolomé de Medina, introductor del beneficio de patio en Nueva España" in *Historia Mexicana* 13.4 (1964): 517-531, and, more recently, Manuel Castillo Martos, *Bartolomé de Medina y el siglo XVI*. The original source for these works is Francisco Fernández del Castillo's transcription of archival documents in "Algunos documentos nuevos sobre Bartolomé de Medina" in *Memorias de la Sociedad Científica Antonio Alzate* 47 (1927): 207-251. The primary manuscript, Medina's explanation of the process, is transcribed in Bargalló, *La minería y la metalurgía*, pp. 118-119.

[188] Rodríguez Sala, "Tres constructors de obras científico-técnicas de minería y metalurgía," pp. 641-653.

[189] Gómez de Cervantes, "Memorial" (1599), pp. 143, 148. Alberto María Carreño's introduction provides the most comprehensive biography of Gómez de Cervantes, whose public service in Mexico is chronicled by Guillermo Porras Muñoz in *El gobierno de la Ciudad de México en el siglo XVI* (México: Universidad Nacional Autónoma de México, Instituto de Investigaciones Históricas, 1982).

[190] Barba, "Memoria al rey" (AGI, Indiferente General, 771; La Plata, 1649), transcribed in Barnadas, *Álvaro Alonso Barba*, pp. 150-156; p. 154.

[191] Barba, *Arte de los metales*, p. 164, 168.

[192] Barba, *Arte de los metales*, p. 192.

[193] With the encouragement of Lizarazu, Barba appealed to the crown for recognition of his service to the empire. After he and Lizarazu had submitted multiple requests, on 9 March, 1637, Barba was granted the right to an audience with the mercury guild of Potosí where, per legal convention, he would perform his experiments before his peers. If the mercurysmiths approved of his method and found the results as beneficial as Barba and Lizarazu had claimed, Barba would receive the compensation that he had sought. It is unclear whether Barba received payment, but his will suggests that he did not die a poor man. The appeals for patronage (*memorias*) and the last will and testament from the Archivo General de las Indias (Charcas, l. 149 and Sevilla, 17 -10-1662) are transcribed in Barnadas, *Álvaro Alonso Barba*, pp. 139-144 and 226-252.

[194] Berrio de Montalvo, *Informes*, pp. 11-11v, and Acosta, *Historia natural y moral de las Indias*, p. 249. See more broadly book 4, chapters 10 and 11.

[195]This westward translation of mining empire forms part of what David A. Lupher calls in *Romans in a New World: Classical Models in Sixteenth-century Spanish America*, "a growing, but by no means widely self-evidence, assumption that the ancient Iberians whom the Romans subjugated were fundamentally the same people as modern Spaniards." Moreover, this naturalization of conquest that located the Spanish experience as colonizer and colonized within an imperial Roman precedent became the self-repeating, auto-authorizing analogical "parallel in the discourse of the conquest of the New World" that "intensified the 'Iberian patriotism' that had suggested the analogy in the first place," p. 189.
[196] Bargalló, *Minería*, p. 223; Barnadas, *Álvaro Alonso Barba*, p. 130; Salazar Soler, "Alvaro Alonso Barba: Teorías de la Antigüedad, alquimia y creencias prehispánicas en las Ciencias de la Tierra en el Nuevo Mundo" in *Entre dos mundos: Fronteras Culturales y Agentes Mediadores* (ed. Berta Ares Queija y Serge Gruzinski, Sevilla: Escuela de Estudios Hispano-Americanos de Sevilla, 1997), pp. 269-298; fn50p292.
[197] Quisbert, personal communication, 3 August 2011, Sucre, Chuquisaca, Bolivia. See also Quisbert's and Platt's discussion of documentary silences in historical anthropology, "Knowing Silence and Merging Horizons: The Caseof the Great Potosí Cover-Up" in *Ways of Knowing: Anthropological Approaches to Crafting Experience andKnowledge*, ed. Mark Harris (New York: Berghahn Books, 2007), pp. 113-138.
[198] The revision is John Murra's, as articulated in Frank Solomon's *The Cord Keepers: Khipus and Cultural Life in a Peruvian Village* (Durham, N.C.: Duke University Press, 2004; qtd. in Platt and Quisbert, p. 116).
[199] Acosta, *Historia natural y moral de las Indias*, p. 239 (book 4, chapter 7); Barba, *Arte de los metales*, p. 59 (book 1, chapter 33).
[200] Capoche, *Relación*, pp. 79-106.
[201] ANBN CPLA 7:336v (7/10/1594, Potosí), 1 f, discussed in chapter four.
[202] On the role of natural philosophy in the structure and curriculum of the early modern university, see Grant, *History of Natural Philosophy*.
[203] Bacon, "A True Report, of the detestable Treason, Intended by Doctor Roderigo Lopez, A Physician, Attending upon the Person of the Queenes Majesty," in *Resuscitatio, or, Bringing into Publick Light Several Pieces of the Works, Civil, Historical, Philosophical, & Theological, Hitherto Sleeping of the Right Honourable Francis Bacon Baron of Verulam, Viscount of Saint Alban* (London: Printed by Sarah Griffin for William Lee, 1657), pp. 151-161; 155. Following the union of the Iberian crowns in 1580 and the defeat of the Spanish armada in 1588, Lopez, a Portuguese *converso* "suspected to be, in sect, secretly, a *Jew*, (Though here he conformed Himself, to the Rites of the Christian Religion)" served as medical doctor to Queen Elizabeth I (151). In that capacity he supposedly gathered intelligence and reported it to the Spanish ambassadors Bernardo Mendoza, Antonio Vega, and Rodrigo Marquez, among "divers others," and was accused more specifically of accepting a payment of some 5,000 crowns, "a very good Jewell, garnished, with sundry stones, of good value," and "besides thanks, and encouragement, an *Abrazo* (which is the Complement of Favour)" from Felipe II to poison the English queen behind the back of Antonio of Portugal (154, 155).
[204] García de Llanos, *Diccionario y maneras de hablar que se usan en las minas y sus labores en los ingenios ybeneficios de los metales* (La Paz [Lima]: MUSEF, 1983 [1609]), p. 3. "Pirca" (stone slab) is one of a number ofQuechua or Aymara terms that make their way into the glossary designed to accompany his *Relación del Cerro dePotosí, el estado que tiene y desórdenes de él*, written for royal officials in Lima in 1609.
[205] Berrio de Montalvo, *Informes para obtener plata del azogue*, pp. 17-19.
[206] Ibid, 9v, 20, 31.
[207] Capoche, *Relación*, pp. 152, 173.
[208] Tied to their chests and with the metal on their backs, they climb three by three; and the leader carries a candle in his hand so that they can see where the tunnels rise and fall, because the mines are so dark and unclear, and the candle only it provides little light and often extinguishes in the wind. And with both hands they are seen climbing and helping as best they can, and climbing with such great difficulty the 900 feet [150 *estados*], or more, that they have descended. But in the mine the distance is more than 2,300 feet [400 *estados*] – which is enough to make a man tired on a flat road, when he carries a burden like they do, and so much the more when they must climb and descend with such great difficulty and risk. And this is what the Indians claim, sweating and breathless, and robbed of any warmth, and the refreshment that they find when they seek to console their exhaustion is to be told that they are dogs, and to be turned around because they brought too little metal, or took too long, or else they are told that they brought only dirt or that they have hidden the metal for their own use. And not four months ago it happened that a miner wanted to punish an

Indian for having stolen silver, but the Indian, fearful of the punishment that he would receive, took shelter in the mine itself. But amid all the confusion he fell and became one hundred thousand pieces (Capoche, *Relación*, p. 109).

[209] de Ovalle, *Historica relación del Reyno de Chile y delas missiones, y ministerios que exercita en el la Compañia de Iesus. A Nuestro Señor Jesu Crist Dios Hombre y a la Santísima Virgen, y Madre María, Señora del Cielo y de la Tierra, y a los Santos Joachin, Ana, sus Padres y Aguelos* (Rome: Francisco Caballo, 1648), book 2 chapter 4, p. 73.
The use of "acudir" marks the transition from de Ovalle's list of "las malas cosas" of the region and into a celebration of "lo bueno, que es tanto." Available from googlebooks.

[210] Capoche, Relación, p. 116, 135.

[211] Sánchez Gómez, ed., *La savia del imperio: Tres estudios de economía colonial*, p. 143; Barba, *Arte de los Metales*, p. 59.

[212] Capoche, *Relación*, pp. 131, 128.

[213] Ibid, pp. 128, 129.

[214] Mather, *Magnalia Christi Americana*, p. 81

[215] Woodward, *Prospero's America*, pp. 2, 11-13; Turner, *Dramas, Fields, and Metaphors: Symbolic Action in Human Society* (Ithaca, N.Y. and London: Cornell University Press, 1974), p. 67. In *The Structure of Scientific Revolutions*, Kuhn defines a paradigm as a "model from which springs particular coherent traditions of scientific research" (10). In seventeenth-century terms we might replace "research" with "experiment, experience, or practice," though Kuhn's formative definition of a scientific paradigm remains a helpful way to understand the powerfully cohesive narrative of English planting and possessing in the New World.

[216] White, *Planters Plea*, pp. 38, 37, 36. EEBO.

[217] Thirsk, "Farming Techniques," p. 167.

[218] White, *Planters Plea*, pp. 32-3.

[219] Mather, *Magnalia Christi Americana*, p. 81; Miller, *The New England Mind: From Colony to Province* (Cambridge, M.A.: Harvard University Press, 1967), p. 189.

[220] Flavell, *Husbandry Spiritualized*, p. 21.

[221] For instance, the edition held in the John Carter Brown Library is full of underlined passages and notes, most likely made by one "Eliph[ale]t Dyers," who marked the copy with his name and "Providence, Sept. 1st 1804." Dyers underlined the abovequoted introductory passage on the "things that do move us," as well as Biblical verse (Romans I.20, qtd on p. 8) and interpretations of the relationship between grace and industry, like Flavell's lament of the "Wretched soul! thy case is sad; it would be better with the uncultivated wilderness, than with such a miscarrying soul, unless the Great Husbandman plough thee up the second time, and sow thy heart with better seed" (143). Toward the end of the book, the markings take the form of straight horizontal lines, squiggly horizontal lines, straight vertical lines and marginal "X"s placed next to passages like Flavell's root metaphors: "Ah, my soul! thou art a degenerate plant; better will it be with the offspring of infidels than with thee, if repentance prevent not" (231). The rest of the passage looks like this:

> Now I live in one family with them, but shortly I shall be |
> separated from them, as far as hell is from heaven; they |
> now tenderly pity my misery, but <u>then they shall approve</u>
> and <u>applaud the righteous sentence of Christ upon me;</u> so X
> little privilege shall I then have from my relation to them,
> that they shall be produced as witnesses against me, and all |
> their rejected counsels, reproofs and examples charged |
> home upon me, as the aggravations of my wickedness (231).

[222] Walsham, *The Reformation of the Landscape: Religion, Identity, and Memory in Early Modern Britain and Ireland* (Oxford and New York: Oxford University Press, 2011) and "Sacred Topography and Social Memory: Religious Change and the Landscape in Early Modern Britain and Ireland" *Journal of Religious History* 36.1 (2012): 31–51; Cañizares Esguerra, *Puritan Conquistadors*; Thirsk, *Agrarian History of England and Wales*; Muldrew, *Food, Energy and the Creation of Industriousness: Work and Material Culture in Agrarian England, 1550-1780* (Cambridge and New York: Cambridge University Press, 2011).

[223] Barker, *The country-mans recreation, or The art of planting, graffing, and gardening, in three books. The first declaring divers waies of planting, and graffing, and the best times of the year, with divers*

commodities and secrets herein, how to set or plant with the root, and without the root; to sow or set pepins or curnels, with the ordering thereof, also to cleanse your grafts and cions, to help barren and sick trees, to kill worms and vermin, and to preserve and keep fruit; how to plant and proin your vines, and to gather and presse your grape; to cleanse and mosse your trees, to make your cider and perry, with many other secret practises which shall appear in the table following. The second treateth of the hop-garden, with necessary instructions for the making and maintenance thereof, with some directions for tabaco. Whereunto is added, The expert gardener, containing divers necessary and rare secrets belonging to that art. Hereunto is likewise added the Art of angling (London: T. Mabb for William Shears, 1654), EEBO; Flavell, *Husbandry Spiritualized*, p. 35, 207.

[224] Fiske, *The Watering of the Olive Plant in Christs Garden. Or A Short Catechism for the First Entrance of Our Chelmesford Children: Enlarged by a Three-fold Appendix* (Cambridge, M.A.: Printed by Samuel Green at Cambridg in New-England., 1657), EEBO; p. 45.

[225] Hooker, *The Soules Implantation A Treatise Containing, the Broken Heart, on Esay 57.15. The Preparation of the Heart, on Luk. 1.17. The Soules Ingraffing into Christ, on Mal. 3.1. Spirituall Love and Joy, on Gal. 5.22* (London: R. Young, 1637) and *The Soules Humiliation* (London: Printed by I. Legat for Andrew Crooke, 1637), p. 132.

[226] Flavell, *Husbandry Spiritualized*, p. 207, 201.

[227] The designation of the apple is from book two, chapter seven of Sir Thomas Elyot's *The Castel of Helthe*, while the reading of soils is from Walter Blith, *The English improver*, p. 110. For a discussion of humoral theory in the imaginative arts of early modern Europe, see Zirka Zaremba Filipczak, *Hot Dry Men, Cold Wet Women: The Theory of Humors in Western European Art, 1575-1700* (New York: American Federation of Arts, 1997). On the growth of market gardening in the communities outside of London, see Thirsk, "Farming Techniques," pp. 196-199.

[228] Kircher's finding is rejected by Robert Sharrock in *History of the propagation and improvement of vegetables* (Oxford: Printed by A. Lichfield, printer to the University, for Thomas Robinson,1660), available on EEBO; Markham, *Book of the English Husbandman* (1635), p. 143; della Porta, *Natural Magick by John Baptista Porta, a Neapolitane; in Twenty Books, Wherein Are Set Forth All the Riches and Delights of the Natural Sciences* (London: Thomas Young and Samuel Speed, 1658), p. 63. EEBO. The rose, apple, and lemon passages are discussed in Mudge, cited below.

[229] Mudge, Ken et al. "A History of Grafting" in *Horticultural Reviews* 35 (2009): 437–495, 465, 480; Sharp, *The Midwives Book, or, The Whole Art of Midwifry Discovered: Directing Childbearing Women How to Behave Themselves in Their Conception, Breeding, Bearing and Nursing of Children: in Six Books* (London: Simon Miller, 1671), p. 123, Adam Matthew Digital < http://www.gender.amdigital.co.uk>, quoted in Davidson, *Breeding: A Partial History of the Eighteenth Century* (New York: Columbia University Press, 2009), p. 29.

[230] This long-established mode of inquiry has received heightened critical interest following feminist interventions in the history and philosophy of science, such as Donna Haraway's *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991). The literature in this field is now immense, and its review would far exceed both the scope of this chapter and my knowledge. Some of the approaches to human-animal relationships in early North American and early modern European history are summarized in Virginia DeJohn Anderson, *Creatures of Empire: How Domestic Animals Transformed Early America* (New York: Oxford University Press, 2004) and *Beastly Natures: Animals, Humans, and the Study of History*, ed. Dorothee Brantz (Charlottesville: University of Virginia Press, 2010). For Latin America, see Pedro Cunill Grau, *Geohistoria de la sensibilidad en Venezuela* (Caracas: Fundación Empresas Polar, 2007), whose national frame can be applied in a broader comparative context as well. In literary studies, see Bruce Boehrer, *Shakespeare Among the Animals: Nature and Society in the Drama of Early Modern England* (New York: Palgrave, 2002) and his more recent *Animal Characters: Nonhuman Beings in Early Modern Literature* (Philadelphia: University of Pennsylvania Press, 2010).

[231] Plattes, "Certain Notes, and Observations concerning Setting of Corn, and the great benefit thereof. Together with several Experiments and Improvements imparted by Gabriel Plats to Mr. Hartlib" in Hartlib's *Legacy* (1655), pp. 184-216; p. 206.

[232] Blith, *English Improver*, p. 92, 66.

[233] Donahue, *The Great Meadow*, p. 69. Donahue cites Mark Overton, "Agricultural Revolution? Development of the Agrarian Economy in Early Modern England" in Alan R.H. Baker and Derek Gregory, eds., *Explorations in Historical Geography* (Cambridge: Cambridge University Press, 1984), and H.S.A.

Fox and R.A. Butlin's edited volume, *Change in the Countryside: Essays on Rural England, 1500-1900* (London: Institute of British Geographers, 1979), especially the chapters by J. Yelling, "Agriculture 1500-1730" and R.A. Butlin, "The Enclosure of Open Fields and Extinction of Common Rights in England, circa 1600-1750: A Review."

[234] Scanlan, *Colonial Writing and the New World, 1583-1671: Allegories of Desire* (Cambridge, England: Cambridge University Press, 1999), pp. 18-32, p. 18.

[235] White, *Planters Plea*, pp. 20, 17, 22.

[236] On the civil and church reforms proposed by the loosely-organized collaborative circle of Hartlib's correspondents, see Charles Webster, *Great Instauration: Science, Medicine, and Reform, 1626-1660* (London: Duckworth, 1975), esp. chapter two, "The Spiritual Brotherhood," pp. 32-99, and *Samuel Hartlib and Universal Reformation: Studies in Intellectual Communication*, ed. Mark Greengrass, Michael Leslie, and Timothy Raylor (Cambridge and New York: Cambridge University Press, 1994).

[237] See for instance Carolyn Merchant's foundational argument in *The Death of Nature* that the violent and dehumanizing metaphors of a subordinated and feminized Nature, in conjunction with the commercialized and mechanized forms of the new science, marginalized the contributions of real women to seventeenth-century science. Scholars who disagree with Merchant's reading have pointed to issues of translation and mistranslation, the role of metaphor in early modern scientific writing, and the relationship between printed and manuscript sources. Much of the work is aptly detailed in Noretta Koertge, ed., *A House Built on Sand: Exposing Postmodernist Myths About Science*, esp. the chapters by Alan Soble (pp. 195-215) and William R. Newmann (pp. 216-226). See also Margaret J. Osler, "The Gender of Nature and the Nature of Gender in Early Modern Natural Philosophy," Peter Pesic, "Wrestling with Proteus: Francis Bacon and the 'Torture' of Nature," and Brian Vickers, "Francis Bacon, Feminist Historiography, and the Dominion of Nature."

[238] See for instance Marco Ambrosoli, *The Wild and the Sown: Botany and Agriculture in Western Europe, 1350-1850* (Cambridge: Cambridge University Press, 1997), David Grigg, *English Agriculture*, Joan Thirsk, *Agricultural Regions*, and G.E. Fussell, *The Farmer's Tools: The History of British Farm Implements, Tools and Machinery AD1500-1900* (London: Bloomsbury Books, 1985) and *Farming Technique from Prehistoric to Modern Times*.

[239] Jacob, "Reflections on Bruno Latour's Version of the Seventeenth Century"; Osler, *Rethinking the Scientific Revolution*; Shapin, *Leviathan and the Air-pump: Hobbes, Boyle, and the Experimental life* (Princeton, N.J.: Princeton University Press, 1989), *The Scientific Revolution* (Chicago: University of Chicago Press, 1996); Schiebinger, *Plants and Empire* and *Nature's Body*; Cañizares Esguerra, *Nature, Empire, and Nation* and "Iberian Science in the Renaissance"; Barrera Osorio, *Experiencing Nature*; Park and Daston, *Wonders and the Order of Nature, 1150-1750* (New York: Distributed by the MIT Press, 1998).

[240] Elliott, *Empires of the Atlantic World*, p. 94. Elliott compares commodity-driven development in colonial Virginia and Alto Perú on pp. 93-97, and his discussion of tobacco, monoculture plantation economies, and slavery provides another helpful comparison of English and Spanish ideas of colonial planting (106), showing that the two were "never far away" from a truly integrative imperial dialogue. Patricia Seed reaches a very different conclusion on the similarities and differences of Anglo and Iberian colonialisms in the Americas. See her *American Pentimento* and *Ceremonies of Possession*. For a discussion of the practices of peopling in North and South America, see her reading of Shakespeare's *Tempest* (1623) and the exceptional "policies of peopling" in "the ABC countries (Argentina, Brazil, Chile)," analyzed in "'This island's mine': Caliban and Native Sovereignty."

[241] White, *The Planters Plea*, p. 25.

[242] Letter to the royal Parliament of England and Wales, *An act for the speedy and effectual satisfaction of the adventurers for lands in Ireland: and of the arrears due to the soldiery there, and of other publique debts; and for the encouragement of Protestants to plant and inhabit Ireland; Together with an order of the Councel of State, dated the first of Iune, 1653. A commission under the Great Seal of England, and instructions thereunto annexed; and also further instructions to the commissioners of Parliament in Ireland, mentioned in this act, and thereby confirmed, Monday the 26th of September, 1653: Ordered by the Parliament, that this act be forthwith printed and published. Hen: Scobell, Clerk of the Parliament* (London: Printed by John Field, Printer to the Parliament of England, 1653); *An act for incouraging Protestant-strangers and others to inhabit and plant in the kingdom of Ireland* (Dublin: Printed by John Crook and are to be sold by Samuel Dancer, 1662), EEBO.

[243] Plat, *New and admirable arte of setting of corne*; Maxey, *New instuction of plowing and setting of corne*; Loddington, *Plantation uuork the work of this generation written in true-love to all such as are*

weightily inclined to transplant themselves and families to any of the English plantations in America : the most material doubts and objections against it being removed, they may more cheerfully proceed to the glory and renown of the God of the whole earth, who in all undertakings is to be looked unto, praised and feared for ever (London: Benjamin Clark, 1682), EEBO.

[244] Kupperman, "The Beehive as a Model for Colonial Design" in *America in European Consciousness, 1493-1750* (Williamsburg, V.A. and Chapel Hill, N.C.: Omohundro Institute of Early American History and Culture, 1995), pp. 272-294. See also Erica Mae Olbricht's comparison of labor in beekeeping and silkworm treatises, "Made Without Hands: The Representation of Labor in Early Modern Silkworm and Beekeeping Manuals" in *Insect Poetics*, ed. Eric Brown (Minneapolis: University of Minnesota Press, 2006), pp. 223-241.

[245] For one of the most widely-read cases of this gendered language of mines and metallurgy, see book 4 of father José de Acosta's *Historia natural y moral de las Indias*.

[246] For an excellent study of linguistic and cultural gender in the history of the English language, see Curzan, *Gender Shifts in the History of English*.

[247] On the history of silkworm cultivation in the colonial era and through the nineteenth century, see the biologist Joseph Ewan's "Silk Culture in the Colonies" in *Agricultural History* 43.1 (1969): 129-142. For a comparison of English engagement with the silk industry in India, see Valerie Forman, "Transformations of Value and the Production of 'Investment' in the Early History of the East India Company" in *Journal of Medieval and Early Modern Studies* 34.3 (2004): 611-641.

[248] Hadot, *The Veil of Isis: An Essay on the History of the Idea of Nature* (Cambridge, M.A.: Belknap Press of Harvard University Press, 2006), p. 136, x.

[249] Linda Peck, *Consuming Splendor: Society and Culture in Seventeenth-Century England* (Cambridge and New York: Cambridge University Press, 2005). The most important source of silkworm knowledge was Jean-Baptiste Letellier's *Memoirs et instructions pour l'establissement des meuriers* (Paris, 1603), translated into English in 1609 and published in two editions, one under the name of William Stallenge. Unattributed passages from the Letellier/Stallenge texts circulate in Williams's *Virginia's Discovery of Silkworms* (London, 1650), Ferrar's *Reformed Virginian Silkworm* (London, 1653, published by Hartlib), and Hartlib's *Legacy* (London, 1655). As proof of the English ability to compete against European producers, Ferrar cites superior English industry and cultivation against "the poor simple people" of Italy, Spain, the Netherlands, and France who grow worms without "any more curiositie" or care (15).

[250] Merchant's formative argument has been supported by historians and philosophers of science like Evelyn Fox Keller, *Reflexions on Gender and Science*, Sandra Harding, *The Science Question in Feminism* and *Whose Science? Whose Knowledge?: Thinking from Women's Lives*, and Katharine Park, in her response to Brian Vickers's reading of Merchant's argument, "'Francis Bacon, Feminist Historiography, and the Dominion of Nature.'" See also Park's *Secrets of Women: Gender, Generation, and the Origins of Human Dissection* (New York: MIT Press, 2006) for a discussion of gender and early modern science outside of England. Scholars who disagree with Merchant's reading have pointed to issues of translation and mistranslation, the role of metaphor in early modern scientific writing, and the relationship between printed and manuscript sources. On translation, see Osler, "The Gender of Nature and the Nature of Gender in Early Modern Natural Philosophy," Pesic, "Wrestling with Proteus," and Soble, "In Defense of Bacon." On metaphor, see Vickers, "Francis Bacon, Feminist Historiography, and the Dominion of Nature." On publication circumstances, see Sarah Hutton, "The Riddle of the Sphinx: Francis Bacon and the Emblems of Science" in *Women, Science and Medicine, 1500-1700: Mothers and Sisters of the Royal Society*, ed. Lynette Hunter and Sarah Hutton (Thrupp, Stroud, Gloucestershire: Sutton, 1997), pp. 7-28.

[251] Three such studies that came out within a few years of Merchant's *Death of Nature* include Pagden, *The Fall of Natural Man*, Crosby, *The Columbian Exchange*, and Gerbi, *Nature in the New World*.

[252] Bacon, *The Works of Francis Bacon* (ed. James Spedding, Robert Leslie Ellis, and Douglas Denon Heath, Boston: Brown and Taggard, 1864), 15 vols., vol. 10 p. 403.

[253] Osler, "The Gender of Nature and the Nature of Gender," p. 73.

[254] Curzan, *Gender Shifts in the History of English*, pp. 48-55; 113, fn19p113.

[255] Curzan, *Gender Shifts*, p. 129, fn2p61, 27-8, p. 117. For a different interpretation of the universality of "man," see Ivy Schweitzer's "Gendering the Universal: The Puritan Paradigm of Redeemed Subjectivity," in *The Work of Self-Representation: Lyric Poetry in Colonial New England* (Chapel Hill, N.C.: University of North Carolina Press, 1991), pp. 1-39.

[256] Hadot, *Veil of Isis*, p. 136; Cañizares Esguerra, "Iberian Science in the Renaissance"; Pagden, *Fall of*

Natural Man.
[257] Bacon, "Of empire" in *Essays*, ed. John Pitchner (New York: Penguin, 2000).
[258] The history of Anglophone scientists' attitudes toward Iberian science is summarized in Cañizares Esguerra, "Iberian Science in the Renaissance." For the historiography of amalgamation in the colonial era (1555-1800), and the geolinguistic or nationalist tendencies associated with the study of the "nuevo beneficio," see Modesto Bargalló, *La amalgamación de los minerales de plata en hispanoamérica colonial*.
[259] Absi, "Lifting the Layers of the Mountain's Petticoats: Mining and Gender in Potosi's Pachamama" in *Mining Women: Gender in the Development of a Global Industry, 1670-2005*, ed. Jaclyn J. Gier and Laurie Mercier (2006), pp. 58-70, 61; Merchant, *Death of Nature*, pp. 3-4; Salazar Soler, "Alvaro Alonso Barba." These attitudes toward the land are characteristic of the early years of colonization of British North America, too, as an enactment of what Annette Kolodny has formatively described in *The Land Before Her* (Chapel Hill, N.C.: University of North Carolina Press, 1984) as "an experience of the land as essentially feminine--that is, not simply the land as mother, but the land as woman, the total female principle of gratification--enclosing the individual in an environment of receptivity, repose, and painless and integral satisfaction" (4).
[260] Acosta, *Historia natural y moral de las Indias*, pp. 222-3. All errors in translation are my own.
[261] *Arte de los Metales*, pp. 51-2.
[262] For a critical reading of these translations, see Soble, "In Defense of Bacon."
[263] Montagu, R.H. Edward, Earl of Sandwich, *The Art of Metals in Which is Declared the Manner of Their Generation and the Concomitants of Them: In Two Books. Written in Spanish by Albaro Alonso Barba, Curate of St. Bernard's Parish in the Imperial City of Potosi, in the Kingdom of Peru in the West-Indies, in the Year 1640* (London: S. Mearne), p. 120. EEBO.
[264] Williams, *Virginia's Discovery of Silke-vvormes with their benefit. And the Implanting of Mulberry-Trees. Also, the dressing and keeping of Vines, for the rich Trade of making Wines there. Together with, the making of the Saw mill, very usefull in Virginia, for the cutting of Timber and Clapboard, to build withall, and its conversion to other as profitable Uses* (London: Thomas Harper by John Stepehson, 1650), p. 23. EEBO. The same printer also published the text under the alternate titles of *Virgo triumphans, or, Virginia Richly and Truly Valued* (1650), *Virgo triumphans, or, Virginia in Generall* (1650) and *Virginia, more especially the south part thereof, richly and truly valued* (1650).
[265] The most important source of silkworm knowledge was Jean-Baptiste Letellier's *Memoirs et instructions pour l'establissement des meuriers* (Paris, 1603), translated into English in 1609 and published in two editions. The first was issued under Letellier's name as *Instructions for the Increasing and Planting of Mulberry Trees* (E.A. for Eleazar Edgar) and the second, with the same title, under the authorship of William Stallenge. Because of its well-known author, Nicholas Geffe's translation of Olivier de Serres's *The Perfect Vse of Silke-Worms, and their Benefit and their benefit With the exact planting, and artificiall handling of mulberrie trees whereby to nourish them, and the figures to know how to feede the wormes, and to winde off the silke. And the fit maner to prepare the barke of the white mulberrie to make fine linnen and other workes thereof. Done out of the French originall of D'Oliuier de Serres Lord of Pradel into English, by Nicholas Geffe Esquier. With an annexed discourse of his owne, of the meanes and sufficiencie of England for to haue abundance of fine silke by feeding of silke-wormes within the same; as by apparent proofes by him made and continued appeareth. For the generall vse and vniuersall benefit of all those his countrey men which embrace them. Neuer the like yet here discouered by any* (London: Felix Kyngston, 1607) was also widely read, and for reasons of political positioning, so too was the *Treatise of the Art of making Silk* (London: Felix Kyngston, 1622) of John Bonoeil, "Frenchman, seruant in these imployments to his most Excellent Maiesty of Great Brittaine, France, Ireland, Virginia, and the Summer-Ilands," which was appended to the royal letter of James I to Virginia Company for the establishment of a silkworm industry in the colony. In Bonoeil's *Obseruations to be Followed for the making of fit roomes, to keepe Silk-wormes in* (London, 1620), the silkworm cultivators were explicitly male: "Those that are perfectly experienced in this businesse, aduise a man by all means to haue as great abundance of Mulberry trees as is possible, and for one that is a good husband to reape good profit, they prescribe the quantity of two or three thousand trees; for with a lesse number a man that will bee a master of this worke, ought not to enterprise this businesse..." (16).
[266] Women's Silk Culture Association, *An Instruction Book in the Art of Silk Culture, New and enlarged edition* (Philadelphia, 1882), p. 8. On silkworm lifecycles, domestic and wild, Paul M. Tuskes, Michael M Collins, and James P Tuttle, *The Wild Silk Moths of North America: A Natural History of the Saturniidae of*

the United States and Canada (Ithaca, N.Y.: Comstock Pub. Associates,1996).
[267] De Serres, *The perfect vse of silk-vvormes*, p. 34.
[268] Paula Findlen, "Courting Nature" in *Cultures of Natural History*, ed. Nicholas Jardine, Emma Sparry, and James A. Second (Cambridge and New York: Cambridge University Press, 1996), pp. 57-74.
[269] Williams, *Virginia, More Especially the South Part Thereof, Richly and Truly Valued: Viz. the Fertile Carolana, and No Lesse Excellent Isle of Roanoak, of Latitude from 31 to 37 Degr. Relating the Meanes of Raysing Infinite Profits to the Adventurers and Planters* (2nd ed., London: T.H. for John Stephenson, 1650), pp. 1-2, EEBO.
[270] *Religio Medici* (London: Printed for R. Scot, T. Basset, J. Wright, R. Chiswell, 1682), p. 88. EEBO.
[271] For a discussion of the language of heroism figures in the Little Gidding community's complex relationship to the church militant and the monarchies of England and Spain, see Reid Barbour, *Literature and Religious Culture in Seventeenth-Century England* (Cambridge and New York: Cambridge University Press, 2002), esp. chapter one, "The Church Heroic: Charles, Laud, and Little Gidding," pp. 21-55. In a talk delivered on 9 November, 2009, at the University of North Carolina, Chapel Hill, Debora Shuger presented part of her current work on the largely unappreciated literary and intellectual contributions of students of the Little Academy, most of whom were women.
[272] On the commercialized and experiential nature of seventeenth-century science, see for instance Steven Shapin, *Never Pure: Historical Studies of Science as if it was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority* (Baltimore: Johns Hopkins University Press, 2010), Harold Cook, *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age* (New Haven, C.T.: Yale University Press, 2007), Harkness, *Jewel House*, and Findlen and Smith, *Merchants & Marvels*.
[273] Bullock, *Virginia Impartially Examined, and Left to Publick View, to Be Considered by All Iudicious and Honest Men* (London, Printed by J. Hammond, 1649), EEBO; Thompson, "William Bullock's 'Strange Adventure': A Plan to Transform Seventeenth-Century Virginia" *The William and Mary Quarterly* 61.1 (2004): 107–128, p. 118-120.
[274] Haraway, *Primate Visions: Gender, Race, and Nature in the World of Modern Science* (New York: Routledge, 1989) and *Simians, Cyborgs, and Women*.
[275] The work of cultural historians of science is both firmly-established and ever-growing within the field of history of science. For an account of the cultural turn and its importance in shaping historical understandings and present-day practices in the discipline of physics, see Suman Seth, "The History of Physics after the Cultural Turn" in *Historical Studies in the Natural Sciences* 41.1 (2011): 112-122.
[276] Cervantes Saavedra, Miguel de, *Don Quijote de la Mancha*, ed. Francisco Rico (Madrid: Alfaguara, [1615, 1780] 2004), pp. 709, 712, 561; Villar, "The Age of Don Quixote" *Essays in European Economic History, 1500-1800*, trans. Richard Morris and ed. Peter Earle (Oxford: Clarendon Press, 1974), 100–112, p. 100.
[277] Ruiz de Alarcón y Mendoza, *La industria y la suerte* (Madrid: Juan Gonzalez, 1628), Biblioteca Cervantes, http://bib.cervantesvirtual.com/FichaObra.html?Ref=446.
[278] Muldrew, *Food, Energy and the Creation of Industriousness*, p. 16, and De Vries, *The Industrious Revolution: Consumer Behavior and the Household Economy, 1650 to the Present* (Cambridge and New York: Cambridge University Press, 2008).
[279] Quevedo, "A una mina," ll. 41-2, 54-55; Spenser, *Faerie Queene* (2.7.33:9 and 2.7.35:4-5). An excellent bilingual edition of Quevedo's work was recently published by the University of Chicago as *Selected Poetry of Francisco De Quevedo: A Bilingual Edition*, translated by Christopher Johnson (2009). For an analysis of the imperial encoding of Guyon's encounter with Mammon, see Maurice Hunt, "Hellish Work in 'The Faerie Queene'" in *Studies in English Literature, 1500-1900* 41.1 (2001): 91-108.
[280] Spenser, *Faerie Queene*, ed. Thomas P Roche. ([1590/1596] Harmondsworth and New York: Penguin, 1978), on the river marriage, see books 4.11 and 4.12. There is a large and important cluster of postcolonial readings of the *Faerie Queene*, too many to list here. Much of the work is summarized in Richard McCabe, *Spenser's Monstrous Regiment: Elizabethan Ireland and the Poetics of Difference* (Oxford: Oxford University Press, 2002). For a study that seeks to shift the postcolonial axis from Ireland and Book V to a circum-Atlantic framework, see David Read's *Temperate Conquests: Spenser and the Spanish New World* (Detroit: Wayne State University Press, 2000).
[281] Plattes, "Certain Notes and Experiences," pp. 195-196.
[282] A phrase recirculated to tragically ironic ends in Melville's *Benito Cereno* (1855).

[283] As quoted in Montecinos, *Anales del Perú*, p. 50.
[284] Bargalló, *La minería y la metalurgía* and *La amalgamación de los minerales de plata*. More recent works that build from Bargalló's essential volumes include Castillo Martos, *Minería y metalurgía,* Julio Sánchez Gómez, *Minería y metalurgia*, and Peter J. Bakewell, "Technological Change in Potosí: The Silver Boom of the 1570's" in *Mines of Silver and Gold in the Americas* (1997), pp. 75-95. For nuanced discussions of the social conditions, cultural patterns, and labor agreements that made possible these advancements, see Bakewell, *Silver Mining and Society*, *Miners of the Red Mountain*, and *Silver and Entrepreneurship*. See also Bakewell's edited volume, *Mines of Silver and Gold in the Americas,* especially the chapters by Alan Probert, "Bartolomé de Medina: The Patio Process and the Sixteenth Century Silver Crisis," pp. 96-130, Ann Zulawski, "Wages, Ore Sharing, and Peasant Agriculture: Labour in Oruro's Silver Mines, 1607-1720," pp. 199-224, and Richard L. Garner, "Long-Term Silver Mining Trends in Spanish America: A Comparative Analysis of Peru and Mexico," pp. 225-263.
[285] Dennis Owen Flynn and Arturo Giráldez, eds., *Metals and Monies in an Emerging Global Economy* (Aldershot: Ashgate, 1997), xix-xx; Bakwell, *Mines of Silver and Gold of the Americas*, xxiii. The use of indigenous mineralogical knowledge is glossed in general terms by Carmen Salazar-Soler in "Alvaro Alonso Barba." On the continuity of the Inca *mita* system, see Gunnar Mendoza's discussion in volume 1 of his *Obras Completas*. On foreigners, see Bakewell, *Silver and Entrepreneurship in Seventeenth-Century Potosí*. The role of New World silver in the establishment of a global economic community is concisely recounted in Flynn and Giráldez, "Born with a 'Silver Spoon.'"
[286] Elliott, *Empires of the Atlantic World*, p. 94. Elliott compares commodity-driven development in colonial Virginia and Alto Perú on pp. 93-97.
[287] Lane, "Raleigh's First Roanoke Colony.
[288] For an account of the ironworks, see Woodward, *Prospero's America*. Many of Child's observations found their way into the natural history that was collaboratively produced by the Boate brothers, Gerard (1604-1650) and Arnold (1600?-1653?), called the "Animadversor" in Hartlib circle correspondence after his *Animadversiones sacræ ad textum hebraicum Veteris Testamenti* (London, 1644).
[289] Child, "Large Letter," p. 85. Child's long letter on English deficiencies is, appropriately enough, physically broken up by the insertion of James I's royal proclamation in favor of silkworm cultivation (pp. 59-62) and the unattributed work of Letellier/Stallenge (pp. 63-68).
[290] On the role of Adamic restoration in English agricultural improvement, see Sarah Irving, *Natural Science and the Origins of the British Empire* (London and Brookfield, V.T.: Pickering & Chatto, 2008). For an edition rich with the images from the Bodleian Library, see James A. Bennett and Scott Mandelbrote, *The Garden, the Ark, the Tower, the Temple: Biblical Metaphors of Knowledge in Early Modern Europe* (Oxford: Museum of the History of Science, 1998).
[291] Acosta's fascinating use of Roman imperial precedent to fashion a kind of *translatio mineralli* (book 4, chapter 7) follows his equally compelling, and disturbing, gendered reading of the mining landscape of South America (chapter 2), where he likens the mineral wealth of Peru to the large dowry that a wealthy father must provide in order to marry an especially ugly daughter, framing his interpretation of the land "sown with metals" and "cultivated in the Christian Religion in our time" in two authorizing relationships of the church: marriage and conversion.
[292] Flavell, *Husbandry Spiritualized*, p. 131, 140.
[293] Hakluyt, *A Discourse Concerning Western Planting* (Cambridge: J. Wilson, 1877 [1584]), p. 82. Googlebooks.
[294] Even for Ferrar, the silkworm remained one possibility for colonial development. Other potential sectors included sugar, spices, cotton, or any of the "Commodities" that "are of no small difficulty to you and the Savages to enterprize" (16).
[295] Hakluyt, *Discourse*, p. 60, 20, 37-38.
[296] Voight, "'Por Andarmos Todos Casy Mesturados': The Politics of Intermingling in Caminha's Carta and Colonial American Anthologies" in *Early American Literature* 40.3 (2005): 407-439.
[297] Brandão, *Diâlogo*, p. 156.
[298] "And so, because people of different conditions from all over the world will come to Brasil to do business, and this commerce is such that they deal with the natives of the land, who generally are blessed with and enjoy their great ability, either from the nature of the climate or as a gift from heaven, the foreigners take all that they find to be good, with which they excellently preserve them for their use" (155).
[299] Potter, "A Bank of Lands," in Hartlib's *Legacy* (1655), pp. 289-300; 292.

[300] On nothingness and its rhetorical position in English imperial discourse, see Jeffrey Knapp, *An Empire Nowhere: England, America, and Literature from Utopia to The Tempest* (Berkeley: University of California Press, 1992).
[301] Flavel, *Husbandry Spiritualized*, p. 60.
[302] Peyton, *The History of the English Language; Deduced from Its Origin, and Traced through Its Different Stages and Revolutions: Being Very Interesting for Persons Ignorant of the Infant State of Their Own Country and Those Revolutions; and for the Benefit of Those Who Aspire to the Perfect Knowledge of Their Mother Tongue* (London: R. Hilton for S. Bladon, 1771), ECCO, p. 17; partly qtd. in Curzan, pp. 28-30.
[303] Dávalos y Figueroa, *La miscelanea austral* (Lima: Antonio Ricardo, 1602-1603), p. 125r.
[304] Curzan, *Gender Shifts*, p. 41.
[305] Platt, *Jewell House of Art and Nature*, p. B2; Blith, *English Improver*, p. 12.
[306] Archivo y Biblioteca Nacional de Bolivia, Sucre: Audiencia de La Paz, Minería 96.2; 23/6/1644/s. XVII-Carangas – 28/6/1644/s. XVII, 7 ff.
[307] Specifically, Sisa was charged with compensating her workers with the "botija de bino" that was forbidden in the region. In New Spain, wine was also prohibited from the mining regions, although Peter Bakewell points out that mezcal and *vino de coco* were permitted. See *Silver Mining and Society in Colonial Mexico*.
[308] It is worth pointing out that San Bernando is the same parish in which the priest and metallurgist Álvaro Alonso Barba (1559?-1661) had written his renowned *Arte de los metales*, published in Madrid four years before Sisa's trial.
[309] On the misogynistic dimensions of colonial mining and metallurgy, see Kuntala Lahiri-Dutt and Martha Macintyre, eds., *Women Miners in Developing Countries* and Pascale Absi, "Lifting the Layers of the Mountain's Petticoats." On the general frame of violence and dehumanization in which the work of mining and metallurgy are framed, see colonial-era histories like Arzáns de Orsúa y Vela, *Historia de la villa imperial de Potosí*. For examples from the scholarly historiography of mining and metallurgy, see Greer, Mignolo, and Quilligan, eds., *Rereading the Black Legend*, Craig and West, eds., *In Quest of Mineral Wealth: Aboriginal and Colonial Mining and Metallurgy in Spanish America*, especially the chapters by Otis E. Young, "Black Legends and Silver Mountains: Spanish Mining in Colonial Latin America Reconsidered," pp. 109-118, and Craig, "Spanish Colonial Silver Beneficiation at Potosí." See also Peter J. Bakewell's discussion in *Silver and Entrepreneurship in Seventeenth-Century Potosí*: "Miners, and especially miners of precious metals, are given, in the popular view, to raucous living, to drinking, gambling, and womanizing. To this expectable boisterousness was added in Potosí awareness that here, even in decline, was the greatest source of silver known in the world, indeed the greatest the world had ever known. The outcome was a ferocious grandiloquence palpable in many aspects of the town's life" (23-24).
[310] In the only other published account of this case, Ann Zulawski suggests that the colonial Spanish authorities did not address Cotes's claim that a woman was not allowed to register the site. Although they did not answer the point in their written decision, I suggest that they did address the claim in their actions. Their ruling complies with the gender-blind policies of discovery outlined in the 1584 *ordenanzas*. See "Social Differentiation, Gender, and Ethnicity: Urban Indian Women in Bolivia, 1640-1725" in *Latin American Research Review* 25.2 (1990): 93-114.
[311] On the role of Islamic centers of learning in translating the treatises of Aristotle, Plato, and Pliny, and in producing new work in the areas of medicine, mathematics, mineralogy and astronomy, see Gutiérrez Rodilla, *La ciencia empieza en la palabra: Anaálisis e historia del lenguaje científico* (Barcelona: Ediciones Península, 1998), esp. pp. 52-64; p. 45. See also Grant, *History of Natural Philosophy*, and Manfred Ullman, *Islamic medicine* (Edinburgh: Edinburgh University Press, 1978).
[312] Rossi, *Philosophy, Technology, and the Arts in the Early Modern Era* (New York: Harper and Row, 1970). See also Simon Werrett, "Explosive Affinities: Pyrotechnic Knowledge in Early Modern Europe" in *Making Knowledge in Early Modern Europe: Practices, Objects, and Texts, 1400-1800*, ed. Pamela H. Smith and Benjamin Schmidt (Chicago: University of Chicago Press, 2007), pp. 68-89, and Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004).
[313] See for instance Donna Haraway, *Primate Visions* and *Simians, Cyborgs, and Women*; Steven Shapin, *Levithian and the Air Pump* and *Never Pure*; and Helen Watson-Verran and David Turnbull, "Science and Other Indigenous Knowledge Systems" in *Handbook of Science and Technology Studies*, ed. Sheila Jasanoff et. al (Thousand Oaks, C.A.: Sage Publications, 1995), pp. 115-39.

[314] As Lauren Benton has shown in *Law and Colonial Cultures*, studying legal documents and frameworks helps to provide "a more nuanced view of cultural interactions in particular colonial encounters" (4).
[315] See for instance Mirrow, *Latin American Law*, and Donato Salvatore, Aguirre, and Joseph, eds., *Crime and Punishment in Latin America*.
[316] Barrera Osorio, "Experts, Nature, and the Making of Atlantic Empiricism" and *Experiencing Nature*; Klein and Sparry eds., *Materials and Expertise in Early Modern Europe*; Cook, *Matters of Exchange*; Newmann, *Atoms and Alchemy*; Cañizares Esguerra, *Nature, Empire, and Nation* and "Iberian Science in the Renaissance"; Schiebinger, *Plants and Empire*; Smith, "Vermillion, Mercury, Blood, and Lizards: Matter and Meaning in Metalworking" in Klein and Sparry, eds., pp. 29-49; Findlen and Smith, *Merchants & Marvels*; Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2001); Osler, ed., *Rethinking the Scientific Revolution*; Castillo Martos, *Minería y metalurgia: intercambio tecnológico*.
[317] Capoche, *Relación*, 131-2.
[318] On the division between Iberian mercury markets, tied to the new benefit of amalgamation, and silver that was smelted using indigenous technologies, see Bakewell, *Miners of the Red Mountain*.
[319] On the degratory environmental and labor conditions of colonial Spanish American mining, see Brown, "Workers' Health and Colonial Mercury Mining at Huancavelica, Peru" and Studnicki-Gizbert and Schecter, "Environmental Dynamics of a Colonial Fuel-Rush."
[320] See for instance Chandra Mukerji, "The New Rome: Infrastructure and National Identity on the Canal du Midi" in Carol E. Harrison and Ann Johnson, *National Identity: The Role of Science and Technology* (Chicago: University of Chicago Press, 2009), pp. 15-32 and Gauderman, *Women's Lives in Colonial Quito*.
[321] On scientific or proto-scientific institutions, see Juan José Saldaña, *Historia social de las ciencias en América Latina* (México, D.F.: Universidad Nacional de México Coordinación de Humanidades, 1996) and Antonio Lafuente and José Sala Catalá, *Ciencia colonial en América* (Madrid: Alianza, 1992). On the text-based tradition of heroic geniuses, see Jacob, "Reflections on Bruno Latour's Version of the Seventeenth Century," and Richard Yeo, "Genius, method and morality: Images of Newton in Britain, 1760-1860" in *Science in Context* 2 (1988): 257-284.
[322] An important exception to this pattern is José María López Piñero's wide ranging and multidisciplinary study of early modern Spanish science, *Ciencia y técnica en la sociedad española de los siglos XVI y XVII* (Barcelona: Labor Universitaria, 1979). For examples of studies that follow a single-author approach or that concentrate on the contributions of a select individual, see for instance Modesto Bargalló, *La amalgamación*, Tristan Platt, "The Alchemy of Modernity," and Carmen Salazer-Soler, "Alvaro Alonso Barba."
[323] For an account of the increases in silver output following the development and implementation of the amalgamation method, see Garner, "Long-Term Silver Mining Trends in Spanish America." Seventeenth-century accounts, like the tables compiled by Gaspar de Escalona y Agüero in his *Gazophilativm regivm prevbicvm* (1675, 190-193) also demonstrate the fluctuations from year to year amid a general increase in silver production from the late-sixteenth through the mid-seventeenth century.
[324] The quotation is from Francisco López de Gómara, *Historia general de las Indias y vida de Hernán Cortés*, ed. Jorge Gurría Lacroix (Caracas: Biblioteca Ayacucho [1552], 1979), p. 367. López de Gómara explains the conflation of personhood or subjectivity with an access to literacy that is more valuable than precious metals in the full passage, arguing that the Spaniards' gift of universal Christian letters more than justifies the few bits of silver that some soldiers and *encomenderos* took from native people: "Hanles enseñado latín y ciencias, que vale más que cuanta plata y oro les tomaron; porque con letras son verdaderamente hombres, y de la plata no se aprovechaban mucho ni todos. Así que libraron bien en ser conquistados, y mejor en ser cristianos" (They have been taught Latin and the sciences, which is worth more than however much silver and gold they took from them, because with literacy they are true men, and with silver they never benefited much or many. So they were freed in being conquered, and moreso in becoming Christians).
[325] Sánchez Gómez, *De minería, metalúrgica y comercio de metales*, p. 321.
[326] Barba, *Arte de los metales*, p. 67.
[327] *Arte de los metales*, p. 51, 119.
[328] Platt, "The Alchemy of Modernity," p. 2.
[329] ABNB EP 3: 673v-674 (12/7/1559, Potosí, Lázaro Águila) 1 f. Three weeks earlier they had agreed to a deal worth 200 pesos (EP 3: 564-565, 21/6/1559), but they declared that bill of sale "rota y candelada y de

ningún valor." The gift of the Rosario property is recorded in EP 3: 949v-950 (18/9/1559, Potosí, Lázaro del Águila) 1 f.

[330] ABNB EP 3: 948-959 (18/9/1559, Potosí, Lázaro del Águila) 2 ff. There is a similar *poder* that Guillermo de Dyste grants to Andrés de Lovaina to administer his mines and refineries "con la gente e indios que vos pareciere" (EP 3: 941v-943, 18/9/1559, Potosí, Lázaro del Águila) 3 ff.

[331] Fernández Montaño: ABNB CPLA 5:321-323 (2/7/1587, Potosí) 3 ff and ALP LAACh 6: 223-223v (14/7/1587), La Plata, 1 f (transcribed in José López Villalba, ed., *Acuerdos de la Real Audiencia de la Plata de los Charcas: 1576-1587* (Sucre, Bolivia: Corte Suprema de Justicia de Bolivia, Archivo y Biblioteca Nacionales de Bolivia, Embajada de España en Bolivia, Agencia Española de Cooperación Internacional, 2005), 10 t.; t. 3 pp. 517-518); Ortiz Picón: CPLA 6:20-20v (18/6/1591, Potosí) 1f; Gallegos: CPLA 7:433v-435 (18/4/1596, Potosí) 3 ff; Rojo: CPLA 6:40 (30/10/1591, Potosí) 1f and CPLA 7:252-252v (12/11/1594, Potosí) 1 f; Triveño: Min-120.9 (15/5/1638, Chichas), 4 ff; Vargas Carrillo: Min-146.6 (1676, Potosí), 4ff; Corro y Sagarra: *Instrucción y forma de beneficiar metales de plata, de modo que se saque toda sin perder cosa alguna de las que hasta agora se perdía cuyo gran aumento se logra con gran brevedad y ahorro de tiempo y con muy poco consumo de Azogue, cuyo secreto y nuevo agente que obra con tanta eficacia descubrió y redujo a práctica en el Cerro de Potosí y toda su Ribera, Don Juan del Corro y Segarra por el año de 1676 con asistencia del Licenciado Don Bartolomé González Poveda, Presidente de Charcas, que en carta de 3 junio de dicho año participó los admirables efectos experimentados al Señor Virrey del Perú y remitió testimonio de autos y tanto de la instrucción que es la siguiente: forma del nuevo beneficio de metales de plata por el Capitán Juan del Corro*. Lima: s.n., 1676; Mendoza: Rück 1/4: 7-7v (3/5/1651, Buen Retiro) 1 f.

[332] As Yanna P. Yannakakis suggests, the "technicalities of litigation" tended to reflect "collective strategizing" rather than the sole work of "a powerful Spaniard." See "Costumbre: A language of negotiation in eighteenth-century Oaxaca" in *Negotiation Within Domination: New Spain's Indian Pueblos Confront the Spanish State*, ed. Ethelia Ruiz Medrano and Susan Kellog (Boulder: University of Colorado Press, 2010), pp. 137-71; 147.

[333] Corzo and Sandi: ABNB CPLA 6:112 (6/11/1592 – 8/12/1592, Potosí) 1 f; Múñoz de Córdova and de la Concha: CPLA 5:364v-365 (20/6/1588, Potosí) 1 f and Min 120.6 (10/6/1589, Lima) 2 ff; Genari and Sánchez: CPLA 7:269v-269a (11/3/1594, Potosí) 1 f; Vergaraesse and Sánchez: CPLA 7:336v (7/10/1594, Potosí) 1 f.

[334] ABNB CPLA 7:252-252v (12/11/1594 Potosí) 1 f and CPLA 7:254v-256 (29/1/1594, Potosí) 4ff. Corona y Orihuela's oven is described in his *memoria***,** with an illustration, in ABNB CPLA 20: 290 (15/5/1635, Potosí), 2 ff. This design built from the work of the physician Lope de Saavedra Barba, described in Sánchez Gómez (1997, 55).

[335] *Arte de los metales*, 68-69, 73-74.

[336] One late-sixteenth-century colonial official remarked that the lack of a viable treatment for *negrillos* was an "inconviniente muy grande … porque eran muchos e no se sabe su beneficio" (ABNB CPLA 6:112; 6/11/1592 – 8/12/1592, Potosí, 1 f).

[337] ABNB CPLA 5: 321-323, 1587.

[338] *Arte de los metales*, 68.

[339] Rodríguez Sala, "Tres constructores de obras científico-técnicas."

[340] At least one eighteenth-century reader continued to credit Juan del Corro with the introduction of the new method of amalgamation into the Villa Imperial. In his 1738 tract, Lorenzo Felipe de la Torre y Barrio Lima vividly describes the "excessivo jubilo" with which the method "que pretendió haver hallado en Potosí Don Juan del Corro" was received. From bull fights in the main plaza to a royal procession through streets decorated with so many "altares" that "parecieron Zodiacos de riqueza, en que cada vno era vna Constelacion de Plata, de Oro, y de Diamantes, para aquella Divina Aurora que las ilustraba," the city's scientific and religious communities were galvanized in collective celebration. *Arte o cartilla del nuevo beneficio de la plata en todo genero de metales frios y calientes* (Lima: Antonio Joseph Gutierrez de Zevallos, 1738), pp. 29v-30. For a study of Corro y Segarra's reception in Mexico, where the second edition of the text was published one year after the Peruvian first edition, see Rodríguez Sala, "Tres constructores." Rojo's reception is recorded by the Cabildo Secular de Potosí in ABNB CPLA 6:40 (30/10/1591, Potosí), 1 f.

[341] ABNB Minas 8.1 (1630, Potosí), 11 ff.

[342] Some of the major contributors to the debate include Carolyn Merchant's original provocation – in the

best sense of the term – *The Death of Nature* and the 25-year retrospective,"The Scientific Revolution and the Death of Nature," *Isis* 97 (2006): 513-533. Merchant addresses some of the responses to the *Isis* edition in "Secrets of Nature: The Bacon Debates Revisited" in *Journal of the History of Idea*s 69.1 (2008): 147-162, as does Katherine Park's essay in the same volume. See also Rosalind Chait Barnett and Laura Sabattini, "A History of Structural Barriers to Women in Science: From Stone Walls to Invisible Walls" in *The Science on Women and Science*, ed. Christina Hoff Sommers (Washington, D.C.: AEI Press, 2009), pp. 54-78. Classic contributions to the field include Evelyn Fox Keller, *Reflections on Gender and Science*, and Sandra Harding, *The Science Question in Feminism* and *Whose Science? Whose Knowledge?*. Harding's more recent scholarship has focused less on the seventeenth century, but it remains central in feminist interventions into the history and philosophy of science. See for instance *Science and Social Inequality: Feminist and Postcolonial Issue*s (Urbana, I.L.: University of Illinois Press, 2006), and *Sciences From Below: Feminisms, Postcolonialities, and Modernities* (Durham, N.C.: Duke University Press, 2008).
[343] Hatfield, *Atlantic Virginia*, and Gauderman, *Women's Lives in Colonial Quito*.
[344] Ash, *Power, Knowledge, and Expertise*.
[345] ABNB Minas 110.5 (2/11/1661 – 22/12/1661, Paucarcolla), 11 ff; 1.
[346] ABNB Minas 145.4 (1656 – 1658, La Plata), 66 ff; 14v.
[347] ABNB Minas 132.10 (8/11/1672 – 10/4/1673, Potosí), 68 ff.
[348] ABNB Minas 57.25 (4/11/1657 – 30/9/1661, Lipez), 6 ff.
[349] ABNB Minas 1.1 (24/9/1562 – 6/11/1568, Potosí – La Plata), 83 ff.
[350] ABNB EP 24: 315-16v (7/10/1572, La Plata, Juan Bravo, escribano), 2ff: 315v.
[351] ABNB EP 22: 156-157v (27/3/1569, La Plata, Juan Bravo), 2 ff. The location of the g*uaca* is not provided in the contract, but it is described in Andrés Eichmann, *Cancionero mariano de Charcas* (Frankfurt and Madrid: Vervuert and Iberoamericana Editorial, 2009), p. 548.
[352] Escalona y Agüero, *Gazophilativm regivm prevbicvm*, pp. 87-88. The proceedings are documented in ABNB Minas 108.2 (2/8/1686 – 7/1/1687, Cepita, Chucuito, and La Plata), 53 ff. For an account of *guaca* excavation and indigenous knowledge, see also Carmen Salazar Soler, "Las huacas y el conocimiento científico en el siglo XVI: a próposito del descubrimiento de las minas de Potosí" in *Saberes y memorias en los Andes: in memoriam Thierry Saignes*, ed. Thérèse Bouysse-Cassagne: Paris: Institut des hautes'etudes de l'amérique latine and Institut français d'études andines, 1997), pp. 237-259.
[353] ABNB EP 24: 288-290v (11/8/1573, La Plata, Juan Bravo), 6 ff; Brockington, *Blacks, Indians, and Spaniards in the Eastern Andes*, p. 7. For case studies of litigation, see pp. 119-123.
[354] ABNB Minas 96.1 (31/1/1625, Lima), 4ff; 1.
[355] ABNB Minas 68.2 (20/10/1676– 15/12/1676, Chayanta), 90ff.
[356] ALP CACh 1463 (4/4/1640, Madrid), 5ff.
[357] ABNB Minas 63.14 (12/12/1651, Chayanta), 39ff, and Minas 63.13 (19/9/1651 – 23/9/1651, Chayanta), 3ff, which includes the maps that depict the town of Pocoata's land claims and Carvajal's competing vision of the terrain.
[358] Bargalló, *La minería y la metalurgía*, pp. 278-81.
[359] Noejovich, "El consumo de azogue: ¿Indicator de la corrupción del sistema colonial en el virreinato del Perú?" in the Columbian Ministry of Culture's annual publication, *Fronteras de la historia* 7(2002): 77-98. Available from the Red de Revistas Científicas de América Latina, España y Portugal at http://redalyc.uaemex.mx; Sánchez Gómez, *Minería y metalurgia en la edad moderna*, p. 55; Brown, "Workers' Health and Colonial Mercury Mining at Huancavelica, Peru," p. 468.
[360] On the demographic composition of seventeenth-century Potosí, see Alberto Crespo's classic study, *Esclavos negros en Bolivia*. For an examination of population records and patterns of mixed-race mine ownership in other áreas of Alto Perú, see Gutiérrez Brockington,*Blacks, Indians, and Spaniards in the Eastern Andes.*
[361] The question of gender in the epistemological formation and practices of geography – land surveying, map making, and mapping disciplinary borders – has moved feminist perspectives to the center of current research in geography, following the influential work of geographers like Gillian Rose and Susan Stanford Friedman. See Rose, *Feminism and Geography: The Limits of Geographical Knowledge* (Minneapolis: University of Minnesota Press, 1993) and Friedman, *Mappings: Feminism and the Cultural Geographies of Encounter* (Princeton, N.J.: Princeton University Press, 1998). Cartography has also come to occupy a more central place in the history of science, as historians like Richard S. Westfall have underscored cartography's role in the interstices of applied mathematics and geography and Jorge Cañizares Esguerra

has shown how cartographic knowledges shaped imperial power. I am curious about the potential of a case like the Pocoata-Carvajal maps, and the absence of such documents in doña Leonor's trial, to contribute to both of these fields: feminist geographies and colonial science. Westfall, "The Background to the Mathematization of Nature" in Jed Z. Buchwald and I. Bernard Cohen, eds., *Isaac Newton's Natural Philosophy* (Cambridge, M.A.: Massachusetts Institute of Technology Press, 2001), pp. 321-339, and Cañizares Esguerra, *Nation, Nation, Empire*.

[362] According to Lauren Benton's wide-ranging and highly-compelling argument about legal frameworks and the global history of colonialism, decentralization is a universal feature of colonial law, for "Wherever a group imposed law on newly acquired territories and subordinate peoples, strategic decisions were made about the extent and nature of legal control" (2). The act of colonization necessarily produces these multiple layers of power, competing claims of authority, and legal pluralism, conflicts expressed in the relationships between and among colonizers and colonized. For specific case studies, see Yanna P. Yannakakis, "Costumbre: A language of negotiation in eighteenth-century Oaxaca" and Gauderman, *Women's Lives in Colonial Quito*. For more general discussions of Spanish American legal structures, see Mirrow, *Latin American Law*, and Salvatore et. al. *Crime and Punishment in Latin America*.

[363] See Gauderman, *Women's Lives in Colonial Quito*, especially chapter 5.

[364] I have been unable to determine what this word means; it may refer to a kind of refinery ("hilaces" could be "helices" or "helixes/corkscrews") or perhaps a place name (although no such place has been identified in the region). I have looked in seventeenth-century mining dictionaries like García Llanos's *Diccionario y maneras de hablar que se usan en las minas y sus labores en los ingenios y beneficios de los metales* (La Paz: MUSEF, [1609] 1983) and contemporary mining dictionaries like Ricardo N. Alonso's *Diccionario minero: Glosario de voces utilizadas por los mineros de Iberoamérica* (Madrid: Consejo Superior de Investigaciones Científicas, 1995). I have also communicated with mining historian Peter J. Bakewell, who unfortunately had never come across the term, either. I hope that a reader will recognize this term and help to define its place in the case of doña Juana. Bakewell, "Re: Mining terms in colonial Alto Perú," emails to the author, 28 September 2011 and 4 October 2011.

[365] ABNB Minas 70.8 (31/5/1688 – 17/7/1688, Ocurí, Chayanta and La Plata), 6 ff.

[366] ABNB Minas 82.15 (23/5/1607 – 2/10/1607, La Plata), 111 ff; 61, 98v.

[367] ABNB Minas 147.6 (27/8/1692 – 10/11/1692, La Plata), 12 ff; 4, 2, 10.

[368] ABNB Minas 70.7 (12/2/1686, La Plata), 6 ff.

[369] ABNB Minas 146.17 (1679 – 1688, La Plata); 165ff; 91v, 155. Barba, *Arte de los metales*, 78.

[370] ABNB Minas 10.4 (24/9/1642, Potosí), 14 ff. The same protector of the Indians who testified in Bartola Sisa's appeal, Don Diego Benites de Maqueda y Villalón, petitioned here for economic and social rights on behalf Diego Quispe Usca Guaman and Diego Rodríguez, the husbands of Inés Amanca and María Amanca. Both Inés and María were nieces of the "discoverer" of Potosí, don Diego Gualpa, the miner who revealed the Cerro Rico to the Spaniards. This case does not suggest that the women have any particular mineralogical knowledge or skilled practices, but it demonstrates how indigenous elites used Spanish legal systems and cultural frameworks designed to protect mining and metallurgical work to their own advantages.

[371] On women's participation in European guilds, see Clare Crowston's literature review, "Women, Gender and Guilds in Early Modern Europe: An Overview of Recent Research" in *The Return of the Guilds*, ed. Jan Lucassen, Tine De Moor, and J. L. Zanden (Cambridge and New York: Internationaal Instituut voor Sociale Geschiedenis, Amsterdam, by Cambridge University Press, 2008), pp. 19-44. On Latin America, see Juan José Saldaña, "Science and Public Happiness During the Latin American Enlightenment" in *Science in Latin America: A History*, ed. Juan José Saldaña and trans. Bernabé Madrigal (Austin, T.X.: University of Texas Press, 2006), pp. 51-92.

[372] Archivo General de la Nación (Lima), Minería 13.51 (22/5/1787, Lima), 2 ff.

[373] AGN Minería 24.3 (2/5/1790, Lima), 42 ff; 7.

[374] AGN, Minería 2.15 (26/11/1790, Lima), 1 f.

[375] So pronounced by governor Juan del Pino Manrique de Lara (1764-1815). The line is recorded in Arzáns de Orsúa y Vela, *Historia de la villa imperial de Potosí*, vol I.cxxxi.

[376] Luis Diez del Corral, *Del nuevo al viejo mundo* (Madrid: Revista de Occidente, 1963), cited in Carlos Prieto, *Mining in the New World* (New York: McGraw, 1973), p. 33.

[377] Bakewell, *Silver and Entrepreneurship in Seventeenth-Century Peru*, p. 25.

[378] For an account of the range of positions occupied by women in the present-day mining regions of

Bolivia, see *Warmi mineral.*
[379] Brown, "Workers' Health and Colonial Mercury Mining at Huancavelica, Peru"; Miller, *Environmental History of Latin America* (New York: Cambridge University Press, 2007).
[380] Bakewell, *Silver Entrepreneurship in Seventeenth-Century Potosí*, p. 20.
[381] Platt, "The Alchemy of Modernity" and Bargalló, *Minería y metalurgía en la época colonial*.
[382] "De re metalica." *Dover Publications*. <http://store.doverpublications.com/0486600068.html> 19 October 2011.
[383] Craig, "Spanish Colonial Silver Beneficiation at Potosí," p. 271.
[384] Bargalló, *La minería y la metalurgía en la época colonial*, p. 99; Young, "Black Legends and Silver Mountains," p. 115.
[385] Agricola, trans. Hoover and Hoover, *De re metallica*, fn13p300.
[386] De Conde, *Herbert Hoover's Latin-American Policy* (New York: Octagon Books, 1970 [1951]), p. 127; Schoultz, *Beneath the United States: A History of U.S. Policy Toward Latin America* (Cambridge, M.A.: Harvard University Press, 1998).
[387] Hoover, *Principles of Mining* (New York: Hill, 1909), p. 185, 191.
[388] The debate over Bolivia's right to a *salida al mar* surfaced with particular intensity during 2003-2004 in what is now called "la guerra del gas." For scholarly accounts of the debate over natural resources, indigenous movements, and Latin American politics, see Alejo Esteban Ticona, *Saberes, conocimientos y prácticas anticoloniales del pueblo Aymara-quechua en Bolivia* (La Paz: Plural, 2010) and Thomas Perrault, "De la guerra del agua a la guerra del gas: gobernanza de recursos, neoliberalismo, y protesta popular en Bolivia" in *Después de las guerras del agua*, ed. Susan Spronk and Carlos Crespo (La Paz: Plural, 2007). For coverage in the popular press, *La fogata* compiled a range of responses to the clash of Chilean and Bolivian interests, edited by Augusto Alvarado, aonikenk02@hotmail.com, and available here http://www.lafogata.org/mar/mar_ boliviano.htm. More recently, the question of Bolivia's status as a landlocked country has emerged in conjunction with the development of alternative energy sources, as the present-day southwestern corner of Bolivia are said to contain the world's largest deposits of lithium, a key element in the development of electric cars and more efficient batteries for electronic devices. See Mabel Aczui, "La fiebre del litio boliviano," in *El País* 7/2/2009. In English, a very good account can be found in Lawrence Wright, "Lithium Dreams: Can Bolivia Become the Saudi Arabia of the Electric-Car Era?" in the *New Yorker*, 22 March 2010.
[389] Bakewell, *Metals and Mines of Latin America*, xii.
[390] Potter, *Feminism and Philosophy of Science: An Introduction* (London: Routledge, 2006), p. 4.
[391] Shakespeare, *Tempest*, in *The Norton Shakespeare* (1997 [1611/1623]), 1.2.230.
[392] Shakespeare, *Tempest*, 3.3.21-23 and 3.2.130-138.
[393] Shakespeare, *Tempest*, 1.2.345-47, 367-68, 353-354.
[394] Although *The Tempest* had long been enlisted by Latin American artists in the imaginative construction of European and American relations and interrelations, it was the intervention of postcolonial thinkers of the Caribbean, like Amié Césaire's critical-creative reworking in *Une tempête* (1968), more than the modernists of South America, like José Enrique Rodó and his *Ariel* (1900), who galvanized critics to reconsider the text. The colonial/postcolonial frame revitalized interest in a text that had always circulated broadly and been imagined in richly diverse aesthetic, cultural, and geographic contexts. The text's movement in, among, and through African, European, and American diasporic communities is studied in Hume and Sherman, eds., *The Tempest and its Travels* (Philadelphia: University of Pennsylvania Press, 2000). See especially the essays by Andrew C. Hess (pp. 121-131), Roland Greene (138-148), John Gillies (180-201), Gordon Brotherston (212-219), and Lucy Rix (236-249). See also Patricia Seed (202-211), discussed below.
[395] Foucault, "Governmentality" in *The Foucault Effect: Studies in Governmentality*, ed. Graham Burchell, Colin Gordon, and Peter Miller (Chicago: University of Chicago Press, 1991, pp. 87-118), 99.
[396] Armstrong and Tennenhouse, "The Problem of Population and the Form of the American Novel" *American Literary History* 20.4 (2008): 667-685, 667; Chaplin, *Subject Matter*. In the opening pages of the book, Chaplin notes that her study does not include the Spanish sources that predate the English and were known to Anglophone readers in translation, but that a comparison of Spanish and English colonial sciences is "a subject that deserves book-length studies in its own right" (18).
[397] Prospero's ascription of earthiness to Caliban is once again bound up in the question of language, encapsulated in his initial address to Caliban: "Thou earth, thou, speak!" (1.2.317). Speaking back to

power, Caliban taunts Prospero to "Do that good mischief which may make this island / Thine own for ever, and I thy Caliban / For aye thy foot-licker" (4.1.214-216). Seed, "'This island's mine': Caliban and Native Sovereignty" in *The Tempest and Its Travels*, ed. Hulme and Sherman, pp. 202-211.

[398] Seed, "Native Sovereignty," p. 205. For examples of fine comparative work, see Seed's *Ceremonies of Possession* and, for a longer discussion of indigenous people's land rights in the Americas, *American Pentimento*.

[399] Bailyn, *The Peopling of British North America*, p. 124.

[400] Seed, "Native Sovereignty," p. 205, fn7p300. It is worth noting that these countries represent nearly seventy percent of the landmass of South America, making them quite large "exceptions" to this finding.

[401] The quotation is from the evocative and memorable scenes of gardening in book 5 of Milton's *Paradise Lost* (ll. 214-215).

[402] Loddington, *Plantation uuork the work*; Letter to Molesworth, *The true way to render Ireland happy and secure, or, A discourse; wherein 'tis shewn, that 'tis the interest both of England and Ireland, to encourage foreign Protestants to plant in Ireland: In a letter to the right honourable Robert Molesworth, one of His Majesty's honourable Privy Council in Ireland, and one of the members of the honourable House of Commons, both in England and Ireland* (Dublin: Printed by and for Andrew Crook, printer to the King's Most Excellent Majesty, and for Eliphal Dobson, 1697), EEBO.

[403] Pagan, Blaise François de. *An historical & geographical description of the great country & river of the Amazones in America. Drawn out of divers authors, and reduced into a better forme; with a mapp of the river, and of its provinces, being that place which Sr Walter Rawleigh intended to conquer and plant, when he made his voyage to Guiana. Written in French by the Count of Pagan, and dedicated to Cardinall Mazarine, in order to a conquest by the Cardinals motion to be undertaken. And now translated into English by William Hamilton, and humbly offered to his Majesty, as worthy his consideration* (London: John Starkey, 1660), p. A4. EEBO.

[404] Letter to royal Parliament of England and Wales, *An act for the speedy and effectual satisfaction of the adventurers for lands in Ireland* (1653); *Act for incouraging Protestant-strangers* (1662).

[405] Eburne, *A plaine path-vvay to plantations that is, a discourse in generall, concerning the plantation of our English people in other countries. Wherein is declared, that the attempts or actions, in themselues are very good and laudable, necessary also for our country of England. Doubts thereabout are answered: and some meanes are shewed, by which the same may, in better sort then hitherto, be prosecuted and effected. Written for the perswading and stirring vp of the people of this land, chiefly the poorer and common sort to affect and effect these attempts better then yet they doe. With certaine motiues for a present plantation in New-found land aboue the rest. Made in the manner of a conference, and diuided into three parts, for the more plainnesse, ease, and delight to the reader. By Richard Eburne of Hengstridge in the countie of Somerset.* London: Printed by G[eorge] P[urslowe] for Iohn Marriot, 1624, pp. 9, 16. Sabin Americana; Kupperman, "The Beehive as a Model for Colonial Design." On seventeenth-century immigration policies for Huguenots in Ireland, see Raymond Hylton, *Ireland's Huguenots and their Refuge, 1662-1745: An Unlikely Haven* (Brighton, England: Sussex Academic Press, 2005), especially chapter one, "The Early Ormondite Refuge, 1662-1680," pp. 19-31.

[406] White, *Planters Plea*, pp. 2, 3, 4.

[407] Bakewell, "Mining," in Bethell, ed., p. 249.

[408] The quotation is from Gaytan de Torres, *Relacion, y vista de oios qve don Manuel Gaytan de Torres, ventiquatro, de la ciudad de Xerez, haze a su Magestad en el Real Consejo de las Indias: por comision que para ello tuuo de las minas de cobre que ay en las serranias Cocorote, prouincia de Veneçuela* (Almería: Ediciones Granata , 1968 [La Habana, 10 de Iunio de 1621]), p. 9v.

[409] Hoover's role in drawing the preset-day borders of Chile, Bolivia, and Peru, following the late-nineteenth century War of the Pacific, is discussed in the conclusion of chapter three.

[410] Ortiz, *La Virgen de la Caridad del Cobre*, p. 127. See also Portuondo Zúñiga, *La Virgen de la Caridad del Cobre*.

[411] Capoche, *Relación*; Barba, *Arte de los metales*; Berrio de Montalvo, *Informes para obtener plata del azogue*.

[412] Nebrija, Antonio de, *Gramática de la lengua castellana*, ed. Antonio Quilis (Madrid: Editora Nacional, 1981 [Salamanda, 1492]), p. 97 (ll. 11-14); Covarrubias Horozco, Sebastian de, *Tesoro de la lengua castellana o española*, Ed. Manuel Camarero y Felipe C. R Maldonado (Madrid: Editorial Castalia, 1994).

[413] Ernesto Mora Queipo, *Los esclavos de Dios: Religión, esclavitud e identidades en la Venezuela del siglo*

XVIII (Maracaibo: Universidad del Zulia Ediciones del Vice Rectorado Académico, 2007), pp. 69-72.
[414] On the recognition of highly-skilled African miners and metallurgists in the copper mines of Cuba, see Díaz, *The Virgin, the King, and the Royal Slaves of El Cobre*. On religious slavery in Venezuela, see Mora Queipo, *Los esclavos de Dios*.
[415] The 66-pound figure was obtained from the assays in Venezuela, while the factor at the Casa de Contratación in Sevilla harvested 75 pounds of copper from the same sample (4). Don Manuel estimated that the site would be operational 270 days each year (13).
[416] Schwartz, *All Can Be Saved: Religious Tolerance and Salvation in the Iberian Atlantic World* (New Haven: Yale UP, 2008).
[417] The earlier settlements organized by the military captain Alonso Sánchez de Oviedo and the priest don Leonardo Ferigo, alternately identified as *clerigo presbítero* and *sacerdote*, had failed. By 1620, don Manuel argued that the foundations of Sánchez de Oviedo's refineries, Ferigo's copper mines, and transportation infrastructure of the port all needed to be set anew (3).
[418] ANBN ALP CACh 728 (13/11/1616, Tomave**)** 8 folios, papel, p. 2; Anchieta, *Cartas: Informações, fragmentos históricos e sermões* ([1583] Belo Horizonte: Editora Itatiaia, 1988), p. 79.
[419] Archivo Nacional de la República de Cuba, Reales cédulas e ordenes, 22 diciembre 1740, 181.1: 1-5v, 2v, 2.
[420] ANRC, Reales cédulas e ordenes, 5 febrero 1738, 143.1, 1-8v: 4v-5.
[421] ANRC, Reales cédulas e ordenes, 22 diciembre 1740, 181.1: 3v, 5. It is unclear how large the copper industry would have been in Mexico at the time. Relative to the silver industry, copper had always been a small sector, and, as John TePaske has shown, the account ledgers of the Caja de Mexico do not show any income from the copper mines after 1691. TePaske, *La Real Hacienda de Nueva España, la Real Caja de México, 1576-1816* (México: Instituto Nacional de Antropología e Historia, SEP, Departamento de Investigaciones Históricas, Seminario de Historia Económica, 1976), s. 779.
[422] ANRC, Reales cédulas e ordenes, 5 febrero 1738, 143.1: 1v.
[423] According to a royal survey, the human property was worth nearly eight times as much as the rest of the estate, which may explain why Salazar y Acuña was so eager to capitalize upon his most valuable asset. ANRC, Reales cédulas e ordenes, 7 abril 1800, 21.37: 1, 4. When the settlement of the Aroa River Valley folded in 1638, a royal survey revealed a similar case for the value of the chattel property relative to the mines and refineries catalogued by don Manuel. The survey of 1638 was conducted by royal treasurer Hernando García de Ribas and is transcribed from the archival manuscript in Paúl Verna's *Las minas del Libertador: Tres siglos y medio de histori- 1972 a venezolana, 1605* (Caracas: Imprenta Nacional, 1977), 58.
[424] The account is helpfully transcribed in Díaz, Appendix 3, pp. 339-340.
[425] Little, "Transforming Work," p. 499; Elliott, *Empires of the Atlantic*, p. 9-10, 106.
[426] Simmons, *The Moorlands of England and Wales: an Environmental History, 8000 BC to AD 2000* (Edinburgh: Edinburgh University Press, 2003), p. 325.
[427] Heaney, *Beowulf: A New Verse Translation* (New York: W.W. Norton & Company, 2001 [1000?]), ll. 1511, 1515, 1526, 1532, 1521-1524
[428] Shakespeare, *Macbeth*, in *The Norton* Shakespeare, op. cit., (1997 [1604?/1623]), 1.3.38-39, 78-79; 75, 76, 129, 122.
[429] Plat, *Jewell House Concerning Art and Nature* (London, 1594), pp. 40-1.
[430] Child, "Large letter," pp. 18-19 and Boates, "Annotations upon the Legacy of Husbandry" (pp. 118-132), p. 119, all in Hartlib's *Husbandry* (1655); "Modern Syphilographers" *Medical Times and Gazette (London): A Journal of Medical Science, Literature, Criticism, and News* 2 (1864): 466-468; p. 467, Googlebooks. See also Alfred Crosby's review of syphilis, "The Early History of Syphilis: A Reappraisal" in *American Anthropologist* 71.2 (1969): 218–227, and literary scholar Juan Carlos González Espitia's forthcoming work on a Hispanic literary history of the disease.
[431] Child, "An Answer to the Animadversor on the Letter to Mr. *Samuel Hartlib* of Husbandry" (pp. 132-172), pp. 140-1, in Hartlib's *Husbandry* (1655).
[432] Gage, *Color in Art* (London: Thames & Hudson, 2006), p. 147.
[433] Plattes, *Macaria*, p. 2.
[434] Evans, Augusta Jane, *Macaria, or, Altars of Sacrifice*, ed. Drew Gilpin Faust (Baton Rouge, L.A.: Louisiana State University Press, 1992), p. 341; Gruesz, *Ambassadors of Culture: The Transamerican Origins of Latino Writing* (Princeton, N.J.: Princeton University Press, 2002).

[435] Many of these images are reproduced and analyzed in detail by Elise Virginia Lemire in *"Miscegenation": Making Race in America* (Philadelphia: University of Pennsylvania Press, 2002). See for instance her discussion of paintings like the anonymous "Miscegenation Ball" (1864) and E.W. Clay's *Practical Amalgamation* (1839), and *Amalgamation Polka* (1845), reproduced on pp. 122, 95, and 124, book illustrations like T.W. Strong's "Mr. Horace Squash" and the "lady of color" in *Boy's Own Book of Fun* (ca. 1852-1866), reproduced on p. 75, and the pamphlet *What Miscegenation Is! And What We Are to Expect Now that Mr. Lincoln is Re-elected* (ca. 1864), pp. 141-3.

[436] Barrera Osorio, *Experiencing Nature*; Cañizares Esguerra, *Nature, Empire, and Nation*; Ferreira Furtado, "Tropical Empiricism: Making Medical Knowledge in Colonial Brazil" in Delbourgo and Dew, eds., pp. 127–152.