CHAPTER TWENTY FOUR

ENLIGHTENED REFORMISM IN IBERIAN CULTURE AND SCIENCE

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INTRODUCTION

From Paris toward the end of 1675—in response to dramatic Portuguese losses in Asia and the Atlantic—the diplomat Duarte Ribeiro de Macedo anxiously penned a policy brief to his peers back home in Lisbon. Macedo had spent the last several years in France, where he was Portuguese envoy to the court of Louis XIV. It was perhaps through his contacts at court that he learned not only of the Royal Society of London but also of its journal, the *Philosophical Transactions*. The London institution, its ambitious publishing program, and the contents of those pages deeply impressed Macedo. They also worried him. The capacity of the Royal Society and its journal to propagate new and useful knowledge about the inner workings of the natural world seemed, to Macedo at least, to strengthen the hand of the English at the very time when Portugal’s empire, especially in Asia, was being torn from its grasp. Should his countrymen not act quickly, Macedo argued, Portugal was certain to lose out. A century later, in 1779, it seemed as though Macedo’s fears had come to pass. That year, in his inaugural address for Lisbon’s Academia Real das Ciências, Padre Teodoro de Almeida insisted that his nation’s failure to create institutions that fostered the sciences had led to the continued decline of Portugal and its empire. Almeida argued that the creation of Lisbon’s new Academia Real, modelled as it was on the Royal Society, would help Portugal regain its proper place among European imperial powers (BNP Res. Cod. 11377, ff. 63-90v; BNP Res. Cod. 11463, ff. 133-145v).

Interpretations of the Enlightenment in the Iberian world have often reflected the vision shared by Macedo and Almeida. The conventional story of the Enlightenment is one in which a particular set of ideas—an attack on aristocratic power and privilege, the loosening of restrictions on individual economic activity, a stress on the rational capacity of the human mind, a distrust of traditional authority, and a concomitant rejection of what was seen as religious mystification and scholastic obscurantism—all emanated outward from the pens of Locke, Montesquieu, and Kant and, more
generally, from England, France, and Germany. The rest of Europe and European dominions overseas were but passive recipients of these ideas (Hesse 2006; Withers 2007). Yet Enlightenment in the Iberian world was not merely derivative of—or a reaction to—foreign ideas and events. The Iberian world fully participated in the Enlightenment, and it did so in ways that reflected the particular priorities, possibilities, participants, and practices that characterised Spain, Portugal, and their far-flung colonies. As was true in London or Paris, Enlightenment in the Iberian world consisted of wide-ranging, multifaceted, and often contradictory projects. For Spanish and Portuguese rulers, these projects drew inspiration from intellectual currents at home and abroad—enlightenment and science were not initiatives that merely radiated from ostensible centres of empire—and they reflected a deep preoccupation with the fate of their dominions both within Europe and overseas (Paquette 2008, 2009).

At the beginning of the eighteenth century, Iberian rulers and their advisors saw that mounting political, economic, and social challenges had dramatically diminished their standing within Europe and reduced their influence around the globe. Political power in both empires was diffuse. Administration was erratic. And colonial outposts were expensive and difficult to defend. Colonial agriculture had begun to flag, and as the production of silver in the Spanish Americas and of gold in Brazil dwindled, so too did the imperial economies of Spain and Portugal. In both Spain and Portugal, the Enlightenment emphasis on secularism, reason, and the rebuke of inherited privilege inspired dramatic reforms that were meant to reverse the ebb of wealth and power. A centrepiece of these reforms was increased support for science—the diligent and disciplined investigation of nature. The reinvigoration of mining, the expansion and diversification of agriculture, and the growth of industry across the Iberian world appeared to demand better training in such areas as mathematics, natural history, chemistry, metallurgy, geography, hydrography, and physics (Paquette 2013, ch. 1; Saldaña 2006; Maxwell 1995; Puerto Sarmiento 1988; Falcon 1982).

Importantly, the Iberian Enlightenment was not merely about science, nor was it solely oriented toward prosaic imperial concerns. The emphasis on human reason, on individual liberty, and on secularism at once propelled and reflected important shifts in cultural and intellectual life more broadly. New and often state-chartered academies emerged and promoted the reinvigoration of arts and letters—of language, rhetoric, and history—in both metropolitan Spain and Portugal alike (Cañizares-Esguerra 2001). Enlightenment influences inspired royal efforts to cultivate not only the talents of elite virtuosi but of poorer subjects too, as part of attempts to focus their minds and energies on pursuits that might serve a public good (Slater and Prieto 2009; Domínguez Ortiz 2005).

Nor, for that matter, was the eighteenth-century emphasis on the investigation of nature within the Iberian world without precedent. To the contrary: within Spain and Portugal and in their colonies scattered from Asia to the Americas, eighteenth-century investigative endeavours built upon earlier efforts. Though strongly influenced, as we will argue, by the international and imperial networks of the long eighteenth century, Enlightenment reforms within the Iberian world are best understood as an amplification of existing traditions and impulses in Iberian society. Indeed, for eighteenth-century imperial leaders, particularly in Spain, crown
initiatives were consciously linked to sixteenth-century precedents. They followed as well upon reformist projects of the late seventeenth century and they spanned the entire eighteenth century (Marcaida 2014; Marcaida and Pimentel 2008; Barrera-Osorio 2008; De Vos 2006).

Here we focus on the latter half of the eighteenth century for two reasons. First, the developments in this period provide useful examples for illuminating the interactions between Enlightenment and science throughout the Iberian world. It was in the later eighteenth century that science was put at the service of Iberian states in ways that were often more centralised, more focused, and more sweeping than ever before. Empire increasingly became the scale of investigative practice, as Spanish and Portuguese rulers commissioned ambitious expeditions to chart anew the plants, animals, lands, and peoples that constituted their empires. Partly as a consequence, places as diverse as Mexico City, Goa, Quito, Luanda, and Rio all intensified their engagement with Enlightenment forms of natural inquiry. And this suggests the second reason for focusing on the late eighteenth century: it is in this period that more fruitful comparisons and contrasts between the scientific activities of the Spanish and Portuguese worlds can be made.

What follows is a brief introduction to science and the Enlightenment in the Iberian world. Beginning with the Iberian peninsula, we discuss some of the most important cultural, institutional, administrative, and investigative developments in metropolitan Spain, Portugal, and their empires. There were important differences between the Spanish and Portuguese imperial experiences and we devote significant attention to these as well. But the history of science in both the Spanish and Portuguese worlds was part of a common, overarching transformation that spanned the eighteenth century. In 1700, the intellectual status of science across much of the Iberian world was contested, its institutional infrastructure was often slight, and its relationship with imperial economic activity and administration often tenuous. By the end of the eighteenth century—although the timing differed, and the particular institutional arrangements varied—science had become inextricably entangled with culture, politics, and society not only within Spain and Portugal but across their respective empires. Science and empire grew increasingly interconnected.

SCIENCE, CULTURE, AND METROPOLITAN REFORM

To meet the demands of imperial renewal, the rulers of Spain and Portugal undertook the reform of old institutions and the creation of new ones. Beginning in the seventeenth century with the establishment of the Reales Estudios de San Isidro in Madrid and the Real Academia de Medicina y Otras Ciencias in Seville, this trend intensified in the second half of the eighteenth century, especially as investigative institutions emerged in which overlapping networks of people and texts—along with plant, animal, and mineral specimens—all converged. Royal support for the sciences in eighteenth-century Spain reached its peak during the reign of Charles III (r. 1759–1788). One major patron of the sciences was the Spanish military, which established several new institutions that focused on engineering, mathematics, astronomy, cartography, and medicine. The crown and its military sought to create a new generation of officers and elites with expertise in these areas. Cádiz, Spain’s primary port city on the Atlantic Ocean, exemplified the “militarisation”
of Spanish science in this period (Lafuente and Peset 1985). During the eighteenth century, Cádiz witnessed the establishment of the Colegio de Cirugía in 1748, the Academia de Ingenieros in 1750, the Observatorio de Marina in 1753, and a learned society, known as the Asamblea Amistosa Literaria de Cádiz, in 1755. All of these institutions were associated with the Spanish military in some way and collectively they made Cádiz an important centre of scientific activity along with other cities such as Barcelona and Seville (Lafuente and Valverde 2003, 9).

Another important place for the sciences in Enlightenment Spain was Madrid, the imperial capital. In addition to several institutions established by the military and institutions focusing on language and the humanities established earlier in the eighteenth century such as the Real Academia Española (1713) and the Real Academia de Historia (1738), the city also became home to the Real Academia de Bellas Artes de San Fernando (1752), the Real Jardín Botánico (1755), and the Gabinete de Historia Natural (1776). These institutions were tangible examples of the crown’s commitment to an Enlightenment ideal of science as at once a symbolic yet practical form of statecraft. While the Real Academia de Bellas Artes trained the artists that participated in expeditions and produced illustrations of flora and fauna, the Gabinete de Historia Natural established Madrid as an important centre where natural objects and reports about natural phenomena were collected, compared, and displayed to showcase the reach and richness of the Spanish Empire (Cowie 2011a; Bleichmar 2012). The Real Jardín Botánico was the crown jewel as it occupied a central place in royal efforts to collect new and useful knowledge about the botanical resources of Spain and its empire.

Portugal witnessed the creation of similar institutions under the auspices, first, of Sebastião José de Carvalho e Mello, the Marquis of Pombal and powerful minister of José I (r. 1750–1777), and then under Maria I (r. 1777–1792). (Note that throughout the text we follow historiographical convention by referring to the minister simply as “the Marquis of Pombal”, although he was not granted the title until 1759.) The Junta do Comércio, Agricultura e Navegação was founded in 1755. Broadly responsible for the regulation of all affairs connected with commerce, it was meant to encourage the development of Portuguese manufacturing in strategic areas. The Colégio dos Nobres was founded in 1761 as a way to develop the human resources of the empire. With a curriculum that incorporated aspects of the New Science such as experimental physics, it was meant to provide children of the nobility with the skills and expertise to be more effective leaders of government and the military. In the middle of the 1760s, the Ajuda Palace became home to the Real Gabinete de História Natural and the Jardim Botânico da Ajuda. These installations grew to include a chemistry laboratory, library, and a collection of scale models of factories and fortifications. As in metropolitan Spain, here too the study of nature had overlapping symbolic and utilitarian functions. The museum and garden hosted public demonstrations and expositions, became a place of entertainment for the royal family, and was frequently used to educate the sons of Maria I (Brigola 2003; Carvalho 1987; Lourenço 2013).

In 1770 the Junta de Providência Literaria began what would be a two-year process of rewriting the statutes for the University of Coimbra—the educational centerpiece of the Pombaline reforms. Fields ranging from theology, law, philosophy, literature, and the sciences were all swept up in the changes. Reflecting the
broadening influence of Newton and Descartes, the biggest reforms were the creation of new faculties of mathematics and of philosophy, the latter of which now included not only metaphysics but also the natural and experimental sciences. The medical curriculum incorporated human dissection into its anatomy instruction. It began to emphasise hygiene and public health and included the work of William Harvey on the circulation of the blood and of Herman Boerhaave on pathology. The university also became home to a press, a new observatory, a botanical garden in 1773, and a natural history collection in 1775—one imported from Padua and expanded with material from Portugal’s colonial possessions (Fiolhais, Martins, and Simões 2013; Pita 2014; Carvalho 1987; Braga 1898).

During Pombal’s ministerial tenure, the intellectual and practical results of such reforms were decidedly mixed. And many of them came under fire or were reversed during the subsequent reign of Maria I. But there was also continuity. The aging Martinho de Mello e Castro remained in his post as Secretary of State for the Navy and Overseas Territories (Secretário do Estado da Marinha e do Ultramar, 1770–1795) and persisted as a steward of the sciences. Bishop Francisco de Lemos, an architect of the Coimbra reforms, remained as the university’s Rector and vigorously—and successfully—advocated to Maria I for the preservation of the curricular reforms, stressing the New Science as the very basis for the apparent prosperity of England, France, the Netherlands, and Russia (Maxwell 1995, 98–107).

Much like the ambitious Pombal, Maria I viewed both the development of Portugal’s human capital and the study of nature as foundational for the prosperity of the kingdom and the empire. And like Pombal, Maria I also created new institutions for the production and dissemination of natural knowledge. The Casa Pia opened its doors to the public in 1782 as a boarding home for the poor that also provided instruction in a range of practical, manual trades ranging from surgery and obstetrics to veterinary medicine and agriculture. In 1779, the queen supported the creation of the Academia Real das Ciências de Lisboa. With its activities organised into three sections—sciences concerned with observation, sciences concerned with computation, and language and literature—the remit of the Academia Real reflected not only the diversification of natural knowledge that characterised the period, but also the ongoing linkage between natural inquiry and other forms of artistic exploration. Other new or reformed institutions where natural knowledge might be produced and put to use included the Academia Real de Marinha (1779), the Academia Real de Fortificação, Artilharia e Desenho (1790), the Academia Real dos Guardas-Marinhas (1796), and the Sociedade Real Marítima, Militar e Geográfica (1798), which was charged with the study of ocean currents and the creation of improved maps and navigational charts (Paquette 2013, 35–44; Simões, Carneiro, and Diogo 1999; Maxwell 1995; Carolina, Mota, and Figueiredo 2013; Cardoso 1989).

In both Spain and Portugal, foreign linkages were vital to these reforms. In late seventeenth-century Spain, a group known as the novatores strongly believed that subjects of the Spanish Crown would benefit from more emphasis on reason and empiricism as well as from greater familiarity with the ideas of Francis Bacon, René Descartes, and Isaac Newton. Benito Jerónimo Feijoo exemplified the activities and influence of the novatores in the early Spanish Enlightenment. The Benedictine monk was both a professor at the University of Oviedo and a member of the Real Academia de Medicina y Otras Ciencias, a scientific society established by the
novatores with royal approval in 1700 (Pimentel 2015; Pérez Magallón 2002). Feijóo challenged what he saw as the superstition and ignorance of his fellow Spaniards and championed reason and empiricism. To those ends he published two multi-volume works that addressed fields ranging from medicine and natural history to philosophy and popular culture—his Teatro crítico universal (1726–1739) and his Cartas eruditas y curiosas (1742–1760) (Pimentel 2015, 87–90; Anderson 2000).

Intellectuals both at home and abroad were similarly central to the spread of ideas and the cultivation of natural knowledge in Portugal and throughout its empire. Estrangeirados were “Europeanised” (literally “foreignised”) Portuguese intellectuals who travelled extensively and in many cases remained abroad—often to escape religious or political persecution. They comprised a loosely connected network of correspondents who served as de facto intermediaries between intellectuals within Portugal and those of Spain and northern Europe. As a group, estrangeirados included ministers, clergymen, aristocrats (often with diplomatic appointments abroad), physicians, and military officers. To refer to these as a unified group and to conceive of them as a network is less a reference to their level of philosophical coherence and epistolary interconnectedness and more to the common circumstances in which they lived and their shared intellectual vocation (Carneiro, Simões, and Diogo 2000).

Regardless, the influence of the estrangeirados within Portugal and across its empire was marked. The Marquis of Pombal and a number of other ministers—like Martinho de Mello e Castro and his successor as Secretário do Estado da Marinha e do Ultramar, Rodrigo de Souza Coutinho—were also estrangeirados. Some of the most influential Portuguese writers of the eighteenth century were also estrangeirados. Fleeing from the Inquisition, the New Christian physician Jacob de Castro Sarmento (1691–1762) moved to England where he became a member of the Royal Society, explored chemical medicine, translated the work of Newton and others into Portuguese, and continued to advise João V (1707–1750) on matters of health (for example Sarmento 1735). António Nunes Ribeiro Sanches (1699–1782), also a New Christian, resided in England, Holland, Russia, and then France, where he collaborated on the French Encyclopédie. He too was concerned with education and his Cartas sobre a educação da mocidade (Paris, 1759) stressed knowledge of physics and instrumentation as essential for proper administrative and military service—a perspective that helped shape the curriculum of the Colégio dos Nobres. In 1763, Sanches’ Método para aprender e estudar a medicina helped establish the importance of botanical gardens for medical study in Portugal. The single most influential writer was probably Luís António Vernei, who lived in Italy and was a member of the Roman Arcadia. Vernei advocated Newtonianism and stressed experiment and reason over traditional authority. His book, O verdadeiro método de estudar, published in Rome in 1746, was an eclectic one covering subjects ranging from logic and orthography to metaphysics. Taken together, the works by Sarmento, Sanches, Vernei, and others amounted to a powerful argument that true knowledge of nature depended upon the combination of books, travel, precision instruments, and the examination of nature in museums and other collections. This perspective was given its most robust expression in José António de Sá’s 1783 Compendio de observações, which would become an influential guide for the Portuguese scientific expeditions.
overseas that in 1783 were just getting underway (Carvalho 1987; Araújo 2003; Maxwell 1995; Carneiro, Simões, and Diogo 2000; Safier 2007).

Foreign nationals within Portugal played an important role as well. Many professors of the Real Colégio dos Nobres (such as Giovanni António dalla Bella) came from northern Italy. At the Ajuda palace, the Paduan native Júlio Mattiazzzi took responsibility for the royal cabinet of natural history and the royal botanical garden. After 1777, the Venetian mathematician Michele Franzini oversaw the continued development of the Ajuda cabinet. Perhaps most influential was the Paduan polymath Domenico Vandelli. Originally a professor of chemistry, Pombal recruited him in 1764 to teach at Coimbra. Vandelli advocated for the reform of the university, championed instruction in the natural sciences, and was instrumental in the creation of both a botanical garden and a cabinet of natural history. It was Vandelli’s own collection in Padua that would become the basis of the collections at Coimbra and Ajuda. Young men from throughout the empire, and especially from Portugal and Brazil, were trained by Vandelli, whose political ascent would later prove instrumental for the administrative appointments of his students (Cardoso 1989, 57–67; Simon 1983).

Vandelli, along with heads of other educational and investigative institutions, participated as well in international networks of exchange. Vandelli corresponded with Linnaeus, exchanged Brazilian seeds for those from Peru with some of his Spanish counterparts, and corresponded with Casimiro Gómez Ortega, the director of the Real Jardín Botánico in Madrid. There were a number of important cross-currents between Spain and Portugal. Benito Jerónimo Feijóo was widely read in Portugal, for example, and Vernei’s Verdadeiro método de estudar circulated widely in Spain (Simon 1983, ch. 1).

Though strongly influenced by international and imperial networks, eighteenth-century reforms were, to varying degrees, the extension of efforts that began much earlier. In Spain, royal patronage of the sciences dated at least to the sixteenth century, when the crown and its advisors realised that they needed to know more about the peoples, places, plants, and creatures of their American territories. To this end, Charles V (r. 1516–1556) established the Consejo de Indias and Casa de Contratación, which oversaw all matters relating to governance of and trade with Spanish America (Barrera-Osorio 2006). These institutions in turn supported the collection of geographic, natural historical, and anthropological information about the colonies. In 1570, Philip II (r. 1556–1598) appointed royal physician Francisco Hernández as director of the first scientific expedition to Spanish America with a charge to study its plants and animals (Varey, Chabrán, and Weiner 2000). At about the same time, Juan López de Velasco, the royal cosmographer-chronicler, used standardised questionnaires in an attempt to solicit commensurate information on a range of geographical, medical, climatic, and other issues from Spanish colonial officials—all in an effort to write a comprehensive account of the peoples and places Spain’s American territories (Mundy 1996; Alvarez Peláez 1993). In the late sixteenth century, Philip II also patronised the sciences and included a botanical garden and alchemical laboratories in the design and construction of El Escorial (Cañizares-Esguerra 2006, 35). Thus, by the eighteenth century, there was a well-established tradition of collecting information and producing knowledge about the natural world embedded in the Spanish colonial government (Crawford 2016, ch. 3).
Although in Portugal reforms variously appear to have been set in motion under either Pombal or Maria I, there were important precedents here as well. Diasporic communities of Portuguese physicians—often but not always New Christians fleeing persecution—had long facilitated the exchange of texts, objects, and ideas between Portugal and other parts of Western Christendom, a process that intensified in the sixteenth and seventeenth centuries (Silva Dias 1952; Farelo 2010; Jordan 2012). The Conselho Ultramarino, founded in 1642, had already undertaken efforts to centralise governance in the hands of better-qualified administrators: educated *letrados* and aristocrats with colonial administrative experience (often in Brazil) were favoured in appointments (Myrup 2015, ch. 2). Meanwhile, vigorous and at times heated debate over medical education and practice had begun to mount among medical practitioners in Lisbon during the middle and late seventeenth century. Proponents of reform asserted the superiority of experience gained either aboard ship or in the empire to traditional book learning and metropolitan practice (Cagle 2018, ch. 8; Curto 1988; Walker 2005). From Paris, Duarte Ribeiro de Macedo had attempted to discipline colonial plant exchanges and described in great detail how Asian plants should be packed, transported, and replanted in Brazil. It would soon be but one attempt among many. The Academia Real de História, founded in 1720 under Dom João V, was not strictly concerned with history and literature but fostered debates in the fields of medicine and natural philosophy—a precursor to the Academia Real das Ciências later (Silva Dias 1952; Mota 2003).

If engagement with the Enlightenment in Spain and Portugal gave new life to existing investigative traditions and institutions, it is also true that in the eighteenth century the sciences became a part of Iberian culture in new ways. The proliferation of investigative institutions, the growing number of books and periodicals published in the vernacular, and the emergence of learned societies all combined to make the disciplined study of nature a much more visible, widespread, and popular endeavour. Knowledge of nature and ways to discipline its production were increasingly shared (Pimentel 2015, 86). Fashionable tertulias, in which like-minded intellectuals and elites assembled to discuss philosophical and literary topics, were one instance. Feijóo’s publications were another. One reason for the popularity of his work was that Feijóo introduced his readers to scientific ideas not in the form of complex philosophical treatises in Latin, but in the form of short essays and, later, letters written in the vernacular and designed to spark his readers’ curiosity. Feijóo followed the lead of other novatores who popularised science in more engaging published formats such as dialogues and even fables (Pimentel 2015, 89).

Another important development was the rise of periodicals. They first appeared in Spain in the mid-seventeenth century. By the 1730s, interest in science had reached the point in Spanish culture such that some publishers began to offer periodicals that focused on the sciences such as *Memorias eruditas para la crítica de artes y ciencias* (1734) and its successor *Diario de los literatos de España* (1737–1742). Meanwhile other periodicals, such as *Correo de Madrid* and *Discursos mercuriales*, began reporting some of the important developments in the sciences of the day (Pimentel 2015, 90–92). Ultimately, such evidence shows that the increase in royal patronage of the sciences was the result of a complex interaction of existing structures of knowledge production and a broader popularisation of science alongside the engagement with Enlightenment ideals by reformers, officials, and elites in Spain.
In Portugal a few decades later, the work of both Casa Pia and the Academia Real das Ciências was similarly part of a wider effort not only to produce and deploy natural knowledge, but to do so in ways that made it more accessible to a wider audience. In 1770 the Junta do Comércio instituted the Aula de Comércio, which provided especially merchants’ children with a three-year course of study in practical mathematics, finance, and administration. The Casa Pia gave rise to a coterie of disciples of the mathematician Anastácio da Cunha. And the Academia Real published findings that its members hoped would spur industrial and agricultural innovation. The Lisbon-based Casa Literária do Arco do Cego undertook a short-lived publishing effort from 1799 to 1801 with the goal of disseminating works of agronomy in the Portuguese Atlantic. Among a number of similar serial or multi-volume publications were the *Gazeta Literária* and the *Jornal Enciclopédico*, the editors for which solicited articles from among their Portuguese contemporaries and ran extracts of foreign work in Portuguese translation. Books also found a more accessible home: the Real Biblioteca Pública da Corte was founded in 1796 with the library of the Real Mesa Censória as the basis of its collection (Simões, Carneiro, and Diogo 1999).

**Imperial Travels and Colonial Entanglements**

In the early 1740s, a curious manuscript began circulating in Madrid. Now believed to have been authored by José del Campillo y Cossío, a Spanish political thinker and former government official, the document recommended setting up a system in which officials in the colonial government in Spanish America submit “samples” of any “bush, root, tree, fruit, resin, mineral [or] rock” that might have “some special virtue for health, pleasure or other uses”. In Spain, Campillo explained, “chemists” would analyse these materials to identify any that might prove “useful to the Monarchy” (Campillo y Cosío 1789, 151–152). In his linkage of imperial prosperity to natural knowledge as well as his emphasis on metropolitan expertise and the centralising function of metropolitan institutions, Campillo was not alone. Decades earlier, Duarte Ribeiro de Macedo had offered a similar vision to his countrymen. In the late eighteenth century at the Real Jardín Botánico in Madrid and the Museum of Natural History in Lisbon, Casimiro Gómez Ortega and Domenico Vandelli, continued to advocate for just such an approach. Imperial prosperity was to be built upon imperial science (Lafuente 2002; Sarmiento 1992; Carvalho 1987; Simon 1983).

Visions of a symbiotic relationship between science and empire also reflected the widespread Enlightenment notion that travel was a privileged source of knowledge about nature (Withers 2007, 87–111). This emphasis was partly a consequence of the distrust of colonial inhabitants and partly due to the increasing emphasis on the primacy of first-hand experience of the world. Of course, something like that sentiment had been longstanding. Expeditions—whether for discovery or conquest—had been an important aspect of the Spanish and Portuguese imperial enterprise since the sixteenth century. Then, too, travellers stressed the importance of wide-ranging travel as a foundation for true knowledge (Silva Dias 1952; Almeida 1995). But in the eighteenth century, expeditions increasingly took the investigation of nature as their primary objective and they became state-directed, globalised, and purposeful in
ways that they had not been before. With the implementation of educational reforms and the founding of new investigative institutions, naturalists in Spain and Portugal now possessed the infrastructure to train personnel, coordinate expeditions, and assemble ever greater collections.

The late eighteenth century in particular witnessed a number of concerted, state-commissioned efforts to chart the geography and hydrography of both Iberian empires, to more thoroughly catalogue the flora and the fauna they encompassed, and to inventory the potential sources of mineral and vegetable wealth they contained. The Royal Botanical Expedition to Peru and Chile (1777–1788), the Royal Botanical Expedition in New Granada (1783–1816), the Royal Botanical Expedition to New Spain (1789–1794, and the Malaspina Expedition (1789–1794) are only the best-known of the more than 60 expeditions that were sent to the Americas and the Philippines between 1760 and 1808 (Berquist Soule 2014; Bleichmar 2012; Cowie 2011b). In the Portuguese world, prominent cartographer Guilherme Joaquim Pais de Menezes set out to remap Angola in 1758, inaugurating a generation of reformist administrative itineraries between Lisbon and Luanda in the 1760s. João da Silva Feijó catalogued the vegetable and mineral wealth of the Cape Verdes from 1783 to 1797 and then travelled through Ceará in 1799 for the same purpose. Alexandre Rodrigues Ferreira explored Brazil extensively from 1783 to 1792. Manuel Galvão da Silva, originally one of four naturalists in Ferreira’s expedition, was posted instead to Mozambique, where from 1783 to 1793 he conducted land, mineral, and mine surveys; between 1793 and 1794 he also catalogued the flora and fauna of Goa. Joaquim José da Silva was also originally a part of the Ferreira expedition but was instead dispatched to Angola, where he worked from 1783 until about 1808 (Simon 1983; Santos 2010; Lopes et al. 2005; Raminelli 1998). With these expeditions, cabinets of natural history swelled with new specimens. Drawings, watercolours, travel accounts, natural histories, and other texts (print and manuscript) multiplied in metropolitan libraries and archives. Iberian colonies were less a source of ontological mystery and increasingly targets of imperial mastery.

There were, however, important differences between the Spanish and Portuguese imperial approaches to the production of natural knowledge. For the Spanish these expeditions represented, in part, a renewal of the sixteenth-century efforts of Francisco Hernández and projects like the Relaciones Geográficas—earlier efforts to systematically gather information about the vast territories of Spanish America (Varey, Chabrán, and Weiner 2000; Barrera-Osorio 2006; Mundy 1996). But in the case of Portugal and its empire, with the exception of the disciplined creation of knowledge about sea and wind currents across the globe, there was no such project until the eighteenth century. Hence, in Portugal, the kind of centrally organised imperial science that Enlightenment reform enacted was a new effort rather than a renewed one (Cagle 2018; Cardim 2002).

In neither case was knowledge of nature simply the outcome of seamless global itineraries, the result only of the labour of men trained in metropolitan institutions, or simply an upshot of the unproblematic remittance of exotic specimens from far-flung colonial peripheries as men like Campillo suggested. Metropolitan writers like Gómez Ortega in Madrid or Vandelli in Lisbon attempted to discipline the eyes, hands, and imaginations of their agents—to turn students and colleagues like Hipólito Ruiz and José Pavón, who led the Peru and Chile expedition, or Ferreira...
who went to Brazil, into philosophical travellers (Bleichmar 2005; Safier 2007). But these men were not the only persons in the Iberian colonial world to claim authoritative knowledge of nature. Although observers in Europe increasingly imagined the colonies as culturally, intellectually, and bodily deficient, natural inquiry was never confined to urban centres of metropolitan Spain and Portugal (Scheibinger 2004; Bethencourt 2014; Smith 2015). Innovative approaches to natural inquiry predated colonial settlement everywhere and remained a pervasive feature of colonial societies. Moreover, investigation of the natural world was an enterprise that engaged the attention and efforts of a diverse range of participants from Amerindians and African slaves to Jesuit and Franciscan missionaries, from Hindu Konkanispeaking herbalists to Muslim midwives from Java, as well as Spanish Creole elites and Portuguese plantation owners in the Americas (Crawford 2016; Prestes 2000; Sweet 2011; Cagle 2018).

Here again, important differences distinguished the Spanish and Portuguese empires. In the decades before the arrival of the royal expeditions in the 1770s and 1780s, many urban centres in Spanish America, including Mexico City, Havana, Bogotá, Quito, Lima, and Buenos Aires, already supported their own cultures of systematic investigation. As in Spain so too in Spanish America: in the eighteenth century, science became a more prominent part of society and culture. The study of nature became a fashionable and, for many, pragmatic pursuit among creole intellectuals and urban elites. José Antonio Alzate in Mexico City, Miguel de Santisteban in Bogotá, Eugenio Espejo in Quito, and José Eusebio Llano Zapata, Cosme Bueno, and Hipolito Unanue in Lima all adapted the investigative methods, values, and ideals of science and the Enlightenment to their local contexts. Institutions, meanwhile, popularised and supported the investigation of nature. These included botanical gardens (Mexico City, 1788; Guatemala, 1796), a cabinet of natural history (Guatemala, 1796), colleges of surgery and medicine (Mexico City, 1768; Lima, 1792), a royal seminary of mining (Mexico City, 1792) and a chemical-metallurgical laboratory (Lima, 1791).

Alongside these new colonial institutions, a colonial periodical literature devoted in part to propagating and disseminating scientific knowledge emerged. These included the Gacetas de Literatura de Mexico (1788–1795), the most successful of several learned periodicals edited by José Alzate in Mexico City, the Mercurio Peruano (1791–1795), a learned journal edited by Jacinto Calero and published in Lima, and the Papel Peródico de Santa Fe (1791–1797), established by Manuel Socorro Rodríguez as well as periodicals published in several other regions of Spanish America in the late eighteenth and early nineteenth centuries. In the pages of these periodicals, Creole elites engaged not only the key scientific ideas of the time, but also provided descriptions of the plants, animals, minerals, and other curious phenomena of their regions. Finally, many of these activities were supported by and associated with the new learned societies that emphasised useful knowledge, known as Sociedades Económicas de Amigos del País, established throughout Spanish America in the late eighteenth century, following the model of those established in Spain in the 1760s (Silva 2002; Nieto Olarte 2007; Arboleada and Soto Arango 2006).

In Portuguese colonies scattered from South Asia to South America, parallels appear to have been few and infrequent. Unlike Spanish America, not a single one of the Portuguese colonies could boast of a university. Only Goa was home to a
press of its own. A rare and (for the moment) understudied example of a colonial investigative institution was the short-lived Academia Científica in Rio de Janeiro, which was established in 1772 in order to foster polite debate in all areas of the arts and sciences (it persisted until 1794, though it had been renamed the Sociedade Literária in 1782). Brazil would only become home to institutions like those of Spanish America after the arrival of the crown and court in 1808. The event gave rise to the creation of botanical gardens in São Paulo, Bahia, Pernambuco, Mato Grosso, and Goias. Rio became home to a botanical garden in 1810 and Olinda did so in 1811 (Jobim 1986). There were, meanwhile, repeated efforts to provide formal medical schooling in Luanda (d’Esaguy 1951; Walker 2016). And in the 1760s plans were hatched for an Aula de Geometria de Luanda to provide practical training in the sciences to would-be colonial administrators (Madeira Santos 2010). But across Portugal’s empire, investigative communities of longstanding had emerged alongside of other, more familiar colonial institutions. Plantations, hospitals, missions, mines, and urban and rural households alike hosted lay-healers of diverse ethnic and confessional backgrounds, who possessed distinctive ways of explaining natural phenomena and highly varied approaches to health and healing (Sweet 2011; Walker 2013; Cagle 2015).

As members of state-directed expeditions commingled with colonial cultures of natural inquiry, they helped facilitate the exchange of Enlightenment ideas and insinuated the colonies into the broad collection of Enlightenment projects. Just as in Spain and Portugal, many in the colonies found common ground with the members of European scientific expeditions because they shared the view that material prosperity hinged on a more thorough knowledge of nature. Yet colonial natural inquiry was never simply an extension of metropolitan objectives. And the convergence of imperial and colonial investigative endeavours threw those differences into high relief. As metropolitan efforts were entangled with colonial cultures of natural inquiry, the very globalising pretensions of Enlightenment science were called into question. Consequently, eighteenth-century voyages did not simply disseminate metropolitan ideas and aspirations. They helped multiply the locations and meanings of Enlightenment itself.

Philosophical travellers collected specimens of plants and animals, and sampled, tested, and remitted potentially valuable minerals. As they did so, these naturalists often had wider metropolitan debates in mind. References to the work of such well-known figures in the European Enlightenment as Georges-Louis Leclerc (the Comte de Buffon), Jean-Jacque Rousseau, William Robertson, and Adam Smith peppered their published and manuscript compositions. Spanish and Portuguese travellers quarrelled with La Condamine in favour of Montesquieu over the alleged degenerative effects of American environments. João da Silva Feijó and Joaquim José da Silva variously employed the Systema Naturae of Swedish natural Carolus Linnaeus in order to identify, describe, catalogue, and classify plants and animals in the Atlantic. In the Amazon, Ferreira hauled a small library with him that included French and German printed works, manuscripts of his countrymen, and the Historia naturalis Brasiliae (Amsterdam, 1648) by the Dutchmen Georg Margraf and Willem Piso (Simon 1983; Safier 2007).

Yet the extent to which metropolitan institutions, colleagues, and international correspondents could discipline their work was always partial. In New Spain, a debate over the Linnaean system emerged between Creole elites and members of...
the Royal Botanical Expedition in Mexico City shortly after the establishment of the expedition in 1787 and a botanical garden in 1788. As required by the Spanish Crown, members of the expedition adhered to the principles of botanical taxonomy and nomenclature developed by the Swedish naturalist Carolus Linnaeus (Lafuente and Valverde 2005). As the expedition sought to institutionalise Linnaean botany in Mexico City, they met resistance from several prominent Creole intellectuals, most notably the priest and naturalist José Antonio Alzate. Alzate and his compatriots rejected the Linnaean system for its emphasis on morphology alone and its disregard for local knowledge of the plant, its medicinal properties, and local environment. In his refutation of Linnaean taxonomy, Alzate questioned the applicability of any European science to American nature, as he observed in 1788, “in New Spain there are products of nature that refute and overturn all theories and botanical systems hitherto devised” (quoted in Lafuente and Valverde 2005, 137). Creole elites in Spanish America and Portuguese travellers in Brazil alike echoed this “patriotic epistemology”, advocating for local scientific traditions as viable alternatives to metropolitan ones (Lafuente and Valverde 2005, 137).

Investigative efforts sponsored by metropolitan authorities also easily became ensnared in colonial politics, often redirecting the investigative focus of newly arrived naturalists. João da Silva Feijó was sent to Brazil as sargento-mor of the militia but also entrusted with answering various questions about natural history in the colony. The political independence of Ceará from Pernambuco in 1799, however, raised questions of the viability of the regional economy and placed special urgency on the identification of exploitable resources. Feijó spent more time assaying silver, copper, and gold deposits, and scouting out iron, chalk, and sulphur mines; he spent far less time on the broader array of plants and animals of interest to colleagues like Vandelli in Lisbon (Lopes et al. 2005).

Other challenges emerged as well. In the case of the Portuguese expeditions to Angola and Mozambique, naturalists held dual appointments as colonial administrators. Colonial officials with advanced education in mineralogy or botany seemed better prepared to foster economic growth in colonies focused on mining or agriculture. In theory, such appointments made sense but these officials soon found that, in practice, the competing demands of administrative duties and the survey of local natural resources quickly became a source of tension. Both appointments required time, personnel, and expertise, which in the case of trained artists and other field assistants were in short supply. That, again, made it difficult to carry out the more extensive surveys of plants, animals, and landscapes that metropolitan colleagues requested. At the same time, the administrative reforms they were charged with implementing might earn them the ire of the very members of colonial society upon whose cooperation their investigative work depended (Simon 1983; Madeira Santos 2010). And finally, attempts to standardise the collection of information—to erect a colonial archive of knowledge with standardised questionnaires, tables for accumulating ostensibly commensurate information, maps drawn to scale, and other devices—all combined to create a vision of fixity that colonial realities did not support. For example, officials in Luanda attempted to establish fixed locations for the ethnic communities under their administrative charge but the capitals of individual ethnic communities changed with death of each soba (ethnic leader).
Hence their settlements lacked precisely the permanence implied by administrative maps. In this and numerous other ways, colonial forms of knowledge often failed to reflect the human landscape they were supposed to represent (Madeira Santos 2010; Safier 2009).

Efforts to coordinate the accumulation of nature and discipline colonial knowledge also, at times, facilitated the appropriation of those efforts by colonial subjects. Amazonian men recruited to collect the drogas do sertão participated in these expeditions in order to serve their own commercial and curative interests. In Angola, literate sobas skilfully manipulated the growing colonial bureaucracy in order to maintain their own privileges (Madeira Santos 2010; Roller 2010). In the Andean world in the late eighteenth century, local officials, merchants, and even indigenous labourers used their knowledge of cinchona bark, one of the most important medicaments in the early modern world, to thwart the attempts of Spanish pharmacists and botanists to assert the authority of European science in the context of Spanish colonial governance (Crawford 2018).

Questions about what kind of person in the socially, culturally, and racially diverse Iberian colonies was authorised to speak credibly about natural phenomena were at the heart of debates on topics ranging from the application and efficacy of medicines to botanical and zoological classification. Many prominent Enlightenment thinkers argued that overseas environments had a degenerative effective on the flora, fauna, and peoples there. Native bodies and minds were increasingly sexualised, racialised, and otherwise rendered inferior. Enslaved persons, indigenous healers, or other colonial inhabitants might hold considerable authority in their communities in the Americas, Africa, or Asia. Philosophical travellers tended to consider the testimony of non-Europeans as less sophisticated and, ultimately, less trustworthy (Gerbi 2010; Weber 2006).

For philosophical travellers, developing robust techniques for the production of reliable knowledge was always a fraught, uncertain, and incomplete endeavour. As had been the case since the sixteenth century, epistemologies variously drew on a combination of books and things, text and observation, erudition and experience. But in the eighteenth century the process of transcription, which was always distinct from the act of observing, became a tool of legitimation: it endowed claims based on personal observation with greater credibility. Ultimately these were the ways by which men like Ruiz and Pavón in Peru and Ferreira in Brazil sought to secure credibility for their work. But transcription entailed, in turn, both books and manuscripts that enabled cross-referencing and comparisons with earlier findings. And it required a community of artists and secretaries to construct the visual and verbal record of observations. Yet in the colonies, books were few and far between, access to a library could be intermittent and unpredictable, intellectual peers were scattered, and reliable assistants were hard to come by. In short, writing and correspondence helped legitimate individual impressions whose epistemic status was endangered by the very circumstances of their creation: nearly alone, far from metropolitan capitals, where indiscipline and degeneration seemed to scar the mind and body. No amount of transcription could reliably resolve the dilemma—although a great deal of ink was expended in the effort on both sides of the Atlantic (Safi 2007; Safier 2008; Simon 1983).
CONCLUSION: POST-ENLIGHTENMENT RAMIFICATIONS

Eighteenth-century Enlightenment ideals inspired reforms that were meant to strengthen the empires of Spain and Portugal. By the turn of the nineteenth century—across the Iberian world—those reforms had fostered two interrelated but contradictory processes: the rise of independence movements that gave birth to new nations in much of Latin America, and the consolidation or extension of empire in Africa, Asia, and parts of the Caribbean. Science and the organisations that supported it were integral to both processes.

In much of Spanish and Portuguese America, the intellectual and cultural exchanges for which the study of nature was central helped sharpen distinctions between creoles and their metropolitan peers. In the Spanish colonies, private associations known as Sociedades Económicas del Amigos del País, which had sustained investigative enterprises into natural resources and new technologies, were often seedbeds of nationalist sentiment and home to clandestine meetings in which Creole elites plotted independence (Glick 1991, 327). The Napoleonic invasion of Spain helped enable the ensuing wars and even natural history was caught up in the turmoil. The materials of the Royal Botanical Expedition in New Granada became the spoils of war when, in 1816, over three decades’ worth of manuscripts, drawings, and specimens were packed into 104 crates and shipped across the Atlantic to Spain (Appel 1994, 123). The wars for independence did not extinguish the scientific institutions and activities that had taken root during the three centuries of colonial rule. With independence, former institutions of imperial science were reimagined as the centres of national science. Patriotism continued to fuel the investigation of nature. Creole elites remained supportive of sciences related to agriculture, mining, and manufacturing in order to foster the economic prosperity of their new nations (Cañizares-Esguerra 2006).

With the Napoleonic occupation of Lisbon, Étienne Geoffroy St. Hilaire, member of the Académie des Sciences and later professor of zoology at the University of Paris, was able to comb through collections from the Portuguese expeditions to the Cape Verdes, Brazil, Angola, and Mozambique. In Paris, those spoils fuelled the study of nature in imperial France (Simon 1983). In Brazil, the birthplace of many Portuguese imperial naturalists—Ferreira and the Silvas among them—eighteenth-century intellectual exchanges would enable the self-conscious articulation of a Brazilian identity in the early nineteenth century. With the arrival of crown and court to Portuguese America in 1808, colonial cities from Olinda and Recife to Bahia and Rio witnessed the development of museums, libraries, and botanical gardens. With independence in 1822, Coimbra-trained specialists like Hipólito da Costa and José Bonifácio became statesmen in a new Brazilian empire (Raminelli 2008; Coclet da Silva 2006; Lopes 2000; Nizza da Silva 1999). For colonies in Asia and Africa, meanwhile, the loss of Brazil led Portuguese rulers to redouble their efforts to locate, identify, and harness the most promising animal, vegetable, and mineral resources (Simon 1976). Throughout the Iberian world—in new nations and across lingering empires—Enlightenment-era institutions persisted, and so too did questions of evidence, expertise, and authority.

ABBREVIATION

BNP Biblioteca Nacional de Portugal
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