Science

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That the so-called scientific revolution coincided with the rise of global trading companies is no coincidence. ‘Science’ in the modern sense was a creation of the nineteenth century. Retrospectively, its origins have often been located in the scholarly societies that began to be founded in various European countries from the seventeenth century onwards.¹ Thus, although rooted in the pan-European ‘Republic of Letters’, the emergence of science has usually been discussed in national terms. In fact, much of what made knowledge and scholarship in this period distinctive from what came before was its increasing embeddedness in a global context. For natural philosophers and others who have been considered proto-scientists, access to information from distant places was often enabled by contacts with trading companies. The process of gathering and assessing such information necessitated new ways of establishing trust in informants; evaluating and experimenting with objects; testing claims; collecting, storing, and collating and comparing. In turn, the global activities of trading companies relied on the results of these processes of gathering and transforming information to assess the goods that they traded in, the lands in which they planned to establish settlements, and the seas they had to navigate.

In this contribution, I will highlight in particular the interactions, formal and informal, between members of the English East India Company (EIC) and scholars associated with the Royal Society and the English universities. These connections overlapped with connections between scholars and other trading companies, including the Royal African Company, once called the ‘twin sister’ of the Royal Society,² and the Levant Company. They also closely resembled the contemporary links between the *Vereenigde Oost-Indische Compagnie* (VOC) and Dutch scholarly institutions including the Universities of Leiden and Utrecht and between the *Compagnie des Indes* (CdI) and *l’Académie royale des sciences* in France. Such connections also had precedents in the interactions between Iberian institutions like the Spanish Consejo de Indias and *Casa de Contratación* and the Portuguese *Estado da Índia* and *Casa da Índia*. As well as

1 Steven Shapin, *The Scientific Revolution* (Chicago: Chicago University Press, 2008).

2 James Delbourgo, *Collecting the World: Hans Sloane and the Origins of the British Museum*. (Cambridge, Mass: Harvard University Press, 2017), 30.

the parallels that can be drawn between these relationships, there were also key differences. The particularities of each of these relationships – centrally, the particular global connections that they sought to navigate and understand – would in fact shaped the distinctive national or colonial practices of science that would emerge by the eighteenth and nineteenth centuries.

Reverting to the terminology of the early modern period, it would be more accurate to speak of ‘useful knowledge’ than of science. Both savant institutions like the Royal Society and the trading companies strove to prove their usefulness throughout this period. As the introduction to this volume makes clear, trading companies had to please multiple constituents, including European and non-European rulers, their own shareholders, and their critics, again, at home and abroad. Similarly, organisations like the Royal Society had to convince royal and governmental funders, sceptical publics, and their own correspondents and informants, that their inquiries were practically useful rather than nonsensical and possible heretical fantasies.³

Trading companies were interested in natural products that could be traded and the machines and techniques used to process them. But, their interests ran far deeper than this. They also wanted to know about the languages, customs, systems of government and religions of the people they traded with. They wanted accurate accounts of their systems of weights and measures and their currencies. It was important to understand architecture and ship-building when establishing settlements and shipyards. Trading companies wanted to know about the environment and climate of each of their potential settlements, whether they were ‘healthful’ or bred disease and what could be done to improve them. Some members of trading companies were even keen to garner support for their own positions in metaphysical debates over the nature of the universe through observations of the foreign beliefs they encountered. The shared interests of the trading companies and savant institutions encouraged the development of networks through which natural and mechanical knowledge could be transformed into useful and profitable information.

While in the early modern period both trading companies and savant institutions lacked formal structures of support for scholarly endeavours, the promise of patronage – both in the settlements and in Europe – led company servants to investigate the natural and mechanical worlds around them. Through such collections of information, members of the trading companies hoped to level

3 Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 2011); Delbourgo, *Collecting the World*, for satires and critiques aimed at the Royal Society during the seventeenth and eighteenth centuries.

patronage, wealth, and even fame as well as to achieve advancement within the company ranks. In what follows, I will discuss some early modern forms of natural and mechanical knowledge to which the EIC's members, servants, and slaves contributed to creating.

Natural Histories, Travel Accounts, and Cabinets of Curiosity

'Natural histories' were early modern data banks on which theories about the world were built: or, as stated in the introduction to Boyle's 'General Heads for the Natural History of a Country', 'the only sure foundation of natural philosophy'.⁴ Cabinets of collection formed the physical counterparts of written accounts and both savants and merchants often contextualised material objects using written texts and vice versa. The EIC was involved in generating both sorts of data, both directly through its instructions to its servants and the collections it maintained in London and indirectly, through its networks of correspondents and advisors.

As Rubiés and Stagl point out, the aim of directing and methodising travel and reports of foreign lands was not new in the mid-seventeenth century, but had its roots in the Renaissance.⁵ Official collections of information about colonial possessions, like those commissioned by Philip II of Castile in the 1570s often followed similar schema to humanist instructions to travellers.⁶ The humanist emphasis on the importance of method was been adopted by compilers of voyages including Richard Hakluyt,⁷ early advisor to the East India Company, and Samuel Purchas.⁸ Purchas' contemporary, Francis Bacon, stressed the importance of methodical or orderly observation, unconstrained as far as possible by theory or prior knowledge, in both natural history and travel.⁹ Natural histories themselves had been pioneered in the Americas, including sixteenth century works like Fernández de Oviedo's 'General and natural history

4 Robert Boyle, *General Heads for the Natural History of a Country, Great or Small: Drawn Out for the Use of Travellers and Navigators* (London, 1692). The essay was first published in *Philosophical Transactions*, 1 (1665–1666), 186–189.

5 Joan-Pau Rubiés, 'Instructions for Travellers: Teaching the Eye to See', *History and Anthropology*, vol 9, nos. 2–3, (1996): 139–190; Justin Stagl, 'The Methodising of Travel in the 16th Century', *History and Anthropology*, vol 4 no. 2 (1990): 303–338.

6 Rubiés, 'Instructions for Travellers', 155–6.

7 Richard Hakluyt, *Principall navigations, voyages, and discoveries of the English nation* (London, 1589 and 1598–1600).

8 Samuel Purchas, *Purchas his Pilgrimage: Or Relations of the world ...* (London, 1613).

9 Rubiés, 'Instructions for Travellers', 176–7.

of the Indies' and Acosta's 'Natural and Moral History of the Indies'.¹⁰ Boyle's younger contemporary Hans Sloane produced a natural history of the English colony of Jamaica.¹¹

Boyle's 'General Heads' are conventional in many senses, including the division of the things to be observed, which begin with the heavens or the airs, followed by the water, and the earth. Like Ovieda and Acosta, Boyle included human customs under the rubric of natural history, a practice that was based on the assumption that people were intimately connected to and shaped by their natural environments. Boyle's instructions were part of a recurrent interest on the part of Royal Society in compiling a comprehensive natural history and they clearly draw on the set of 'Directions' that the Royal Society compiled and sent to correspondents abroad, some of which were published in the *Philosophical Transactions* along with the responses they received.¹² The main innovation in Boyle's text might be the several instruments which he suggests should be provided to a traveller in order to make observations, many of which had been invented by Boyle himself or by his associate Robert Hooke. These include a 'travelling baroscope' for measuring the 'specific gravity of the air'; a pair of scales and weights for examining the weight of water along with a device for drawing up water from deep below the surface of the sea.¹³ That some travellers were equipped with such instruments is evident from a list of the instruments that Hooke provided Robert Knox to carry on his later voyages.¹⁴ Nonetheless, the natural histories that were produced in and around Company settlements continued to rely for the most part on the unaided observations of the individual traveller along with information supplied by a range of informants.

Unsurprisingly given both the antecedents of the genre and the popularity of travel literature, seventeenth century natural histories remained entangled

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- 10 José Acosta, *The Natural & Moral History of the Indies*, trans. Edward Grimeston, ed. Clements R. Markham. London: Printed for the Hakluyt Society, 1880; Fernández de Oviedo, *Historia General Y Natural De Las Indias*, ed. José Amador de los Ríos (Madrid, Impr. de la Real academia de la historia, 1851–55).
 - 11 Hans Sloane, *A voyage to the islands Madera, Barbados, Nieves, S. Christophers and Jamaica, with the natural history of the herbs and trees, four-footed beasts, fishes, birds, insects, reptiles, &c. of the last of those islands*. London: Printed by B.M. for the author, 1707.
 - 12 M.B. Hall, 'Arabick learning in the correspondence of the Royal Society', in G. A. Russell (ed.), *The 'Arabick' Interest of the Natural Philosophers in Seventeenth-Century England* (Leiden: Brill, 1994), 147–157, 149.
 - 13 Boyle, *General Heads*.
 - 14 See Anna Winterbottom, 'Producing and Using the Historical Relation of Ceylon: Robert Knox, the East India Company and the Royal Society'. *The British Journal for the History of Science / Publ. for the British Society for the History of Science*. 42 (2009).

with accounts of the authors' own adventures. The first volume of Jean (or John) Chardin's account of Persia, including an account of the travellers of its author from Paris to Istaphan and the coronation of the Shah was published in French and in English in 1686, followed by a full edition in 1711 which also contained the natural history of Persia.¹⁵ Robert Knox's *Historical Relation of Ceylon*¹⁶ similarly mingled an account of his own capture and life on the island with a natural history and political account of the central kingdom of Kandy. The medical man and traveller John Fryer's *New Account of East India and Persia*, also combines personal travel account with a natural history and a political narrative, focusing in particular on the military campaigns of the Maratha leader Shivaji.¹⁷ English natural histories and travel accounts closely resembled other European accounts, and there was a brisk industry of translating these works, often with additional elements added by the translator: for example the work of Jean-Baptiste Tavernier appeared in English only a year after its publication in French, with two other accounts appended to it.¹⁸

Neither an emphasis on first hand observation of the natural world nor the production of orderly accounts of foreign lands were confined to Europe and its colonies in the early modern period. As Ebba Koch pointed out, the Mughal Emperor Jahangir (r. 1605–27) better fit Bacon's model of a philosopher-king than any of his European contemporaries.¹⁹ In his *Jahangirnama*, the Emperor reports a series of observations and experiments.²⁰ Jahangir was following a tradition of natural-historical description begun by his ancestor Babur (r. India 1526–30), who described Indian flora and fauna in his *Baburnama*. In terms of travel writing, the ten volumes of the seventeenth century Ottoman traveller Evliya Çelebi are perhaps the most extensive travel narratives

15 John Chardin, *The Travels of Sir John Chardin into Persia and the East-Indies: The First Volume, Containing the Author's Voyage from Paris to Ispahan ...* (London, 1686).

16 Robert Knox, *An Historical Relation of the Island Ceylon* (London, 1681).

17 John Fryer, *A New Account of East-India and Persia in Eight Letters: Being Nine Years Travels, Begun 1672 and Finished 1681* (London, 1698).

18 Jean-Baptiste Tavernier, *Les six voyages de Jean Baptiste Tavernier* (Paris, 1676), translated as *The six voyages of John Baptista Tavernier ... to which is added A new Description of the Seraglio Made English by J.P. Added likewise a Voyage into the Indies &c. By an English Traveller, never before Printed* (London, 1677).

19 Ebba Koch, 'Jahangir As Francis Bacon's Ideal of the King As an Observer and Investigator of Nature', *Journal of the Royal Asiatic Society* vol. 19 no. 3 (2009): 293–33.

20 Jahangir and W M. Thackston, *The Jahangirnama: Memoirs of Jahangir, Emperor of India* (New York: Oxford University Press, 1999). For example, see 143–4 for an experiment Jahangir carried out on a chicken to test the theory that bitumen would heal broken bones and 24 for an account of the fruits recently introduced to India.

of the era, although they were not published until the nineteenth century.²¹ Some Ottoman travel texts were printed in the early modern period, including the compendia of travel accounts by Katib Celebi (or Haji Khalifa) (1609–57), which were published in early eighteenth century Istanbul. In both Persia and Iran, early modern accounts of travel and geographical accounts were not published, but did circulate in manuscript form. Chinese accounts of foreign peoples and lands were produced in great numbers in this period, often though not invariably following the formal gazetteer style.²²

How much of an influence contemporary accounts in non-European languages exerted on natural histories and travel texts produced in and around the EIC settlements is uncertain; while some seventeenth century European authors claimed to have based their works on texts in Asian languages, serious engagement with them probably began only in the eighteenth century when, for example, parts of the *Jahangirnama* were published by James Anderson and Francis Gladwin.²³ However, compilations of voyages made in Europe did continue to include older works on geography and travel in Arabic and Persian. For example, Melchisédech Thévenot's collection of voyages contains a translation of an account apparently by Abu'al-Fida (1273–1331 CE) of the climates of India and China, translated from a manuscript in the Vatican.²⁴ In other words, there seems to have been a lag, sometimes of centuries, between written descriptions of travel and natural history in non-European languages and their use by Europeans. Nonetheless, those compositors of travel narratives and natural histories who spent time in Asia courtly settings would have had oral access to some of the philosophical debates of the era.

Information drawn from natural histories was used in both scholarly projects and by the East India Company itself, sometimes in collaboration. For example, the orientalist Thomas Hyde (1636–1703) referred to Chardin's account of the inscriptions at Persepolis. Hyde also used Knox's accounts of the Sinhala language in his investigations into comparative linguistics. The EIC's use of Armenians as brokers in their Indian settlements was based on Chardin's account of their role in Persia while Knox's account of rice growing and the production of iron in Ceylon prompted the EIC to experiment with the same techniques

21 Muzaffar Alam and Sanjay Subrahmanyam, *Indo-persian Travels in the Age of Discoveries, 1400–1800* (Cambridge: Cambridge University Press, 2007), 6–7.

22 Strassberg, *Inscribed Landscapes*.

23 Translations were made by James Anderson in his *Asiatic Miscellany* of 1786 and by Francis Gladwin in his *History of Hindustan* in 1788, c.f. 'Translator's preface, *Jahangirnama*, ix.

24 Melchisédech Thévenot, *Relations de Divers Voyages Curieux* (Paris, 1696). See also Hall, 'Arabick learning in the correspondence of the Royal Society', 151.

in their settlement on the South Atlantic island of St Helena. Travel accounts in other European languages were also mined for useful information. For example, an article in the first issue of *Philosophical Transactions* exacts information on the manufacture of saltpetre (used to make gunpowder) in Mughal India from Thévenot's collection of voyages.²⁵ Scholars and EIC officials tried to verify the information contained in natural histories and travel accounts by including particular points in their lists of inquiries or circulating the texts to other correspondents for corrections and additions. For example, Robert Hooke and Robert Hoskins recruited the Hanoi-born Samuel Baron to correct Jean-Baptiste Tavernier's account of Tonkin (northern Vietnam).²⁶

Publishing a natural history in seventeenth century England could result in preferment for its author in the circles of both natural philosophers and merchants. Chardin, Knox, and Fryer were all elected to the Royal Society on the basis of their writings and Chardin became the ambassador of the East India Company to Holland. But natural histories and travel accounts were not guaranteed publication or financial success: the accounts of Thomas Bowrey and Samuel Baron remained unpublished during their authors' lifetimes. Notably, Moses Pitt's ambitious 'English Atlas' project – which was intended as the composite natural history that several members of the Royal Society imagined – not only remained unfinished, but bankrupted Pitt in the process.²⁷

Many of the authors of natural histories or accounts of travel also collected objects; both natural and manmade. The tradition of *Wunderkammern* or 'cabinets of curiosity' had integrated commerce and scholarship since its inception. In the sixteenth century, the influential Fugger family of bankers not only assembled their own collections but helped put together those of the Wittelsbach Duke Albrecht V of Bavaria and the Habsburg Holy Roman Emperor Rudolf II of Prague. As Meadows notes in his study of Hans Jacob Fugger's role in conceptualising the Wunderkammer, such collections served many practical and symbolic functions, 'being not only instruments of diplomacy and display, but also pragmatic tools of economic statecraft, repositories of ready funds for unexpected wars and disasters, sites for cultural and technological production, and active, functional, and practical laboratories

25 [Anon] 'Of the Way, Used in the Mogol's Dominions, to Make Saltpetre', *Philosophical Transactions*, vol. 1 (1665–1666), 103–104.

26 Winterbottom, *Hybrid Knowledge*, Chapter 1.

27 Michael Harris, 'Pitt, Moses (bap. 1639, d. 1697)'. *Oxford Dictionary of National Biography*. Ed. H. C. G. Matthew and Brian Harrison. Oxford: OUP, 2004. Online ed. Ed. David Cannadine. Jan. 2008. Last accessed, 13 Nov. 2017.

for a variety of crafts and disciplines'.²⁸ By the seventeenth century, it was possible to buy whole cabinets of curiosity, although cabinets were more often assembled through a combination of gifts and individual purchases.²⁹

Both the Royal Society and the East India Company in this period held repositories of objects, which served both to entertain visitors and to aid in their practical investigations into the natural and human worlds and how they might be turned to the profit of the English nation. The Royal Society's repository was begun in 1663 and was integrated into the British Museum in 1781, by which time it seems to have been a 'substantial and significant collection'.³⁰ It had been assembled through a combination of chance gifts and objects acquired through targeted requests or purchases. In 1664, the Royal Society offered to cover the costs of members of the EIC who collected and transported specimens.³¹ Like written natural histories, the contents of the Society's repository reflected both the natural and human worlds, with animal, vegetable, and mineral specimens positioned alongside mummies and body parts, tools, clothing and ephemera. In a recent study of the East India Company's nineteenth century museum, Jessica Ratcliff described the institution as combining the functions of displaying curiosities and curating useful knowledge, also noting that objects often circulated through the museum before being passed on to other institutions.³² Something similar was true in the earlier period: certain specimens were displayed for curious visitors and others lent out to scholars who could report back on their worth. Sometimes, the East India Company made deliberate enquiries about the worth of their collections, as was the case in 1680, when two representatives of the Company attended a meeting of the Royal Society to inquire about the uses and value of a bezoar stone that had been presented to their servants by the ruler of Bantam.³³ For Company servants, supplying curiosities could bring similar advantages to publishing natural histories, including potential preferment in the Company hierarchy.

28 Mark A. Meadow, 'Hans Jacob Fugger and the Origins of the Wunderkammer', in Pamela H. Smith and Paula Findlen (eds.), *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe* (New York: Routledge, 2002), 182–200, 182.

29 Paula Findlen, 'Commerce, Art, and Science in the Early Modern Cabinet of Curiosities', in Smith and Findlen (eds.), *Merchants and Marvels*, 297–323.

30 Jennifer Thomas, 'A 'Philosophical Storehouse': The life and afterlife of the Royal Society's repository' unpublished PhD thesis, Queen Mary, University of London, 2009.

31 Jennifer Thomas, 'Compiling 'god's Great Book [of] Universal Nature': the Royal Society's Collecting Strategies'. *Journal of the History of Collections*. 23.1 (2011): 1–13.

32 Jessica Ratcliff, 'The East India Company, the Company's Museum, and the Political Economy of Natural History in the Early Nineteenth Century', *Isis* (2016): 495–517.

33 Winterbottom, *Hybrid Knowledge*, 28.

Private collectors rivalled institutional collections in this periods as sources of information and exchange and of patronage for those could supply exotic curiosities. Most notable in this period was Hans Sloane, whose collection came to form the basis for the British Museum and who provided both support for the Royal Society's repository and competition.³⁴

Cabinets of curiosity also existed in the overseas settlements of the EIC. For example, Governor Stringer of St Helena during the 1660s had a cabinet of curiosity that he displayed to visitors containing the dried skin of a sea cow, ambergris, five pounds of civet, bags of cornelian, knife handles of agate, satin from China, Japan canes and a large number of unspecified goods from India.³⁵ An inventory of the possessions of another governor of St Helena, Blackmore, who died in 1690 lists his collections including a large amount of materials from Tonkin, China, and Bengal, precious stones including cornelian, diamond, as well as boxes made from silver, ivory and copper, 'turkey-work' chairs and a bezoar stone. This Governor also had a considerable library; along with several religious works this included several practical works like the 'Mirror for Magistrates', as well as 'Cooke upon planting', a work on salt marshes, histories of China and Persia, Bacon's 'Natural History' (*Silva Silvarum*), and a work by Grotius (probably *Annales et Historiae de Rebus Belgicis*).³⁶

Asian rulers and scholars also made collections of exotic objects, animals, and even people and supplying these demands was in fact a key motivation for Company servants to collect. Jahangir described a north American turkey, and a zebra from Africa as having been imported by the 'Franks', in one of his infrequent references to European activities in India.³⁷ The mid-seventeenth century rulers King Narai of Siam (1656–1688) and King Rajasimha II of Kandy (r. 1634–1686) were also notable for their collections of exotic things and indeed people, both kings surrounding themselves with foreign advisors, ministers and guards.³⁸ As was the case within Europe, supplying objects for such collections could be way for merchants to establish a 'social nexus' with Asian

34 Delbourgo, *Collecting the World*.

35 Simon de Renneford, *Histoire des Indes Orientales*, Paris, 1688, Vol. 8, Bk 2.

36 St Helena Archives, *Consultations*, Vol. 3, f. 280 02 December 1690.

37 Jahangir, *Jahangirnama*, respectively, 24 and 206, 133, depicted in a watercolour by Mansur dated 1612 and reproduced on this page, 360, also depicted by Mansur in a watercolour dated 1620–1621.

38 Ian Hodges, 'Western Science in Siam: A Tale of Two Kings', *Osiris*, 13 (1998): 80–95. Gananath Obeyesekere, 'Between the Portuguese and the Nāyakas: the many faces of the Kandyan Kingdom, 1591–1765', in Zoltán Biedermann and Alan Strathern (eds.) *Sri Lanka at the Crossroads of History* (London: University College London Press, 2017).

rulers.³⁹ The correspondence of the Company factory at Fort St George with the Nawab of Golconda and his representatives is largely concerned with the sort of gifts to be procured for the Nawab and others at court – including spectacles and sandalwood – and with protocols of behaviour towards him.⁴⁰ But as this example shows, supplying gifts of curiosities was also a means for Company representatives to subordinate themselves to local rulers. For the rulers involved, treating Company servants as the suppliers of curiosities in return for favours was intended to emphasise this subordinate position. As Sujit Sivasundaram notes in the case of the rulers of Kandy, Asian rulers were seeking to make Europeans in Asia their vassals, while Europeans held the same goal towards these rulers.⁴¹ Thus, exchanges of objects in the context of the overseas factories of the EIC was more of a struggle for power as displayed through the control of people, things, and information than an equal exchange.

Botany, Zoology, and Medicine

While in the seventeenth century a ‘natural history’ was a miscellany of observations about the natural and human world, it later took on a more specific meaning associated with botany and zoology. William Roxburgh, who would become the EIC’s first naturalist, was born in 1751. In the generations before him, while observations of flora and fauna appeared in natural histories and travel narratives, the professional pursuit of botany, and to some extent zoology, remained bound up with medicine. Nonetheless, the seventeenth and early eighteenth centuries were key in terms of the establishment of international networks through which large volumes of botanical collections were transmitted, the emergence of systems of classification, and the expansion of botanical gardens.

European accounts of Asian nature began with the work of Garcia de Orta, a ‘new Christian’ of Spanish descent who lived and worked in the Portuguese colony of Goa in the late sixteenth century.⁴² de Orta’s *Colóquios dos simples e drogas e cousas medicinais da Índia* (Goa, 1563) cross-referenced his

39 Meadows, ‘Hans Jacob Fugger and the Origins of the Wunderkammer’, 184.

40 IOR G/19/26.

41 Sujit Sivasundaram, *Islanded: Britain, Sri Lanka, and the Bounds of an Indian Ocean Colony* (Chicago: Chicago University Press, 2013), 71.

42 For a useful recent compilation of studies of de Orta and his work, Palmira Fontes da Costa ed. *Medicine, Trade and Empire: Garcia de Orta’s Colloquies on the Simples and Drugs of India (1563) in Context*, edited by. (Burlington, VT, USA, 2015).

own observations of Asian medicinal products, many conducted in his own gardens, with those of the ancients, Arabic medical authorities and his own humanist contemporaries. It was translated into Latin by Carolus Clusius, becoming a best-seller throughout early modern Europe.

Clusius' translation, along with his work in the Leiden botanical gardens, encouraged a close collaboration between botanists based in Holland, and particularly at the University of Leiden and servants of the VOC. Some botanists worked in the East Indies before taking up positions at the Leiden gardens, including Paul Hermann, who practiced as a physician in Dutch Ceylon before returning to Holland in the 1680s to head the Leiden botanical gardens. This generated both published works and an exchange of plants that were raised in the botanical gardens and animals, whose dried skins or skeletons were exhibited in the cabinets of curiosity that accompanied the gardens. Published accounts included Jacobus Bontius's accounts of the diseases prevalent in Java and the local plants used to treat them, composed in the 1620s and 1630s; Georgius Everhardus Rumphius' accounts of the nature of the Moluccas and Ambon, composed in the 1660s and 1670s and Willem ten Rhijne, whose work on Japan included descriptions of acupuncture and moxa.⁴³ Most famous is Hendrik Adriaan van Reede tot Drakenstein's *Hortus Malabaricus*, a twelve-volume work produced in modern Kerala with the assistance of numerous South Asian and European botanists, collectors, draftsmen and published in 1678–1693.⁴⁴

Compared with the strength of the connections between the VOC and botanists at the University of Leiden and the wealth of published works on the flora and fauna of the Dutch colonial possessions in Asia, the contribution of the EIC settlements to the understanding of the Asian environment seems scanty at first. However, while EIC servants with an interest in nature lacked the patronage that was forthcoming from the Heren XVII, a network of private patrons, often associated with both the EIC and the Royal Society provided incentives for collecting information and specimens. No published works dedicated specifically to Asian flora and fauna emerged from the EIC settlements before the late eighteenth century work of William Roxburgh and Patrick Russell.⁴⁵ Nonetheless, by the mid-seventeenth century, descriptions of exotic plants and creatures made their way into general works of botany – like

43 Harold J. Cook, *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age* (New Haven: Conn: Yale University Press, 2007).

44 J. Heniger, *Hendrik Adriaan Van Reede Tot Drakenstein (1636–1691) and Hortus Malabaricus: A Contribution to the History of Dutch Colonial Botany*. (Rotterdam: CRC Press, 1986).

45 Menon, Minakshi. *Making Useful Knowledge: British Naturalists in Colonial India, 1784–1820*. Unpublished PhD thesis, University of California, San Diego, 2013.

Parkinson's classic *Theatrum Botanicum*, which gives accounts of numerous trees, plants, and animal products from the East Indies alongside species from the West Indies and Africa.⁴⁶ Meanwhile plants appeared in physic and pleasure gardens and animals in menageries. Similarly, remedies from the East as well as the West Indies made their way into household remedies and apothecaries' shops.⁴⁷ Ironically, the incorporation of exotic remedies into the wares of apothecaries and the practice of physicians run alongside a growing sense of 'English' medicine during the seventeenth century, which attempted to exclude the influence of foreign authors, including the Arabic authors who had been influential in the medieval period.⁴⁸ The early tendency towards incorporating exotic remedies into what was considered 'English' medicine continued in later stages of imperialism. From an early stage, the *London Pharmacopoeia* and later the *British Pharmacopoeia*, incorporated numerous medical substances originating in India, while the first official *Indian Pharmacopoeia* was published only in the 1950s.⁴⁹

Materia medica and live plants and animals were sometimes imported by the East India Company in an official capacity, but more often they were the result of private trade or exchange between Company servants and apothecaries, botanists, and those who made a living from curiosities, including exotic creatures. Between the late seventeenth and early eighteenth century, the Madras surgeon Edward Bulkley cultivated numerous patrons and business partners in London, including the apothecaries James Petiver and Leonard Plukenet, the botanist John Ray, and the gardener and treasurer of the East India Company, Charles du Bois. Like his predecessor Samuel Browne, Bulkley supplied these contacts with specimens – including numerous volumes of dried plants annotated with their local medical uses – in return for books, specimens or seeds from elsewhere or preferment within the Company. Bulkley also supplied drugs directly to apothecaries, including his brother-in-law, who had a shop in London.⁵⁰ No less important in motivating investigations into nature in the Company settlements was the preferment that could be gained in Asian

46 John Parkinson, *Theatrum botanicum: the theater of plants: or, An herball of large extent* (London, 1640).

47 Patrick Wallis, 'Exotic Drugs and English Medicine: England's Drug Trade, c. 1550–c. 1800', *Social History of Medicine*, 25 (2012): 20–46.

48 Andrew Wear, 'English medical writers and their interest in classical Arabic medicine in the seventeenth century', in Russell (ed.), *'Arabick' Interest*, 266–277.

49 Nandini Bhattacharya, 'From Materia Medica to the Pharmacopoeia: Challenges of Writing the History of Drugs in India', *History Compass* 14, 4 (2016): 131–139, doi: 10.1111/hic3.12304.

50 MS Sloane 3321, fol. 18, Edward Bulkley to James Petiver, FSG 12 October 1699.

courtly settings by combining a successful cure with knowledge of local protocols of treatment and diplomacy. Bulkley and Browne both received patronage from the Nawabs of Arcot, including official posts within the Mughal empire, in return for the treatments and services they provided. Networks of botanical and zoological exchange also existed between European settlements in Asia. Browne and Bulkley kept up an exchange with the Bohemian Jesuit pharmacist and collector Georg Joseph Kamel SJ (1661–1706) in the Philippines. Ship's surgeons were often entrusted with specimens that were being transferred between settlements or remitted to London.⁵¹

Despite the lack of published works on Asian nature associated with the early EIC, Company servants transmitted manuscript accounts and drawings as well as specimens back to Europe. A notable example is the work of the Scottish surgeon and naturalist James Cunningham (ca. 1665–1709). Cunningham was the surgeon to the EIC at Amoy (Xiamen) in 1697–1699 and later Chusan (Zhoushan), 1699–1703 and in the short-lived settlement of Pulo Condore where he was imprisoned from 1705–7.⁵² Cunningham sent over 600 species of Chinese plants to correspondents in London including James Petiver, Leonard Plukenet, and Hans Sloane. Cunningham also collected animal specimens, including a collection of shells that he sent to Petiver in 1697 and insects sent to the same correspondent in 1701. His collections also encompassed the Canary Islands, Batavia in Java, Malacca, St Helena and the Cape of Good Hope.⁵³ Cunningham commissioned Chinese artists to make several volumes of drawings of local plants including their names in Chinese script; in total, he collected 1,200 drawings of plants from Amoy.⁵⁴ His written descriptions of nature included a letter to the Royal Society that was published in *Philosophical Transactions* in 1702 which includes a description of the various sorts of tea that were received from China.⁵⁵ Joseph Banks referred back to this article of Cunningham's when

51 Winterbottom, *Hybrid Knowledge*, Ch. 4.

52 Jane Kilpatrick, *Gifts from the Gardens of China: The Introduction of Traditional Chinese Garden Plants to Britain, 1698–1862* (London: Frances Lincoln, 2007).

53 For the Canary Island collections, Arnaldo Santos-Guerra, Charles E. Jarvis, Mark A. Carline, Michael Maunder, and Javier Francisco-Ortega, 'Late 17th century herbarium collections from the Canary Islands: The plants collected by James Cunningham in La Palma', *TAXON* 60, 6 (2011): 1734–1753. For the insects, British Library, Sloane MS 3321, f. 89, James Cunningham to James Petiver, Chusan, November 22 1701. Collections by Cunningham in the Sloane herbarium are: H.S. 59, from China made in 1698 and at the Cape of Good Hope in 1699; H.S. 252, collections from Amoy, Chusan and the Crocodile Isles; H.S. 253, plants from Batavia and Pulo Condore; H.S. 257 from the Cape; H.S. 289 from Batavia.

54 British Library Add MS 5292–4; Kilpatrick, *Gifts from the Gardens of China*, 37.

55 James Cunningham, 'Part of Two Letters to the Publisher from Mr James Cunningham, F. R. S. and Physician to the English at Chusan in China, Giving an Account of His Voyage

advising the East India Company about their project of importing tea growing into India in the late eighteenth century.⁵⁶ Like most of his contemporaries, Cunningham did not confine himself to botanical collecting, but also collected manuscripts and other curiosities. For example, in a letter to Hans Sloane from Chusan in 1703, he refers to sending Chinese works on religion, a description in Chinese of the island of Putuo Shan, and a map of the Ning-po (Nigbo) river by a French priest.⁵⁷ He also made meteorological observations in Amoy.⁵⁸ In other words, he aimed at the sort of total natural history described by Boyle.

James Cunningham sent seeds to be cultivated by gardening friends in England, including James Petiver and Robert Uvedale.⁵⁹ This was part of a long tradition of introducing exotics and techniques from the east. Medieval Britain borrowed from Islamic traditions of horticulture, via Andalusia, including adopting techniques selective breeding of plants as well as plants themselves.⁶⁰ By the sixteenth century, the Ottoman Empire had become a major centre for gardening. Networks of gardens were important from the beginning of European colonial expansion, both in the overseas settlements and in colonial capitals. They served both practical and spiritual purposes, providing experimental spaces for projects of acclimatisation and classification and speaking to the urge to return to Eden by reuniting the species scattered across the world.⁶¹ The early Italian botanical gardens at Pisa and Padua, founded in 1544–5 received plants from travellers to the new and old worlds.⁶² Diplomats and members of the trading companies sent or brought back specimens from the Ottoman empire. Edward Pococke, chaplain to the Turkey merchants in Aleppo in 1630–6 brought back a plane tree and fig tree, which still survive in Christ Church College in Oxford.⁶³ The trickle of seeds brought back to Europe in the sixteenth century became a flood in the seventeenth. During the 1690s the seeds sent back from the settlements apparently filled a barber's shop,

Thither, of the Island of Chusan, of the Several Sorts of Tea, of the Fishing, Agriculture of the Chinese, Etc. with Several Observations Not Hitherto Taken Notice of'. *Philosophical Transactions*, 23 (1702): 1201–1209.

56 IOR private papers D993, 'BANKS, (Joseph), Sir Memorial dated 27 December 1788'.

57 British Library Sloane MS 4039, f. 85.

58 British Library Sloane MS 3323, ff. 81–84.

59 Kilpatrick, *Gifts from the Gardens of China*, 45.

60 John Harvey, 'Coronary Flowers and their "Arabick" Background', in Russell (ed.) *'Arabick' Interest*, 297–303.

61 Richard Drayton, *Nature's Government*.

62 Cristina Bellorini, *The World of Plants in Renaissance Tuscany* (Farnham, Surrey: Routledge, 2015).

63 Harvey, 'Coronary Flowers and their "Arabick" Background'.

which the Society turned over to the Royal Society to experiment with. The Society passed these seeds onto their network of gardeners with some impressive results.⁶⁴ By this stage, innovations like heated greenhouses were beginning to enable gardeners to grow plants that would not earlier have survived.

Gardening was a key part of the early East India Company settlements, each of which contained several 'Company' and private gardens. Again, these gardens served a number of functions, practical and symbolic. In Mughal India, similarly to Europe, gardens were symbolic of territorial claims and orderly government. The Company garden in Madras, the EICs most important Indian settlement during the late seventeenth and early eighteenth centuries were redesigned at the beginning of the eighteenth century to include wide walk ways, fish ponds, and bowling green and a large space for the display of 'curiosities'. In 1708, the Company used the garden to receive an important grant from the Mughal rulers of nearby Arcot.⁶⁵ Governors of the settlements and the surgeons often requested plants from other settlements or from London to grow as food or export crops or for use in medicine in the Company gardens. The Company gardens were often tended by slaves, some of whom became experts, and were rewarded through payments or allowances.⁶⁶

Astronomy, Physics, and Mathematics

In 1676, Edmond Halley (1656–1742) left Oxford to travel to the EIC settlement of St Helena in the South Atlantic. He was carrying a sextant with a radius of 5 ½ feet, quadrant of about 2-foot radius, a pendulum clock, a telescope of 24 metres, and some smaller telescopes, and two micrometres.⁶⁷ On a high point of the island, he built a small observatory with the aim of compiling a catalogue of the southern stars and observing the transit of Mercury. Accurately observing and timing this astronomical event could, as Halley later pointed out, help determine the parallax of the sun and hence the distance between the earth and the sun. Halley's own estimation was, however, only about one-fifth of the true distance. Despite poor weather conditions, Halley determined the position of 341 stars, which he published in his catalogue of 1678–9 and which were later incorporated into John Flamsteed's *Historia Coelestis Britannica* of 1725.⁶⁸

64 Winterbottom, *Hybrid Knowledge*, Ch. 4, 133.

65 Winterbottom, *Hybrid Knowledge*, Ch. 4, 126; Stern, *Company State*, 199.

66 Winterbottom, *Hybrid Knowledge*, Ch. 6.

67 Eugene F. McPike (ed.), *Correspondence and Papers of Edmond Halley* (Oxford: Clarendon Press, 1932). 'Memoir of Halley, by (?) Martin Folkes', 2.

68 Angus Armitage, *Edmond Halley* (London: Nelson, 1966), 29–36.

In practice, the value of Halley's own observations and of the transit of Venus that occurred in 1761 and was famously observed by Captain Cook were limited by weather conditions and the difficulty of keeping clocks telling the correct time aboard ship or in hot and humid conditions. It was the difficulties involved in using pendulum clocks to keep accurate time aboard ship that prompted the investigations of Robert Hooke and Christiaan Huygens into spring-wound watches.⁶⁹ Halley's make-shift observatory was the only one in the Company settlements until the founding of the Madras Observatory in the late eighteenth century and was not apparent maintained after his departure. Nonetheless, as Halley pointed out in his *Atlas Maritimus & Commercialis*, the Royal Society did succeed in collecting observations of latitude and, to some degree, longitude from locations across the world through their contacts with diplomats, travellers, and member of the trading companies.⁷⁰ Equipping a variety of people to make observations was aided by the development of a number of specialist workshops and shops in London by the mid-seventeenth century.⁷¹ The task of determining longitude and the development of marine chronometers to enable more accurate measurements at sea were from 1714 onwards taken up by the Board of Longitude.⁷² Members of the EIC provided both demand for instruments and data from their observations in the eighteenth century.⁷³

In travelling to St Helena, Halley was following the example of other astronomers of his age including John Greaves (1602–1652), who under the patronage of Archbishop Laud, had travelled to Constantinople, Rhodes, Alexandria, and Cairo, where he carried out observations and surveyed the pyramids. As well as making his own observations, Greaves collected works on astronomy in Arabic and Persian during his travels. In making use of Arabic and Persian texts, Greaves was following the example of earlier European astronomers, including Copernicus, whose use of the Tusi couple developed by Nasir al-Din al-Tusi

69 A. R. Hall, 'Robert Hooke and Horology', *Notes and Records of the Royal Society of London*, 8, 2 (Apr., 1951): 167–177. Huygens had also perfected the pendulum clock, beginning in 1657.

70 Edmond Halley, *Atlas Maritimus & Commercialis: Or, A General View of the World so far as Relates to Trade and Navigation* (London, 1728).

71 James A. Bennett, 'Shopping for instruments in London and Paris', in Smith and Findlen (eds.), *Merchants and Marvels*, 370–398.

72 Cambridge Digital Library, *Board of Longitude*, <https://cudl.lib.cam.ac.uk/collections/longitude>. Last accessed 23 November 2017.

73 Alexi Baker, 'Commissioner of longitude', Katy Barret and Eoin Philipps, 'Chronometer' and Richard Dunn, 'Lunar distance method' in Cambridge Digital Library, *Board of Longitude*.

(1201–1274) was central to his explanation of the motion of heavenly bodies in *Commentariolus* and *De revolutionibus*. How Copernicus became aware of the Tusi couple remains uncertain, but it was probably via a later text referring to al-Tusi's work which had arrived in Italy as a result of diplomatic contacts and conflicts between parts of the Ottoman and Persian empires and parts of Italy, notably Venice and Padua.⁷⁴ The European astronomers who followed Copernicus became aware of the work that had been carried out in the fifteenth century observatory of Ulug Beg (Muhammad Turghay, 1393–1449) in Samarkand, in Central Asia, then part of the Timurid empire. Greaves' collection of manuscripts included Ulug Beg's work *Zij-I Jadid-i Sultani*.⁷⁵ Further copies of this work arrived in Oxford and Thomas Hyde used them for his translation of the work, commissioned by the Royal Society, in 1665.⁷⁶

As well as containing mathematical innovations like the Tusi couple, Arabic and Persian astronomical texts, along with the ancient Greek and Roman texts, could be used to answer questions like whether the obliquity (axial tilt) of the earth and the moon's orbit had changed over time. For example, Halley correctly argued based on a comparison of measurements by Ptolemy, al-Battani, and contemporary observers for the secular acceleration of the moon over time. Making astronomical observations and consulting a range of astronomical texts also had practical implications: notably for navigation and mapping and for calendrical reform, which was an important question in the seventeenth century, which saw the transition from the Gregorian to the Julian calendars. Joseph Scalinger (1540–1609) who introduced the modern system of reckoning time, made a comprehensive survey of calendrical systems, including Japanese and Mexican.⁷⁷

By the seventeenth century, natural philosophers had access to some data regarding Asian astronomical and calendrical traditions. The best positioned Europeans to acquire information about Chinese science were Jesuit missionaries. The Jesuit mission was associated with the mathematical and astronomical sciences from 1600, when Matteo Ricci took up residency in Beijing and

74 Peter Barker and Tofigh Heidarzadeh, 'Copernicus, the Tūsī couple and the East-West Exchange in the Fifteenth Century', in Miguel A. Granada, Patrick Boner and Dario Tessicini, *Unifying Heaven and Earth: Essays in the History of Early Modern Cosmology* (Barcelona: Publicacions I Edicions De La Universitat De Barcelona, 2016), 19–57.

75 There are copies in the Bodleian, Greaves 5 and in St John's College. C.f. Raymond Mercier, 'English Orientalists and Mathematical Astronomy', in Russell (ed.) *Arabick Interest*, 158–214.

76 Thomas Hyde, *Gadāwil-i Mawāḍi'-i Tawābīt Dar Tūl Wa-'araḍ Kih Bi-Raṣad Yāfta Ast Uluḡ Bīk Ibn-Šāhruḥ Ibn-Tīmūr Sive Tabvāe Long. Ac Lat. Stellarum Fixarvm* (Oxford, 1665).

77 Mercier, 'English Orientalists and Mathematical Astronomy'.

several Jesuits were appointed to the Imperial Astronomical Bureau. From mid-century, a group of French Jesuits became involved with the surveys carried out by the Qing emperor Kangxi (r. 1662–1723).⁷⁸ In India, the early eighteenth century ruler of Jaipur, Jai Singh (r. 1699–1743), built on the cosmopolitan exchanges between Arabic, Persian, and Sanskrit astronomy that had taken place in the Mughal courts from Akbar onwards. Jai Singh also engaged with Ulug Beg's work. He built huge astronomical observatories in Jaipur, [Delhi and Ujjain] and gathered experts around him, including a group of Portuguese Jesuits and in collaboration with them, sent a delegation to Lisbon in 1728–30, returning with copies of the works of French astronomer Philippe de la Hire (1640–1718) and John Flamsteed (1646–1719). A similar exchange occurred between France and Siam, where King Narai requested telescopes, time pieces, terrestrial and celestial globes and astronomical tables from the Paris Observatory, which a delegation from the Siamese kingdom to Paris visited in 1685. During the 1680s, King Narai had observatories built in Siam and joined French astronomers in observing events like lunar eclipses.⁷⁹

In contrast with French and Portuguese missionaries and diplomats in Asia, neither EIC servants nor scholars in Britain engaged directly with astronomy in Asia before the mid-eighteenth century. The reasons for this probably included the lack of direct contact in Protestant Britain with Jesuits, equipped as they were with an unusual level of training in both natural philosophy and languages. While some EIC servants did learn Persian in the settlements, Sanskrit was almost unknown to them and their scholarly contacts in Britain in this period and this ruled out access to the classics of *jyotisha* (astral sciences) as well as much of the newer work (and instruments) that had been produced as a result of dialogue with Persian astronomy in the Mughal period.⁸⁰ Chinese was also off limits to most British factors and scholars in this period. There are a few exceptions to this general lack of engagement. The EIC factor John Marshall who worked in the Bengal factories in the 1670s tried to relate his conversations about religious philosophy with a local Brahmin, Madhusudana Radha, to questions about time, astronomy, and metaphysics.⁸¹ Thomas Hyde used his interactions with the Chinese convert to Christianity, Micheal Shen Fuzong to discuss questions including astronomy, and Shen annotated Hyde's translation

78 Steven J. Harris, 'Jesuit Scientific Activity in the Overseas Missions, 1540–1773', *Isis*, 96, 1 (2005): 71–79.

79 Hodges, 'Western Science in Siam'.

80 Dhruv Raina, 'Revisiting Social Theory and History of Science in Early Modern South Asia and Colonial India', *Extrême-orient Extrême-Occident* 36 (2014): 191–210.

81 See Winterbottom, *Hybrid Knowledge*, Ch. 3.

of Ulug Beg's star catalogue.⁸² Hyde also had access to the astronomical work of Ferdinand Verbiest, one of the Jesuits serving the Qing dynasty.⁸³ Members of the EIC settlements did not become aware of Jai Singh's observatories until the account of Robert Barker in the 1770's, who assumed them to be ancient monuments.⁸⁴ Direct engagement between Indian and British astronomy did not begin before the late eighteenth century and was by then hampered by the inequality of access to patronage and information involved in colonial rule.

Conclusion

Early modern natural philosophers and trading companies were connected through their knowledge practices. These included keeping detailed records of correspondence, meetings, and committees, soliciting information from a range of correspondents, recirculating this information for corrections and additions, and using the information as the basis of experiments and theories (whether about the potential products of a particular place, the best crops to introduce to a settlement, or what caused the variation of Earth's magnetic field). In this sense, the concept of 'transoceanic corporate sociology' could be applied as easily to savant institutions like the Royal Society as to trading companies. As Harold Cook has argued, the ways in which scientific and economic development unfolded from the scientific revolution to the nineteenth century were not inevitable; however, science and economy were co-produced.⁸⁵ Both science (or natural philosophy) and trade are highly specific to particular places as well as taking place on a global scale. For example, searching for useful plants was a global activity during the seventeenth and eighteenth centuries, but was shaped not only by the environments of particular places but by local systems of value and classification. Similarly, the exchange of commodities was determined not only by the available commodities but also by local conventions governing investment and labour.

In collecting and compiling information, members of trading companies were heavily reliant on the collaboration of local informants and collaborators,

82 Shen' annotations to the tables derived from Ulug' Beg are in British Library Reg. 16 B. xviii (now classified as a British Library printed book 10055.ee.32), fol. 28.

83 Noël Golvers, *Ferninand Verbiest S.J. (1623–1688) and the Chinese heaven*, Leuven Chinese Studies, xii, (Louvain, 2003).

84 Robert Barker, 'An Account of the Bramins Observatory at Benares', *Philosophical Transactions*, 67 (1777): 601.

85 Harold Cook, 'Moving About and Finding Things Out: Economies and Sciences in the Period of the Scientific Revolution', *Osiris*, 27, 1 (2012): 101–132.

willing or unwilling. The types of information they collected were also shaped by local realities and knowledge systems. Thus, the forms of knowledge produced in company settlements integrated global and local realities. The information that was imparted by informants must be assessed according to the priorities and aims of the informants themselves as well as the company servants that recorded it and passed it on, again with their own agendas shaping its form and contents. In this sense, natural and mechanical knowledge was the product of negotiation. Demonstrating European knowledge and command over the natural world by gifting curiosities was an important sense in which trading companies could make themselves useful, subordinate themselves, to local rulers; a process that was vital to obtaining the network of grants and charters that they required to maintain their position.

Natural and mechanical knowledge was useful and hence valuable knowledge, to trading companies, natural philosophers, and rulers. Therefore it was rarely freely exchanged, but was guarded and carefully dispersed to the best source of patronage in limited quantities. While the interests of these different parties overlapped, therefore, this did not lead to an open and free exchange of information, but to competition. The characterisation of the age as one of 'contained conflict' thus applies as much to the exchange of knowledge as of commodities and land.⁸⁶ In the early modern period and beyond, both trade and natural philosophy were ruled as much by secrecy and close circles as by circulation and open networks.⁸⁷ Therefore, the specific characteristics of national or colonial science that emerged from this period were formed by ignorance as well as by knowledge; by the failures to communicate information across cultures as much as the successes.⁸⁸

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- 86 For contained conflict see Sanjay Subrahmanyam, *Mughals and Franks: Explorations in Connected History* (New Delhi: Oxford University Press, 2005).
- 87 Koen Vermeir and Dániel Margócsy, 'States of Secrecy: An Introduction', *British Journal for the History of Science*, 45 (2) (2012): 153–164 and other papers in this special issue.
- 88 Robert N. Proctor and London Schiebinger (eds.) *Agnotology: The Making and Unmaking of Ignorance* (Stanford: Stanford University Press, 2008).

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