The making of a quinologist: *Cinchona*, collections, and science in the work of John Eliot Howard (1807-1883)

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Declaration of Authorship

I Kim Walker hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed:

Date: 6.3.23

In memory of Bridget Evans (née Lloyd) (1934-2022), the Great Great Granddaughter of John Eliot Howard who kindly gave time to share her family history.

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Abstract

The subject of this thesis is the career of the quinologist and industrialist, John Eliot Howard (1807-1883), his cinchona bark collections and scientific work. The approach is collections-based, combining archival and object-based research, to understand Howard's collections assemblages, scientific practices, networks of specimen and knowledge exchange. Howard's primary collections and archives are in the Economic Botany Collection and Library and Archives of the Royal Botanic Gardens, Kew.

Working in his family's pharmaceutical factory at Stratford, Howard had the financial, technological and cultural resources to develop specialist expertise relating to cinchona and its constituent quinoline alkaloid, helping to develop the discipline of quinology. His career reflects wider historical developments including scientific specialisation, evolution of species and mass pharmaceutical manufacture. Howard's extensive research led to expert consultation work for the Government's British-Indian cinchona project, and the family firm becoming Britain's leading quinine suppliers.

Much historical research has been done on cinchona collection in South America and its transplantation in South Asia, less is known about the ways in which these collections and the knowledge they generated were mobilised within Britain. This thesis asks how the work of Howard, located far from the fields of origin or cultivation of cinchona, influenced its use and that of its alkaloids.

Chapter 1 of the thesis introduces a historical context for cinchona research. Chapter 2 presents the methods, the archival and collections sources and the results of a meta-analysis for the Kew specimens. Chapter 3 introduces Howard and the development of his family business. Chapter 4 explores his professional development as a cinchona expert and his influence within quinology. Chapter 5 examines Howard 'in the lab': his collections and scientific practices. Chapter 6 analyses how Howard developed his scientific interests as he moved 'out of the lab' into the garden. Chapter 7 then explores Howard's circulated works through his books, illustrations, distribution and reception. The final chapter presents conclusions and a view of future research beyond the thesis.

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Chapter 1 | Cinchona: A ‘Magnificent Tree’

Ce magnifique et grand arbre que je voyais pour la première fois, et qui était depuis longtemps le sujet de mes rêves. Je restai en extase devant ses belles écorces argentées, ses larges feuilles d'un vert chatoyant, et ses fleurs d'un parfum si doux, qui rappellent un peu celles du lilas.

[That magnificent tree, for so long I had seen it in my dreams and now it was before me. I lingered in ecstasy contemplating the beautiful silvery bark, those broad leaves of shimmering green, and flowers of such a sweet perfume, reminiscent of the lilac.]

(Auguste Delondre [in 1847], *Quinologie*, 1854. p. 21, translation with thanks to Emily Danby, from Walker & Nesbitt, 2019)

Figure 1.1 Cinchona calisaya [oil painting] by Marianne North, Java, 1870.
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1.1 Cinchona: a historical context

The role of botanical drugs is a major theme in the histories of medicine and empire. In recent years, historians have used postcolonial and decolonial lenses to analyse the effects of colonial bioprospecting and knowledge appropriation (Chakrabarti, 2014; Parry 2004; Schiebinger, 2004; Schiebinger & Swan, 2007). The ways in which medicinal plants or knowledge are exploited for profit remains a live issue today: understanding the history of this exploitation is necessary in addressing its contemporary implications (Osseo-Asare, 2014). Cinchona is important to these discussions because, as the only effective treatment for malaria known to Europeans, it was a 'tool' of imperial expansion and thus a major focus of imperial botany (Headrick, 1979; Philip 1995). Its colonial role has been studied by many historians, including Lucille Brockway (1979, 2002), Kavita Philip (1995), Richard Drayton (2002), and Rohan Deb Roy (2017). They have demonstrated the role the tree played in the history of the global transfer of plants and the establishment of large-scale colonial plantations. In addition, they highlight the key role played by botanic gardens, especially Kew, in the development of economic botany as 'centres of calculation' and as nodes of imperial plant exchange.

This thesis focuses on the study of British cinchona science in the nineteenth century, through the practices and influence of John Eliot Howard (1807-1883), eminent quinologist (expert in cinchona and quinine), pharmaceutical manufacturer at the family firm of Howards and Sons, bark collector and consultant. Howard was based in Tottenham, London, at the political centre of the British Empire. Between 1850 and 1883, he helped to popularise the term 'quinologist', became the foremost British expert on the subject and was extensively consulted on the British Indian plantations. This thesis proposes that Howard was himself an important 'centre of calculation' in this history, as influential in his own way as Kew, but acting as an external consultant.

Howard never saw cinchona in its native South American range nor at the Asian plantations where it later grew. Instead, his expertise relied on tapping into this stream of trade specimens flowing towards London, as well as extensive global networking. He recreated Andean forests through his collections, laboratory analyses and later, garden cultivation. Howard's legacy, a large bark collection and associated archival files now mostly lie in the Economic Botany Collection (EBC) and Archives at the Royal Botanic Gardens, Kew (RBGK). These serve as a rare extant example of a working botanical collection in the field of medicinal plants.

This thesis explores the field of quinology through Howard's collecting practices, networks and publications. This chapter introduces the historical context and breadth of research on cinchona in which this thesis, and Howard, can be placed. After brief descriptions of the cinchona tree and its role in treating malaria, I explore cinchona's introduction to Europe, the identification of botanical species and their constituent quinoline alkaloids. Then I address the bioprospecting of cinchona species, their transfer to Asia and the establishment of plantations. In conclusion, I develop four research questions relating to Howard's role in this wider story of cinchona.

1.2 A 'magnificent tree': The genus *Cinchona*

The *Cinchona* genus is in the coffee family, Rubiaceae (Figure 1.1 and Figure 1.2). Current botanical treatments identify 23 to 24 species so far (Andersson, 1998; Aymard, 2019; Maldonado et al., 2017a). *Cinchona* was first named in 1753 by Linnaeus, based on illustrations made by Charles de la Condamine in 1737 (de la Condamine, 1737; Linnaeus, 1753). The trees grow wild at altitudes of 500-3,000 metres in the cloud forests of the Eastern Andes, in Colombia, Ecuador, Peru and Bolivia (Figure 1.3) (Andersson, 1998). The bark of *Cinchona* species contain quinoline alkaloids, predominantly quinine and cinchonine, as well as their isomers quinidine and cinchonidine (Howard, 1864; Maldonado et al., 2017b). While all four alkaloids can be used in the treatment for the parasitic disease, malaria, quinine is the alkaloid most used in Western medicine (Maldonado et al, 2017a). Three species have dominated cultivation from the mid-nineteenth century: *C. officinalis* L. (pale bark), *C. calisaya* Wedd. (yellow bark) and *C. pubescens* Vahl (red bark) (Andersson, 1998; Howard, 1862). The genus is under threat due to exploitation for its alkaloid content since the seventeenth century. However, due to a lack of data and because it is extensively cultivated, it is not yet on the IUCN Red List (García et al., 2022).

Figure 1.2 Leaves, flowers, seeds and bark of *Cinchona corymbosa* (syn. *C. pitayensis* Wedd.) (Karsten, 1858).
Image Biodiversity Heritage Library. Contributed by Missouri Botanic Gardens**.**

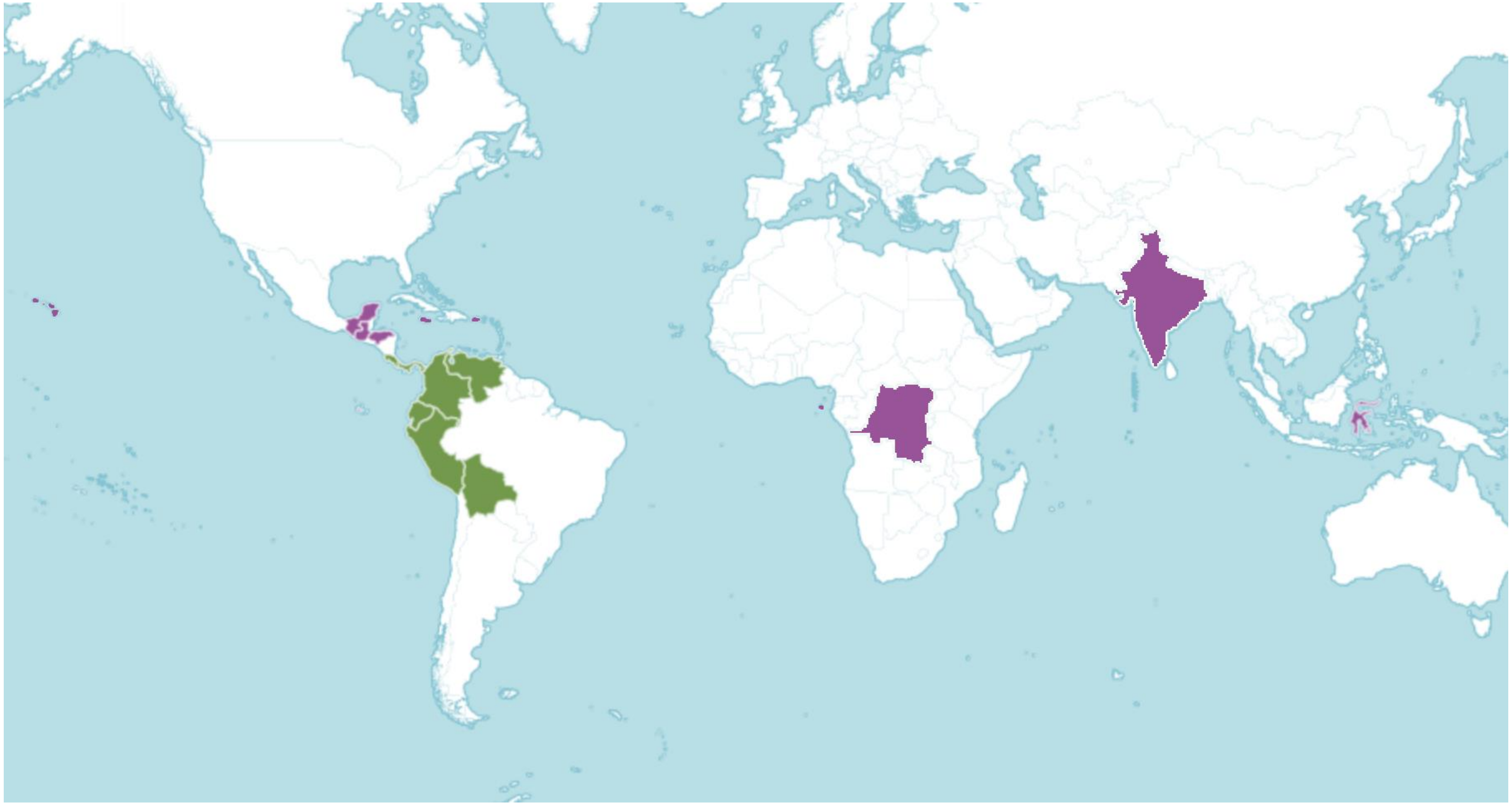

Figure 1.3 Distribution of *Cinchona*: native (green) and cultivated/naturalised (purple), by country.
Adapted from POWO (2022).

Cinchona grows as an evergreen tree or shrub, to around 18 metres high, with lilac-scented, tubular flowers coloured white to pink. The fruit is an ovoid-ellipsoid capsule which splits to release many tiny seeds with membranous wings which aid wind-dispersal (Andersson, 1998). All features of the plant vary in relation to environmental influences and phenotypic variation making it difficult to differentiate species (Andersson, 1998; García et al., 2022). Species identification has perplexed researchers since *Cinchona* came to European notice and the subsequent struggle to understand it is a key theme at the heart of this thesis.

As an Andean native, it was a geographically remote plant to Europeans, inaccessible to the physicians and apothecaries who used it most. Their main contact with the tree was through pieces of medicinal bark arriving at European trade ports tightly packed in leather *serons*[1] (Figure 1.4) (van Gorkom, 1883; Howard, 1862). During the eighteenth and early nineteenth centuries, several European expeditions set off to understand economically valuable South American flora, with particular interest in cinchona. These were mostly undertaken by the Spanish, colonial rulers of cinchona's native range. These included those led by Hipólito Ruiz López (1754-1816), José Antonio Pavón Jiménez (1754-1840), Alexander von Humboldt (1769-1859), Francisco José de Caldas (1768-1816) and José Celestino Mutis (1732-1808) (Bleichmar, 2009; Cuvi, 2022; Pérez et al. 2004; Steele, 1964; Walker et al., 2022). Collections of cinchona from these expeditions remain some of the earliest and most extensive surveys of the genus, connecting multiple specimens with local knowledge and trade names. These collections provided foundational references for nineteenth-century quinologists such as Howard, who purchased parts of Ruiz and Pavón's *La Real Expedición Botánica al Virreinato del Perú* (1777-1816) for his own research. The importance of this collection to Howard and the wider field of quinology is discussed in Chapter 4.

[1] *Serons* are leather packages in which cinchona bark was packaged to protect it from the climate on ships during travel, see Figure 1.4.

Figure 1.4 A seron.
Cinchona bark was dried and broken into pieces to be exported from South America. The bark was packed in weather protecting canvas or leather serons. Image Wellcome Collection.[2]

1.3 Malaria, mosquitoes and the 'miracle' cure

> *Dase un arbol que llaman de calenturas en tierra de Loja, con cuyas cortezas, de color de canela, echas polvos dados en bebida el pefo de dos reales, quita las calenturas i tercianas; an echo en lima effetos milagrofos.*
>
> [[there is] a tree which they call the fever tree in the land of Loja, whose bark, of the colour of cinnamon, made into powder and given as a beverage at a weight of two reales, cures the fevers and tertians; it has produced miraculous results in Lima.][3]

It has been nearly 400 years since the first certain reference to the medicinal use of cinchona, quoted above. Since then, much has been written about the *arbol de calenturas* and its 'miracle' curative properties for treating malaria. Indeed, John Eliot Howard identified no fewer than 637 key works published on cinchona and quinine by

[2] Image name: Bag for cinchona bark, 1777-1785. https://wellcomecollection.org/works/hgn3gd24
[3] De la Calancha, 1638, p. 59. Translation with thanks to Fred Carnegy.

1826 (Howard, 1862). Between the late eighteenth and the twentieth centuries the numerous medicinal treatises were joined by expeditionary accounts attempting to record and understand the tree in its native habitat. In the nineteenth century, cinchona and its constituent quinoline alkaloids were written about as a product of profitable pharmaceutical manufacture, as a solution to tropical disease and enabler of imperial control. This body of writings and related archives has resulted in a significant body of historical research published over the last two decades (Brockway, 2002; Deb Roy, 2017; Headrick, 1979; Honigsbaum, 2001; Philip, 1995; Roersch van der Hoogt, 2015; Roersch van der Hoogte & Pieters, 2014, 2015a, 2015b).

Malaria is an infectious disease caused by blood-dwelling parasites in the *Plasmodium* genus. The parasite is spread from an infected person to a new host through the bite of breeding mosquitoes (*Anopheles* genus). During a complex life cycle the parasites inhabit and consume the human host's blood cells resulting in aches, chills, fevers, weakness and eventual death in severest forms (ECDC, 2021). Malaria is recognisable in historic texts due to its distinct symptom profile of cyclical fever-chills occurring every 24, 48 or 72 hours, known as quotidian, tertian and quartan fevers. We now know that these 'clockwork' cycles are influenced by the life cycle of different parasite species (García et al, 2001; Warrell & Gilles, 2019). Malaria affects hundreds of millions of people today, predominantly in Asia and Africa amongst economically disadvantaged communities unable to easily access healthcare. The pregnant, children under five and the elderly are particularly susceptible (WHO, 2021). In contrast, malaria is little seen in Europe today and then only as an introduced disease brought back by travellers from tropical areas, or infections spread from those travellers, though there are concerns over its return due to climate change (ECDC, 2021, Piperaki & Daikos, 2016).

However, until the late twentieth-century, the disease, known as ague, was widespread across Europe. In places such as Britain, cases decreased around the second decade of the twentieth century and endemic malaria has therefore fallen out of living memory (Kuhn, et al. 2003; Daikos, 2016).[4] Understanding that malaria was a significant

[4] The last cases reported at county level in Britain were in 1910, though there is evidence it may have

problem at home, as well as in its colonies, helps us to understand why cinchona was so important to Europeans.

Untreated, malaria is highly debilitating and often fatal and no effective treatments were known to Europeans until the introduction of cinchona bark to their pharmacopoeia. This explains, therefore, why its use earned a 'miraculous' reputation (de la Calancha, 1638; Crawford, 2016; Gänger, 2020; García et al. 2001). The origin story of the use of cinchona to treat malaria has not yet been fully elucidated. Unlike many other medicinal plants, it does not clearly follow the pathway whereby Indigenous or traditional usages were translated into Western medical use (Voeks, 2018). No evidence has been found in pre-Hispanic archives of cinchona as a remedy for any condition (Crawford, 2016).

In the case of malaria, archaeological and genetic evidence suggest that the Spanish brought the most virulent forms of the malarial parasite (*Plasmodium falciparum* and *P. vivax*) to South America, in their bodies and those of Africans they enslaved (van Dorp et al., 2020; Rodrigues et al., 2018). There is some genetic evidence for the pre-Hispanic existence of a milder form of avian malaria (Poinar, 2011). The absence of serious forms of malaria from pre-Hispanic South America would naturally reduce the need for anti-malarial drugs at that time.

Perhaps cinchona bark was used by Indigenous peoples for treating non-malarial fevers, leading to its later use as a treatment for malaria. However, medical evidence is that cinchona is anti-parasitic rather than directly fever-reducing. The constituent alkaloids are toxic to the blood-dwelling parasites, therefore preventing fever by destroying the root cause.

It was the varying ability of cinchona to treat different kinds of fever that was used as a diagnostic category in one of the earliest treatises on the bark by Italian physician, Francesco Torti (1658-1741) (Torti, 1712). Figure 1.5 shows an engraving from Torti's

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been present in isolated spaces until the First World War. Malaria was eradicated in Europe at large in 1970, see references cited.

work, the treatise *Therapeutice specialis and febres periodicas perniciosas* depicting a *Lignum Febrium* (fever tree). The left side of the tree shows fevers responsive to cinchona and the tree blossoming back to life. In contrast, the right-hand side of the tree is unresponsive and withering away (Jarcho, 1993; Klein & Pieters, 2016; Torti, 1712). This suggests that cinchona is not a direct febrifuge, or it would be effective against many fever types.

It is unlikely that we will know for certain whether cinchona was used as medicine prior to Spanish arrival, whether for malaria or other illnesses. However, researchers agree that Indigenous expertise likely discovered the treatment (Crawford, 2016; Gänger, 2020, Oliveros, 2017; Pérez et al., 2004). For historian Andrew Crawford (2016, p. 38), Indigenous groups '[were] the fathers and founders of the Botany of Peru' with a mastery of plants and their uses. The medical systems of the Spanish occupiers shared elements of spiritual cosmologies with some local traditional healers, have which may have resulted in a medicinal compatibility and subsequent fusion (Crawford, 2016; Philip, 1995). As the earliest records of the miraculous cure arose in busy cities and trading ports such as de la Calancha's Lima, its development as a medicine was likely formed in the space where the two cultures met: It was here that traditional expertise in the local flora intersected with Spanish experience of *falciparum* malaria.

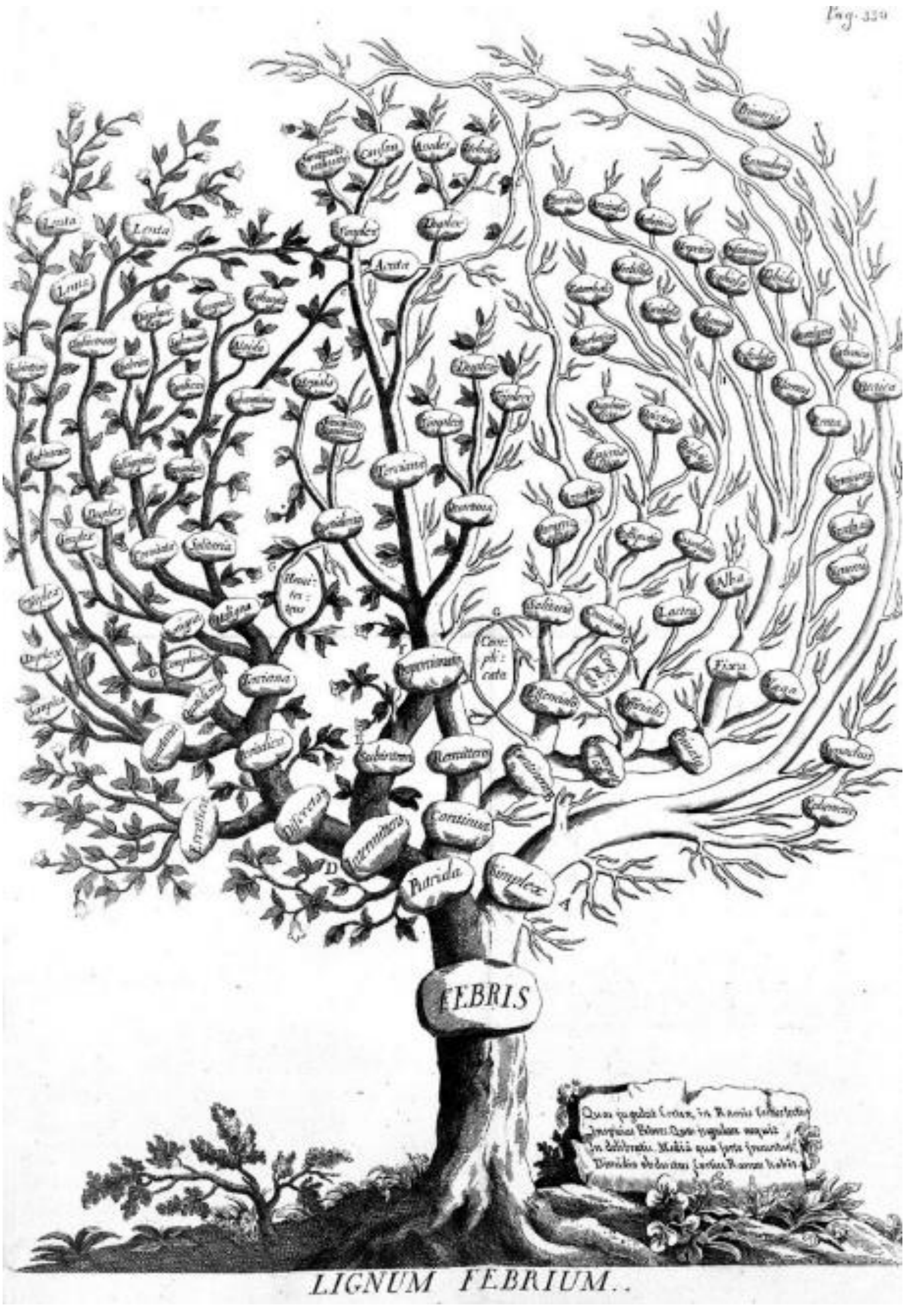

Figure 1.5 The *lignum febrium* [tree of fevers], 1712, by Francisco Torti.
(Torti, 1712). Image Wellcome Collection.

1.4 Cinchona in Europe: reception and identification

Shortly after de la Calancha's 1638 record, cinchona bark imports began to arrive in Europe (de la Calancha, 1638; Klein & Pieters, 2016; Wallis, 2012). Like many exotic medicinal plants, the physical presence arrived in Europe long before the knowledge of how to use it (Maydom, 2019). Its novelty left cinchona in an unsettled position, its efficacy not yet established: 'the codification of knowledge was lagging behind the bark's acculturation' into wider European medicine (Klein & Pieters, 2016, p. 22).

Cinchona's medical use was complicated by uncertainties over its identity. Scholars believe that early records of ineffectiveness may have been due to inappropriate dosage, accidental misidentification, or intentional adulteration by unscrupulous traders (Crawford, 2009; Haggis, 1941; Klein and Pieters, 2016; Posadzki et al, 2013). Initially, cinchona was confused with other imported barks such as Peruvian balsam (*Myroxylon balsamum* (L.) Harms syn. *M. peruiferum* L.f). which was used as a topical anti-infective, but is ineffective as an anti-malarial (Haggis, 1941).

One seventeenth-century author complained of adulteration of cinchona bark by cheaper, locally accessible (to Europe), bitter-tasting barks such as cherry (*Prunus avium* (L.) L.) and '*Cassia cariophilata'* enhanced with a coating of bitter aloe latex (*Aloe* spp.). Unscrupulous European pharmacists were said to tincture cinchona bark to extract the medicinal properties, reselling the exhausted, ineffective bark for a double profit (Blégny & Talbor, 1682). By Howard's time, the issue had not lessened and he notes the high price of barks led to 'spurious imitations, going so far as the preparation of barks of other trees dyed red, or even, as in a specimen in my possession, coloured by means of red-lead' (Howard, 1862, *C. succirubra*, p. 10). Adulterations such as this are not unique to cinchona and remain a common issue in botanical medicine markets to this day, particularly with valuable medicinal plants. Sometimes the adulteration is obvious when in raw form, but for processed products such as bark powders, the issue may only be highlighted through DNA sequencing or chemical analysis, unavailable to Early Modern physicians (Ichim, 2019; Raclariu et al., 2018; Srirama et al., 2017).

Understanding of cinchona bark efficacy was also complicated by other factors. The variable chemical content (and therefore variable efficacy) of its diverse species and varieties would have been difficult to determine based solely on physical pharmacognostic techniques, such as visual and taste tests. Cinchona's intense bitterness does not come solely from quinine. Other bitter alkaloids are contained in varying amounts and not all are antimalarial (Jackson, 2023). Therefore, bitterness does not always equal efficacy. The bitter taste test can also be foiled by adulterants, as noted above (Klein & Pieters, 2016; Maehle, 1999).[5] For buyers, as well as traders, a system was needed to understand the efficacy and profitability of barks (Deb Roy, 2017).

As further expeditions to Andean forests were organised over the late eighteenth century, more and more *Cinchona* species were recognised. Connecting these species and their origins to the myriads of trade names applied to imported cinchona bark was an active area of research. The Linnean binomial system for naming and organising species was introduced in 1735, but took time for widespread adoption and hence did not help clarify understanding of the genus (Linnaeus, 1735). *Cinchona* species and varieties were then categorised and debated in contrasting ways by different authors, resulting in the description of hundreds of species and varieties, despite the difficulty in applying these to trade barks divorced of other identifying botanical features, such as leaves and flowers (Andersson, 1998; Howard, 1862; Pérez et al., 2004). To resolve the issues around chemical variability and adulteration, a practical pharmacognostic categorisation of bark types via a visual system evolved. These trade names were based on categorisations such as:[6]

- Origin, e.g. 'Carthagena bark', *Cascarilla crespilla de Jaén de Loxa*; etc.[7]
- Colour, e.g. *roja* (red) *naranja/naranjada* (orange), *amarilla/o* (yellow) *morada/o* (purple), *blanc* (white), *pallida'*(pale), etc.,
- Physical properties *blanc fibreux* [fibrous] *de Jaen*, and *China rubra dura* [hard], etc.

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[5] Howard described such a test in a letter to Clements Markham, dated 12 September 1859, as cited p.95, *Cinchona notebook 2* (CRM/56), Royal Geographical Society Archives.
[6] Howard, 1855; 1862; Charles Ledger to John Eliot Howard, 22 December 1874, JEH/1/42, Library and Archives, RBG Kew.
[7] It is likely in many cases that 'origin' name refers to the trading point or port at which the bark was purchased at or embarked from rather than the site of the plant itself. E.g. Loxa (Loja) bark, a mountainous town that likely served as a meeting point for many drug trade routes.

- Part of tree harvested, *tabla* (trunk), *charquecillo* (large branches), and *canuto* (small branches)

This association of bark names with medicinal value varied between publication/author and was much debated. Trade names were not necessarily linked to a single botanical species, different authors favoured different barks,[8] and species availability changed over time: as one area's resources became exhausted, other locations with alternative species came on to the market but sold under similar trade names. Just before his 1860 collecting trip, for example, Clements Markham (1830-1916) wrote that he 'went to Tottenham and consulted Mr Howard, the great quinine manufacturer' about the best species to target.[9] Advising Markham, Howard described the issue:

> The caqueta (C. lancifolia) of New Granada was pretty much exhausted from 1849 to 1855, Since this became less productive, attention has been turned to the Pitaya, lancifolia and lucumaefolia. Of these three, [illeg.] an immense quantity has been bought in the last seven years, but the supply is beginning to fail. From Peru also a great quantity has been brought, called West Coast Cartaghena, being the bark of C. lucumaefolia, Stupea and Lanceolata. The Calisayas of Caravaya and the less accessible barks of Bolivia still come over in measure.[10]

The categorisation of cinchona bark developed into the discipline of quinology, following the early nineteenth-century arrival of chemical laboratory techniques that enabled the quantitative analysis of each bark's constituent alkaloids. John Eliot Howard's status as a quinologist was based on his extensive collection of barks which he analysed using these chemical techniques in his London laboratory, as discussed in Chapter 4 (Howard, 1853; 1862).

The relationship between the classification of barks in trade and botanical species was a central problem in the history of cinchona and this leads to a core theme in this thesis: through what methods did quinologists such as Howard grapple with the hydra-like *Cinchona* genus, its morphological and chemical variability, its mysterious origins and

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[8] Howard (1862, *C. micratha*, p. 10) cites local preferences, for example, 'This kind is much sought after for the Russian market'.
[9] Entry for 21 May 1859, *Cinchona notebook 1* (CRM/55); See also other correspondence in this and *Cinchona notebook 2* (CRM/56). Royal Geographical Society Archives
[10] Howard to Markham 13 July 1859 as cited p. 166, *Cinchona notebook 1*. (CRM/55), Royal Geographical Society Archives.

many trade names? The conundrum went beyond simple quality control at trade points: determining which species exerted the strongest medicinal properties became highly relevant to imperial interests too.

1.5 Imperial plantations

The efficacy of cinchona in treating ague (malaria) meant that it was gradually accepted as a primary treatment in Europe. By the eighteenth century, it constituted 40% by volume of English drug imports from South America and it has been estimated that in the 1770s, between 100,000 to 450,000 doses (figure depending on the size of the dose) were imported annually (Wallis, 2012). Interest in cinchona cultivation grew over the early nineteenth century due to a range of factors: increasing confidence (and therefore demand) in Europe, fears of overharvesting of bark from the wild cinchona trees in the Andes, South American political instability and concerns over the control of disease in tropical colonies (Brockway, 2002; Howard, 1879, King, 1876; Roersch van der Hoogte & Pieters, 2014).

Targeting species for a cultivation project relied on the identification of efficacious species. This meant that a way to quantify quinine alkaloids in cinchona bark was required. Techniques were developed in 1820 for isolating quinine (Pelletier and Caventou, 1821) and in subsequent years for the other three main quinine alkaloids (Howard, 1864; Lesch, 1981; Wisniak, 2013). This enabled the identification of alkaloid-rich *Cinchona* species and, as well, the development of accurate dosing for prescription and for medical trials (Brockway, 2002; Roersch van der Hoogte & Pieters, 2014).[11] This key event in the history of quinology as a discipline is discussed further in Chapter 3, but is noted here as an important factor that contributed towards the successful establishment of plantations in European colonies (Veale, 2010)

The development in the use of quinine as a prophylactic (rather than only as a cure) also increased the importance of supply and control. European mortality rates on expeditions into the African interior were remarkably high. For example, in Sierra Leone

[11] Also see Parry (2004).

between 1817 and 1836, recorded death rates were 483 per thousand troops, on the Gold Coast (Ghana) 667 per 1000 (Headrick, 1979). However, Scottish explorer William Balfour Baikie (1825-1864), showed that quinine was effective as a daily preventative. On a trip up the Niger River in 1854, all dosed members of the crew survived (Baikie, 1856; Headrick, 1979). Headrick (1979) famously described quinine as a 'tool of empire', used for protecting the health of explorers to new territories. This newly discovered power of quinine was one of the drivers that enabled the European 'scramble' for colonisation of Africa (Headrick, 1979; 2009). Quinine could also be used for protecting the health of military and civil workers within established colonies (Baber, 1996; Deb Roy, 2017; Brockway, 2002). The cultivation of cinchona trees for mass quinine production therefore plays an important part in the histories of medicine and empire (Brockway, 2002; Chakrabarti, 2014; Drayton, 2000; Headrick, 1979; Philip, 1995).

However, it took many years for large-scale cultivation to become a reality. Seeds were procured by the Spanish by 1788 but there was no attempt to plant them in Madrid (Walker et al., 2022). Spanish government attitudes towards cinchona sources were that they were never-ending and, later, that cultivation was best controlled from South America (Crawford, 2009). A few unsuccessful attempts were made to establish factories for alkaloid production in South America. Dr. Bennett in Pelechuco, Bolivia, tried to manufacture quinine in 1834, [12] and Markham reported an Italian attempting the same in La Paz, Bolivia and that a 'Frenchman ruined himself in an attempt to establish a manufactory for this purpose at Puno, on the banks of Lake Titicaca'.[13] In 1848, French-trained British botanist Hugh Algernon Weddell brought back some seeds and seedlings of cinchona from an expedition to Peru and Bolivia, which were grown for botanical interest in the Paris *Jardin des Plantes*. In 1854, some plants were sent from Paris to be grown at Kew, Edinburgh and Chiswick.[14] Some of these were

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[12] Ledger wrote that he had seen these buildings. Charles Ledger to John Eliot Howard, March 1881, JEH/1/42, Library and Archives, RBG Kew.

[13] No dates given, but between 1820 and 1866. Clements Markham to the Secretary to Government, Revenue Department, Fort St. George, 16 January 1866, *British Parliamentary Paper No. 353, East India (Chinchona plant)*, Section I, Item No. 85, p. 213.

[14] Dr Forbes Royle, to James Melville, 3 January 1854, *British Parliamentary Papers No. 118, East India (Chinchona Plant)*, India Office 18 March 1863, pp. 4-5.

then sent on to India in 1855 but not all survived the journey and the few that did were killed by winter frosts (Brockway, 2002; Howard 1853; Weddell, 1849).[15] It became clear that large-scale cultivation required large-scale collecting.

Cinchona collecting, like much other botanical and zoological collecting, was framed by Europeans as a rescue mission for 'purely humanitarian principles' (Drayton, 2013; van Gorkom, 1883, p. 237). This was to counteract a potential 'quinine famine' from South American overharvesting ('Bark and quinine', 1862, p.12; Markham, 1862; Philip, 1995, Roersch van der Hoogte & Pieters, 2014). Reports stated that most accessible Bolivian barks had been exhausted, followed by supplies from New Granada (Colombia) (Markham, 1862; Howard, 1862). Anxieties existed over threat to future supplies, with bark allegedly being sold at 'enhancement of its price, rather than to the continued preservation of its supply'.[16] Clearly aware of the ethical implications around taking cinchona from South American markets, collector Clements Markham justified such projects in the collective interest of humanity:

> …under any circumstances the South Americans, who owe to India the staple food of millions of their people, and to the Old World most of their valuable products — wheat, barley, rice, apples, peaches, sugar-cane, the vine, the olive, sheep, cattle and horses — should not desire to withhold from the people of India a product which is essential to their welfare. (Markham, 1862, p. 338)

The Dutch were the first to establish plantations of cinchona, in their colony of Java (Indonesia) (Goss, 2013; Roersch van der Hoogte & Pieters, 2014). In 1851, German botanist Justus Karl Hasskarl (1811-1894), working for the Dutch, entered Peru to collect cinchona. Hasskarl went under a false name, Dr J. Carlos Müller, knowing that the local people would not consent to the plant being taken by Europeans (Figure 1.6). Clemente Henriquez, a guide and assistant, was subsequently threatened with having his feet cut off for his role in taking the plant (Markham, 1862; van Gorkom, 1883).

[15] Thomas Thomson to W. Grey, 14 May 1855, *Parliamentary Papers No. 118*, *East India (Chinchona Plant)*, India Office 18 March 1863, p. 6.
[16] Dr John Forbes Royle, 27 June 1852, 'Report on the introduction of Chinchona plants into India', 18 March 1863, as cited in *Parliamentary Papers No. 118*, *East India (Chinchona Plant)*, Item No. 3, pp. 1-3.

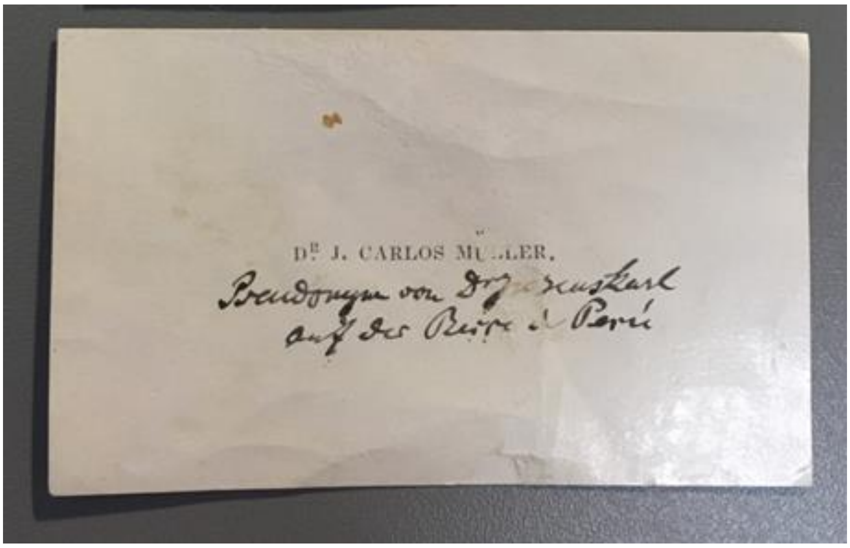

Figure 1.6 A business card of Dr J. Carlos Müller, the pseudonym used by Justus Karl Hasskarl during his cinchona collecting trip in 1850.
Author's own image, EBC Naturalis.[17]

Despite this, Hasskarl sourced several hundred seeds and plants (of which only 75 survived the crossing) and these were sent to the first Government station in Bandung, Java (van Gorkom, 1883; Roersch van der Hoogte & Pieters, 2014).

Demonstrating Howard's expertise within the field of quinology, Hasskarl's specimens were sent to Howard for description, naming the plant *C. pahudiana* How., after the Dutch Minister of Colonies, Charles Ferdinand Pahud (1803-1873). However, in his published analysis, Howard expressed concern that the quinine content would lead 'to disappointment' (Howard, 1862, *C. pahudiana* section, p. 5). Due to Hasskarl's journey being undertaken quickly and with subterfuge, it seems that the suitability of the source trees was not assessed: the variety he took produced bark with a very low alkaloid and only 'fit for firewood' content (around 0.2% quinine, Table 1.1) ('Cinchona cultivation', 1871, p. 80). By 1862, over a million trees had been grown in Java before the plantation director was ordered by the Government to halt cultivation and to experiment with other efficacious varieties (Roersch van der Hoogte & Pieters, 2014). The race to grow cinchona had got off to a false start.

[17] This card was found used as a label in Hasskarl's bark collections. Economic Botany Collection, Naturalis Biodiversity Centre, Leiden (Items 2110197 & similar on 2110200).

British cultivation was suggested in 1813 by Dr Whitelaw Ainslie and in 1835 and 1854 by John Forbes Royle (Veale, 2010).[18] However, it was not until nearly a decade after the Dutch that a British project was initiated. In 1859, William Hooker, Kew's director complained that 'The Dutch have already got plantations of Cinchona 30 feet high, and we not a live plant in India for want of some energetic practical men to direct such operations.'[19] With the support of Hooker and Kew, the Secretary of State of India commissioned a collecting project, led by Clements Markham. Markham meticulously planned the trip, consulting a range of experts, including Howard, on which regions to focus on and species and local forms to source.[20] For example, Howard suggested the Huánuco district for collecting uritusinga trees (*C. calisaya* Wedd.) and discussed whether quick-growing but labour-intensive shrubby cinchonas were preferable over tree-forms. He also provided trade names, probably because those would be most familiar to guides and bark gatherers.[21]

Markham, botanist Richard Spruce (1817-1893), and a Peruvian-based Englishman known as 'Pritchett' collected samples from different sites across the Andes. Markham and Pritchett would cover districts across the Peruvian and Bolivian Andes, Spruce the Ecuadorian. Markham and Spruce were assisted by horticultural experts sent by Kew to oversee transport accompanied by protective Wardian cases: John Weir assisted Markham, Robert Mackenzie Cross attended Spruce. The British project aimed to collect all principal species for growing to enable experimentation, so as many varieties from different areas as possible were to be gathered (Brockway, 2002; Howard, 1862; Markham, 1862; Veale, 2010).

To ensure any cinchona species collected was sufficiently rich in quinine alkaloids on-site bark analysis would be preferred, indeed Markham's notebooks record that he

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[18] Dr Forbes Royle, 27 June 1852, 'Report on the introduction of Chinchona plants into India', 18 March 1863, as cited in *Parliamentary Papers No. 118*, *East India (Chinchona Plant)*, Item No. 3, pp. 1-3.
[19] William Hooker to Clements Markham, 20 November 1859, as cited p. 65, *Cinchona notebook 1.* (CRM/55), Royal Geographical Society Archives.
[20] These lists of books, notes, records of meetings and letter extracts can be seen in *Cinchona notebook 1* (CRM/55) and *Cinchona notebook 2* (CRM/56). Royal Geographical Society Archives.
[21] John Eliot Howard to Clements Markham 13 July 1859 as cited p. 66; John Eliot Howard to Clements Markham 9 August 1859 as cited p. 18-21; both *Cinchona notebook 1* (CRM/55). Royal Geographical Society Archives.

investigated this as an option.[22] However, Howard advised against it:

> I do not think the test proposed by Pereira or any such simple and rapid experiment would be of any advantage. The only real test is the extraction of the alkaloids, and this, being a complex chemical operation, is best affected [sic] in Europe. The taste of the bark, if by use you learn to distinguish quinine, would be far the most reliable guide. If the bark could be sent home, 1 or 2 lbs would suffice well for analysis.[23]

Howard, and others, sensibly pointed out that a basic test was not practically useful: only quantitative alkaloid extraction could provide proper assessment of quinine content, a process which required chemicals and equipment too bulky and dangerous for carrying out in the field. Howard wrote to Markham that it would 'be best to send all promising samples to Europe' - by Europe, he essentially meant himself.[24] However, the long journey for shipments between South America and Europe ruled out any prospect of rapid transmission of analytical results.

Ultimately, bioprospecting for cinchona relied heavily on local expertise or on luck. Furthermore, cinchona trees, already notoriously difficult to identify, were becoming rare and therefore harder to find, even with expert local guides (Howard, 1862; Gramiccia, 1987; Markham, 1862). Therefore, Markham spread his bets by collecting hundreds of plants from many varieties which were sent on via Kew to the first plantation in the Nilgiris Hills of Southern India (Figure 1.7; Figure 1.8) (Brockway, 2002; Howard, 1862; Veale, 2010).

Markham's trees died on arrival in India due to poor substrate and exposure on their long journey, followed by delays at Indian ports (Honigsbaum, 2001; Markham, 1862). However, being a thorough collector, he had also gathered seeds of *Cinchona succirubra* (syn. *C. pubescens*), *C. micrantha* Ruiz & Pav., *C. nitida* Ruiz & Pav., *C. peruviana* How.

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[22] 'Pereira II part II /2.119, Test for quina. If a substance suspected to contain quina be foundered, then [sharpen?] with ether and afterwards successively treated with chlorine and ammonia, the liquid will assume a green colour if the slightest trace of quina be present.' John Eliot Howard to Clements Markham, 9 July 1859, as cited p. 95, *Cinchona notebook 2*. (CRM/56), Royal Geographical Society Archives.

[23] John Eliot Howard to Clements Markham, 9 July 1859, as cited p. 95, *Cinchona notebook 2*. (CRM/56), Royal Geographical Society Archives.

[24] John Eliot Howard to Clements Markham, 7 October 1859, as cited p.96, *Cinchona notebook 2*. (CRM/56), Royal Geographical Society Archives.

(syn. *C. calisaya*), all which became a few thousand thriving plants by late 1861 (Howard, 1862; Markham, 1862). In addition, other plants collected by Spruce survived including an alkaloid-rich species *C. succirubra*. Later, Cross returned to the Andes, sending back further species (Wedd.) Wedd. (Brockway, 2002; Howard, 1862; Markham, 1862; Roersch van der Hoogte & Pieters, 2014; Veale, 2010).

Howard himself also contributed trees towards the project. Through his contacts in the Andes, he had received a variety of *C. officinalis* (var. *uritusinga*) with a high quinine content which he had grown on in his glass house. From a single sapling sent in 1862, over 60,000 trees were eventually propagated (Howard, 1885). This species, along with Howard's influence on the project is further discussed in Chapters 4 and 6 (Howard, 1862; Howard, 1885).

Figure 1.7 Cinchona plants arriving in Ootacamund [Ooty], 1861 (Markham, 1862)
Image Biodiversity Heritage Library. Contributed by University of California Libraries.

Figure 1.8 Sir W. Denison and others planting the first quinine tree in the Neilgherry [Nilgiris], India, 1862.
(*The Illustrated London News, 1862)*. Wellcome Collection.

1.6 Chemistry, cultivation and quinology

Sourcing and breeding chemically valuable species of Cinchona was essential in establishing plantations. This has been explored in the context of Indian plantations by Lucy Veale (2010) in her PhD thesis *A historical geography of the Nilgiri plantations*. Likewise, the Dutch plantation system has also been analysed by researchers Arjo Roersch van der Hoogte and Toine Pieters (2014; 2015a; 2015b), as well as Andrew Goss (2013). This has led to interesting comparisons of the two empire's cultivation objectives and strategies. The British aimed to develop a cheap mixed-alkaloid febrifuge for domestic use in India, whereas the Dutch were interested in export sales of the main quinine alkaloid. Roersch van der Hoogte and Pieters (2014, p.12) have shown that this era of plantation science relied on new laboratory techniques, influenced by an influential German pharmaceutical industry and reliance on purified, standardised chemicals (Roersch van der Hoogte & Pieters, 2015a; Semedo et al, 2022). These factors drove a shift from 'green imperialism' to what the authors term 'colonial agro-industrialism', controlling both horticulture and chemistry in the pursuit by the Dutch of quinine-rich species.

Differences in the objectives of each Empire's cinchona project led to contrasting trajectories. Despite the Dutch having nearly a decade's head start in cultivation, early mismanagement and growth of a chemically poor species meant that success was not immediate, the British only effectively caught up in scale by 1862. The British grew a variety of different species in various Indian locations with an aim of producing as much bark as possible for cheaper alkaloid mixes. In contrast, the Dutch centralised their project, growing fewer, quinine-dominant species in one location, with specialist laboratory-led breeding projects. The Dutch were thus able to control their project outputs more effectively. This led to global market dominance for quinine sales that led well into the twentieth century, while the British projects gradually faded away (Goss, 2013; Roersch van der Hoogte & Pieters, 2014; Veale, 2010). These trajectories were partly influenced by chance: each Empire's cinchona species were acquired by luck as much as focused selection methods. These species, with their variable and contrasting alkaloid profiles directed the success of each empire's projects.

As noted earlier, the Dutch had focused on *C. pahudiana* which had failed to be chemically viable. However, after 1865 they switched focus to a quinine-rich variety which they had received from a British businessman working in the Andes: Charles Ledger (1818-1905) (Roersch van der Hoogte & Pieters, 2014). Ledger had been working on a project to trade Alpaca for breeding. One of his guides was a bark collector called Manuel Icamanahí (?-1871),[25] possibly of Aymara descent, who was able to visually assess *Cinchona* varieties for efficacy (Gramiccia, 1987; 1988; Holland, 1932; Jaramillo-Arango, 1949). While on a trek together, Ledger had asked if they would find the 'true' bark of cinchona, i.e. the best variety. Icamanahí had stated: 'No Señor, the trees here about do not see the snow-capped mountains.' Ledger recorded that he 'could hardly contain my laughter, but when I went to bed a few hours later, I could not sleep for thinking of Manuel's answer'.[26] Ledger later recalled the event when he read of the British pursuit of cinchona *and* requested Icamanahí to source the best-quality seeds to sell to the government. Although this act was prohibited and Icamanahí had previously refused all other requests, he accepted Ledger's commission. However, bad frosts destroyed the flowers a few seasons running and the task took 5 years to complete. In 1865, Icamanahí and his sons eventually managed to gather and dry a quantity of seeds from the best trees. Ledger offered the seeds to Kew Gardens. However, Kew's director, William Hooker, had just died and in absence of other experts, most of the seeds were turned away. It is not entirely clear why this occurred, but it may have been because the Indian plantations were already considered an established success and therefore the seed was not necessary. They were instead sold to the Dutch on the advice of John Eliot Howard, who was aware of Ledger's financial precarity (Gramiccia, 1987; Honigsbaum, 2001; Holland, 1932; Howard, 1862).[27]

The plants grown from Icamanahí's seeds were named *C. ledgeriana* in honour of Charles, rather than the man who had identified, gathered and ultimately died for them: shortly after, Icamanahí was jailed for his role in sourcing these seeds, badly beaten and later died from his wounds (Gramiccia, 1988; Honigsbaum, 2001).

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[25] Often anglicised in texts as 'Incra Mamani' (Jaramillo-Arango, 1949). Ledger used 'Mamani' spelling.
[26] Charles Ledger to John Eliot Howard, 22 December 1874, JEH/1/42, Library & Archives, RBG Kew.
[27] Ledger also sold some to the Government of Queensland with whom he had been dealing in Alpacas. Charles Ledger to John Eliot Howard, 22 December 1874, JEH/1/42, Library & Archives, RBG Kew.

It was Icamanahí's seeds that enabled the Dutch to lead the global quinine trade by the 20th century: the variety had proven to be as Icamanahí had promised and was particularly rich in quinine (5-13%, Table 1.1). With the realisation of the value of this variety, the Dutch took the following drastic approach:

> The greater part of seedlings and cuttings of our old Calisayas (Hasskarl's, Schuhkraft's, Madras) that still remained in the propagating houses or in the nursery grounds were thrown away and Ledgerianas propagated as fast as possible by cuttings and seeds from the best trees. All other Cinchonas have been cut in the neighbourhood of the seed giving Ledgerianas to prevent their degeneration. Seeds are only taken from those trees, whose superiority has been proved by examinations.[28]

Their cultivation strategy shows how the Dutch organised their project, focusing on fewer species, cutting away flowers (and pollen) to reduce the risk of hybridisation, or 'degeneration' (van Gorkom, 1883, p. 102). They also had a centralised control system with a single director overseeing the general project, with chemists working alongside. In India however, a mixture of independent and government gardens allowed to follow their own in-house horticultural expertise where hybridisation was not always controlled (Roersch van der Hoogte & Pieters, 2014; van Gorkom, 1883; Veale, 2010).

Despite potential competition, plant exchange freely occurred between the British and Dutch. In 1862, the Dutch sent plants of *C. calisaya* and *C. pahudiana* to help with the Indian plantations, perhaps in the hope that an exchange would be mutually beneficial (Howard, 1862).[29] This difference in cultivation and lack of apparent competition was perhaps partly due to differing aims of the two empires as well as an understanding of different geographical ecological influences.

While targeting the most chemically active species for cultivation would seem to be the most logical approach, cultivation was complicated by ecology. Like others, Howard

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[28] Letter to Howard, from M. Moens, 5 December 1873, as cited in Howard, 1876, p. 52.

[29] Other evidence of this international collegiality includes Markham instructing Hooker to 'let the Frenchmen have a few specimens of each species of cinchona' referring to live plants on their way to India. Clements Markham to Sir William Jackson Hooker; from India Office, 24 Feb 1862. Directors' Correspondence, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas2059

understood that the chemistry of alkaloid production in cinchona appeared to be influenced by environmental influences such as altitude, exposure to sunlight, drainage etc. On this basis he argued that different species should be matched to the different conditions found in the various Indian plantations that were scattered across the country, for example:

> The site most approved for trial of the C. succirubra is close to the travellers' bungalow at Nediwuttum [Naduvattam], on the northern side of the Neilgherry [Nilgiris] hills. The forest, it seems, covers a declivitous slope, at an elevation of about 5000 feet, and extends to the verge of the steep descent to the table-land of Wynaad… (Howard, 1862, p, xv)

Over 60,000 plants from Ledger's seeds were grown in the Nilgris, but they were poorly suited to the environment (Holland, 1932). Later, they did better in Ootacamund [Ooty], but produced insufficient bark for economic extraction. Howard wrote of the *ledgeriana* that:

> The contents in alkaloid are just the same as the C. officinalis of my introducing; but the calisaya is reported to assume a spindly character of growth at Ootacamund and, perhaps, is less suited to the climate. (Howard, 1876, p. 115)

Charles Ledger recorded that this failure to thrive was likely because of Icamanahí's saying, later reflecting that 'In India the seeds were not planted near the snow-capped mountains.[30] Ultimately, the British focused on species they felt more suited to the Indian climate: hybrids of *C. succirubra* and *C. officinalis*, despite warnings from Howard that this would result in unfavourable, quinine-poor chemistry. (Holland, 1932; Howard, 1869; 1876).

Within the first British Indian plantations, how was chemistry measured? In the absence of a suitable quinologist or chemist in India, Howard himself was appointed by the India Office to make official analyses (Veale, 2010). He reported that the *Cinchona* species cultivated, predominantly *C. succirubra* and *C. officinalis*, had a reasonable chemical profile, but contained various mixed-alkaloids (quinine, quinidine, cinchonine and cinchonidine) (Table 1.1) which were 'commercially, but not medicinally, a

[30] Charles Ledger to John Eliot Howard, 22 December 1874, JEH/1/42, Library & Archives, RBG Kew.

disadvantage'.[31] This led to the British starting successful medical trials in 1866 showing the efficacy of each one, with Howards and Sons providing the 'pure and simple' alkaloids for the research (Howard, 1876; 'Preliminary report', 1867' Roersch van der Hoogte & Pieters, 2014).[32]

Table 1.1 Cinchona species and their alkaloid contents in percentage (%), cultivated in Dutch Indonesian and British Indian plantations in the nineteenth century. [33]

19th C name	Modern determination	Quinine	Quinidine	Cinchonine	Cinchonidine	Total alkaloids
C. pahudiana	*C. calisaya* Wedd.	0.2	-	0.5	0.4	1.1
C. ledgeriana	*C. calisaya* Wedd.	5-13	0-0.5	0.2-1.5	0.1-1.5	5.3-16.5
C. succirubra	*C. pubescens* Vahl.	1-1.25	0.01	1.5-4	2-2.5	4.51-7.76
C. officinalis	*C. officinalis* L.	2-4	0.03	1-3	0.4-1	3.43-8.03

The success of the trials led the British to pursue production of a mixed-alkaloid febrifuge that was cheaper to produce and could utilise the mixed-alkaloid trees being grown. In 1866 a quinologist for the Nilgiris, John Broughton, was brought in (Veale, 2010). He developed a product called 'amorphous quinine', a mixture of the alkaloids in an uncrystallised, but dispensable form that patients could tolerate.[34] While this signalled some hope for success, the production eventually ran at a loss, as well as causing storage issues, turning to a sticky cake that required additional steps to turn it into a usable product.[35] The failure of amorphous quinine may also have been related to an earlier enterprise by German chemist Justus von Liebig (1803-1873). In 1846 he

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[31] Report of an analysis of the fourth remittance of bark from India, 1 August 1865, by John Eliot Howard. *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866, Section I, Item No. 51, 134-136.

[32] See the series of letters discussing the trials starting at p. 136, *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866.

[33] Adapted from Groothoff, 1925 as quoted in Roersch van der Hoogte & Pieters, 2014; and Veale, 2010.

[34] See the interesting exploration of the symbolism of the label 'quinine' to Indian alkaloidal mixes in relation to their use in Deb Roy (2017).

[35] Committee appointed to report on the effiCiency of the Cinchona factory at Neddivuttum to the Secretary to Government, Revenue Department, dated 28th November 1874. BPP, 1875, p. 181. As cited in Veale, 2010

attempted to secretly buy up stocks of post-manufacture quinine waste to produce (and patent) an 'amorphous quinine' in Britain. Chemists pointed out that the chemistry was imperfect and that it was simply a poorer quality version of Howard's quinidine ('Deaths-Bullock', 1905; Redwood, 1846). The dubious circumstances under which this launch took place developed into a chemical scandal around the integrity of the industry, and questions of purity marred the product's acceptance in Britain (Jackson, 2023; Simmons & Brock, 2022). Whether the alkaloid's tarnished reputation cast a shadow over Broughton's attempt is not clear. Either way, Broughton left his role in 1873 after the product failed to become viable and little more is heard of him (Veale, 2010).

Although mixed-alkaloid products were technically just as efficacious as quinine, public suspicion over its quality and purity led to poor uptake at India (Deb Roy, 2017; Veale, 2010). Deb Roy (2017) discusses the values of chemical 'purity' and 'commodity racism', whereby the mixed alkaloids were not considered fit for consumption by Europeans, who were sold pure quinine instead. Howard himself stated that there would be no 'confidence in any medicament not considered good enough for Europeans' (Howard, 1876, p. ix). He was not the only manufacturer who realised this, Karl Jobst (1816–1896) in Stuttgart, son of Friedrich Jobst discussed in Chapter 3, also agreed that mixed-alkaloid were an unprofitable project (Howard, 1876). Though other alkaloid production at various Indian sites was eventually established by the 1880s, these were often run with unsustainable losses and eventually closed (Deb Roy, 2017).

While Jobst's and Howard's insights were those of experienced businessmen, this must be assessed in the light of their vested interest in the sale of pure alkaloids. While Howard's consultancy work for government was unpaid, he would however, have benefitted from being the first to analyse (and therefore know) the progress of the plantations, a certain amount of control of the scheme's outcomes, and additionally, through the promotion of his status through his role as the foremost expert quinologist.

Not only was the quality of the alkaloids questioned, but also the location of production. Earlier projects to produce 'at site' in South America, were unsuccessful. It was considered that the technology and knowledge, at that point only available in Europe, was the key to production.[36] However, Clements Markham, usually a supporter of Howard, felt:

> It is very desirable, however, that the alkaloids themselves extracted from other ingredients of the bark, should be brought within the means of the poorest native family, and until this is done chinchona cultivation in India is not a perfect success. To suppose that this can be effected by sending bark to England, to be turned into quinine and sent out again for sale at 20 shillings an ounce, is absurd.[37]

Deb Roy (2017) has suggested that Howard's business objectives took priority over his humanitarian beliefs. Deb Roy also suggests that Howard encouraged the growth of trees producing mixed-alkaloids in India, as a prerogative of Howards and Sons to maintain the market lead for pure quinine. However, as stated earlier, Howard did also warn the British Indian government that producing a mixture of quinine alkaloids would be an issue (Howard, 1869; 1876). Bernelot Moens (1837–1885), Director of the Government Cinchona Gardens in Java, also recorded that Howard's opinion swayed market prices, suggesting an 'unworthy motive' (as cited by Howard, 1873, p. 21). However, Howard strongly objected, pointing out he was not the only one to report on the early poor alkaloid results of the Javanese bark (Howard, 1873, p. 21). Howard also recommended Ledger's seeds to the Dutch after the British turned them down. While Howard could not have known their value, it does show that he was not against competition from the Dutch plantations, who were in any case more of a threat to Howards and Sons quinine sales than those in British India.

Deb Roy suggests that Howard suggested moving the quinine-rich barks to Europe and thus could 'conveniently access the barks from Madras in London as sources of cheap raw material' (p. 168). He cites a letter from Howard in 1864 where he advises the government would 'reap more profit from sending in to the European market the raw

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[36] Proceedings of the Madras Government, Revenue Department, 11 February 1875. JEH/2/5. Library & Archives, RBG Kew.

[37] Clements Markham to the Secretary to Government, Revenue Department, Fort St. George. 16 January 1866, *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866, Section I, Item No. 85, p. 213.

material than the half-manufactured product'.[38] However, as Figure 1.9 and Appendix 1 shows, the company bought few Indian barks until 1872, when they started to produce a cheaper, mixed-alkaloid (Deb Roy, 2017). After repeated unsuccessful attempts at profitable alkaloid production in India and in the face of growing fever, in 1874 Howards and Sons were given access to the Nilgiris barks in return for producing alkaloids for the British Indian market for a short period of time (Deb Roy, 2017). However, as can be seen in the figure, Indian-sourced barks remained in the minority for their alkaloid production, which relied instead on South American barks, notably until Howard's death.

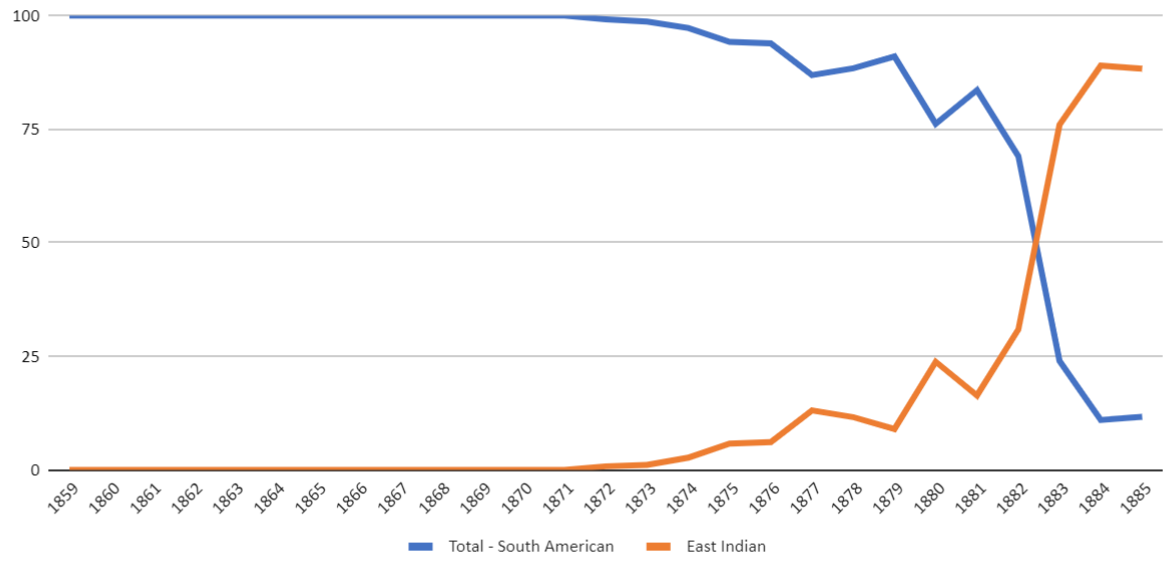

Figure 1.9 Percentage of cinchona bark by origin used in quinine production at Howards and Sons, 1859-1885.[39]

Eventually the British-Indian plantations, plagued by unstable bark market prices, pressure from European manufacturers and without the efficient Dutch government-led model of Indonesia, fell out of major production by the beginning of the 20th century, leaving the market free to Dutch dominance (Goss, 2013; Roersch van der

[38] Quote by Howard, 15 June 1864. Home, Medical, 9–11 A, January 1884, National Archives of India. As cited in Deb Roy (2017).
[39] Data for Figure sourced from *Laboratory Calculations Book*, Ref: 90/360/E2/A5, Redbridge Archives. See also Appendix 1 for full data set.

Hoogte, 2014; Roersch van der Hoogte & Pieters, 2014; 2015a; 2015b; Veale, 2010).[40] Interestingly a mixed-alkaloid product was brought to the global market successfully in the 1930s: Totaquina, which had a minimum of 20% quinine, had been shown in trials to be as effective as pure quinine, but with cheaper production and better marketing ('Cinchona policy', 1935; Hicks & Chand, 1935; Raymond, 1946).

As noted, one of the reasons given for establishing Asian plantations was due to unsustainable harvesting in the Andes. Howard himself had originally been a proponent of this theory.[41] While there is no doubt that some traders were unscrupulous and wasteful in their approach, there is also evidence of sustainable harvesting in South America (Hooker, 1839; Howard, 1862). In 1876, Howard discussed how South American sources never seemed to slow, with an abundant and quick-growing species from *Nueva Granada* (now Colombia) being discovered shortly after the establishment of the plantations (Howard, 1876).

Further complexity in the story has been revealed by scientific analysis. Genetic analysis has shown that both the Dutch-grown varieties, the quinine-rich *C. ledgeriana* and quinine-poor *C. pahudiana* are both, in fact, varieties of *C. calisaya (*Andersson, 1998). So why the variability in alkaloid content? *Cinchona* presents wide phenotypic variation meaning that members of the same species can vary in both morphology and chemistry, influenced by environmental factors, particularly altitude. It also tends to hybridise, resulting in variable chemistry in subsequent generations (Andersson, 1998; Maldonado et al., 2017b). Nineteenth-century scientists were aware of this variability and therefore Howard focused on varieties (chemotypes) rather than species, as is discussed further in Chapters 5 and 6 (Howard, 1862; von Humboldt et al., 2008).[42] These variable characteristics help to explain why understanding *Cinchona* botany was so elusive, why species descriptions by different authors so often disagreed and why

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[40] See also Clements Markham's Letter to Hooker, 1911, Miscellaneous Reports (MR/205).
[41] See p. 166 for Howard's explanation to Markham about supply worries, *Cinchona notebook 1* (CRM/55), Royal Geographical Society Archives.
[42] Weddell, also aware of this, advised Markham to note down the environmental factors affecting the trees he collected, in a letter dated 10 August 1859, as cited pp. 16-18, in *Cinchona notebook 2* (CRM/56), Royal Geographical Society Archives.

consistently high yields were difficult to establish in plantations. It has taken late twentieth and early twenty-first centuries advances in genetic analysis to enable a clearer (but not yet full) understanding of this complex genus and many questions are outstanding (Andersson, 1998; Canales et al., 2022a; 2022b, 2022c; Maldonado, et al., 2017b).

1.7 Research questions

Beyond the numerous general histories of cinchona (Duran-Reynals, 1947; Honigsbaum, 2001; Rocco, 2003; Walker and Nesbitt, 2019), detailed studies have naturally focused on distinct geographical areas and temporal periods. The South American origins of cinchona, the role of botanical exploration and its incorporation into European pharmacopoeia have recently been explored by Crawford (2006), Gänger (2020), Oliveros (2017) and Klein & Pieters (2016). Cinchona as a plantation crop in Asia and Africa has been explored by Goss (2013), Roersch van der Hoogte (2015), Roersch van der Hoogte & Pieters (2014, 2015a, 2015b), Semedo et al. (2021; 2022) and Veale (2010). Quinine manufacture in Europe has been investigated by Anna Simmons (2014; 2018; Simmons & Brock, 2022) and Andrew Slater (1955; 1964) in the wider context of pharmaceutical manufacturing in the late eighteenth and early nineteenth centuries. Ziegler's study focuses on quinine manufacture by the Jobst company in Germany (Ziegler, 2003). In contrast, the European nexus of quinology in the nineteenth century, integrating the study of the botany, chemistry and medical application of cinchona, in the scientific centres of Britain, France, Germany, Italy and elsewhere, has not been explored in detail and is the focus of this thesis.

John Eliot Howard, located in London, at the centre of the British Empire, is the key quinologist in the British cinchona story. He was a prolific networker and writer on cinchona, gathering one of the largest collections of cinchona barks known in Europe. These collections, now housed at Kew, represent 'lost forests' of Andean wild trees that no longer exist. The size of these collections and their connection to publications and archives hints at their importance in the British story of cinchona and was the original prompt for this project. Howard acted as government consultant on the cinchona projects in India, but little is known about his scientific work, previous research having focused on his religious influence (Mathieson, 2018; 2020; West et al., 2016).

Drawing on the larger history elaborated in this chapter, this thesis addresses four main research questions relating to John Eliot Howard and his role in the history of cinchona:

1. How did Howard develop his expertise and sustain his scientific networks? Chapter 3 introduces Howard and the development of his family's pharmaceutical manufacturing firm, Howards and Sons, and his first appearances within scientific circles as an expert around 1851. Chapter 4 explores the development of quinology and the early collection histories of cinchona. This chapter also looks at Howard's pathway to recognised expert and the influence he eventually exerted as a consultant in the British cinchona story. Here there is also a discussion of Howard's role as an external expert, contributing chemical and botanical knowledge above and beyond Kew's expertise. The subsequent chapters explore the practical side of Howard's work: the dried (Chapter 5) and living collections (Chapter 6) which provided his data sets in the development of his expertise.

2. How did Howard practice his science, located distant from the habitats of cinchona, wild in the Andes and cultivated in Asia? Chapters 5 and 6 examine his collections; in the context of his laboratory and the living collections, captured on photographs taken in his garden. Howard's personal collection of reference barks is made up of those he analysed in his laboratory as he built expertise leading up to the 1860s. Then, reflecting the tree's transfer to cultivation in British India, Howard moved from the laboratory into the garden to build up the materials and knowledge to continue his work.

3. How was his knowledge communicated and circulated? Chapter 7 explores Howard's publications and circulation of knowledge through the publication of large, colour-illustrated guides to the identification and analyses of cinchona barks and outcomes of the Indian plantation trials. These books

built upon previous quinological guides but added to the work with additional microscopical imaging, extensive chemical analyses and opinions that influenced cultivation. These guides not only communicated his findings to others but also represented his expertise, enabling his positioning as an authority on cinchona. His strategy for circulating this work is also explored.

4. What does a collections-based approach, which combines evidence from scientific collections and from textual sources, contribute towards pharmaceutical history? Chapter 2 sets out the methodology of the thesis: the application of quantitative and qualitative analysis to collection assemblages, curator biographies and networks. As mentioned, collections of materia medica, particularly nineteenth century are under studied and this project explores the value of economic botany collections for contributing to the history of medicine.

The concluding Chapter 8 responds to these questions and considers the wider implications of the thesis.

Chapter 2 | Methods, Sources & Analysis

2.1 Introduction

This thesis centres on the historic *Cinchona* bark specimens housed in the Economic Botany Collection, Royal Botanic Gardens, Kew. This chapter introduces the methodology used to interrogate these collections, followed by a description and history of the key sources and an overall analysis of Kew's cinchona collections.

Kew holds one of the world's largest collections of cinchona bark and herbarium specimens, representing the British Empire's interest in its medicinal properties during the nineteenth century. The collection is believed to be rivalled only by the collection at the Naturalis Biodiversity Centre, Leiden, which represents the similar, contemporary, interest of the Dutch Empire. A comparison of the two collections tells us about their shared and contrasting interests and the collections' trajectories over time (see below, 2.6.3).

Early during the research, it became clear that the largest sub-collection of cinchona specimens today in the Kew collection originally belonged to John Eliot Howard, these comprising around a third of the current collection. Howard collected trade barks between 1823 and 1883 and his collection includes specimens from a Spanish expedition, of 1777.[43]

Given the varied origins of the Kew collection, assembled between 1847 and 2002, incorporating orphan collections from other institutions, my analysis takes two forms: first, as an overall Kew assemblage, shown to be representative of British (and to some extent Spanish) engagement with cinchona; and, second, as analysis of the individual sub-collections that make up the whole. For both purposes an emphasis on object provenance is an essential precursor. Overall, the Kew collection shows how a leading British quinologist helped shape cinchona botany and quinine drug development during the

[43] Howard noted he owned older barks (which are no longer traceable or existing within the current collection): 'Thus, also, specimens of Loja bark given me by Mastenbroek as from the collection of Sir J. C. Brandt, and reaching as far back as 1722' (Howard, 1862p. vii)

nineteenth century, both at home and on imperial projects.

2.2 Exploring Kew's collections

The Museum of Economic Botany was established in 1847 by Sir William Hooker, the first director of Kew (in its state-funded form), to encourage the study of botanical and botanical-related products. Hooker wrote that it would be a:

> …depository for all kinds of useful and curious Vegetable Products neither the living plants of the Garden nor the specimens in Herbarium could exhibit; and that such a collection would render great service, not only to the scientific botanist but to the merchant, the manufacturer, the physician, the chemist, the druggist, the dyer, the carpenter and cabinet maker, and artisans of every description, who might here find the *raw material* (and to a certain de extent, also the *manufactured* or *prepared article*) employed in their several professions, correctly named, and accompanied by some account of its origin, history, native country, etc. (Hooker, 1855, p. 3)

The origin of this purpose is rooted in the wider history of botanic gardens, particularly in relation to healing and medicinal plants such as cinchona (Cornish, 2013). The first botanic gardens in the sense of 'enclosures set apart for the cultivation of plants of some definite economic or aesthetic value' can be traced back to many ancient cultures (Hill, 1915, p. 186). In Europe however, some of the earliest formal botanic gardens were the *hortus medici*, medicinal gardens, established in the sixteenth century with the purpose to educate physicians and provide *materia medica* for nearby hospitals. These gardens likely evolved out of medieval monastic gardens, established for a similar purpose of providing medicinal materials for the community (Bermejo, 2021; Forbes, 2008; Cunningham, 1996; Hill, 1915; Rakow & Lee, 2015; Spencer & Cross, 2017). In the eighteenth and nineteenth centuries, as part of the global expansion of empire and infrastructure, plant exchange and study increased. European botanic gardens developed institutionally into a purpose beyond the practical, medicinal or aesthetic into places of wider scientific study (Nesbitt, 2022). They also directly supported Imperial projects and networks, becoming repositories of plants flowing through colonial projects. Many of these plants had an economic value, for example, as foods, medicines, materials, dyes and fuels (Brockway, 2002; Cornish, 2013; Drayton, 2000; Endersby, 2008).

At Kew, the garden's living collections were managed alongside the preserved scientific collections and research spaces, particularly the Museum of Economic Botany from 1847 and the Herbarium (the latter established in Hunter House in 1852).[44] On one hand, plants were received in the garden, acclimatised, grown and sent on to support colonial projects, on the other, specimens for study were absorbed into the collections which supported botanical research and knowledge production.

A central purpose of Kew's Museum (alongside educational display) was to support industry's use of plant raw materials (Cornish, 2013). As in Hooker's words in the opening quote, the intended audience included 'the physician, the chemist, the druggist'. It was to these medical users that a significant part of the collection was devoted. Today, about one quarter of its >100,000 specimens are medicinal in nature, usually in the form of crude drugs. Many of these medicinal specimens have come as later accessions from medical and pharmaceutical institutions and reflect the central role plants played in medicine and trade in the nineteenth and twentieth centuries. Renewed attention to curation and research relating to the *materia medica* collection in the last two decades reflects the continued importance Kew places on the heritage and research of people-plant relationships (Cornish, 2013; Cornish & Nesbitt, 2014; Nesbitt, 2022).

Of the medicinal portion of the Economic Botany Collection, the largest group of specimens represented, by far, are those related to the anti-malarial cinchona bark (n=1,091). As mentioned in Chapter 1, the relative inaccessibility of the tree to European pharmacists and botanists meant that trade barks were relied on in understanding the genus. These bark samples were used as critical, 'proxy' tools used to help 'recreate forests' in the laboratory, becoming substitutes for remote Andean trees inaccessible to the regular chemist. The size of the Economic Botany Collection *Cinchona* collection represents the effort expended on the subject. Without the physical remnants of this

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[44] Hooker maintained his own herbarium, which was kept separate from Kew's and absorbed into the collection in 1867 (Lucas, 2007). The library was formed at the same time as the Herbarium in 1852, a later research laboratory came in 1878 (Desmond, 2007).

collection, the efforts and the practices of scientists would be difficult to estimate through textual works alone.

Although Kew has often been presented as central to the cinchona science and transplantation story, my detailed analysis of the trajectory of most of the specimens at Kew suggests that their connection to Kew is not as close as expected. While Kew supported the cultivation and horticulture efforts, an examination of the provenance of its bark collections show that the British Indian government relied on external expertise for chemical and botanical questions. The current collections reflect this history: the majority of specimens related to this history, i.e. those central to major publications and analysis, were acquired by these external experts, such as John Eliot Howard and not by Kew itself. This will be discussed further in the following sections and those relating to the role of Howard are developed in Chapter 4.

2.3 Methodology

Specimens, archives and publications provide the raw material for the discussion in this thesis. Qualitative and quantitative methods have been combined to establish narratives at the specimen, collection, curator and network-levels. At the specimen-level, a form of object biography is used through the analysis of a specimen's materiality (such as labels, packaging and form of object). This allows a reading of the object's history, origins and trajectory. At the collection-level, assemblages are explored to trace how multiple objects came to be gathered together in various sub-collections and what this tells us about their meaning over time. For curator-level insights (i.e. into Howard), his collections, archives, as well as his written works, by and about him, are analysed and connections traced, with objects mapped onto the archives. At the topmost level, an analysis of the networks Howard maintained is also traced, following the flow of knowledge and specimen exchange to and from his collections. These approaches have each contributed to reveal the spaces, places, practices and influences of Howard the quinologist.

2.3.1 Combined approaches: biographies, assemblages and networks

History can be read in many ways. Textual sources as tools of communication are readily accessible to the historian. However, within museum studies, collected objects are also understood to also provide additional, equally valid, sources of information. By reading an object's 'materiality', an 'object biography' can be extracted to give supplementary dimensions to narratives. The use of a material lens to research history has been strongly influenced by anthropological and archaeological disciplines. In archaeology, the non-written is often the only resource for understanding the past. In anthropology, the non-written and non-verbal aids the understanding of human experiences. Combined, these have helped shape an appreciation and 'reading' of the material world (Appadurai, 1986; Kopytoff, 1986; Longair & Hannan, 2017).

2.3.2 Object biographies

Tracing an object's provenance and trajectory can reveal a 'social life' or 'career' that can also tell us of the spaces around it and people that have engaged with it (Kopytoff, 1986, p. 66). The ever-changing value of the object over time can be explored to reveal who, what, where and how it was used by different owners and curators (Appadurai, 1986; Kopytoff, 1986). One major influence on this object-level view and its relationships is from Actor Network Theory developed by French philosopher Bruno Latour. In Latour's theory, 'actors' in a story may include both people *and* things. Objects are given equal value to the human in a challenge to anthropocentric worldviews, allowing their agency to be better understood (Latour, 1987).

Methodologies of material biographies and how they can inform histories of museum collections, have been well summarised by Longair and Hannan (2017). A material approach to histories of collections in museums has spawned many interesting projects from the Manchester Museum to the Pitt Rivers Museum and British Museum (Alberti, 2005; Cornish 2013; Dudley et al., 2012; Dritsas, 2005; Driver & Ashmore, 2010; Driver et al., 2021; Gosden & Larsen, 2007; Hicks, 2010; Joy, 2009; Ulrich et al., 2015). An early example of the popularisation of these histories showing object agency in the UK was seen in James Burke's 1978 TV show *Connections* and a 2010 British Museum project resulting in a book and BBC radio show, *History of the world in 100 objects.* These highlighted the importance of, not just magnificent artworks, but also 'everyday' objects and their societal impacts (Burke, 1978; MacGregor, 2010).

In his concern with object provenance, Howard was in a sense engaged in object biography himself, examining the clues on trade bark to trace their origins. Likewise, historians working with specimens can learn much from their form. By looking at a slice of cinchona bark, its form can inform us of its origin. If it is a large slab, it was harvested from the tree's trunk. If it is a small quill, it came from the branches. The lichens attached can tell us of the environment around it: how much sun, shade, moisture (Thus et al., 2021). The packaging and label style and handwriting can give hints as to who handled the object and what value it held at different periods. Does it have an original collector's label or a museum label? Does it show numbering from an exhibition, revealing it had value for display and education? Are there multiple labels? These are some of the ways in which the barks can be interrogated.

The mobility, circulation and recirculation of objects in and out of the Kew Museum were themes explored in the *Mobile Museum* project (Driver et al., 2021; Cornish & Driver, 2020). These focus on objects and their movements over time which reveal the value and networks to which they belong, another strong theme that has been brought out in cinchona histories. The *Mobile Museum* project has been important in highlighting that in the nineteenth century, objects rarely arrived with finality in a museum, instead related specimens were commonly (re)circulated between institutes and individuals. In addition, the project showed that at Kew, data did not have a mono-directional flow within the empire: from the peripheries to the metropole. Instead, it circulated to and from different places, changing as it went (Cornish et al, 2017; 2020; 2021; Driver et al., 2021). Similarly, this project on cinchona has shown similar fates of objects: barks were swapped, traded, split and (re)circulated between multiple players in large networks of exchange and this is explored further in Chapter 4.

Historic specimens within national and international herbarium are frequently consulted by botanists to understand the additional material 'clues' that can answer questions of morphology, taxonomy, distribution, conservation and even historic information (Friis & Balslev, 2017; Rønsted et al., 2020). However, *materia medica* within wider Economic Botany Collections are understudied as sources for object biography: while research on Early Modern medicinal cabinets, mainly Dutch, have received some analysis within the literature, there is less on other types of medicinal plant collections, particularly those dating to the nineteenth century (Boulboullé, 2019; Hardy, 2017; van der Ham & Bierman, 2017; MacKonochie & Heinrich, 2019). Not only are these collections of interest historically, but are also potential resources for drug discovery (Rønsted et al., 2017).

2.2.3 Collection assemblages & curator biographies

From the object-level to the collection-level, tracing the interaction between objects through their assemblages reveals additional layers of history. How and why did these objects come to be together? What connected values did they hold? What relationships can be traced? In what ways does their collection change their value (Byrne, 2013)? Rodney Harrison thus discusses 'the idea of museums as meshworks and as material and social assemblages' (Harrison, 2013, p.13). This complex 'meshwork' requires a subtle approach to unpick the weavings (and the action of the weaver) within existing collections. Therefore, collections-based projects require a multi-layered approach to capture the different viewpoints of the objects to give a story of the overall assemblages: tracing relationships through the material and archival. For example, are there clues which relate objects to each other: labels, number systems, packaging, form? Many projects have been based on these ideas (Alberti, 2012; Byrne et al., 2011; Cornish, 2013; Dudley et al., 2012; Gosden & Larson, 2007).

Chris Gosden and Frances Larson explored the history of the collections within the Pitt Rivers Museum through an exploration of the relationship between people and objects, combining qualitative and quantitative approaches (Gosden & Larson, 2007). Their project gave an overview of the collections numerical and origin data and went beyond to explore the histories of makers, collectors, curators and objects. This revealed a story of the collection through its assemblages and the contexts and trends in which they were formed. They used quantitative meta-analysis to highlight themes within the collections that reveal collection formations in what they described as 'collecting rhythms'. These rhythms show trends for collecting, movements between places, dates related to historic events etc. This created a framework to discuss the history of the museum beyond the data: their contextualisation within history to map their movements across time and space.

Understanding the object biographies alongside the social and cultural lives of their curators helps also aids understanding of assemblage. For example, in the Gosden and Larson project, the researchers show that the curator directly impacts the formation of the collections. The museum founder General Augustus Pitt Rivers (1827-1900) came from a military background and had an interest in ethnology and archaeology. For example, an interest in firearms combined with latest evolutionary theory led to his collection, and typographical display, of weaponry. This understanding of the curator displaying his racist beliefs, typical to museums of this era, shows that British/Europeans believed they were technologically and evolutionarily advanced over other cultures. Likewise, in this thesis, it is important to understand Howard's beliefs and motivations and how they affected his work. Howard was profoundly religious and this influenced the ways in which he interacted with science, in turn influencing his collection practices. Howard rejected theories of natural selection and therefore his understanding of species which in turn affected his understanding and interpretation of the *Cinchona* genus. These beliefs acted in some ways to obscure, rather than clarify, knowledge of the genus and focused his collections towards understanding chemical, rather than botanical, varieties. This theme is explored further in Chapter 6.

2.3.4 Networks & centres of calculation

The circulation of objects, and associated scientific knowledge, relied on extensive, close-knit, self-regulated networks of exchange. These objects were often circulated and recirculated at different times with different values, as explored in Chapter 4. Howard networked widely. His collections and archives show he maintained an international circle of collectors who exchanged, circulated and recirculated *Cinchona* barks and correspondence.

Howard's role within cinchona history can be viewed through the lens of another Latourian concept: 'Centres of Calculation'. These are sites (for example Kew) or even individuals (such as Howard) that act as 'super nodes' in a network, where knowledge is accumulated, produced and circulated (Jons, 2014; Latour, 1987; Miller, 2011). Howard maintained one of the largest collections of *Cinchona* barks known and consulted for the British Government on the matter of species and chemistry to inform the plantation projects. The size and influence of his own collections, now kept at Kew, reveal his individual influence on the tree's history as a centre of calculation. The life of specimens within networks are complex, often simplified at catalogue level – though they passed through many hand and were worked upon in many ways, it is often the original, or most recent, collector that is named, the rest lost or silenced (Alberti, 2005; 2012; Jardine et al., 2019). Managing specimens beyond the explicit catalogues means complicating histories of circulation and exchange. A focus on Howard is central, but it is also the analysis of his networks and colleagues that will add nuance to his methods of working.

2.4 Sources

This study interrogates multiple sources: object, archival and printed. The key sources at the centre of the thesis are the cinchona specimens and associated archives at the Royal Botanic Gardens, Kew. Further related satellite archives, collections and publications have been used and are described in the following sections. These additional resources contain specimens, correspondence, photographs, laboratory analysis, notes and reports.
The cinchona collections used in this thesis are accessible in diverse formats and collections, as follows:

- **Plant specimens**
    - **Kew Economic Botany Collection** 1,091 bark, wood, seed and chemical accessions of *Cinchona* and related species. Some of the diverse formats of specimens is shown in Figure 2.1.
    - **Kew Herbarium:** 912 dried *Cinchona* pressed plant specimens.
    - **Non-Kew Collections** Pharmaceutical Society; Wellcome Collection; Real Jardín Botánico de Madrid; Naturalis Biodiversity Center, Leiden.
- **Archives**
    - **Kew Archives:** Economic Botany Archive; Kew Library & Archives
    - **Other Archives:** London Metropolitan Archives; Redbridge Council; Royal Pharmaceutical Society; Wellcome Collection.

Howard's specimen collections and archives undertook a complex journey before arriving at Kew. Their trajectory, as well as splinter collections that now lie elsewhere, are seen in Figure 2.2 and Figure 2.3.

In the following sections, each collection and archive are briefly described, followed by further in-depth analysis of Kew's specimens overall.

Figure 2.1 Examples of Kew's Economic Botany specimens.
Clockwise from front: A cinchona bark harvester's knife, quinine sachet and tablet tin; cinchona bark samples with a chemical analysis label; a yellow Indian quinine tin; a Totaquina tablet box; Herbarium specimen of India-cultivated tree leaves and barks; A Pharmaceutical Society jar of bark; wood specimen from *La Real Expedición;* in the centre: Manuel Icamanahí and Charles Ledger's seeds. Image Author's own.

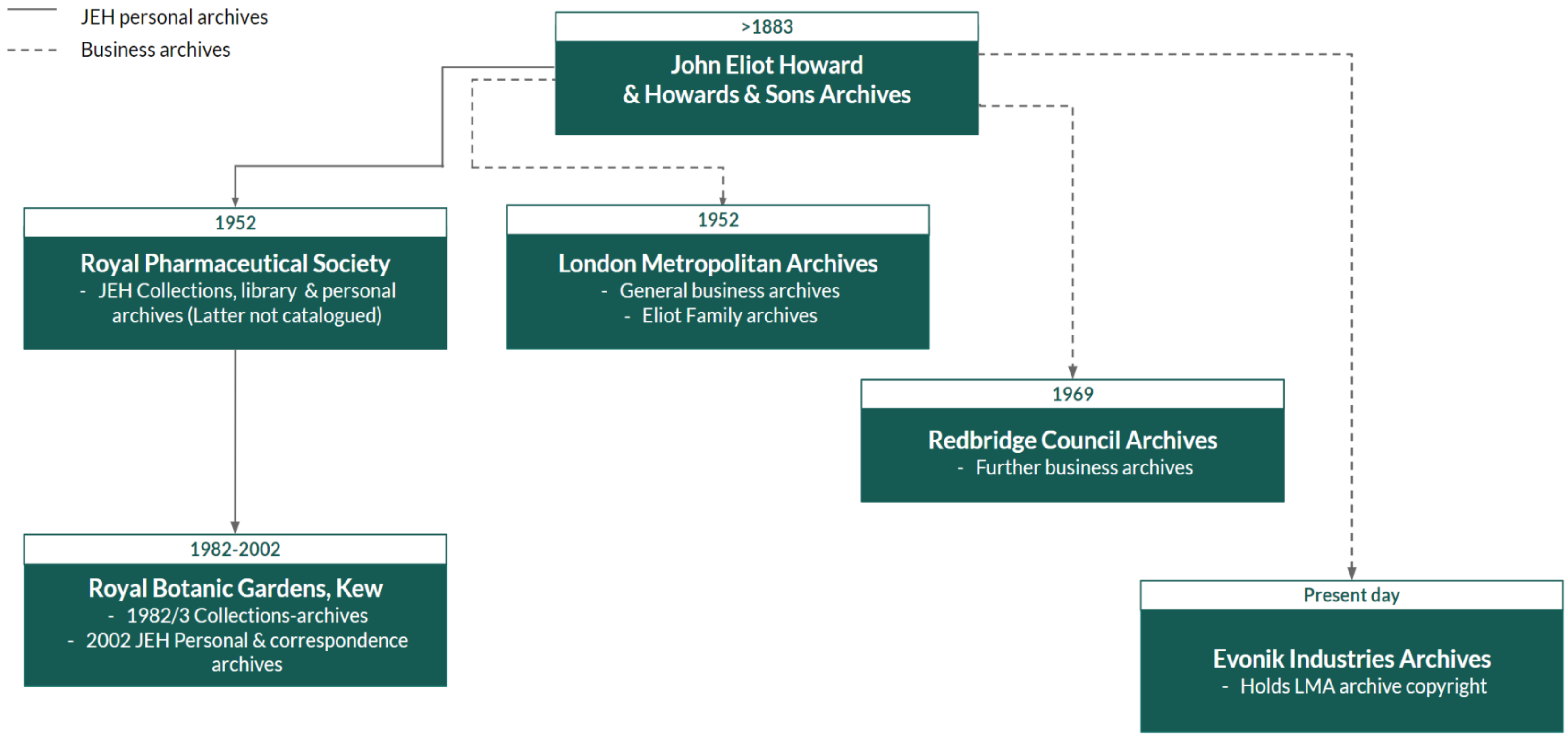

Figure 2.2 Trajectory & current location of John Eliot Howard (JEH) & Howards & Sons archives.
Compiled from data from Archive catalogues and Richmond et al. (2003)

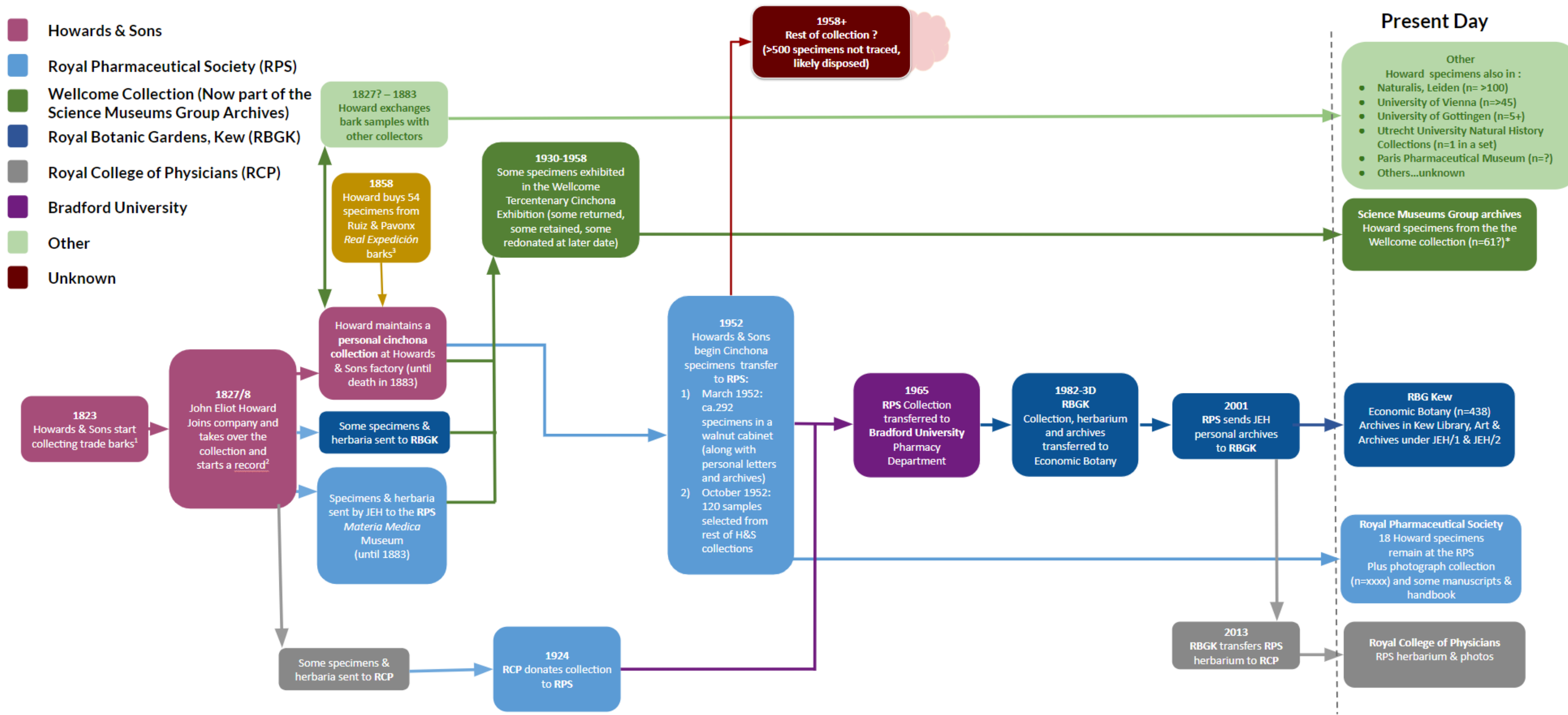

Figure 2.3 Trajectory & current location of John Eliot Howard specimen collections.

2.4.1 Botanical specimens

Economic Botany Collection

The collection contains 1,091 specimen accessions of *Cinchona* and related genera (Table 2.3). 'Related species' refer to those that either were once classed as *Cinchona* and since moved into new genera, were used for quinine analysis, or classed as adulterants/spurious. These include closely related Rubiaceae members including *Ladenbergia* Klotzsch. (syn. *Cascarilla* (Endl.) Wedd.), *Remijia* DC,[45] *Exostema* (Pers.) Bonpl. and *Cinchonopsis* L. Andersson. It also contains specimens of Theaceae member, *Gordonia fruticosa* (Schrad.) H. Keng (syn. *Laplacea quinoderma* Wedd.) and a specimen of *Olea europaea* L. (Oleaceae).

The original cinchona Economic Botany Collection catalogue data was downloaded and enhanced in a Microsoft Excel data table in 2001/2002 as part of a Wellcome Trust funded project led by Mark Nesbitt, working with a team of volunteers. It records (where known) genus, species, vernacular names, dates, donors, sources, geographical origins, label data, format, notation, links to literature, as well as other technical curation data such as catalogue numbers and shelving organisation. This catalogue was used as the basis for corroborating and adding additional information, including the 'related' species, literature, chemical analysis and reconnection of samples. During this project, the collection database records for Pharmaceutical Society specimens were for the first time correlated against the original nineteenth-century catalogue cards from the Society's Museum.

Much of Kew's cinchona collection is assembled from twentieth-century donations: the Materia Medica of the Royal Pharmaceutical Society's Museum, donated in 1982/3; the Chelsea College Department of Pharmacy in 2013; and the botanical collections of the Natural History Museum (formerly British Museum) in 1979-1982 (Hudson, n.d.). These are described further in section 2.6.2.

[45] Other species in the Economic Botany Collection were surveyed but did not return any results including: *Joosia* H. Karst, *Machaonia* Bonpl., *Macrocnemum* P. Browne, *Pimentelia* Wedd., *Nauclea* L. and *Uncaria* Burch., as well as Theaceae genus *Gordonia* Ellis. (syn. *Laplacea* Kunth.).

For this thesis, plant names were updated by linking the original name ascribed by the original collector to Kew's database *Plants of the World Online*.[46] This database incorporates the species concepts of Andersson's (1998) taxonomic monograph of the genus *Cinchona*.

The majority of the South American and all the Indian Economic Botany Collection specimens were digitised to support desk analysis and reduce handling. The images will be made available online to enhance the Economic Botany Collection catalogue and support further research on the collection. Imaging of the entire collection was intended but was interrupted due to lockdown during the COVID-19 Pandemic.

Some items were chemically and genetically sampled to enable analysis of the alkaloid content and genera in a related collaborative research project resulting in papers on 'Historical chemical annotations of Cinchona bark collections are comparable to results from current day high-pressure liquid chromatography technologies' (Canales et al., 2020) and 'Museomic approaches to genotype historic *Cinchona* barks' (Canales et al., 2022a). The significance of the findings in these papers for this thesis is discussed in Chapters 5 and 6.

Herbarium

The herbarium at Kew is a physical database. The ca. 7 million herbarium and 1.5 million Fungarium specimens are arranged in cupboards and for the most part, physical presence is required to access the stored 'data' present on each specimen sheet. Relatively few specimens are on a digital database, or available online, except type specimens and others digitised as part of more recent projects. A project to digitise and database all the specimens by 2026 began in late 2022.

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[46] https://powo.science.kew.org/

Since only about 90 specimens of the *Cinchona* herbarium collection (n=912) had been digitised prior to the start of the research for this thesis, it was decided to photograph and database the entire collection, a process completed in 2018. This part of the project was undertaken by a collaborative citizen science project with Kew Gardens and DigiVol.[47] Only the *Cinchona* genus was covered due to the size of the collections and the capacity of the digitisation team. The images and data are now available as part of Kew's public Herbarium Catalogue 'HerbCat'.[48]

Collections beyond Kew

Other cinchona bark collections with connections to Kew's specimens are held at the Royal Pharmaceutical Society's Museum; the Wellcome Collection (housed by the Science Museum Group); the Real Jardín Botánico de Madrid; and the Naturalis Biodiversity Centre, Leiden.

While the Royal Pharmaceutical Society donated much of its materia medica collection to Kew's Economic Botany Collection in 1982, it retained a small selection of representative objects for display. This includes 33 *Cinchona* specimens of which at least 17 belonged to Howard and these were assessed in 2018 to record their data.

In 1930, the Wellcome Medical Museum (now part of the Wellcome Collection) held an exhibition marking the supposed tercentenary of the discovery of cinchona. Barks and other display items were loaned from key collections including Kew, the Royal Pharmaceutical Society and Howards and Sons (Wellcome, 1930). A set of around 60 accessions of Howard's cinchona barks, shown in the exhibition, still exist in the Science

[47] Herbarium specimens imaged by Madison Johnson, MA student, Cultural Heritage at University College London (UCL). The citizen science project was facilitated by the Atlas of Living Australia, a collaboration with RBG Kew. 'Cinchona, the fever tree, Kew Specimens Part 1', which transcribed 364 specimens <https://volunteer.ala.org.au/project/index/30555294>; and 'Part II', which transcribed a further 454 specimens <https://volunteer.ala.org.au/project/index/30555294>. This brought the total of digitised specimens to 912, as some type specimens were already previously digitised. The images and data are now online as part of the Kew Herbarium Catalogue http://apps.kew.org/herbcat/gotoHomePage.do

[48] http://apps.kew.org/herbcat/navigator.do

Museum. Many of these accessions are in the form of multiple barks displayed in their original exhibition glass frames, with their tercentenary catalogue number still attached (Figure 2.4). These barks were briefly surveyed in early 2018, but they remain inaccessible due to their relocation project with other Science Museum collections to the Museum's store in Wiltshire, where they remain a source for further research after they reopen in 2024 ('Library and Archives', 2022).

However, basic database information for these specimens was provided by curators, as well as some retained archives at the Wellcome Collection (discussed below in the archives section of this chapter). In addition, items from Kew and Howard in 1930 are described in the exhibition catalogue and this has helped enable reconnection of some objects. The exact trajectory of all items in this exhibition is unclear: correspondence indicates that they were on a loan basis, but Howard specimens appear to have been re-donated in 1958 and have possibly retained their Wellcome packaging in the meantime. Were the 1930 Wellcome exhibition specimens sent again, on a permanent basis, during the period that Howards and Sons were relocating their collections in the 1950s? It is unclear why these were chosen as some other Wellcome items (not displayed in the same way) are now at Kew. This question, and others, remain an area for further research once the Science Museum Archives have reopened (Walker et al., 2022).[49]

Other international collections were also surveyed as part of this project. This was partly to enable comparison to those at Kew and partly to trace collection relationships (Walker et al., 2022). An overview is given here (the Leiden collection is also discussed further in section 2.6).

- The Naturalis Herbarium, Wood and Economic Botany Collection, Leiden (n=2,069). The barks were databased and digitised by ex-Collection Manager, Gerard Thijsse and the present author as part of a collaborative project funded by

[49] Wellcome Collection 'Wellcome Historical Medical Museum and Library Index Cards' 347/1958 - 427/1958.

a Martin Fellowship in 2017. A paper is in preparation discussing its history and comparing the two collections and it is expected that this number will increase.

- Real Jardín Botánico de Madrid's specimens from the *La Real Expedición Botánica al Virreinato del Perú*, *1777-1816*. These barks, woods, herbarium, copper plates and original illustrations (n=243) were surveyed in 2019. Collaborators were Nataly Allasi Canales (Copenhagen University) and Esther García Guillén (RJBM). This survey enabled a tracing of the collection's history and trajectory to show its relationship with the Kew *La Real Expedición* barks. This work, extending beyond the remit of this thesis, was published in the *Anales del Jardín Botánico de Madrid*: 'Reconnecting the *Cinchona* (Rubiaceae) collections of the 'Real Expedición Botánica al Virreinato del Perú' *(1777-1816)* (Walker et al., 2022). This work on Howard's acquisition and use of historic Spanish specimens is referenced throughout this thesis.

Figure 2.4 Example of Cinchona bark collected by John Eliot Howard, as displayed at the 1930 Wellcome exhibition.
The numbers on the cases correspond to the catalogue number in the Wellcome Tercentenary exhibition handbook (Wellcome, 1930). Image A654756 Science Museum Group.

2.4.2 Archives

As discussed above, the starting point for this project is the analysis of the Kew *Cinchona* specimen collections and associated archives. The thesis then focusses specifically on the collections, experiments and publications of Kew's principal consultant. John Eliot Howard, whose archives are kept across various institutes. The relevant archival sources are briefly summarised here.

General archives relating to Kew's involvement with cinchona, particularly the Miscellaneous Reports and Illustrations files, are kept in the Library and Archives department, with some illustrations kept in the Herbarium, filed near the *Cinchona* specimens. Archival data related to the John Eliot Howard collections is kept in two places at Kew: The Economic Botany Collection and the Library and Archives. The Economic Botany Collection archives contain specimen-associated archives such as catalogue cards, photographs and a box file of letters about the donations, which arrived from the Royal Pharmaceutical Society with the collections in 1982/3 (Hudson, n.d.). The Library & Archives holds Howard's personal archives which contain correspondence, notes and reports, donated by the Royal Pharmaceutical Society after renewed interest from Kew in 2002. Kew also holds a complete set of the Society's *Pharmaceutical Journal and Transactions*, a primary publication output for Howard.

The business papers of Howards & Sons are in the collections of the London Metropolitan Archives (LMA) and Redbridge Council Archives. Other significant archives associated with wider *Cinchona* knowledge include those at the Wellcome Collection related to the 1930 tercentenary exhibition. While the specimens are kept by the Science Museum, exhibition data remains at the Wellcome. Much of the archive is digitised and available on their online catalogue.[50] Specimen and archive donations for display were lent by Kew, Howards and Sons and the Royal Pharmaceutical Society (amongst others). Catalogues of

[50] Wellcome Collection Catalogue, https://wellcomecollection.org/works

these contain relevant materials as discussed in Chapter 5.

The above-described archives are more fully described in the following sections. Most of the archives are in the English language, though some Dutch, Spanish, French and German archives were accessed with the assistance of collaborators and Google Translate.

Royal Botanic Gardens, Kew: Library & Archives

Kew's own *Cinchona* archives are chiefly stored under the 'Miscellaneous Reports', as well as the *Cinchona* ''Illustrations files' found in the Library and Archives.[51] Because cinchona was an important subject in the history of Kew, the Miscellaneous Reports include 26 bound volumes of reports, articles, accounts, notes and correspondence to and from Kew regarding *Cinchona*, arranged by country (Table 2.1). These give an insight to the wider *Cinchona* story, important in contextualising this thesis.

In 2002, the Royal Pharmaceutical Society donated a previously uncatalogued personal archive belonging to John Eliot Howard to Kew's Library and Archives, accessioned under the classification Personal Papers JEH/1-JEH/3. Howard's archives include press cuttings, publications and most importantly, correspondence about his *Cinchona* work. This archive has been central to this thesis, providing an insight to Howard himself, his practices, collections and networks. Parts of these archives have been reconnected to objects, particularly in Chapters 4 to 6.

Royal Pharmaceutical Society

Following the 2002 Royal Pharmaceutical Society archival donation to Kew, other related documents were discovered at the RPS. These include Howard's notebook,[52] offprints and some correspondence to Howard. These have been retained and catalogued at the

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[51] Miscellaneous Reports (catalogued under MR) and Illustrations (No specific catalogue numbers), Library and Archives, RBG Kew.

[52] Descriptions and analysis of specimens of bark collected by John Eliot Howard from bark imported into England in 1828 and subsequent years and arranged in 1850, 1997.057, Royal Pharmaceutical Society Archives.

Society. The handbook has been an important resource for understanding Howard's practices and is mentioned at various points and discussed in Chapter 5.

In addition to these items there is a set of photographs of *Cinchona* trees which Howard grew in his Tottenham Garden. Howard gave a lecture on the cultivation of *Cinchona* at the Society and donated the relevant photographs (Howard, 1869). These images correspond to duplicates in the Kew Library & Archives and the herbarium of the Royal Pharmaceutical Society (which is now housed in the Royal College of Physicians). Chapter 6 discusses the story that the photographs tell of Howard's shifting focus from laboratory to garden.

Table 2.1 Kew's Miscellaneous Reports relating to cinchona.

Catalogue No.	Title (which includes area & dates covered).
MCR/5/1/43	India. Economic Products. Cinchona c. (1859-1888).
MCR/5/1/51	India. Cinchona. Return. East India (Cinchona plant) (1852 – 1866)
MCR/5/1/52	India. Cinchona- Return. East India (Cinchona cultivation) (1866 – 1877)
MCR/5/1/53	A Papers relating to the Cultivation of Cinchona Plants in India (1866-1870)
MCR/5/4/1	Sikkim. Cinchona Febrifuge (1880 – 1888)
MCR/5/4/2	Sikkim. Cinchona (1863 – 1900)
MCR/5/4/3	Sikkim. Cinchona (1865 – 1913)
MCR/5/6/8	Bengal. Cinchona Government Cinchona Plantations and Factory in Bengal Annual Reports (1912 – 1937)
MCR/5/9/13	Madras. Cinchona (1860 –18 97)
MCR/5/9/14	Madras. Cinchona Reports (1861 – 1885)
MCR/5/9/15	Madras. Cinchona Reports (1885 – 1900)
MCR/5/9/16	Madras. Cinchona reports Correspondence, Reports etc. (1902 – 1939)
MCR/5/10/13	Ceylon. Cinchona (1859 -1890)
MCR/10/1/1	St. Helena. Cinchona (1868 -1898)
MCR/15/3/2	Jamaica. Cinchona (1860 – 1900)
2/IND/46	India. Red Bark (1899).
5/C/5	Cinchona. [Africa] (1917)
5/C/5/1	Cinchona. Manuscripts connected with Holland's article on ledger bark and red bark (1931).
5/C/5/M	Cinchona. Miscellaneous correspondence (1862).
5/C/5/MA	Cinchona. Miscellaneous correspondence (1931)

Howards and Sons

Howards and Sons was the pharmaceutical manufacturing business owned by generations of the Howard family. Established in 1797, it progressed through various name changes and restructures until production ceased in 1975. An overview of company changes is seen in Table 3.1 of Chapter 3. It appears that as part of these various restructures over time, archives and specimens became surplus to requirements and were deposited in different archives. An overview of these archive movements is represented in Figure 2.2. In general, the archives fall into two sections: the Howards and Sons business archive and John Eliot Howard's personal archive.

The Howards and Sons business archives are divided into two major parts: those donated to the London Metropolitan Archives in 1952 and those donated to the Redbridge Council Archives in 1969. Howard's personal archives were also donated in 1952 to the Royal Pharmaceutical Society, later sent on to Kew in 2002 to join Howard's collections. It seems that quinine was no longer central to sales and an upcoming company restructure in 1953 may have inspired the 1952 and 1958 donations. By 1969, the company was winding down, finally ceasing production in 1975. This may explain why the archives were deposited at the London Metropolitan Archives in 1969 (Richmond et al., 2003). After this, any remaining Howards & Sons (and subsidiary) business archives have been maintained by those companies that absorbed the company. The copyright for Howards archives is owned by a German chemical company, Evonik Industries.[53]

London Metropolitan Archives

The Howards and Sons business archives were sent to the London Metropolitan Archives in 1969 and listed under various accession numbers, but the papers for the period of interest during Howard's lifetime are classified under ACC/1037 (years 1798-1950).[54] These comprise 12.96 linear metres of boxes. They contain correspondence and

[53] Thanks to Dr. Andrea Hohmeyer at Evonik for copyright permissions.
[54] The rest of the archive related to the Howard and Eliot family history and were accessioned separately from the business documents under ACC/1017. There are a couple of later archives.

laboratory notes giving insight to the business practices and influences on manufacture by J. E. Howard and are referred to throughout this thesis.

Redbridge Council

The Redbridge archives were accessioned later than the LMA deposits. They appear to be useful summaries retained from the (LMA) bulk paperwork. As such they summarise the purchases and sales relating to quinine. The archive includes the 'Laboratory Calculations Book' (90/360/E2/K2) 1856-1956, breaking down quinine sales by type. There is also a book entitled 'Q' showing profit and loss, prices of bark and chemicals used in manufacture of quinine (90/360/E2/A4). These two books have been important for findings discussed throughout this thesis, particularly in Chapter 3.

Wellcome Collection

The Wellcome Collection archives contain exhibition accession data from the cinchona tercentenary anniversary exhibition of 1930.[55] The exhibition handbook also contains details of the objects displayed, their data and descriptions. Many of the items on display were Howard and Kew samples. They have been important in tracing Howard's collection trajectory as discussed in Chapter 5.

Parliamentary Papers

British parliamentary papers comprising the official correspondence relating to the introduction of cinchona into India were bound in what were also known as 'Blue Books' due to the colour of the original covers (see Table 2.2).[56] This includes Howard's correspondence, analytical reports and opinions of Howard by others. This has helped to contextualise his influence and impact, as discussed in Chapter 4.

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[55] See in particular Tercentenary Exhibition files WA/HMM/EX/C <https://wellcomecollection.org/works/xys3cfdg>, as well as other items found scattered throughout other WA/HMM subcollections, Wellcome Collection.

[56] These are available from the U.K. Parliamentary Papers at ProQuest https://parlipapers.proquest.com/parlipapers

Table 2.2 Parliamentary papers relating to the introduction of 'Chinchona' into India.

Dates	Book No.	Title	Publication Date/Compiler
March 1852 - March 1863	118	East India (Chinchona Plant): Copy of Correspondence relating to the Introduction of the Chinchona plant into India, and to Proceedings connected with its Cultivation	18 March 1863 E.D. Bourdillon
April 1863 - April 1866	353	East India (Chinchona Plant): Copy of further Correspondence relating to the Introduction of the Chinchona Plant into India, and to Proceedings connected with its Cultivation	June 1866 E.D. Bourdillon
April 1866 - April 1870	432	East India (Chinchona Cultivation): Copy of all Correspondence between the Secretary of State for India and the Governor General, and the Governors of Madras and Bombay, relating to the Cultivation of Chinchona plants.	9 August 1870 H. L. Anderson
August 1870 - July 1875	120	East India (Chinchona Cultivation): Copies of the Chinchona Correspondence (in Continuation of Return of 1870)	21 March 1876 George Hamilton
August 1870 - July 1875	279	East India (Chinchona Cultivation). Copies of the Chinchona Correspondence	20 June 1877 George Hamilton

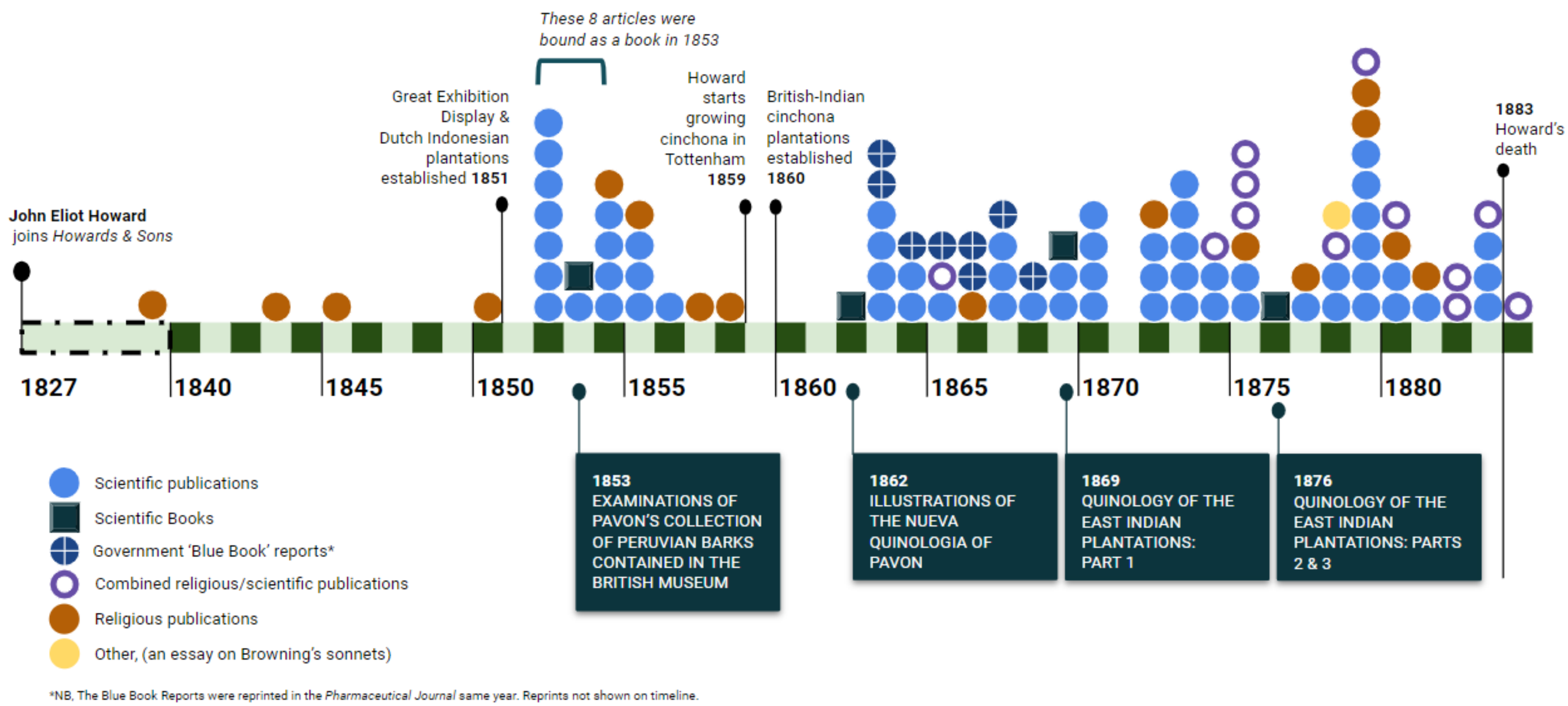


Figure 2.5 A timeline showing John Eliot Howard's major publications.[57]

[57] This is not exhaustive, but includes all those in the Pharmaceutical Journal, Books and significant others as highlighted in Howard (1885). See Appendix 3 for the publications list by title.

2.4.3 Publications as sources

In addition to wider literature cited herein, a number of publications authored by John Eliot Howard have been of special importance. These include his journal articles published in the *Pharmaceutical Journal and Transactions* between 1851 and 1883, which are discussed throughout the thesis: a bibliographical list is given in Appendix 3 and article outputs seen in Figure 2.5. These publications are discussed further in Chapters 6 and 7. Other important outputs by Howard include his three books, also discussed throughout and with an analysis in Chapter 8: *Examinations of Pavon's collection of Peruvian Barks in the British Museum* (Howard, 1853; 1855);[58] *Illustrations of the Nueva Quinologia of Pavon* (Howard, 1862); *The Quinology of the East Indian Plantations* (Howard, 1869; 1876).

The story within the pages of this thesis would be significantly less detailed if it was not for the posthumous biography written by his wife Maria, *Memorials of John Eliot Howard of Lord's Meade, Tottenham* (Howard, 1885). This has been an essential text in understanding Howard's personal life, religion, science and how they combined within his life and work.

2.5 An analysis of Kew's cinchona collections

Table 2.3 and the following sections show an overview of Kew's cinchona collections (herbarium and EBC specimens). The analysis gives a breakdown of:

- **Type**: bark, herbarium, wood, seed, chemical, other (which constitutes rare items like glass, dyes and resins)
- **Origins:** geographical analysis of sources between places such as wild sourced in South America vs. cultivated, such as India and Indonesia (SE Asia).
- **Species**: Based on updated names according to *Plants of the World Online* (RBGK, 2022)

A detailed analysis of dates was not possible due to a lack of consistent data. However,

[58] Howard uses the spelling Pavon, rather than Pavón. This spelling is retained when the book title is mentioned.

most specimens are known to be generally nineteenth century. Where dates are important to the story, these have been highlighted in the text. Numerical data was compiled and summarised using dplyr 1.0.8 (Wickham et al., 2022) in R version 4.1.2 (RCore Team, 2021). The charts and tables are given below.

Table 2.3 Number of specimens by type in the RBG Kew Collections

	Economic Botany Collection[59] (*Cinchona* and related genera)	**Herbarium (*Cinchona* spp. only)**
Herbarium sheets (Including duplicates)	8	912
Bark samples	936	Occasional examples attached
Wood samples	56	0
Seed samples	29 (inc. 23 packets in one accession)	0
Other Specimens (Leaves, resins, dyes, ashes)	7	0
Products/chemicals	77	0
Paraphernalia	4	0
Total*	**1,117 (1,091 accessions)**	**912**
Total items by type	2,003	
Total no. of accessions	**1,995**	

[59] No. by type in the EBC includes items accessioned as one item but contain more than one type. E.g. a herbarium sheet that also has bark samples is counted twice: once as a bark and once as a herbarium.

2.5.1 The Herbarium

There are 912 *Cinchona* herbarium sheets in the herbarium collection. As noted above, only the specimens filed under *Cinchona* were databased due to time limitations. However, some of the names within the collection are out of date and have been classed under their recent name using *Plants of The World Online* for the purposes of this project (RBGK, 2022). The geographical origins of the herbarium specimens are shown in Figure 2.6. Nearly half the collection (n=428; 47%) are wild-collected (i.e. South American). The rest were gathered from various cultivated origins (n=484; 53%), predominantly British India (n= 162; 18%) and Africa (n=166; 18%). Reflecting cultivation trends, the Indian specimens date from mid to late nineteenth century, followed by later plantations established in Sri Lanka and the Caribbean. The African specimens date post-First World War, when Britain took control over German research institutes in its colonies there.[60]

It is difficult to determine specimen collection dates precisely, due to lack of specimen data, particularly the early-mid nineteenth-century South American specimens. An additional issue is that the collection date does not always coincide with the date of arrival at Kew. Estimated arrival dates for some can be ascertained from additional clues such as Kew date stamps. When Kew absorbed major collections, these collections were date stamped on entry. This includes the collections of Kew Directors, George Bentham (1800–1884) and William Hooker, stamped 'Herbarium Benthamianum 1854' and 'Herbarium Hookerianum 1867' (Lucas, 2007). Therefore, only general estimates on dates for earlier specimens can be given:

- There are around 500 herbarium specimens likely to have been collected pre-1900, though not all have an assigned date[61]
- Of these, around half have a confirmed collection date
- The earliest specimens with confirmed dates are from 1777-1816, but some are likely

[60] E.g. the Amani Institute in Tanzania researched Cinchona.
[61] This is evidenced by a combination of evidence such as label style, handwriting, incoming herbarium stamps, London smog pollution darkening the edges (i.e. the older, the 'dirtier' they appear.

older[62]

- It is not clear how many *Cinchona* herbarium specimens existed at Kew before 1855, based on Howard's assessment it was relatively few (Howard, 1855).[63]

The oldest herbarium specimens include *La Real Expedición* collections (1777-1816, which are often dated as 1777 but are dated later by my work); and a collection from Aylmer Burke Lambert, taken from a Spanish frigate prior to 1815. Both these collections were accessioned later at Kew after Lambert's death (Howard, 1855; Miller, 1970; Pupulin, 2012; Walker et al., 2022).

The relatively small number of herbarium specimens show that Kew did not take an active early role in *Cinchona* knowledge production before expeditions to establish cultivation in 1859, partially because the herbarium was new (1852). However, the collection grew significantly over the latter part of the century. This is partly because access to South America improved and interest grew in controlling the genus for cultivation. This is discussed in Chapter 4.

The three most abundant species in the herbarium are both common in the wild and are commonly cultivated: *C. calisaya* (28%), *C. pubescens* (27%) and *C. officinalis* (14%), Figure 2.7 and Figure 2.8.

[62] These are those from Aylmer Bourke Lambert's collection which includes some specimens given to him by José Pavón from *La Real Expedición Botánica al Virreinato del Perú* (1777-1816)

[63] The official herbarium was established just three years previously in 1852, although more specimens were likely to have been in Hooker's collection which was absorbed in 1867, see note about stamps in the previous paragraph (Lucas, 2007). Howard does not give an exact number and discusses specimens in obtuse ways that make it difficult to assign one, but included 14 specimens from Ruiz and Pavón, specimens from Lambert's herbarium and from Bentham.

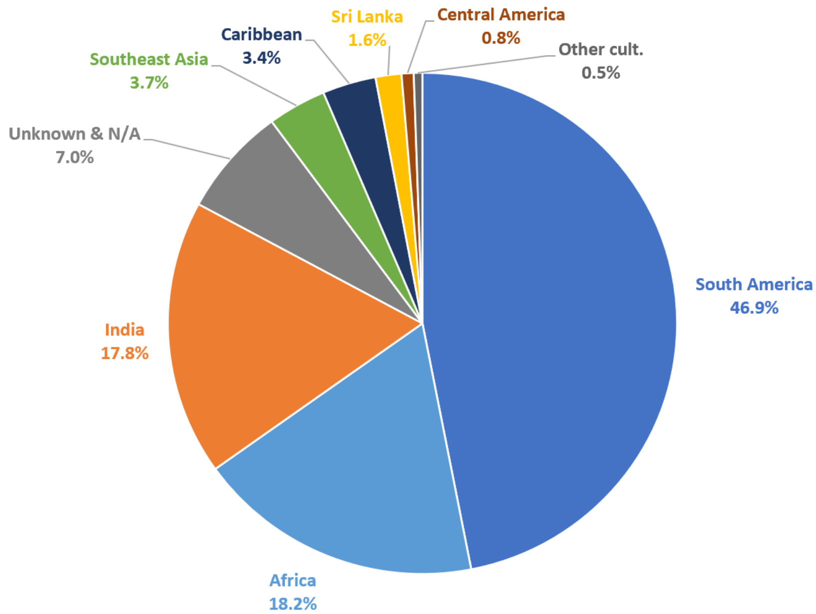


Figure 2.6 Kew Herbarium specimens by geography (n=912).
Unknowns & N/A refer to items with lack of recorded origin data. 'Other, cultivated' refers to grouped specimens cultivated in places such as European botanic gardens.

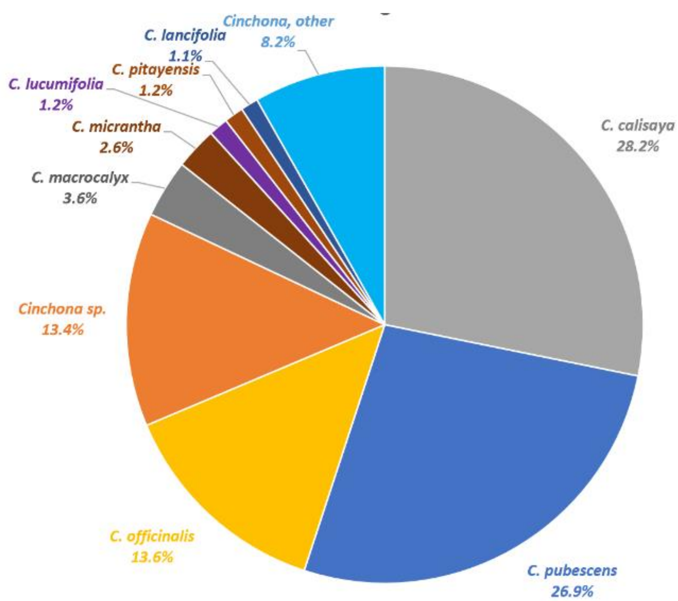


Figure 2.7 Kew Herbarium specimens by species (n=912). '
Other Cinchona' category includes a further 75 specimens within a further 20 species (each with fewer than 10 occurrences). Breakdown in the next figure.

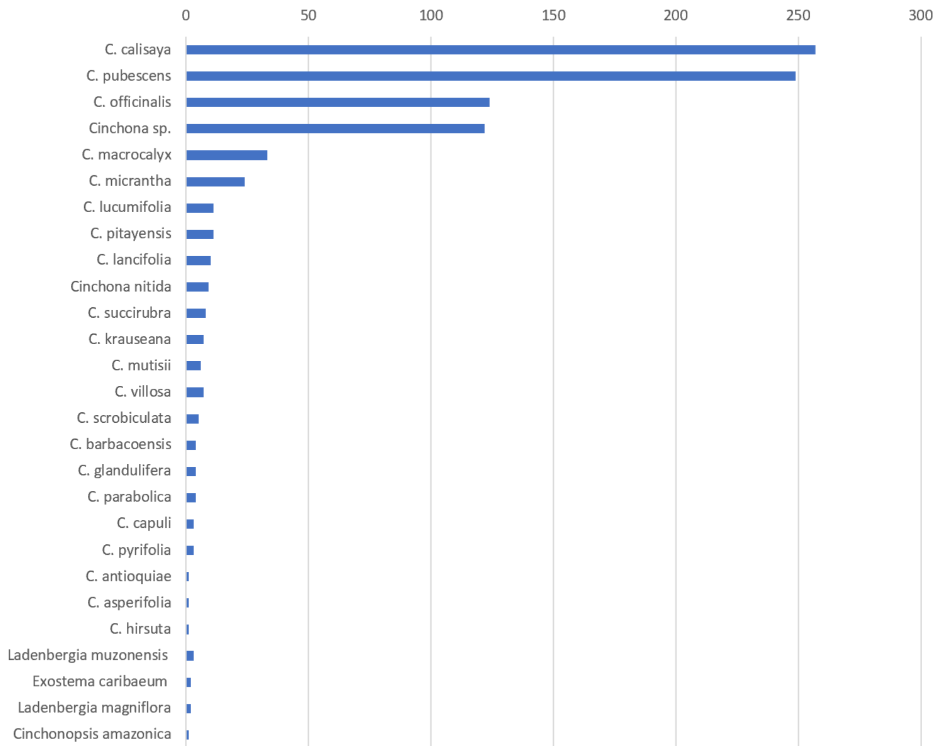


Figure 2.8 Herbarium specimens by species (n=912).

2.5.2 Economic Botany Collection

The EBC collection has been categorised by type: bark, wood, seed, herbarium,[64] product (i.e. bottles of chemicals such as quinine, cinchonidine etc.), other (leaves, resins, dyes) and associated paraphernalia (including collection tools, stained-glass moulded to the bark, and an empty quinine tin) (Figure 2.1 and Figure 2.9). Many of the specimens are bark samples (n= 936; 84%), which reflects the purpose of the collection: the bark is the part of the tree from which quinine is extracted. It was sold at market in this form and was collected both for extraction and to understand its botanical identification, therefore is the main category found in such spaces.

The geographical origins in Figure 2.10 show that the majority of samples are South

[64] The herbarium specimens in the EBC were used as display items in the museums. These are different in purpose from the specimens kept in the larger Herbarium at Kew. Some have additional data such as bark samples attached.

American (n=668; 61%). This is because most of the collections were collected before cultivation, combining trade samples used for pharmacognostic purposes within schools of pharmacy. As noted earlier, these nineteenth-century collections were later accessions at Kew, transferred there between 1979 and 1983. The next largest region of origin is British India (n=189; 17%), reflecting colonial plantation projects there. The rest of the collection comes from plantations established subsequently such as Sri Lanka and the Caribbean. A small amount shows there was some exchange with the Dutch for Indonesian barks, grown in their own plantations. Around 10% of the collection is of unknown origin, from items that have no bark provenance (e.g. chemicals) or that lack data. This may be because it has been lost or the value of some barks were used as tools for botanical identification and not to understand trade/origins.

The numbers of species collected (Figure 2.11Figure 2.12Figure 2.13) were calculated on the basis of current accepted names. Due to some lumping of species in the history of the collections, there has been some renaming based on different historical understandings of the genus. However, the most updated names needed to be used and this meant returning to, and updating, the *original* determination as received in the specimen's original collection and usually to be found on the oldest labels or Pharmaceutical Society index cards. Names were not used direct from the Economic Botany Collection database as these had not been consistently updated. The original label data was transcribed and then this name was entered into *Plants of the World Online* to discover the modern accepted name (RBGK, 2022). Of original names, there are around 90 species, hybrids and varieties listed, but this was filtered down into 19 of the 23 species defined today. It is likely many of the earlier names were misattributed and it would take genetic sampling to ascertain the true species in this, and all, *Cinchona* collections. As with the Herbarium, the commonest species named are: *C. pubescens* (24%), *C. calisaya* (17%) and *C. officinalis* (14%). For unknown *Cinchona* sp., the figure refers to items that have not been determined, have lost their data or were ascribed to a *Cinchona* species that could not be mapped to an accepted name. Figure 2.11 breaks down the top three species, distinguishing between how many were cultivated or were wild-collected.

Much of the collection came later to Kew, including important sub-collections in the Economic Botany Collection. A major donation of 10,000 materia medica came from the Royal Pharmaceutical Society in 1982/3, of which 520 include *Cinchona* and related genera examined in this project. Between 1979 and 1982, 120 cinchona specimens were accessioned from the Natural History Museum (formerly British Museum (Natural History)) after a curatorial decision that their economic botany collections were better based at Kew (Cornish, 2011). Another 119 cinchona specimens came from the Chelsea College School of Pharmacy (Harrod Collection) in 2013. These three donations constitute nearly 70% of Kew's current cinchona collection. Of the rest, discounting all twentieth and twenty-first century collections, leaves 215 specimens that were likely to have been in the Economic Botany Collection between 1847 and 1899. Of these, 145 have accession dates compared to 70 which do not. This means that around 10-20% of the current collection were accessioned during the period examined in this thesis, i.e. from 1847 (opening of EBC) to 1883 (Howard's death). The Pharmaceutical Society and British Museum Collections contained some of the oldest specimens now at Kew: those of *La Real Expedición Botánica al Virreinato del Perú*, *1777-1816* as mentioned in section 2.4.1 (Collections beyond Kew section).

The Pharmaceutical Society specimens contain a historically important sub-collection, that of John Eliot Howard, whose collections are the focus of this thesis. Howard's collections are ca. 438 strong, forming around 40% of Kew's current Economic Botany cinchona collection. Of these, 280 were donated to the Pharmaceutical Society either during his lifetime for the Society's training school museum (n=135) or via his personal collections donated by the family company to the Society between 1952-1958 (n=145 extant).[65] These items, as mentioned, arrived at Kew between 1982 and 1983.

Some of the remaining barks in the collection were directly donated to the EBC by Howard

[65] More were donated but some were destroyed by insect damage and is discussed in Chapter 5.

(n=51), whereas other Howard specimens have arrived from other collections such as the British Museum and Chelsea School of Pharmacy, which came to Kew between 1979 and 2013. The trajectory of Howard's collections is shown in Figure 2.3. Howard's bark collections are discussed further in Chapter 5.

La Real Expedición's collections were of formative value for Howard, as discussed in later chapters, as well as being explored by Walker et al., 2022 whereby the relationship of the Kew material to the original *Real Expedición* collections in Madrid were traced.

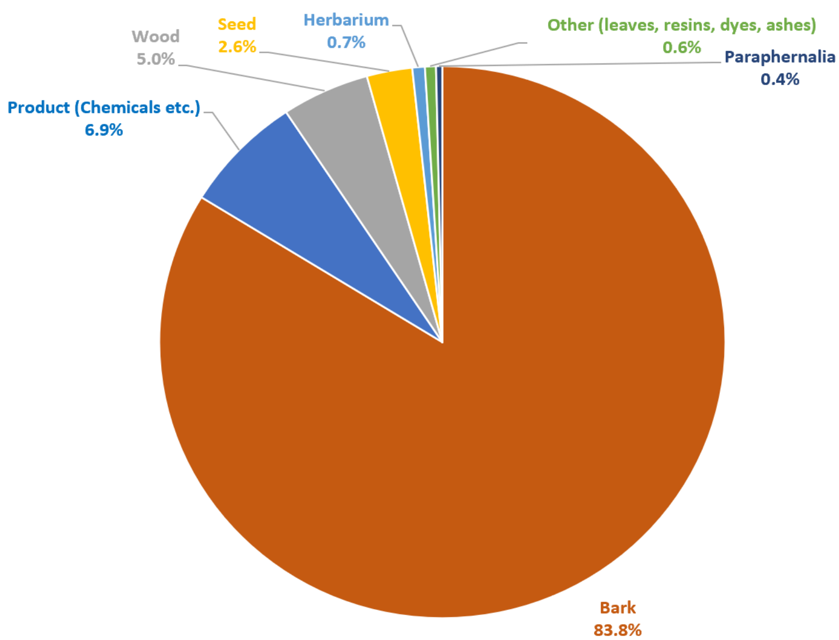


Figure 2.9 Economic Botany Collection Cinchona, by object type.
'Other' category includes paraphernalia, resins, dyes and leaves. (n=1,117 types from 1,083 accessions); some accessions contain more than one type of category, e.g. a specimen containing an herbarium with a bark is counted twice).

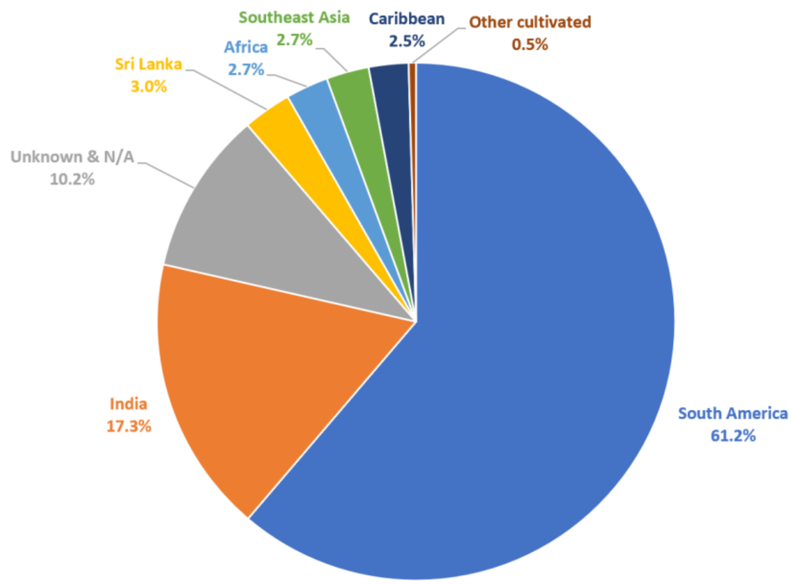


Figure 2.10 Economic Botany Collection specimens by origin.
(n=1,083) Unknowns refer to items with lack of recorded origin data, or because they are untraceable, e.g., chemical products. Other, cultivated refers to specimens from places like UK but with a number under 5.

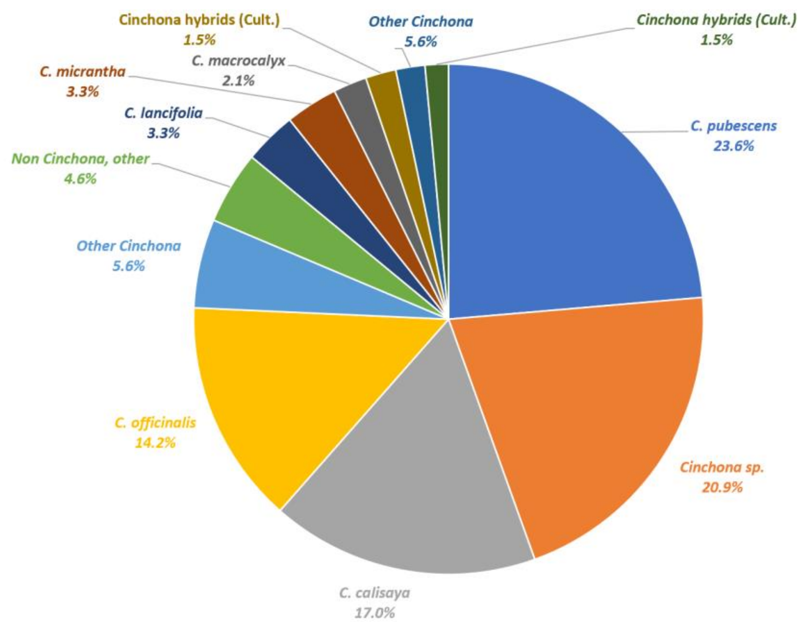


Figure 2.11 Economic Botany Collection specimens by species.
(n=1083). 'Other Cinchona' category refers to 7 grouped species with <15 occurrences. Non-cinchona were also grouped under one category. Figure 2.12 and 2.13 for breakdown.

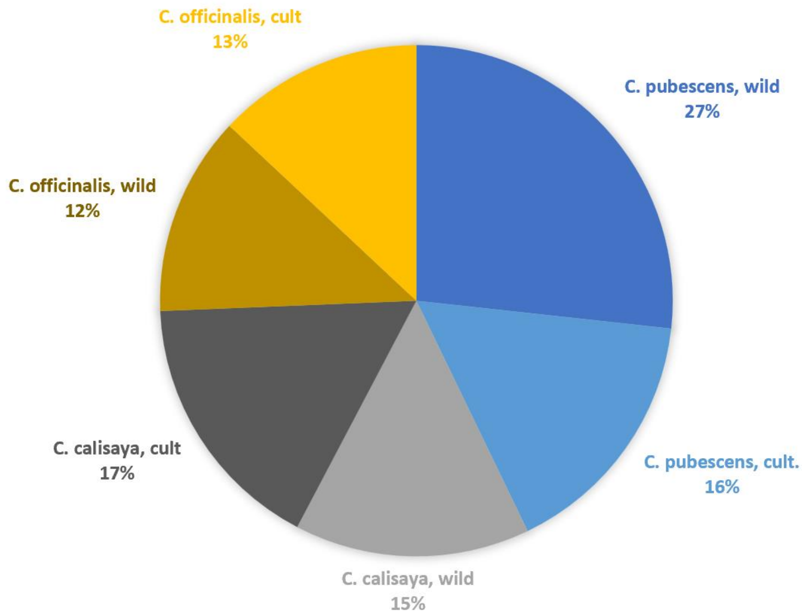


Figure 2.12 Economic Botany Collection specimens, top three collected specimens wild-collected vs. cultivated.

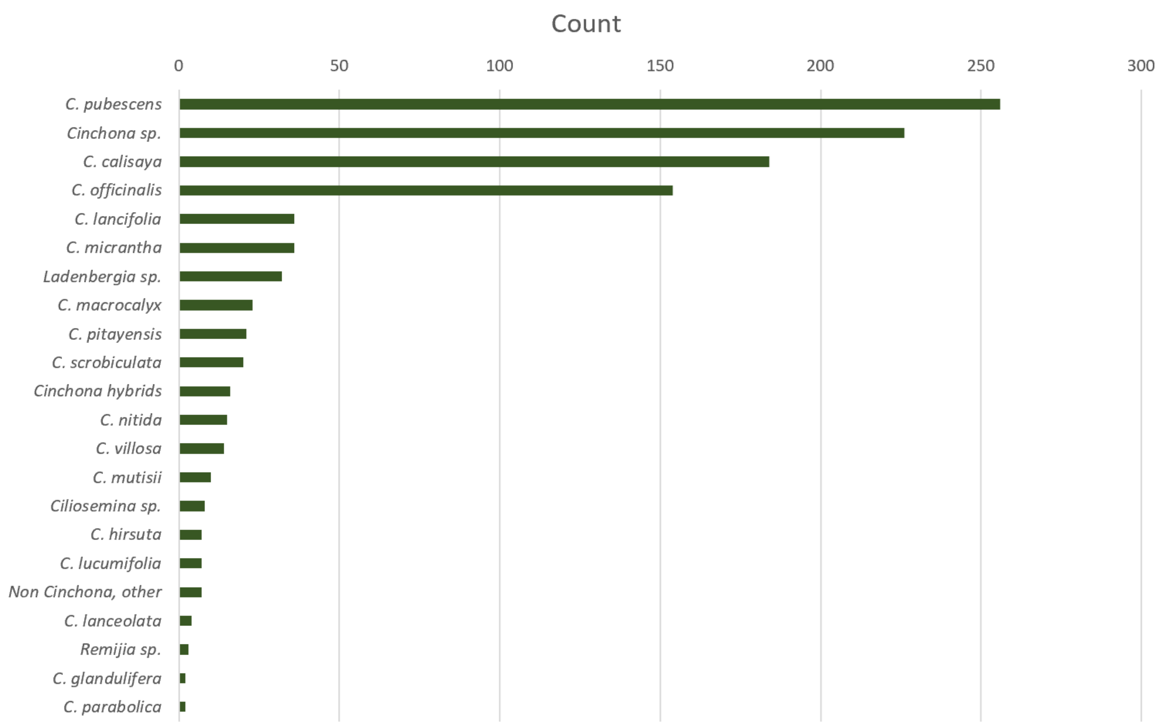


Figure 2.13 Economic Botany Collection specimens by species (n=1083).

2.5.3 Kew and Leiden: Collections compared

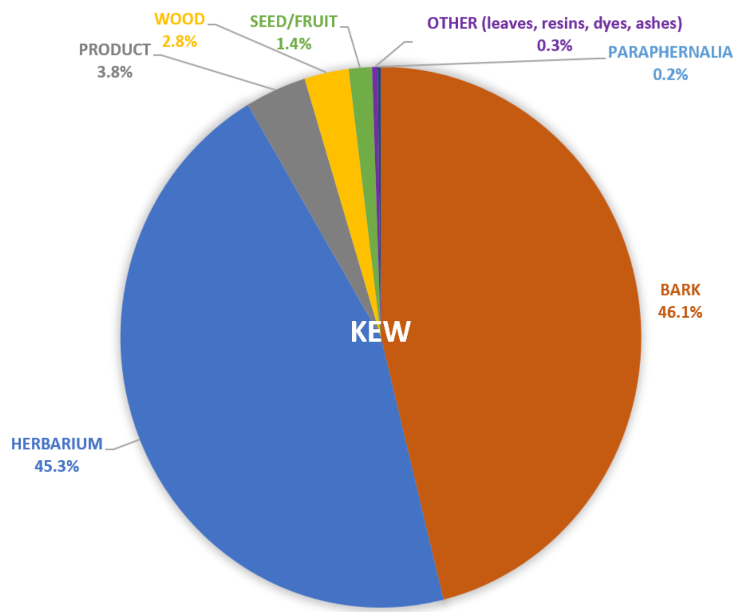
As discussed above, Kew's collections reflect early pre-plantation interest in *Cinchona* as represented by its early dominance of South American species. Subsequently, British colonial plantations became a focus and specimens were received from these areas. A short project databasing and documenting the collections of the Naturalis Biodiversity Centre in Leiden, Netherlands was undertaken just before the research for this thesis began and enables a comparison. Naturalis is a national collection, like Kew, where most of the country's important botanical collections are stored, including many older, now closed collections finding their final home there. Naturalis also maintains similar sized *Cinchona* collections: Leiden n=2,069; Kew n=1,995. These contemporary collections reflect these two empire's *Cinchona* projects and show some interesting comparisons and contrasts.

Figure 2.14 and Figure 2.15 show the category types and geographical origins from each collection. While both collections are dominated by a mix of South American and plantation collections, Naturalis represents the Dutch story. The dominant collections are from their own plantations in Indonesian colonies (n=864; 41.8%), followed by South America (n=733=35.4%). The sub-collections at Naturalis are predominantly sourced from other institutions, having been accessioned after their closure. These institutions were repositories for the plantations, leaving the collections of trade-collected South American barks from smaller collectors in the minority (Walker & Thijsse, in preparation).

In contrast, Kew focuses naturally on British colonial plantations in India, but importantly, the majority of the collections are South American emphasis of the Kew collection reflects the history of pharmaceutical collectors in Britain, who were the source of many of the Kew collections. In addition, Kew was not central to the plantation projects in India and therefore the collections do not have many Indian samples (Roersch van der Hoogte & Pieters, 2014). Many of the Indian samples now at Kew came from the India Museum collection (transferred in 1879), as well as exhibitions such as the Colonial and Indian

Exhibition of 1886 (Cornish, 2013).

As discussed in Chapter 1, a *Cinchona* plantation was established in Bandung, Dutch-Indonesia in 1851. The Dutch focused on fewer species, high in quinine alkaloids, leading to global quinine trade domination by the 20th century. The collection in Leiden contains around 75 different varieties represented in the original names. The Naturalis determinations are not yet updated to current species names, as many of these are obscure, requiring further research. However, of the correct names, Leiden like Kew, seems focused around the same top three species as those that were ultimately cultivated: *C. calisaya* (ca. 586 specimens), *C. pubesens* (ca. 325) *and C. officinalis* (135), forming around 50% of the current Leiden collection (with more likely housed under different names).



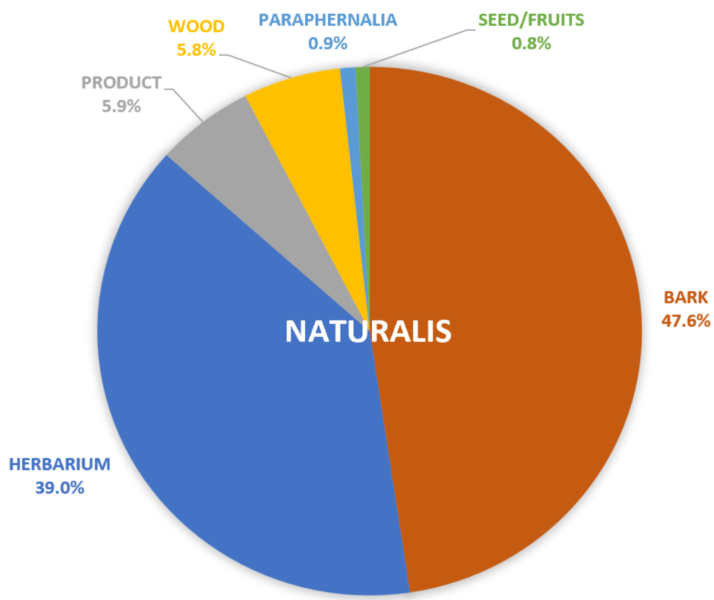


Figure 2.14 Kew and Naturalis: Collection breakdown by category type, overall.
(i.e. Herbarium + Economic Botany Collections): Royal Botanic Gardens, Kew. (n=2,003/1,995 accessions) and Naturalis Biodiversity Centre, Leiden, (n=2,068).

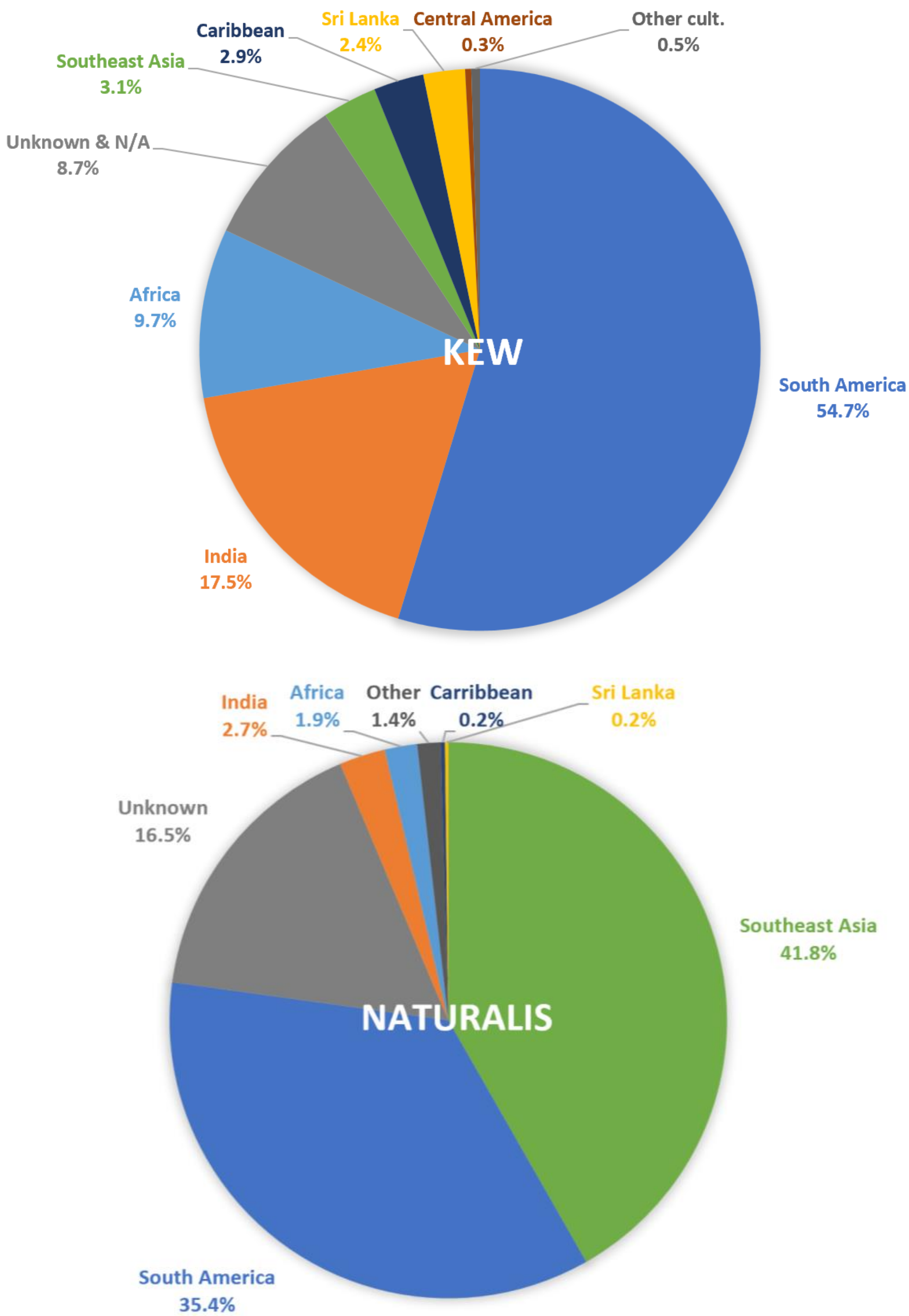


Figure 2.15 Kew and Naturalis: Collection breakdown by geographical origin, overall. (i.e. Herbarium + Economic Botany Collections) of the Royal Botanic Gardens, Kew (n=1,995), and Naturalis Biodiversity Centre, Leiden, (n=2,069xxx).

2.6 Summary

The Kew *Cinchona* specimens, perhaps the world's largest collection, are a historically important resource for understanding the history of the genus, quinine and the role of Kew in the development of this important nineteenth-century drug. This chapter has set out the approach to their analysis: collections-based, drawing on many types of evidence from the archives to build a picture of the curator, the collection biographies and assemblages. It is clear however, that the core of today's collections of cinchona at Kew, those which are central to this history, are those that originally belonged to John Eliot Howard. Kew's collections and other associated satellite collections and archives are important tools for uncovering these stories. While this chapter has presented an overall analysis of the collections, sub-collections (at Kew and beyond) will be further analysed in depth in the following chapters to answer specific questions about Howard.

Analysing the history of Howard through a material collections focus enables a response to the research questions set out in Chapter 1. The barks and their labels are the basis of insights into how Howard practised his science in the laboratory and reveal his approach to cinchona science (Chapters 5 and 6). Uncovering the provenance of these specimens alongside his correspondence archives show how he managed knowledge of an Andean tree while located far from its origins and reveal the networks he maintained along which specimens could flow (Chapters 4 and 5). Tracing these flows, as well as finding connections between important specimens-archives-publications also reveals how Howard communicated his work (Chapters 4 and 7).

Chapter 3 | The Origins of a Quinologist: John Eliot Howard and the Business of Quinine

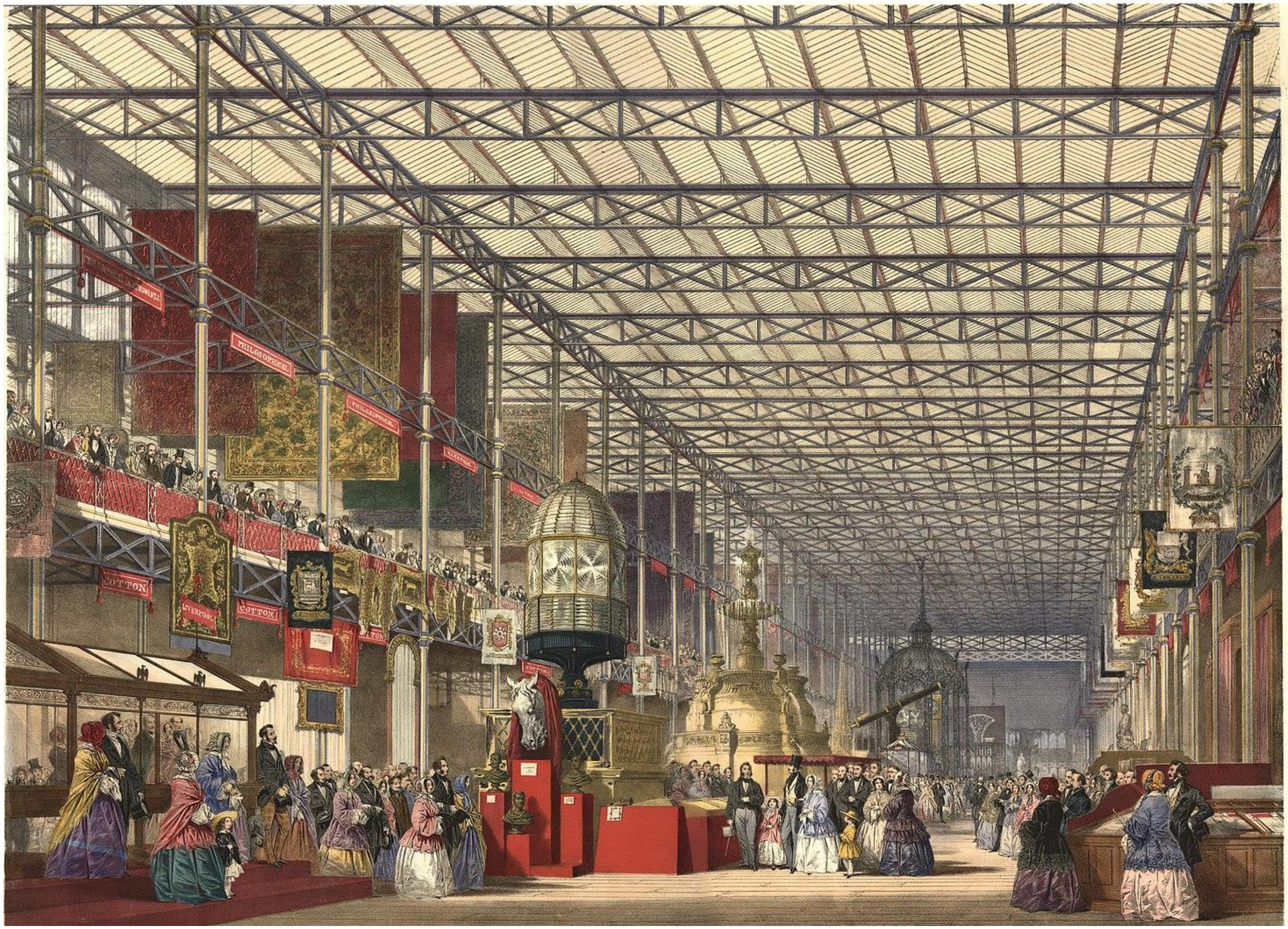


Figure 3.1 The British Nave of the Great Exhibition.
Print from Dickinson (1854). © The Trustees of the British Museum.

3.0 Vignette - The Crystal Palace, 1851

Moving through the doors like sand through an hourglass, crowds flow. Ladies in a kaleidoscope of Sunday-best linen and silk, behatted gentlemen in dark suits or bright military gear and children wide-eyed and round-mouthed in wonder. Above, sparkling in the sun 293,655 panes of glass filter light onto the theatre below. This is the Great Exhibition of the Works of Industry of All Nations. Six million people will tread its 10 miles of exhibits and stare in awe at the 100,000 objects that showcase global human ingenuity: a parade, a festival, a celebration.

The exhibition is the brainchild of Queen Victoria's consort, Prince Albert and civil engineer Henry Cole, curated to inspire and promote industry and arts of all imagination: from Irish linen to Chinese silks, slices of timber from far-away forests to high tech machinery, finely wrought jewellery to grand stained-glass windows. Down the broadwalks wonders march: Glass fountains, the Koh-I-Noor diamond, a lighthouse head, a stuffed elephant. The space is bedecked with colourful banners and burgundy signs signalling each section, chosen to represent the four exhibition themes: raw materials, machinery, manufacture and arts.

Walk through the South Entrance, heading towards the British Nave, past the great crystal fountain and up the wrought iron stairs to the first floor. Peer over the central balcony down to the central displays: Dent's station clock towers over the chemical trophy, a shimmering display of immense red, yellow, green and blue crystals mirroring the palace around it. Alum, Rochelle salts, nitrate of potash, soda and spermaceti worth £1,000 have been distilled by William Pattinson, a chemical manufacturer from Newcastle-Upon-Tyne. Turning away from this, a wander through the Paisley shawls leads to the chemical section proper where glass cabinets display hundreds of the latest and most important chemical drugs and medicines from around the world. The display by pharmaceutical manufacturers, Howards and Kent, is almost unobtrusive, a contrast to the technicolour pomp and glory around it: one hundred chemicals and raw products. Amongst these, the diminutive slices of fever bark don't catch the eye. They exemplify the company's vast cinchona collection representing trade imports for the past 20 years. It also contains barks sourced by their curator, the quinologist John Eliot Howard, from contacts across a European network. The labels read:

1. Various calisaya bark (*Cinchona calisaya*)
2. Carabaya bark (*C. ovata*)
3. Cusco bark (*C. pubescens*)
4. Carthagena bark (*C. cordifolia*)
5. Red bark
6. Crown Bark
7. Grey Bark
8. Loxa Bark
9. Various descriptions of barks used for adulteration
10. cinchona australis
11. Cascarilla macrocarpa 52986?
12. Cascarilla carua
13. Cascarilla magnifolia
14. Buena hexandra
15. Exostema Peruviana or tacumez bark
16. Laplacea quinoderma
17. Salts of quinine and cinchonine: Disulphate, sulphate, citrate, hydrochlorate, phosphate, and tartrate,
18. Quinidine.[66]

The display drew comments from the *Pharmaceutical Journal* which described it as 'unique', and was awarded a prize medal. ('The Great Exhibition – Official award of the prizes', 1851, p. 15.) It is this exhibition of barks, and the firm's in-house expertise, that enabled Howard's access to historic institutional collections and the first of many journal articles for the Pharmaceutical Society. Howard donated the display for the Society's Museum, the first of many donations throughout his career.[67] This gift was undeniably philanthropic but also, no doubt, a shrewd move. Howard and Sons items would not only help train pharmacists but also be a form of marketing to graduates about to enter practice and stock their dispensaries with choice products.

[66] 'Great Exhibition', 1851, p. 14.
[67] 'Donations to the museum' 1852.

The Crystal Palace exhibition marked a pivotal point for Howard, at the age of 44, when he moved from solely working for family business interests and came to wider public notice for his collections. His collection practices change around this period, as will be discussed in Chapter 5. His work swiftly led to wider recognition, as he entered the scientific world as a collector, pharmaceutical educator, expert, consultant and quinologist.[68]

[68] Sources drawn upon this vignette include: Anderson, 2015; 'Great Exhibition', 1851; The Great Exhibition—Official award of the prizes', 1851; Hunt, 2011; Morson, 1997a; 'Plan of the Great Exhibition, 1851; Stephenson, 1851.

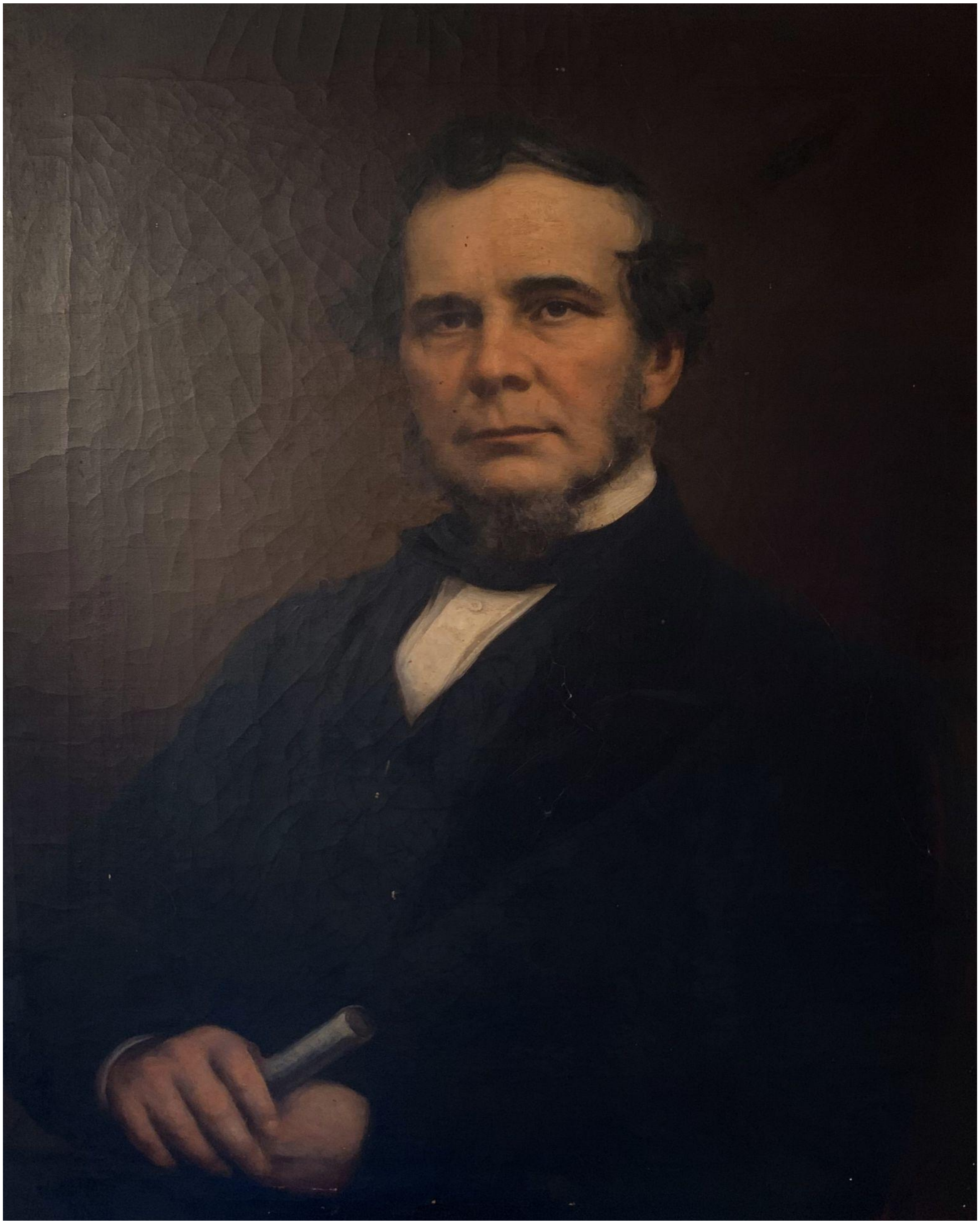


Figure 3.2 John Eliot Howard (1807-1883).
Howard could be holding a scroll, a test tube, or a cinchona specimen jar (Figure 5.7).
Oil painting circa. mid-nineteenth century, artist unknown. In the possession of Howard descendants and reproduced with kind permission of Tabitha Fox.

3.1 Introduction

As discussed in the previous chapter, the demand for quinine as a medicinal and imperial tool increased over the nineteenth century. By the time of his death, in 1883, John Eliot Howard was widely acclaimed as a one of the most important quinologists, of his time (Figure 3.2) ('Obituary' 1883a; 1883b). This chapter traces the origins of Howard's interest in quinology in his role within the Howard family business, situated within the wider context of the development of pharmaceutical manufacturing in the nineteenth century. The chapter also explores the influence of Howard's family life on his religious, scientific and humanitarian beliefs.

Howard was a member of the well-known Quaker family whose Stratford-based factory, Howards and Sons, produced chemicals such as borax, tartaric acid and quinine between 1797 and 1975. His development as a businessman and a man of science was eased by good timing and opportunity. He joined the family business in 1823, just as quinine started becoming a profitable chemical for manufacture. The Howard family was a large, wealthy, close-knit and well-connected group, already successfully established in many aspects of manufacturing, science and industry. Not only did family circumstances provide the financial and educational opportunities for him to thrive, but they also supplied a social foundation to launch him into his career. His quinological works not only expanded research on the botany and chemistry of cinchona, they also enabled the family business to become leaders in the mass-manufacture of quinine.

3.2 Quinine and the alkaloid industry

In the early years of the nineteenth century, there was a shift from the use of whole plant drugs towards that of extracted, purified chemicals (Chakrabarti, 2014; Houghton, 2021). As part of a wider industrial 'chemical revolution', this led to a transformation of the scale and practice of medicine and pharmacy (Chakrabarti, 2014; Slater, 1955; Roberts & Werrett, 2017). As the active chemicals of botanical drugs were isolated one after the other, novel types of scientific research, laboratory-based mass-manufacturing and commerce arose across Europe, particularly Britain, France, Germany and the Netherlands (Chakrabarti, 2014; Porter, 1999; Slater, 1955; Slinn, 1995). This new industry supported, and was supported by, the expansion of European empires. At the same time as tropical areas were opened up to exploitation, tropical plants flowed into laboratories for investigation and medicines flowed back out to combat diseases, especially those that challenged imperial projects (Chakrabarti, 2014; van der Hoogte & Pieters, 2014).

Rapid developments in technology and engineering, particularly through enhanced factory machinery for production, as well as canal and later railway links for distribution, supported the upscaling of manufacture; no longer was medicine limited by the size of the chemist or apothecary shop (Anderson, 2021; Kemp, 2014; Mercelis et al., 2017; Roberts & Werrett, 2017). The chemical revolution of the early nineteenth century also provided the setting in which pharmacologists, and quinologists, were able to develop their specialist skills in connecting botany and chemistry (Slater, 1955)

The isolation of quinine and other active chemicals from medicinal plants reduced dependency on unreliable raw plant drugs with several important outcomes. Firstly, doctors could measure dosage instead of relying on whole plant preparations that exhibited variable efficacy (Greenwood, 2004). Secondly, scientists could now quantify active content and connect species with chemistry, allowing the targeting of species for extraction and cultivation. Thirdly, the purified chemical could be extracted, quantified and sold as a 'pure', reliable product by manufacturers. Promoting chemical purity in medicine was a popular marketing strategy in the nineteenth century. This was influenced by a wider concern regarding adulterations in food and medicine leading to regulation through the Sale of Food and Drugs Act 1875. (Deb Roy 2017; Houghton, 2021; Jackson, 2023; Russell et al., 1977; Ziegler, 2003).

The first alkaloid isolations to be published were of narcotine (now known as noscapine) in 1803 and morphium (morphine) in 1806, both isolated from the latex of opium poppy (*Papaver somniferum* L.) (Drobnik & Drobnik, 2016; Roersch van der Hoogte, 2015;

Schmitz, 1985). The term 'alkaloid' itself was coined later in 1818 by Carl Meissner who based the category on their alkaline properties and who assigned the -ine suffix to future alkaloid classification, renaming morphium as morphine (Schmitz, 1985). Other alkaloid isolations quickly followed including the two main alkaloids derived from cinchona: 'cinchonin', was originally extracted by Lisbon-based Bernardino Antonio Gomes in 1810 (Pita et al., 2022). However, it was refined and renamed cinchonine in 1820 alongside the more famous quinine, by the French chemists, Pierre-Joseph Pelletier (1788–1842) and Joseph-Bienaimé Caventou (1795–1877) (Pelletier & Caventou, 1821; Ziegler, 2003). Another French chemist, Louis Pasteur (1822-1895), published in 1853 on the other two major cinchona alkaloids and his discovery of molecular chirality (chemical mirror images also known as isomers): he had discovered quinidine (an isomer of quinine) and clarified the identity of cinchonidine (an isomer of cinchonine) (Gal, 2019).

The 1820 isolation in particular signalled the start of an era of mass-production of purified alkaloids, with quinine one of the earliest to be manufactured at a large-scale (Chakrabarti, 2014; Ziegler, 2003). By 1827, Pelletier was mass-manufacturing quinine, 90,000 oz (2.55 metric tons) of quinine was being produced in France every year (Morson, 1997b; Wisniak, 2013). Some of this was exported to other countries including Britain and America who quickly looked to break the 'French monopoly' (Slater, 1964, p. 124).

The first successful commercialisation of quinine production in Britain was achieved by Alexander Low in Jersey, and Thomas Morson (1799-1874) in London. Low had studied in Paris between 1816 and 1822, writing his thesis on medical use of quinine. On his return to Jersey in 1822, he started to manufacture quinine, sending it for sale via his brother in India, but the venture was short lived.[69] Similarly, Morson also learnt his skills in quinine production from the French, studying in Paris between 1818 and 1820 under Pelletier himself. He swiftly transferred his skills to London for commercial production in 1821, and became the first to manufacture commercially within Britain, and continued to do so for

[69] Howard family correspondence on Alexander Low, ACC/1037/853/1/21, London Metropolitan Archives.

some years. However, while Morson successfully built up four manufacturing laboratories across London, they maintained their retail businesses too. Howards dominated the quinine scene, perhaps given an advantage by their large, centralised factory, manufacturing focus, and in-house expertise from John Eliot Howard ('A short account', 1916; Morson, 1991; Morson, 1997b; Richmond et al., 2003).

3.3 The business of quinine: Howards & Sons

> C'est notre metier [It's our business], we have to live by the practice of Chemist art, and not by exhibiting it as a science. The success of our endeavours, under the vigorous competition which every ingenious man has here, to sustain, depends on using, while we can do it exclusively, the few new facts that turn up in the routine of practice. (Luke Howard, 1822)[70]

Howards and Sons chemical manufacturers was established in 1797 and was passed down through five generations of the Howard family until it was sold in the 1950s (Table 3.1) The origin of the business lies with the family patriarch and Quaker chemist, Luke Howard (1772-1864) who established it with financing from his father's successful tinware business (Slater, 1955). Luke Howard was a prolific publisher on meteorological science but never published on chemistry, as explained in the opening quote: restricting knowledge of processes gave an edge on business.

Luke Howard's chemical training started at fifteen when he was apprenticed to a chemist and druggist, later gaining commercial experience working for a wholesale drug supplier in Bishopsgate ('An Aged Relative', 1865). In 1796, he partnered with fellow Quaker, William Allen (1770-1843) of Plough Court Pharmacy. Allen later took responsibility for the pharmacy while Luke managed the laboratory in Plaistow, Essex, assisted by another Quaker chemist, Joseph Jewell (1763–1846) ('An Aged Relative', 1865; Burton, 2017; Slater, 1955). Company sales came predominantly from production of borax, camphor and saltpetre. but it also produced around 71 other chemical and medicinal products. In addition, the partnership was not only in the business of production and dispensing, it also

[70] As cited Bud & Roberts (1984, p. 24).

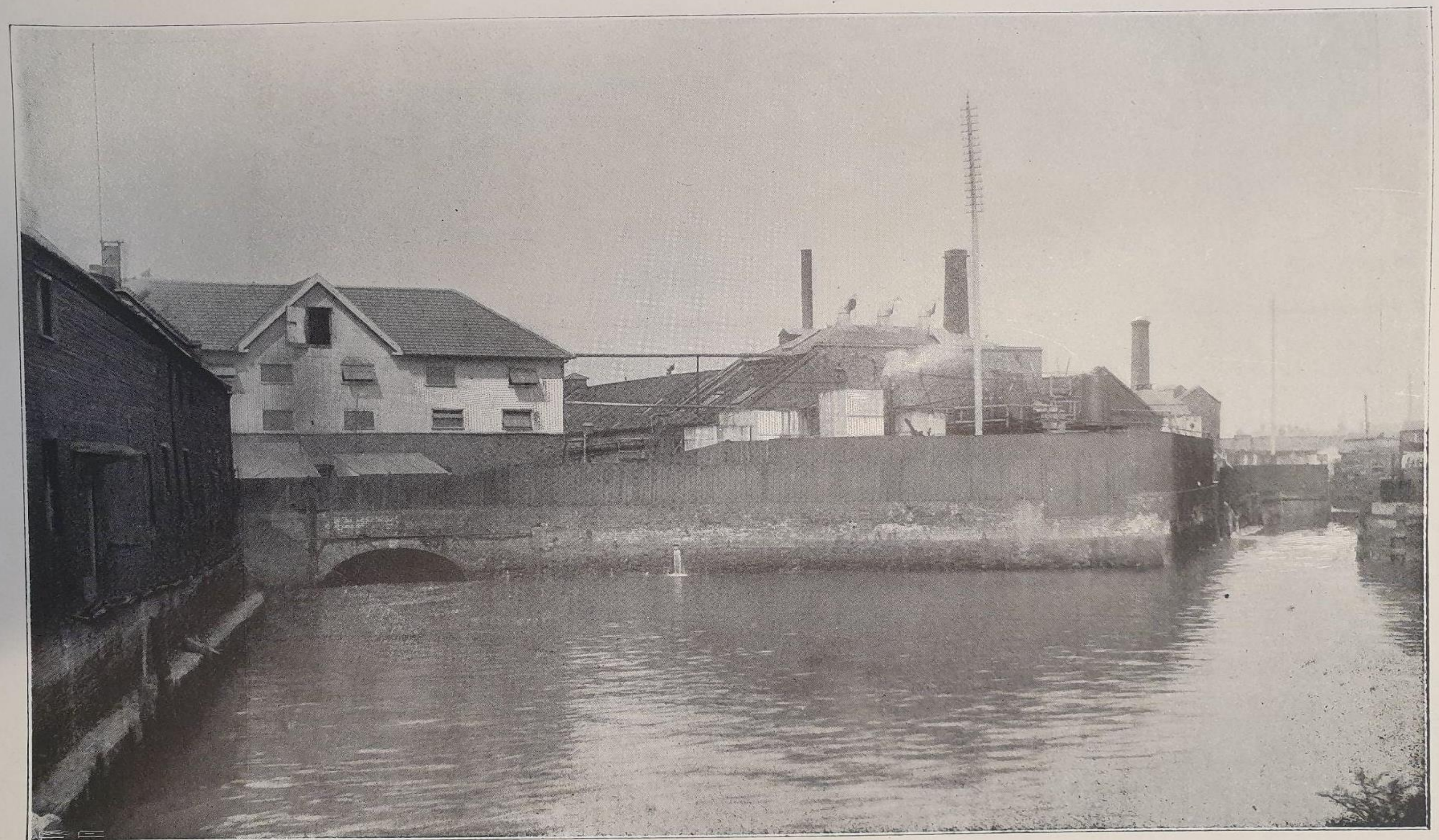
undertook original research in developing and refining extraction methods (Simmons, 2017; Slater, 1955).

Around 1806, the partnership between Howard and Allen was amicably dissolved, with Luke Howard and William Allen separating off their respective business spaces of the Plaistow chemical laboratory and the Plough Court dispensing pharmacy ('Howards and Sons chemical works', 1897; 'Howards of Stratford and Ilford', 1914; Slater, 1955). In 1841, Allen became a founding member of the Pharmaceutical Society, an important network for pharmacists and manufacturers (Hudson & Boylan, 2013). Howard then set up a company under the name L. Howard & Co., which evolved under many partnerships, eventually becoming Howards & Sons in 1858. The naming, economic and business history of Howards and Sons from 1797 has been researched by Slater (1955) and Richmond et al. (2003) and summarised in Table 3.1

Table 3.1 Dates, names, partners and locations of Howards factory 1797-1975[71]

Date	Name	Partners	Location/Notes
1797-1806	Allen & Howard	William Allen, Luke Howard	Plaistow, Essex
1805-1806	L. Howard & Co.	Luke Howard	1806, City Mills, Stratford, improvements and rebuilding until 1807
1807-1823	Howard, Jewell & Gibson	Luke Howard, Joseph Jewell & John Gibson	
1824-1830	Howard, Jewell, Gibson & Howard	Luke Howard, Joseph Jewell, John Gibson & Robert Howard	Luke Howard and Joseph Jewell retire on 31 December 1830
1832-1837 or 1841	Howard, Gibson & Co.	John Gibson, Robert Howard, John Eliot Howard, Robert Gibson & John Kent	
1841-1858	Howards & Kent		
1858-1903	Howards and Sons	Robert Dies 1871, after which John Eliot becomes a sleeping partner. David and Dillworth Howard takes on management.	1875, parts of factory destroyed by fire; 1898 Move to Ilford
1903 onwards	Howards & Sons Ltd.	Wider members of the Howard Family	1914 City Mills lease given up
…	…	Up until 1949, Howards and Sons existed with many subsidiaries, see Richmond et al. (2003)	1949, subsidiary Thorium PLC established a new radiochemical factory in Amersham
1953	Howards of Ilford	Known by this name in advertising prior to 1953.	
1961	Howards of Ilford	Laporte Industries Ltd takeover	
1975	Bilstar Ltd	Manufacturing ceases	

[71] Table 3.1 data taken from: 'Howards, 1797-1947', 1947; 'Howards and Sons chemical works', 1897; 'Howards and Sons', 2020 'Howards of Stratford and Ilford', 1914; Slater, 1955; Richmond et al., 2003; 'The origin of an old chemical factory', 1897; 'Work of the radiochemical centre', 1949 and ACC/1037/005-010, London Metropolitan Archives.



CITY MILLS, FROM HIGH ROAD.

Figure 3.3 Quinine Department. Howards and Sons, City Mills, Stratford (right, with three chimneys) ca. 1897.
Image from ‘Howards and Sons Chemical Works, 1797-1897’ (1897).

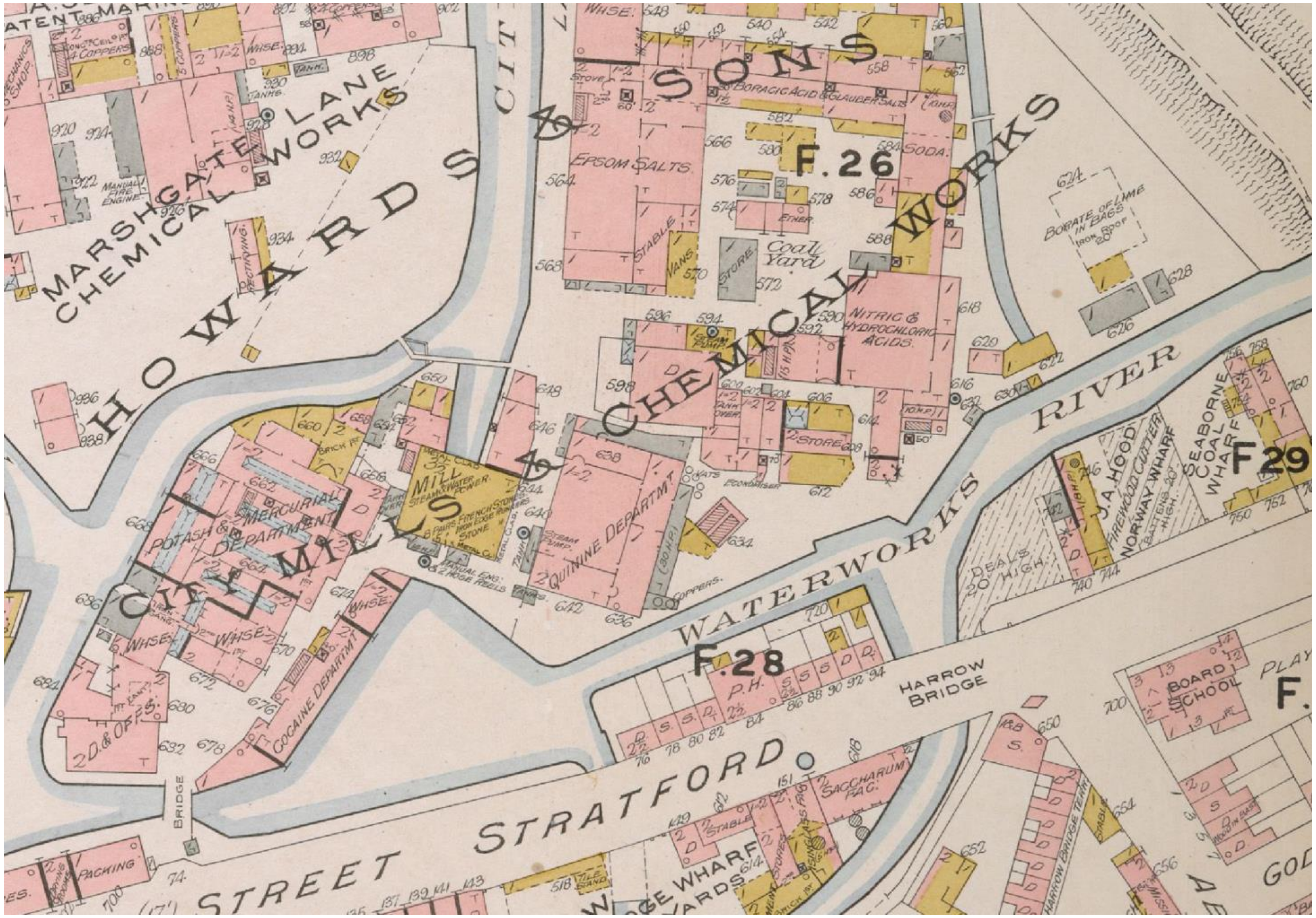


Figure 3.4 Quinine department (centre) at Howards & Sons.
Goad Insurance Plan of London North East (Goad, 1893).

3.3.1 A Stratford factory

In 1807, business expansion called for larger premises. Luke Howard moved the firm's laboratory to City Mills in Stratford, a site in industrial use since the thirteenth century (Figure 3.3 & 3.4) (Powell, 1973; Slater, 1964). The marsh location had the benefits of three types of transport link: road, canal and eventually, rail. These led directly to and from the city - and from there, the world beyond. An example of growth during the Industrial Revolution, the Stratford site had expanded to include many specialised factories and sites of industry that formed an indirect interdependence: paper mills, copper works, textile bleaching and dye mills, as well as other chemical factories (Christie, 2017; Clifford, 2018). Stratford was a vital part of London's industrial landscape and a nucleus of practical chemical (and other) research and development.

Howards and Sons' move reflected a wider industrial shift in pharmaceutical manufacturing: from small-scale shop to large-scale factory as discussed above. The relocation to City Mills was important because larger industrial processes could be established using the power from existing water mills (Clifford, 2018; Slater 1955). This automation was enhanced by gas installation at the factory in 1823 and the addition of a steam powered engine in 1829 (Slater, 1964).[72] The mill provided the larger space for increased scale of manufacturing, with roofs described as towering over 40 feet high ('Howards and Sons chemical works', 1897). Figure 3.4 shows the 1893 factory footprint. The original factory building can be seen in the yellow central 'Mill' building straddling a creek to the left of the Quinine Department.

The relocation translated into business success. They mass-produced and supplied mainly wholesale chemicals such as cocaine, borax, tartaric acid, calomel, Epsom salts and other ingredients used in pharmaceutical medicines ('Howards and Sons chemical works', 1897;

[72] Advertisements of steam powered machinery listed Howards and Sons as users to show the confidence that would be given in the engineering. See 'Hayward, Tyler & Co, Improved rider pattern horizontal steam engine' on the last pages of Howard (1877b).

Slater, 1964; Strauss et al., 1867). Records show that in 1821, 30 workers were employed, by the 1830s, there were 43 and by 1867, there were 200 (Simmons, 2017; Strauss et al., 1867). Company Archives at Redbridge include numerous receipts for imports of crude drugs via the East India Company. The global roots of many ingredients are noted to include Tibetan tincal, East Asian camphor and South American cinchona bark (Simmons, 2017).[73] Simmons (2017) suggests that early development of pharmaceutical industry production to the large-scale processes is visible in the example of Howards and Sons, for example, through their purchase of 5 tons of saltpetre in September 1819.

The processing of these chemical products benefitted from investment in modern technology, equipment and research (Figure 3.5). As a visitor described in 1867, they were shown:

> …a well-appointed laboratory, in which we find every possible appliance for analysing samples… this little chamber gives us at once the key to the secret of the continuous growth in eminence and importance of [Howards and Sons]… founded by two men [Luke & John Eliot Howard] of high scientific attainments, they were amongst the first of our chemical manufacturers who recognised the value of conducting a scientific manufacture on scientific principles; and the scale upon which the business is now carried on, and position that their productions occupy in the markets of the world are standing proofs of the truth of the doctrine that theory and practice must always go hand-in-hand in manufactures. (Strauss et al. 1867, p. 149).

[73] Redbridge Archives contain many files of such receipts, but two examples include 90/360/E2/F1 and 90/360/E2/F1.

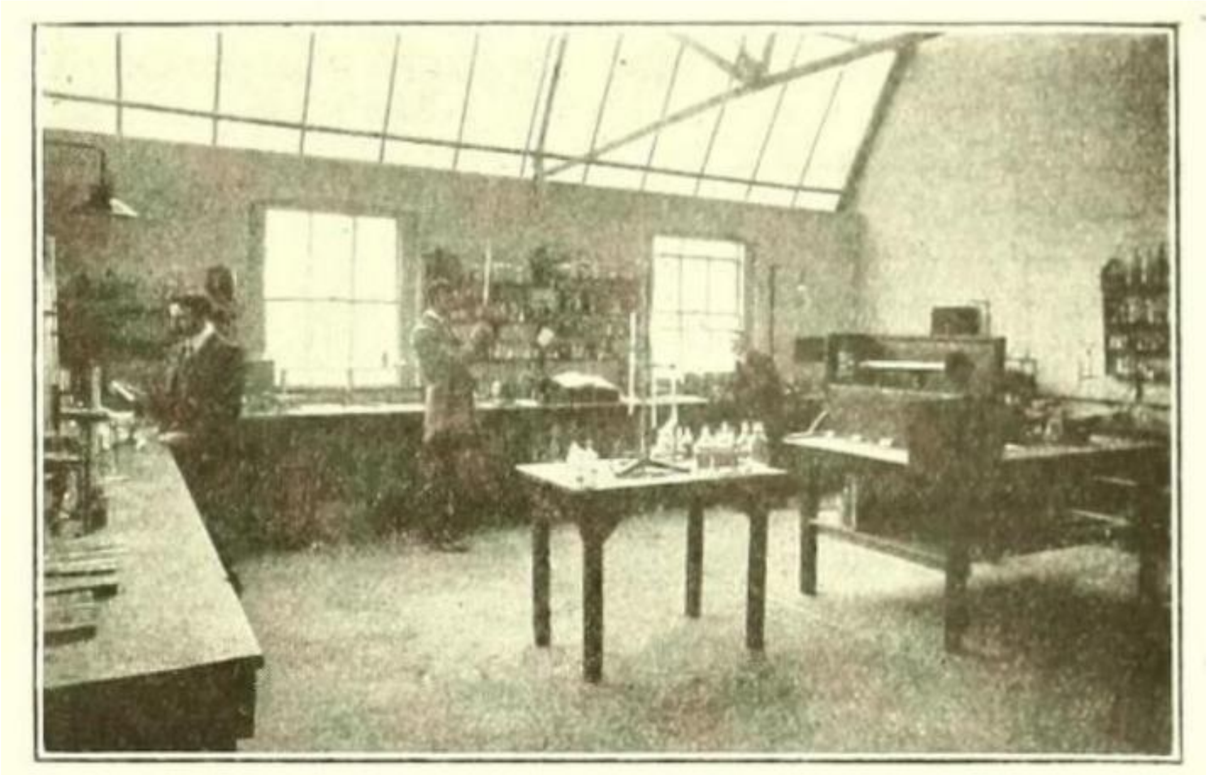


Figure 3.5 A factory laboratory at Howards & Sons, 1914
Image from 'Howards of Stratford and Ilford' (1914).

3.3.2 Quinine production

And when the quinine trade begun,
Frenchmen got nearly all the run,
which made them well contented;
But I won't rob them of their crown,
They ought to have what is their own,
They first the trade invented.
But I began my skill to try,
and wished to rise up quite as high,
as any French practiser;
But I the Frenchman's way forsook,
and work'd by my old thinking book,
and got a little wiser.
(Joseph Jewell, 1846, p. 38)

Following the isolation of quinine in 1820, the company was quick to recognise the value of transforming cinchona bark into a profitable, refined crystalline powder. As mentioned earlier, Howards and Sons were not the first chemists to introduce quinine manufacture to Britain, however, they were one of the first to mass produce on an industrial scale in 1827, eventually becoming the main British supplier by the early twentieth century ('Howards of Stratford and Ilford', 1914).

Slater (1955) suggests that the firm's early business success was based on the chemical skills of Jewell who had partnered with Luke Howard in 1813, Howard being preoccupied with meteorology. As the poem at the beginning of this section suggests, Jewell had developed his own method for extracting quinine (Slater, 1964). This occurred around 1823, just as John Eliot Howard graduated school and joined the company. John joined in quinine research around 1827, Jewell noting: 'a young one filled my place and ran a faster quinine race than I, a slow progressor'. Howard eventually became a business partner by 1832, shortly after Jewell retired (Jewell, 1846, p. 39).[74] John Eliot Howard was trained by Jewell via a 'pupilage at pans and stills', learning the chemical extraction and

[74] ACC/1037/005-010, London Metropolitan Archives.

pharmacognosy (drug quality assessment) skills required for processing cinchona bark into quinine (Howard, 1885; 'Howards and Sons Ltd' 1903, p. 581.). A record of Jewell's method of extraction has not been found, but it is likely a similar, possibly improved method that John Eliot Howard went on to use in the business (Slater, 1964).[75] Simmons (2017) notes that pharmaceutical secrecy was an important part of successful business practice, as implied also by Luke Howard's quote at the beginning of the section/ This may explain why the recipe remains elusive. As Luke Howard stated in the quote at the beginning of Section 3.3 success despite 'vigorous competition' was about concealing rather than exhibiting skills in an effort to keep exclusive control (Howard, 1822, as cited in Bud & Roberts, 1984, p. 24). In *A visit to England's workshops* (Strauss, 1867), the general extraction method was described (See Chapter 5, vignette). However, a descendant of the Howard's expressed 'considerable surprise' that 'my forebears, usually, from all accounts, the most reticent of men, should have allowed such a detailed description of their process to have appeared in print!' (Howard, 1931, p. 15). Still, weights and measures, vital for the method, were not given and this may have maintained secrecy. Perhaps the account also omitted crucial steps.

It is difficult to pinpoint the date when Howards and Sons began production of quinine. Although Jewell developed a technique for extracting alkaloids around 1823, Slater (1955) suggests these were classed as 'cinchona alkaloids'. This may indicate the difference in dates given in company histories stating that 'quinine' production started in 1827. The date of the company's bark collection shows that cinchona bark was being bought from earlier date: Strauss et al (1867, p. 144) recorded that the collection contents 'consist of typical specimens of every year's importation, from 1824 to the present time' which suggests some form of alkaloid production occurred before the 1827 date.[76]

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[75] Later mid-century recipes exist in the records of Howards and Sons (Chemists), such as the Extractions Book, ACC/1037/292, London Metropolitan Archives.
[76] Howard's own handbook organising the company barks starts in 1828. While this may suggest the bark collections themselves started around the 1827 date, it likely only reflects the beginning of Howard's interest in quinine, which started in 1827 according to his personal diary (Howard, 1885).

Company records are incomplete and it is difficult to ascertain precise profitability of quinine compared to other products as a whole (Slater, 1955).[77] Surviving records show that during the late nineteenth century, quinine sales alone were highly profitable, equivalent to millions of pounds per year in modern prices (

[77] See London Metropolitan Archives, records of Howards and Sons (Chemists) ACC/1037

Table 3.1 and Figure 3.6).[78] In 1867 it was recorded that Howards and Sons processed around 1 ton of cinchona bark per day. Cinchona bark contains between 3% and 6% quinine alkaloid by weight, which means production of 30 to 60kg of quinine alkaloids per day. Howards and Sons recorded that profit from quinine alone that year came to £231,000 (equivalent to around £14 million pounds today), (Appendix 2, Figure 3.6).[79] Figure 3.6 and Appendix 2 reveals between 1862 (date of Howard's first book) and his death in 1883, company profits increased by over 2.5 times.

In Figure 3.6 and Appendix 2, Howards and Sons company quinine profits are divided into 'home', 'foreign' and 'government' sales. Between 1861 and 1867, Howard provided official consultation to the British Indian cinchona plantations and continued to exert considerable influence on plantation decision making after this period (Howard, 1876; Howard, 1885). He provided this service gratuitously, not receiving any direct monetary reward, although the government bought large amounts of Howards and Sons pure alkaloids for trials on thousands of patients in 1866.[80] There is also evidence they exported large amounts of quinine, being asked to tint their product for sale in India to show its authenticity (Deb Roy, 2017). Howard's role may also have resulted in indirect profits: generally, sales significantly increase after this period of consultation. Though correlation does not imply causation, a plausible hypothesis is that Howard's fame and circulated publications may have functioned as positive marketing tools, increasing confidence in company expertise, which translated into confidence in company products then purchased by pharmacists and chemists at home and abroad.

How else can the importance of quinine to the company be evaluated? Looking at the insurance map in Figure 3.4, the large size of the quinine department compared to other

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[78] Data taken from Laboratory Calculations Book, Redbridge Archives, 90/360/E2/A5
[79] 'Laboratory Calculations, 1862-1902, 90/360/E2/A5, Redbridge Heritage Centre Archives; The National Archives, 'The National Archives - Currency Converter: 1270–2017', accessed 25 November 2019, http://www.nationalarchives.gov.uk/currency-converter/.
[80] *British Parliamentary Paper No. 353, East India (Chinchona plant)* (1863-1866), Section I, Item No. 51, p. 134.

departments may reflect the scale of the production of quinine in relation to other products. In addition to this, the company's appearance at exhibitions, such as the Great Exhibition of 1851 described in the opening vignette to his Chapter, show the central role that cinchona and quinine products played in the displays, again highlighting its wider significance. Records show exhibition displays continued after 1851: Howards and Sons thus had a prize-winning display at the International Exhibition of 1862 in London, this time alongside illustrations and living specimens grown by Howard (Hanbury, 1862).[81] And at the Paris Exposition of 1867, over 180 barks were displayed in what Howard, described as a 'great Babel show' (Howard, 1885, p. 20; 'International Exhibition', 1862; Proctor, 1869).

Howards and Sons were the largest British supplier of quinine, but how did the business compare to other companies in Europe? The French had successfully dominated the early quinine market, through the isolations of Pelletier and Caventou and later through Delondre (see Sections 3.2 and 4.3). French samples can be found within Howard's collections, showing their contribution was not insignificant, however this remains an area for further research, much of the French collections remaining inaccessible. In contrast, more is known about German business. Ziegler (2003) studied Jobst & Co, a similar company based in Stuttgart. Parallels can be drawn between the two companies in that they were both family-led businesses producing quinine from around 1827. However, there are key differences. The founder, Friedrich Jobst (1786-1859), was an entrepreneurial businessman first and foremost and did not train as a pharmacist. Ziegler shows that, in Germany at least, there is evidence that not all manufacturers arose directly from pharmacists like the Howards and Sons. In contrast to Howard, Jobst also took a central role in business strategy, whereas in J.E. Howard's case, other members of the family fulfilled this role, enabling him to focus solely on his research.

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[81] The drawings were likely from Howard's recent 1862 publication, *Illustrations of the Nueva Quinologua of Pavon* which was illustrated by artist Walter Hood Fitch.

By 1914, the *Chemist and Druggist* noted that Howards and Sons were the sole British company producing quinine, in a market largely controlled by the Dutch monopoly (‘Howards and Sons (Ltd)’, 1903; ‘Howards of Stratford and Ilford’, 1914). Redbridge archives show the company’s quinine sales peaked in 1940 due to war demand, followed by an interruption due to the Japanese invasion of Indonesia blocking exports from Java.[82] Later, sales generally declined as quinine demand waned in preference of chloroquine and the company focused attention on other profitable products such as aspirin (Coatney, 1963; Krafts et al., 2012; Richmond et al., 2003).

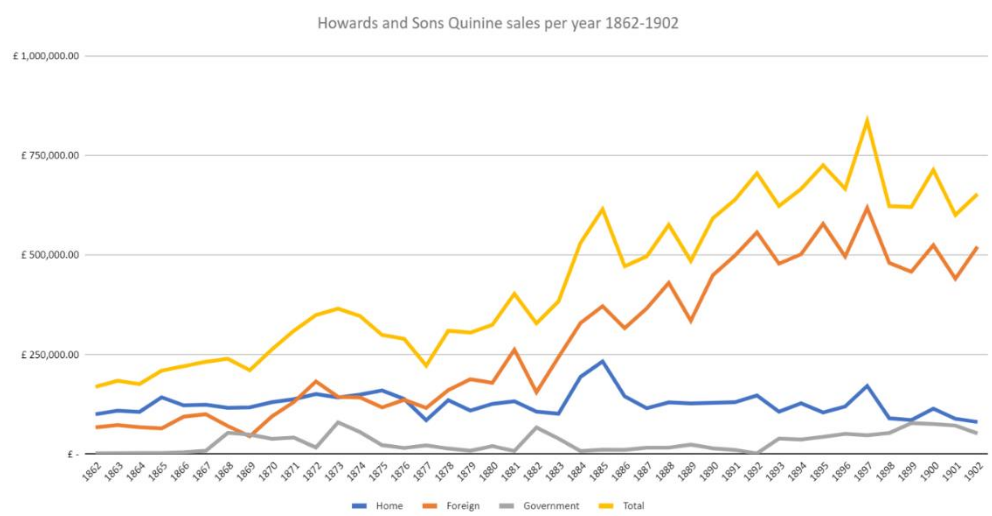

Figure 3.6 Quinine Sales per year 1862-1902, sourced from Appendix 2.

[82] Howards 1847-1947 A treatise compiled by Bernard F Howard in 1956, Redbridge Archives, 90/360/F1/7

3.4 John Eliot Howard: A biographical introduction

The chapter's opening vignette describes Howard's first known public display of barks at the Great Exhibition of 1851. At the time of the display, John Eliot Howard was 44, with nine children and his work had affected his health. His wife, Maria, recorded:

> This was the year of the Great Exhibition, presided over by Prince Albert. The collection of chemicals and barks exhibited by the firm occupied much time and thought, and the award of a special medal was a very gratifying result; but the health of your father gave way, and for the remainder of the year he suffered from inflammation of the knee-joint, and was for some time on crutches; in the autumn he spent several weeks at Umberslade, a hydropathic establishment, where he received much benefit, and also was enabled to minister spiritual comfort to some patients who were in the house. (Maria Howard, 1885, p. 21)

Despite this, Howard's career as a cinchona expert was established and continued to grow over the following years. The Great Exhibition represents the moment John Eliot Howard came to the fore, but who was the man who both curated scientific displays but also 'ministered spiritual comfort'?

The following sections explore the social and cultural influences on Howard's life. A timeline showing an overview of significant events in Howard's life is provided in the following Table 3.2.

Table 3.2 A timeline of key dates in Howard's life[83]

Year	Event	Place of residence
1807	Born 11 December. Home educated for early years.	Plaistow, Essex
1821	Went to Quaker-run Josiah Forster's School, Tottenham	Tottenham, Summers in Ackworth (bought by LH in 1820)
1823	Joined Stratford works to learn practical chemistry, rides out daily to Stratford by horseback (estimated 1 hour each way, approx. 3.6 miles)	Living with Uncle John Eliot (Namesake) in Bartholomew Close, London EC1A
1824	Family business starts producing quinine.	"
1825	Becomes partner in family firm. Meets Maria Crewdson, future wife.	"
1827	First diary record of interest in quinine	"
1828	Proposed to Maria Crewdson.	"
1829	Made partner in family company	"
1830	**March**: Uncle John Eliot dies, Moves in with Aunt in Bruce Grove, Tottenham. JEH rides out to Stratford daily by horseback. **9th September:** Marries Maria Crewdson, moves to her family home in Kendal for a few months before returning to London.	Bruce Grove, Tottenham Helme Lodge, Kendal Lords Meade, Tottenham
1851	Display of cinchona barks and alkaloids at the Great Exhibition which won a prize medal.	Lords Meade, Tottenham
1853	Publication of book (made up of articles published 1852-3) 'Examination of Pavon's collection of Peruvian barks contained in the British Museum'. Membership of the Pharmaceutical Society.	"
1855	Publication of the appendix to 'Examination', Examines the collection at Kew.	"
1857	March, elected Fellow of the Linnean Society	"
1860	Indian cinchona plantations established	"
1862	Publication of *Illustrations of the Quinology of Pavon*	"
1869	Publication of *The Quinology of the East Indian Plantations*	"
1874	June 4th, elected Fellow of the Royal Society	"
1876	Retired from Stratford	"
1883	Hanbury Medal from the Pharmaceutical Society (awarded for high excellence in original research into the natural history and chemistry of drugs)	"
1883	22 November: John Eliot Howard dies.	"

[83] Table 3.2. data taken from 'Obituary' 1883a; 'Obituary; 1883b; Slater, 1955; Kirkwood & Lloyd, 1995; Howard, 1885.

3.4.1 Howard's family life

> But [Luke] Howard gives us with arranging mind
> A new display of science's latest find;
> What once could not be brought within our view,
> He grasps it fast, and makes us see it too.[84]

The Howards of Tottenham were an affluent, socially prominent family, members of the Quaker Society of Friends, influential in the history of science and religion in late eighteenth and nineteenth-century Britain (Slater, 1955; West et al., 2016). John Eliot Howard's grandfather Robert (1738-1812) made his fortune from introducing a Swiss lamp widely used in homes across Britain (Slater, 1955). His father Luke Howard was founder of the family pharmaceutical manufacturing business and joint-founder of the Quaker-led, scientific debating club, the Askesian Society (Slater, 1955; West et al., 2016). This club provided a space for networking with scientists and businesspeople of his time, including those that were otherwise excluded from higher education, like Quakers. It was here in 1803 that Luke presented his meteorological research on 'the modification of clouds' (Howard, 1803). Luke conceived a cloud-pattern classification system and his ideas influenced nineteenth-century culture beyond science, inspiring artists and writers from Constable to Goethe (see the above poem quote): his terminology is still in use to this day and has been called the 'namer of clouds' and 'Father of meteorology.' ('An Aged Relative', 1865; Burton, 2017; Hamblyn 2002; Howard,1803; Howard et al, 1976; Pedgley, 2003; Scott, 1976; Slater, 1972; Stephens, 2003).

Luke Howard's love of natural history went beyond his business needs as a pharmaceutical manufacturer, it also extended into his home life. In a biography of Luke's life written by a relative shortly after his death, it was noted he was:

> …very diligent in his attendance at the laboratory, and very persevering in any experiments which could throw light on the science of Chemistry. He had a room fitted up in his own house with various sorts of instruments for scientific

[84] An extract of Goethe's poem, *Howard's Ehrengedächtnis*, in Honour of Luke Howard, translated by J. G. Cotta 1840, cited in Howard, 1885).

> investigation, and this room was a very favourite resort in his leisure hours. ('An Aged Relative', 1865, p.7)

Luke wrote in 1792, that chemistry was a not only a 'noble science' but also a 'lasting source of amusement' (as cited in 'Howards, 1797-1947', 1947). John Eliot was the fifth child born to Luke and his wife Mariabella and he was educated at home with his siblings, amid his father's laboratory experimentation ('An Aged Relative', 1865). This early exposure to scientific pursuits and laboratory workings appears to have captured the imagination of the young children and influenced his son's later career choices. In the memorial of Luke's life, another passion both father and son shared is revealed: as a child Luke was noted to have spent much time studying botany and collecting specimens 'which gave much pleasure to his parents and friends' ('An Aged Relative', 1865, p. 4). However there is no evidence that John Eliot received anything beyond a basic school training in botany.

As discussed earlier, Luke Howard's first pharmaceutical business was established with 'lifelong friend', fellow Quaker and chemist William Allen. Allen later established the Pharmaceutical Society at Plough Court in 1841 and, as the Royal Pharmaceutical Society, it remains an influential professional association to this day (Howard, n.d., as cited in Slater, 1955. p. 25). The Howard-Allen connection may have later helped John Eliot's introduction to the wider pharmaceutical network and aided introduction to publishing in the Society's *Pharmaceutical Journal and Transactions*, one of his main research outlets Although Luke does not appear as a founding member of the Society, his oldest son and brother of John, Robert Howard (1801-1871) does ('Members', 1841).

Natural history and societies, such as the Askesian established by Luke Howard, also give us another insight into John Eliot's scientific pursuits. These scientific societies allowed the 'social legitimation' and increased cultural capital of 'marginal men' such as the Howards, who were nonconformist middle-class traders. This allowed an enhanced social standing providing access into the upper levels of society, since science was traditionally seen as a gentlemanly pursuit (Davidoff & Hall, 2002; Thackray, 1974, p. 678). Historian of science Arnold Thackray has shown that by the 1830s and 40s, it was common to find descendants of manufacturers ‘active in the consolidation of science within the central value system of English life’ and ‘generational patterning’ (Thackray, 1974, p. 678-679). Howard’s pursuit of science, even if associated with family business, was part of this social movement, building upon and continuing the advancements of his grandfather and father in society. This may also partly explain why Howard provided much cinchona consultation work for free, rather than seeing it as a profitable opportunity. Slater (1955, p. 82) posits that Luke Howard’s interests were ‘professional rather than commercial’, as business was the only avenue in which he could pursue his scientific interests. This seems to be also true of his son.

John Eliot’s mother, Mariabella (née Eliot, 1769-1852), herself a member of another prominent Quaker family, was recorded to have divided her time between her family’s education and the philanthropic work, something common to Victorian middle-class women and members of the Quaker network (‘An Aged Relative’, 1865; Tusan, 2009; Davidoff & Hall, 2002). The focus of Mariabella’s philanthropy included promoting the abolition of slavery and advocating the education of poor families, later becoming a superintendent of a school in Ackworth (Kirkwood & Lloyd, 1995).

Mariabella and Luke had eight children in total, many of whom did not survive into adulthood. The eldest surviving sons were Robert and John Eliot who moved into business with their father. Robert performed the managerial position within the factory, while John the research. However, Robert was a chemist in his own right, having helped found the Pharmaceutical Society and occasionally producing informative letters and articles, though not at his brother’s rate. For example, he published a letter in 1854 critiquing an article on ‘the mode of distinguishing quinine from quinidine’ in which he shows he well understood the method of preparing the alkaloids. In addition he was also involved in the family philanthropy. The sons appear to have got on well and their connections evidence more of the intertwinement of business, religion and life (‘An Aged Relative’, 1865; Howard, 1854; ‘Obituary of Robert Howard’, 1872).

John Eliot married Maria Crewdson (from another prominent Kendal Quaker family) in 1830, both aged 23, subsequently producing nine children over a period of 18 years. These family responsibilities, along with his work in the family business may have influenced the character of John Eliot Howard's cinchona work – he rarely travelled beyond Europe and never to cinchona's native habitat in South America, nor to the plantations of India, instead experiencing cinchona through the docks and lab benches (Howard, 1885; Kirkwood & Lloyd, 1995).

John Eliot and Maria Howard (Figure 3.7) appear to have had a close relationship. He wrote frequently in letters and poetry of his love for her and their family (Howard, 1885). It is clear Howard relied on Maria for emotional, as well as practical support: a 'beloved helpmeet to win me back to brighter thoughts', which also suggests that Howard may have tended to a melancholy nature (as cited in Howard, 1885, p. 105).

The early influence of his mother's humanitarian philosophies and his father's scientific pursuits and networking clearly laid the foundations of two key threads that weave through the life and pursuits of John Eliot Howard: science and humanitarianism.

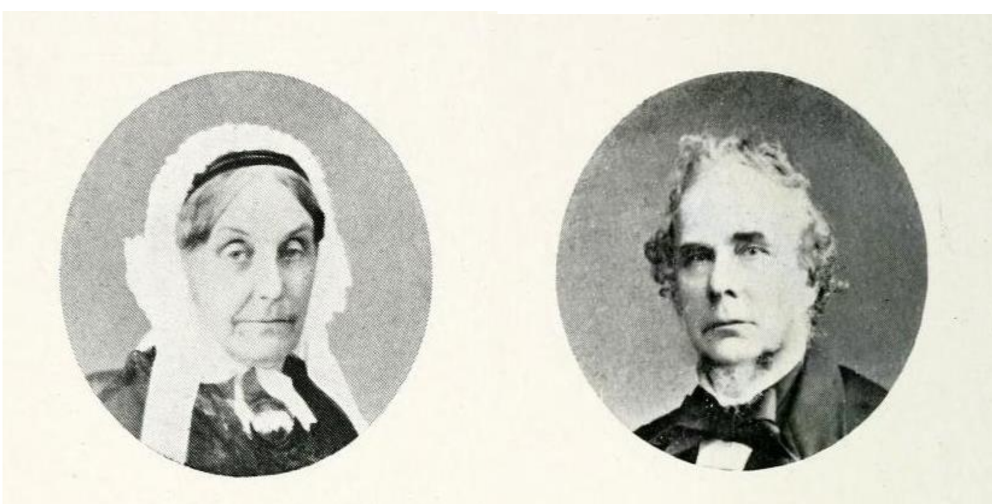

Figure 3.7 Maria Howard née Crewdson (1807-1892) & John Eliot Howard.

Image from *Photographic pedigree of the descendants of Isaac and Rachel Wilson.* (Benson, 1912, p. 284).

3.4.2 Heavenly things: Howard and spirituality

> But whilst thus occupied in natural science his heart was set upon heavenly things… he gave himself to preaching the Word, and caring in many ways for his fellow Christians - ministering to the sick and needy, and seeking to serve all who came within his reach.' (Maria Howard, 1885, p. 18.)

Howard and his religious influences have been explored elsewhere, for example, in Mathieson's (2018; 2020) work on the relations of science and religion at the Victoria Institute (of which Howard was a founding member); in research on the shift by Howard's family from the Quaker faith towards Brethrenism, with John Eliot himself a key figure (West et al., 2016); and in discussion of the role of the Quaker faith as an influence on Howards and Sons (Slater, 1955). In this section, the early influence of the Quaker faith on Howard's philosophy will be emphasised. The role of Quakers in the development of science, social welfare and commerce in Britain during and after the Industrial Revolution has received much attention from historians. Their representation in the wealthy upper-middle class was notable (Brooke & Cantor, 2000; Cantor, 1997; 2003; Cookson, 2004; Davidoff & Hall, 2002; Slater, 1955; Turnbull 2014; Tusan, 2009; West et al., 2016).

From early on in their history, Quakers loomed large in the members lists of many scientific, philanthropic and commercial societies, not least the Royal Society itself, to which Luke and John Eliot were elected Fellows in 1821 and 1874 respectively (Howard, 1885; Slater, 1972).[85] As Quakers were excluded from higher education, the fostering of social networks through such organisations meant that the community developed other ways to provide intellectual and business support within the Quaker group, strengthened by intermarriage (Davidoff & Hall, 2002; Slater, 1955). Some of today's most famous successful brands have early Quaker roots, including Cadburys, Rowntree, Frys, Quaker

[85] *Candidate Election Certificate for John Eliot Howard (1807-1883)*, Certificates for Election 1874, NA6285. Royal Society Archives, London.

Oats, Clarks shoes, Barclays and Lloyds Banks. (Cantor, 1997; 2003; Turnbull, 2014). In addition, the establishment of banks that were originally 'not-for-profit' also allowed the lending of money to members to develop commercial interests. For example, the Lloyd banking family was closely associated with the Howards. An early bank manager, Howard Lloyd, married John and Maria's daughter, Mariabella (Kirkwood & Lloyd, 1995).

As suggested by Maria Howard in the quote that introduced this section, religion played a major role in Howard's life, even above his scientific work. From around 1833, he studied Hebrew to better appreciate religious texts (Howard, 1885).[86] Howard was born into a family of active Quakers, becoming a 'birthright' member. However, along with many members of his family, he resigned from the Society of Friends in 1836 in a 'Quaker Controversy' over theological concerns. Howard moved allegiance to the Plymouth Brethren (Howard, 1885, p.9; Kass & Kass, 1998; West et al., 2016). Historian Rosemary Mingins (2003) explores the wider shift towards evangelicalism in the Quaker movement during this period, suggesting it was in response to wider political and social changes. The reasons for the shift are complex but were partly to do with a yearning for a more vocal, evangelical style of worship and a desire to increase readings and lectures within meetings. Members questioned the Quaker doctrine of the 'Inward Light' whereby group worship was not led by selected preachers, but generally a silent meeting open to any within the congregation who felt moved to speak in the moment as guided by the Holy Spirit. This included women, a contrast to the Plymouth Brethren who do not allow women to preach (Davidoff & Hall, 2002; Mingins, 2003; Howard, 1885). Howard's own feelings on the place of women can be seen when he wrote 'I have a great respect for the judgement and Christian feeling of our 'women friends' in its right place', i.e. not in the religious space (as cited in Howard, 1885, p.91).

Although Howard left the Society of Friends with his family, he did not cut off his associations with Quaker colleagues entirely. Writing to his mother in 1836:

[86] Howard also spoke French, German and Latin (Howard, 1885).

> I deeply regret the manner in which some Friends who have left the Society have thrown themselves off from Friends, as I believe it not likely to be beneficial either to themselves or to those whom they have left, and I can sincerely say we have no such intention. Indeed there are no persons with whom one can more comfortably co-operate in charitable associations, or mix in ordinary intercourse; and as the Society undoubtedly contains very many bright examples of Christian excellence, it seems uncharitable to act thus. We feel that the visit which we have received from the Overseers places us in a different situation. I should at present prefer quietly resigning my connection with the body to being considered a disorderly member, or under dealing. (As cited in Howard, 1885, p. 85)

John Eliot Howard established his own place of worship in June 1839: a Plymouth Brethren meeting hall in Brook Street, Tottenham (Figures Figure 3.9). The building remains in use by its congregation today, with original architectural features and Howard's original credo on the wall (Figure 3.8)('Brook Street Chapel', n.d.; Kirkwood & Lloyd, 1995). Howard himself went on to preach to the congregation two to three times weekly, and oversaw attendance reaching 200, leading the conversion and baptism of many (Howard, 1885). Attendees at the chapel included many influential figures in nineteenth-century science and literature including the poet Emily Bowes (1806-1857), her husband and naturalist Phillip Gosse (1810-1888), Founder of children's homes, Dr Thomas Barnardo (1845-1905), Founder of the Exclusive Brethren, John Nelson Darby (1800-1882), and missionary James Hudson Taylor (1832-1905) ('Brook Street Chapel', n.d.; West et al., 2016).

Maria Howard's memorials record her husband as being in the habit of 'rising very early to secure the time' to work on theological questions (Howard, 1865a, p. 4). The volume of Howard's religious writing competes in number with his scientific ones and include the first and last of his publications (Figure 2.5). Scientific publications arose later in his life after the age of 44, instigated by a display of his barks at the Great Exhibition in 1851, as discussed in this chapter. Howard also combined the two themes, giving lectures on reconciling 'scripture and science' at the Victoria Institute (Howard, 1865a; Livingstone et al., 1999; Mathieson, 2018). Also known as the Philosophical Society of Great Britain, the Victoria Institute was established in 1865 to defend the Bible against scientific challenge in the wake of Charles Darwin's (1809-1882), 1859 publication *On the Origin of Species* (this is explored further in Chapter 6). In the context of the longstanding debate over the relations between science and religion, Howard appears as something of a conservative figure at least in relation to biblical authority (Brooke & Cantor, 2000; Cantor, 1997; 2003; Lightman, 2001; Mathieson, 2018). His resistance to Darwin's theories of species change affected his understanding of cinchona (this is discussed further in Chapter 6).

Howard's religious convictions cannot be overlooked when attempting to understand his scientific works. Both science and religion were clearly fundamental to his work and motivations. His religious works often contained scientific references, though his scientific works rarely mention religious points. When they do arise, it is clear that Howard was seeking to harmonise the two spheres to which he devoted much of his public life.

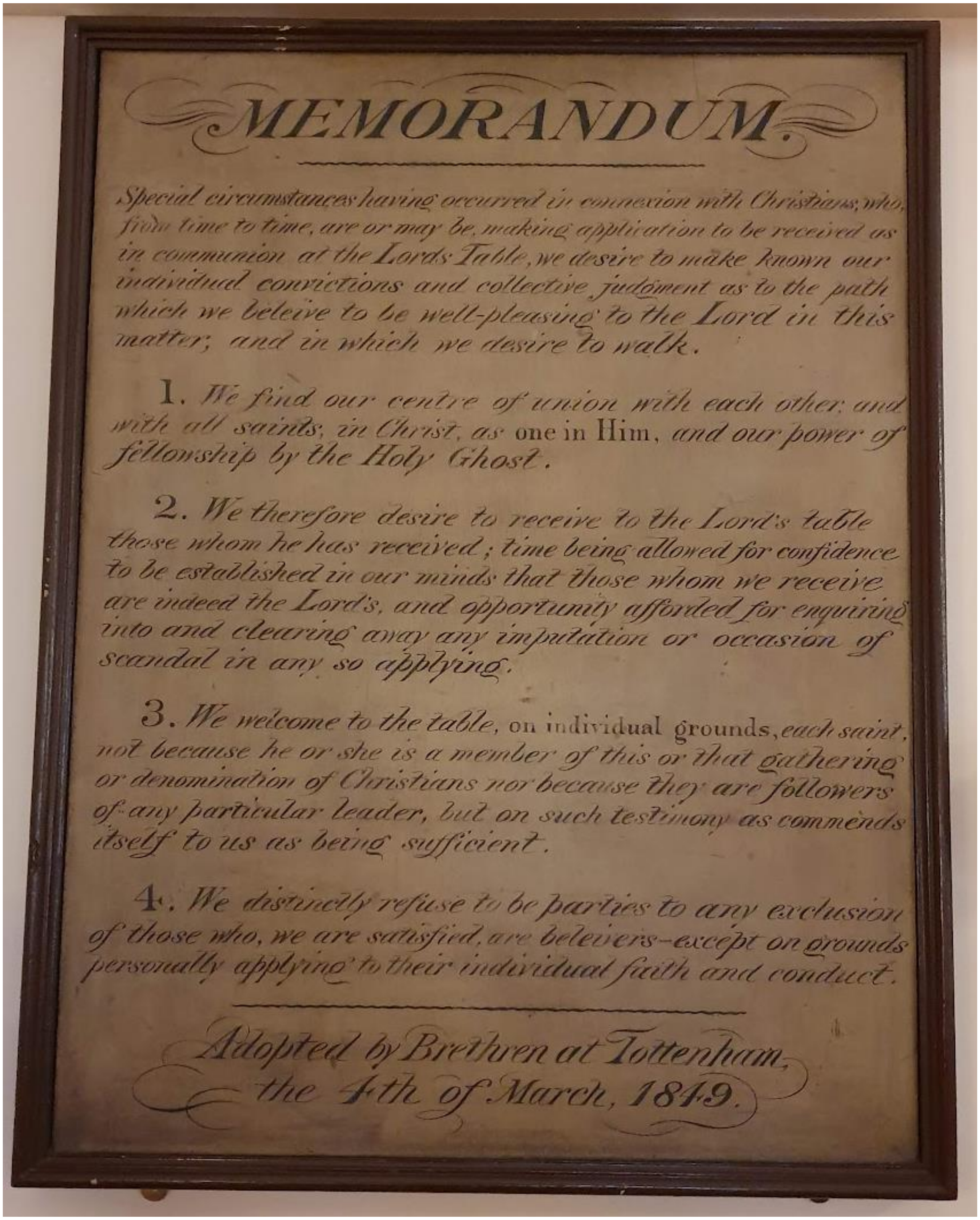

Figure 3.8 Howard's original chapel Brethren memorandum of 1849.
The sign remains by the entrance to the Brook Street Chapel. Author's own image.

Figure 3.9 Brook Street Chapel, set up by John Eliot Howard 9 June 1839.
Top: With permission from John Frost, Brook Street. Bottom: The Chapel today (Ohsimone, 2008).

3.4.3 Charitable associations and humanitarian motivations

Amongst Howard's early influences, Quaker beliefs regarding humanitarian works are clearly important. As the quote above from Howard's letter to his mother indicates, his resignation from the Society of Friends did not preclude continuing 'charitable associations' (Howard, 1885, p. 85). Howard was described as of 'unworldly character and habits… though opulent, he lived simply… using his wealth in his Master's service' ('Obituary', 1883b, p. 596). Throughout his life he continued to dispense philanthropy through and beyond his Quaker connections. During a cholera outbreak in 1849, for example, Maria Howard recorded:

> At Stratford it was very bad, the population almost decimated. My husband remained at home, going daily to the works—occasionally seeing the sufferers and giving away much medicine, which was of great use in many cases. (Maria Howard, 1885, p. 19)

Howard had also been involved in introducing a cheaper quinine alternative to the market, sulphate of quinidine, giving away doses freely to those who asked (West et al., 2016). Howard's humanitarian works didn't end with pharmaceutical charity. He set up a scientific institute and library for workers in the family business and the sacks that cinchona bark and other materials came in were made into clothing for the poor in Lancashire where a depression had taken place (Strauss et al, 1867). He also donated financial aid for relieving 'Sheffield Distress', a period of intense poverty ('The Mayor's distress fund', 1879).

On a broader scale, Howard provided financial aid to the anti-slavery cause and was a member of the Society of the Suppression of the Opium Trade ('Basle Evangelical Mission', 1864). In 1859, he was a signatory to a fervent public appeal regarding opium smuggling into China (Alexander et al., 1859, all quotes from p. 3). The appeal is steeped in language that places British civilised superiority over 'semi-barbarous' peoples, describing a 'cruel advantage taken of the weakness of a half-civilised State'. However, the horror of British collusion is spelled out: How, do the authors ask, will those responsible justify themselves before God? They go on to urge the readers to be roused for the 'moral sense of England….

before it is past your power of recall' (Alexander et al., 1859, p. 3). Among the other fifteen names signing the plea, there are notable anti-slavery campaigners such as Robert Fowler (1798-1904), later Lord Mayor of London, Quaker activist Joseph Sturge (1793-1859) and a range of other notable public figures including Major General Alexander of the Madras Army and the Quaker pathologist Thomas Hodgkin, who was related to Howard through marriage (Kass & Kass, 1998).

While Howard protested against oppressive measures in China on one hand, he also funded friend and fellow Brethren, James Hudson Taylor, to establish Christian missions in China on the other. Undoubtedly this was with the intention of saving its population from 'barbarous' ways towards a more Christian one. In addition, he also supported the imperial project of cinchona cultivation in India, tied into colonial domination (Howard, 1885; West et al., 2016). As a man of his time, Howard believed that bringing 'civilisation' and 'morality' to the non-British world was essential, but it must likewise be done in ways that met his moral standards. In this context, the question of self-interest arises: for example it has been suggested that Howard's promotion of quinological research was motivated by commercial gain (Deb Roy, 2017). However, a deeper review of his life shows the reality was more complex. Howard's work for Kew and for the Indian government was provided free-of-charge, without remuneration. Kew's Director professed Howard to have a 'well-sustained reputation of being an enlightened philanthropist, who has energetically aided the Indian Government' (Hooker, 1879, *C. Calisaya* section). In addition, within Howard's lifetime the company continued to purchase South American barks, only shifting to a reliance on Indian-cultivated sources after his death, therefore not directly profiting from his work, as was discussed further in Chapter 1. As shown in this section, Howard's scientific work was as at least as strongly influenced by Howard's humanitarian works as an evangelical Christian, as it was by the search for profit.

3.4.4 The affair of the basket

The aspects of Howard's personal life discussed thus far have drawn heavily on his wife's memorial, written in a hagiographical style common to the period. However, less positive views of Howard's personality and his family business are evident in other sources. In 1993, a meeting of Howard family descendants took place to celebrate the centenary of the 'Lord Meade's Budget', a family newsletter started in 1893. This meeting led to a small self-published biography of John Eliot Howard compiled by two of his great, great grandchildren. Within this booklet is a telling family story highlighting tensions within the family's business.

John Eliot Howard's main role in the factory was as a research scientist, while his elder brother Robert directed the commercial side. After Robert's death in 1871, the succeeding senior partner (by age) was John Eliot, but the company was managed by Robert's two sons, Samuel and David along with John Eliot Howard's eldest son, Dillworth (Kirkwood & Lloyd, 1995). There were subsequent hierarchical conflicts as recorded by Geoffrey Howard, Robert's great-grandson:

> They were all men of strong character, absolutely straightforward and upright but with fairly hot tempers. John Eliot had left the Quakers but was an unbending Plymouth Brother… he was a difficult and obstinate man when opposed. Dillworth was a terrific worker and held strong views, but naturally took his father's part when differences of opinion arose. Samuel had revolted against the narrow religious views of his parents and had little use for that side of his uncle's character… [and was] determined to have his own way… [Samuel] chafed hotly at the restrictions placed on his work by his colleagues. Furious quarrels resulted as to who should be the greatest among them... The partners met every morning and the opened mail was brought in a basket which had always been placed before the head of the firm for action. After Robert's death, a scramble for the basket used literally to take place, these really serious-minded men each seizing it and tearing it out of each other's hands in a struggle to be recognised as the Presiding Genius of the Conclave… (Geoffrey Howard, cited in Kirkwood & Lloyd, 1995, p.16)

According to this account, the situation was only resolved when another member of the family, Robert's younger son Theodore, joined the company. Theodore was a 'devout and honest Christian' who was well liked and held a peace-making role (Kirkwood, 1995, p.17). Perhaps Theodore's devout religious leanings earned the respect of his uncle, allowing him to calm the troubled waters. Shortly after the incident, John Eliot Howard became a sleeping partner. John's son Dillworth and Robert's son David take on the management. David had been trained in quinine extraction by John Eliot and appears to have taken on more of the chemical management, publishing his own works on cinchona for the *Pharmaceutical Journal* ('Howards, 1797-1947', 1947; Kirkwood & Lloyd, 1995).[87]

3.4.5 The death of Howard

> A large number of neighbours, rich and poor, awaited the funeral... while the address was given the utmost stillness prevailed, and tears involuntarily flowed from many eyes.[88]

Howard died following a brief illness on the 22 November 1883, shortly before his 76th birthday, just a few days after preaching at his chapel. Only one of his nine children had predeceased him and he had seen the growth of his family's business to one of the largest European manufacturers. His success is reflected in the fortune of his estate, £43,548 (equivalent to ca. £3 million pounds today),[89] bequeathed to his wife and children.[90]

Howard established himself as an authority in two spheres: a specialist scientific field and a deeply observed religious life. While these two pursuits may seem at odds with one another, they were merely a representation of a single passion: seeking the truth at the heart of the matter. Though Howard was undoubtedly motivated in business, the search for profit was also tempered by his humanitarian and spiritual beliefs. The reach of his achievements was reflected in the description of his sizeable funeral cortege with thousands of mourners. Over 30 carriages containing respected members of religious and scientific circles were in attendance, including the President of the Pharmaceutical Society, the Lord Mayor Sir Robert Fowler (1828-1891), as well as Lord Justice of Appeal and Quaker, Sir Edward Fry (1827-1918). It was reported that mourners felt that 'the best man in Tottenham has gone from us' ('Obituary', 1883b, p. 596).

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[87] See also Howard, D. (n.d.). *Notes on cinchona bark.* Manuscript, EBC, RBGK.
[88] 'Obituary 1883b, p. 592.
[89] The National Archives Currency Converter 1270-2017. (TNA, 2018)
[90] Grant of Probate 6 February 1884 and Last Will and Testament of John Eliot Howard, Principal Probate Registry, England & Wales.

Howard was buried at Tottenham Cemetery (Figure 3.10). An obituary of his life in the *Pharmaceutical Journal* for December 1883 concluded with the following statement:

> The labours of John Eliot Howard are over, but the harvest is far from being yet reaped. Many a poor sufferer who never heard his name will profit unconsciously from the work of his life, and the wreath of cinchona leaves laid on his coffin was a fitting emblem of the service he has rendered to humanity.[91]

3.5 Summary

John Eliot Howard, entering pharmaceutical manufacturing around the time of the isolation of quinine, was well placed to start a career as a specialist researcher in his family's pharmaceutical manufacturing business, Howards and Sons of Stratford. With their London location in an industrial hub, cutting-edge technology, cheap labour and access to global trading networks, this gave the space and means for Howard to develop his expertise on cinchona. His place in the factory laboratory, developing his chemical and pharmacognostic skills and dipping into trade networks is discussed in Chapter 5.

His large and well-connected family provided John Eliot Howard an early foundation in devout religious and humanitarian principles which shaped his entire life and work. In particular, his abiding belief in the bible as the ultimate source of authority set him on a course which involved public disagreement with more radical interpretations of Darwinian theory and certainly affected how he saw cinchona species, as discussed in Chapter 6.

Although Howard's work started off within the commercial and industrial sphere, the display of his cinchona barks at the Great Exhibition of 1851 signalled a shift to a more public-facing career as a researcher. The next chapter examines the making of Howard's career as a quinologist and especially the key role of his cinchona collections within his particular brand of science. Unlike his father, Howard took quinology beyond the idea that *'C'est notre metier'*, helping to turn it into a scientific field in its own right.

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[91] 'Obituary', 1883a, p. 439.

Figure 3.10 Howard's gravestone, Tottenham Cemetery.
Image Author's own.

Chapter 4 | Objects of Unusual Study: The Making of a Quinologist

Figure 4.1 Cinchona bark collected as part of *Real Expedición Botánica al Virreinato del Perú y Chile* 1777–1816.

These barks were analysed by Howard in his 1853 *Examination of Pavón's collection of Peruvian barks contained in the British Museum*. EBC 52506, RBG Kew. Image Author's own.

4.0 Vignette - The British Museum, 1852

A series of dark boxes run in a line across a large table. Inside lie barks in various sizes from fingernail-sized chips and pencil-slim quills to big flat slabs. The shades of colour range from light cocoa-brown through to deep rust-red. Small discs of wood sit alongside the boxes, pale tops gleaming dully under the light, with an inch or two of dark bark encircling them. The size of the palm of a hand, they represent slices from a ghostly branch, the space around them echoing the limb they once belonged to. The bark and woods on the table are the remains of long-gone Peruvian cinchona trees that once stood in front of the Spanish botanists, Ruiz and Pavón on their Spanish Royal expedition 75 years before. One might expect these important specimens would be housed in the Royal Botanic Gardens in Madrid, but they are now in London. Hovering above the specimens with an analytical eye, is the quinologist John Eliot Howard. To him, these barks and woods are pieces of an incomplete jigsaw puzzle, which, when placed together, will reveal the key to understanding the perplexing taxonomy of the *Cinchona* genus. Howard is not alone for this examination. He stands alongside the famed Jonathan Pereira, Professor of Materia Medica at the College of the Pharmaceutical Society and both men have brought their own personal collection of specimens for comparison.

Howard has spent nearly a quarter of a century building up his own personal cinchona cabinet, drawn from the packages of barks which flow through his family's quinine factory doors and into bubbling vats. These specimens act as a reference collection beside which other barks can be compared and their chemical value assigned. Among this collection of trade barks are others sent through a European network of quinologists, experts who exchange and circulate samples, and knowledge, of cinchona. The barks Howard has brought today come from a number of sources, including botanist Hugh Algernon Weddell who travelled to Peru collecting cinchona; French pharmacist Nicolas Jean Baptiste Guillaume Guibourt (1790-1867); and specimens originally collected by explorers Alexander von Humboldt (1769-1859) and Aimé Bonpland (1773-1858), given to him by the Parisian *Muséum national d'Histoire naturelle.*

Parts of Howard’s own collection were recently on show at the Great Exhibition of 1851, winning a medal for excellence and gaining Howard renown for his expertise in a specialist subject. The doors to the British Museum had been opened by both this recent recognition and through his connection to Pereira and other well-known cinchona experts. Howard’s examination of the Ruiz and Pavón collection represents the next phase of his research: delving deeper for knowledge on the origins of trade barks arriving on the shores of England, by connecting them to field-corroborated specimens gathered in their distant Andean homeland.

Others before Howard had struggled to define cinchona, even if they were lucky enough to visit the cloud forests where it grew. However, they did not have chemical experience and cutting-edge laboratory tools Howard now had at his fingertips. Howard would now attempt to answer age old questions with modern techniques. The problem was pressing. Only a year previously, the same year as the Exhibition, the Dutch had set up their own cinchona plantations in Indonesia and would soon be mass-producing quinine. It would not be too long before the British would follow suit. Howard sensed an opportunity for a home-grown expert. Based on his examination of these specimens in the British Museum and others, he would soon produce a series of expert articles in the pages of the *Pharmaceutical Journal*, sealing his reputation as Britain’s leading quinologist.

4.1 Introduction

> The importance of the febrifuge alkaloids to the family of mankind has rendered the plants yielding these medicinal products the objects of unusual study… [the *Nueva Quinologia*] will, I hope, not be without fruit in extending the knowledge of the family of the Cinchona, and promoting the introduction of these plants into new regions of the earth. (Howard, 1862. p. i)

As discussed in the previous chapter, the start of an era of alkaloid isolation and mass-production in the pharmaceutical industry was the setting for Howard's early-stage career (1823-1851). The family business supported his chemical and pharmacognostic interests, his skills honed on the trade barks flowing through the factory doors. Howard's professional connections in the cinchona trade world enabled him to build networks of knowledge and specimen exchange and provide an expert display at the Great Exhibition of 1851, signalling a new type of research, analysing Andean collected specimens to add to his factory bark collections. He now possessed enough recognised expertise to gain access to key collections in the British Museum and Kew. These contained, older, wild-collected, botanically assessed material to which Howard could connect his pharmacognostic knowledge. His trade barks were compared and verified with these comprehensive institutional specimens, further augmenting his knowledge and skills.

This chapter explores the next stage of Howard's work: his development as an expert quinologist through the collections he examined and the networks he built over the 1850s, exchanging and circulating bark specimens. This period resulted in his first scientific publications about the British Museum and Kew specimens in 1853 and 1855 respectively (Howard, 1853; 1855). Discussion of this work is set in the historical context of the evolution of quinology, starting with the Spanish-South American expeditions of the late eighteenth century.

As Britain sought to catch up with the Dutch to mass-cultivate cinchona in the 1850s and 60s, Howard's research positioned him as a key specialist. This led to his consultation on the British imperial project transferring cinchona from the Andes to plantations in British

India. Although existing historiography emphasises Kew's role in this transfer (see section 4.6), Howard himself was a key influence on Indian cultivation and alkaloid mass-production.

4.2 From the Andes to Europe: Early cinchona collection

As outlined in Chapter 1, cinchona was the only known effective treatment for malaria in Europe from the seventeenth until the early twentieth century. This translated into high market demand, increasing over the eighteenth and nineteenth centuries as European empires expanded into tropical colonies (Wallis, 2012; Headrick, 1979). However, the market relied on raw materials arriving from remote and sometimes obscure origins. Until the mid-nineteenth century, the only contact most Europeans had with the Andean tree was through the hard-to-distinguish bark pieces which arrived on trade ships. Though physicians and pharmacists trained in pharmacognosy may have been able to distinguish a trade bark as true cinchona rather than an adulteration, chemical variability was also an issue. Selecting alkaloid-rich barks often depended on chance as much as skill (de Blégny & Talbor, 1682; Bergen, 1821; Crawford, 2016; Howard, 1853; Klein & Pieters, 2016).

The Spanish Crown, colonial ruler of most of South America until the 1820s, understood that scientific knowledge would enable better control of the continent's commodities, particularly cinchona. Throughout the second half of the eighteenth century, state-sanctioned expeditions were launched to capture biological data and ethnobiological knowledge from the area (Bleichmar, 2009; Crawford, 2016). Other Europeans also embarked for South America during this period, most famously Alexander von Humboldt in a self-financed trip (with official Spanish permission) between 1799 and 1804 (Cuvi, 2022; von Humboldt et al., 2008). However, this period's wealth of botanical collecting was predominantly the result of Spanish projects, due to their political control of the area and its infrastructure (Bleichmar, 2009; García Guillén & Muñoz-Paz, 2003; García Guillén & Noya Santos, 2016).

However, data-gathering efforts were complicated. Cinchona was, and remains, notoriously difficult to understand botanically. Rivalry between various South American expeditions and botanical hierarchies back home in Spain clouded knowledge production about the genus leading to obscured, contested and concealed knowledge (Crawford, 2016; Perez et al., 2004). An example of this is shown in the rivalry between two competing expeditions. José Celestino Mutis (1732–1808), led the *Expedición Botánica al Virreinato de Nueva Granada* 1783-1816.[92] Hipólito Ruiz López (1754–1816) and José Antonio Pavón Jiménez (1754–1840) led *La Real Expedición Botánica al Virreinato del Perú y Chile* 1777–1816[93] (from now on referred to as *La Real Expedición)*. Outputs from the respective expeditions were numerous, each leading to cinchona herbarium and bark specimens collected alongside ethnobotanical knowledge of harvesting, uses and importantly, the folk taxonomy key to understanding trade names. However, explorers from each expedition hotly disagreed over several questions: the taxonomy of cinchona, which were the most valuable species and which species of red bark was the original and most medicinal: the Peruvian or Nueva Granadian (Howard, 1862, García Guillén, & Muñoz-Paz, 2003; García Guillén, & Noya Santos, 2016; Steele, 1964; Perez et al., 2004).

Disagreements arose because the explorers, stationed in different localities, were viewing different species localised to each area, lacking a wider realisation of the complexity of the genus and biased by commercial interests (Howard, 1862; Perez et al., 2004). The botanists' issues with identification are well described by Howard decades later as 'mischievous' (Howard, 1853; 1862, *C. succirubra* p. 10). There is evidence that the issue of the identity of the original cinchona was resolved by polymath Francisco José de Caldas (1768-1816). Inspired by Humboldt, he carefully prepared topographical maps to show the different species localities. Unfortunately, he was shot in 1816 by Spanish Royalists, and no longer around to promote it, his work suppressed (Perez et al., 2004). Botanical confusion remained.

[92] Royal Botanical Expedition of the New Kingdom of Granada.
[93] Royal Botanical Expedition to the Viceroyalty of Peru and Chile.

The argument over species identification was not resolved until phylogenetic assessment by Lennart Andersson nearly 200 years later (Andersson, 1998). His work highlighted how the visible diversity of *Cinchona* is due to the genera's morphological variability and tendency to hybridise. Andersson filtered 330 *Cinchona* species names down to a couple of dozen. Today, the current number stands between 23 and 24. This is likely to continue to grow as new species are found. Andersson's research explains the difficulty facing early botanists attempting to understand cinchona and why there was such bitter contention between parties (Andersson, 1998; Bleichmar, 2008; Howard, 1862; Lambert, 1821; Perez et al., 2004).

Compounding the challenges of fieldwork in South America were rivalries at home in Spain. Botanists at the *Real Jardín Botánico*, Madrid, were also divided in opinion. The *Jardín* in Madrid was the intended repository for *La Real Expedición* data, including the cinchona specimens, but due to the directorship given to Antonio José Cavanilles (1745-1804), the rival of Ruiz and Pavón's mentor, Casimiro Gómez de Ortega (1741-1818), ownership of the collections became fractured (Perez et al., 2004; Walker et al., 2022). Ruiz and Pavón were not consistent in the objective of sending specimens to the *Jardín's* collections. Instead, they maintained their personal control by establishing their office outside the garden's geography and influence (Rodríguez Nozal, 1993). Another intended output of the expedition was the publication of a series of monographs on the flora of Peru. However, due to the vast and apparently unmanageable number of specimens and data gathered, only three of the eleven volumes were produced (González Bueno & Rodríguez Nozal, 1996; 2006; Pupulin, 2012; Walker et al, 2022). Nonetheless, two treatises on cinchona were published: the *Quinologia* (Ruiz, 1792) and *Suplemento a la Quinología* (Ruiz & Pavón, 1801).

These eighteenth-century collections consisted of specimens directly obtained in the field, i.e. not acquired through trade, along with supplementary botanical data which could be used to help untangle the genus and link them to those found in trade. The *Real Expedición's* data was not only of value to Howard and quinology, they were also valuable training tools for other collectors. Explorers Alexander von Humboldt and Aimé Bonpland arranged a viewing of the *Expedición* specimens, including the cinchona, with Ruiz and Pavón in Madrid in 1799 before embarking on their trip to South America (von Humboldt & Bonpland, 1814). Later, Clements Markham also visited Madrid to see cinchona specimens before his own 1860 Peruvian collecting trip (Markham, 1862).

The existence of rich South American collections in Europe was vital to knowledge production, particularly for sedentary scientists like Howard who were unable or unwilling to travel. Fortunately for Howard, a remarkable historical incident gave him access to these precious collections. After Ruiz' death in 1816, Pavón appears to have covertly sold and gifted parts of the collection to other institutes and collectors outside Spain. Part of the cinchona collection was sold to Aylmer Bourke Lambert (1761-1842), a founding Fellow of the Linnean Society (Miller, 1970). This caused controversy when discovered and led to problems for Pavón. A visitor to Lambert's house in 1827 noted:

> Whilst we were employed in viewing Count Lambert's treasures, a little man dressed in black entered the apartment; and he cast a glance full of sorrow and indignation upon some packages which belonged to the herbarium of Ruiz and Pavón (Schultes, 1830, p. 63)

This indignant character was Mariano Lagasca (1776–1839), Director of *La Real Jardín Botánico Madrid*, in English exile due to Spanish political instability. After Lambert's death, these specimens were auctioned off, purchased by the British Museum and it was there that Howard studied them in 1852 (Walker et al, 2022). The examination of Pavón's collection contributed to the development and refinement of Howard's knowledge of the genus, deepening his expertise and enabling him to take on the mantle of 'quinologist'.[94]

4.3 The emergence of quinology as a discipline

The discipline of 'quinology', combining expertise in both the botany and chemistry of the

[94] Further commentary on the Ruiz & Pavón collection and the central role it played in Howard's research can also be found in Chapter 5 (as part of his collections practices) and Chapter 7 (regarding the publication of the manuscript).

Cinchona genus, evolved from these systematic Spanish expeditions. The term itself appears to have arisen around the time Ruiz and Pavón used it as the title of their two cinchona publications: the *Quinologia* of 1792 and the *Suplemento a la Quinologi*a of 1801 (Ruiz, 1792; Ruiz & Pavón, 1801). 'Quino' is an adaptation of 'quina', the Spanish term for cinchona, which is itself a loan word taken from the Quechua word for the tree. 'Logia' refers to the Latin for 'study of/discourse', the English equivalent is 'ology', as found in words like 'biology' and 'theology' (Haggis, 1941; Harper, n.d-a; n.d.-b).[95]

However, there is evidence these botanists did not coin the term. A few years before, in 1785, Casimiro Gómez Ortega wrote to Viceroy Gálvez in South America:

> *Todo lo cual conspira con las acertadas providencias de Vuestra Excelencia y con el concepto de lo urgente que es publicar el tratado de la Quinalogia que tiene ofrecido remitir con preferencia a otras obras suyas Don Josef Celestino Mutis y esperamos por instantes llegue a manos de Vuestra Excelencia…*[96]
>
> [All of which conspires with the correct measures of Your Excellency and with the concept of how urgent it is to publish the treatise on the Quinalogia that Mr. Josef Celestino Mutis has offered to refer in preference to other works of his and we hope that for a moment it reaches the hands of Your Excellency…]

Note the spelling uses 'quina', rather than 'quino' which Ruiz uses. No evidence has emerged of Mutis using the term himself, either in his diary or publications (Mutis & Hernández de Alba Lesmes, 1957).[97] Further research may find it in his letter archives; however, it is clear it was not a term he regularly used. It was probably Ortega who coined the term. It appears that Ortega, in an attempt to control cinchona knowledge was attempting to force Mutis' hand and so control all publications emerging about the genus. Ortega was a mentor to Ruiz on the opposing expedition and there was a bitter rivalry

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[95] Some researchers have suggested the Quechua word quina has been misapplied. Haggis (1941) shows that quina means 'bark' and 'quinquina' meant bark of barks, incorrectly assigned to *Cinchona* when it should refer to Balsam of Tolu (*Myroxylon peruiferum* L.f.). This issue shows the difficulty of communication between different language groups within Spanish-controlled Andes and was further exacerbated with the transatlantic connection to Europe.

[96] Casimiro Gómez Ortega to Viceroy Gálvez, 25 April 1785. AJB, Division III, 2, 3, 5,6, Archives, Real Jardín Botánico de Madrid. Translation by Fred Carnegy.

[97] Personal communications with archive curator, Esther García Guillén, Archives of the Real Jardín Botánico, Madrid.

between the parties (see previous section) (Bleichmar, 2008; Perez et al., 2004).

Google Ngram Viewer[98] for the word '*Quinologia'* among Spanish texts shows the term arrives around the time of Ruiz and Pavón's publications in 1792 (Figure 4.1). Whoever coined the term, Ruiz and Pavón are undoubtedly the ones who popularised it.

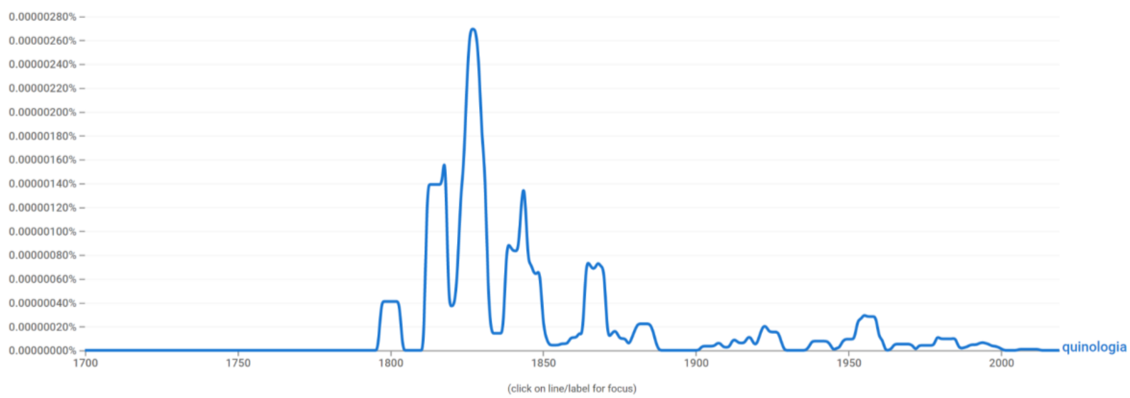

Figure 4.2 Google Ngram Viewer: 'Quinologia' (Spanish texts).[99]

Amongst English-language texts, instances of use of the English term 'quinology' arose much later than the Spanish equivalent, just before Howard's 1862 publication *The Nueva Quinologia of Pavón* (Howard, 1862) (Figure 4.2). A few initial references appear from the 1830s due to literal translations in advertisements and references to Ruiz' work (i.e. appearing in English as the 'Quinology' of Ruiz).[100] It appears again later as a translated term with the use of 'quinological' in a translation of Weddell's French work in the pages of *The Chemist* (Weddell, 1850). *The American Journal of Pharmacy* appears to have adopted the term earlier than the English, reporting on quinology in 1843 (Art. XLIII, 1843).

The first instance of Howard himself using the term 'quinology' is in *The Pharmaceutical*

[98] There are acknowledged limitations of the Google Ngram Viewer, such as incomplete data sets and problems with text recognition, but the tool can give a useful indication of general trends.
[99] Google Ngram Viewer, Accessed 20 October 2022.
[100] See an example in de Candolle (1831) and de Godoy (1836)

Journal in 1856 (Howard, 1856). Here, Weddell himself seems to have applied the term to Howard's work, stating in a letter cited by Howard: 'in reference to Quinology, you have evidently solved one of its most interesting desiderata' (Howard, 1856, p. 211). Howard then continues to use the term in subsequent publications. All his formal books bear a form of the word in the title (Howard, 1862; 1869, 1876).[101]

The widespread acceptance of the English term around this mid-century period, particularly its use by Howard, may reflect the similarity of the name to the alkaloid quinine. As mentioned above, quinine was isolated and named in 1820 by the French pharmacists Pelletier and Caventou (Pelletier & Caventou, 1821). The two men were inspired by the French common name for the bark, *quinquina*, derived from the same South American etymological roots as the Spanish term. However, they did not use the disciplinary term about themselves.[102] The isolation of quinine is clearly significant to the development of quinology. The method provided the ability to make quantitative alkaloidal values on barks and brought cinchona botany into a chemical age. This was a new angle, a chemical solution to answer complex botanical questions that, as we have seen, were still in disarray by Howard's time.

[101] Formal books refer to Howard's books published with the intent of being a book, rather than articles later bound as books.
[102] The French equivalent of this would be *quinologie*.

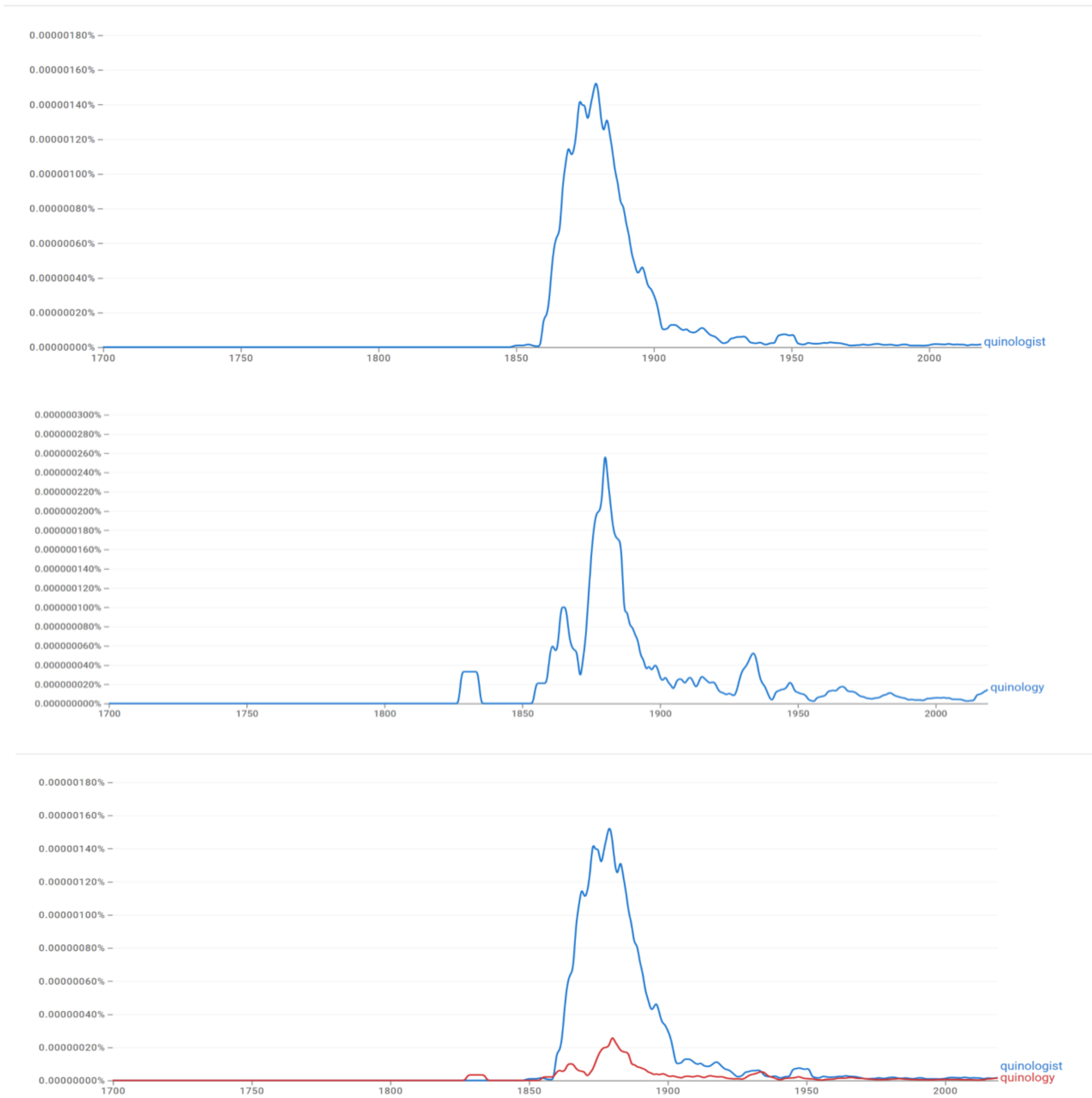

Figure 4.3 Google Ngram Viewer searching English-language texts for the term (from top, down) 'Quinology' & 'quinologist', with a comparison.
Google Ngram Viewer, Accessed 20 October 2022.

Further French influence seems to be a major driver in the acceptance of the term. Pharmacists Auguste Pierre Delondre (1790-1865) and Apollinaire Bouchardat (1806-

1886) used the term, slightly before Howard, in their 1854 work Q*uinologie des quinquinas* (Delondre, & Bouchardat, 1854). Delondre, with an interest in developing a quinine business which he later established with Pelletier, had visited cinchona forests in 1846 and this brought an edge of deeper expertise to the publication (Jaussaud, 2018; Ziegler, 2003). The publication took a classic quinological approach combining pharmacognosy, chemistry and botany to assess barks found in trade. Colour bark illustrations of aided identification alongside alkaloid analysis, though it lacked any botanical illustrations (see Chapter 7, Table 7.1 for a comparison of historical cinchona manuals). As a pharmaceutical manufacturing contemporary with botanical and chemical skills, Delondre was a key influence on Howard.[103] However, in contrast to Howard, Delondre visited South America to see the tree himself. Delondre is quoted in Howard's first full-colour guide of 1862, when he refers to their respective collections, classifications and chemical analyses to which to compare and contrast his own findings.

Another trans-channel influence on Howard was through Hugh Algernon Weddell (1819-1877), a physician and botanist who had twice explored South American cinchona forests in 1841 and 1851.[104] He was British born but had grown up in France and gained a French education. After he returned from his South American trips, Weddell worked in Paris for the *Muséum national d'Histoire naturelle*, later settling in Poitiers. He published his *Histoire naturelle des quinquinas* in 1849 and was a key influence on cinchona studies as well as Howard. Howard's letter archives reveal a long, close relationship with Weddell with whom he discusses 'quinological' works throughout their lifetime correspondence.[105]

As the nineteenth century evolved, so did the terminology around quinology. The term 'quinologist', used to denote someone who performs quinology, increasingly appears in relation to official posts in British Indian plantations where an integration of chemistry and

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[103] Although Howard occasionally refers to the work of 'Delondre and Bouchardat', he more often than not refers solely to Delondre (Howard, 1862)
[104] Jstor Global Plants (n.d.) Hugh Algernon Wedell. https://plants.jstor.org/
[105] See letters from Weddell to Howard using this term, 18 November, 1869 and 8 October 1875, both filed under JEH/1/15, Library & Archives, RBG Kew.

botany skills could ensure profitable cinchona crops (Figure 4.3). Such was the rarity of the skill set, however, that appointing a plantation quinologist took some effort. In a letter dated January 1866, Clements Markham highlights the problem:

> I would not venture to express any further opinion respecting this appointment if it was one of an ordinary character, but in truth the number of men who are capable of filling it is so exceedingly small that the choice is narrowed, so far as I am aware, and I have made diligent enquiries, almost to one man. There are several learned quinologists in Europe, some like M. Delondre, in extreme old age, while others such as Dr. Phoebus, M. Guibourt, Mr. Weddell, Mr. Howard, Mr. Hanbury, Carl Zimmer & C. are not in a position to accept an offer of this kind.[106]

As Markham's commentary reveals, those claiming the title of 'quinologist' tended to come from chemistry and pharmacy-related backgrounds, rather than pure botany, showing the medicinal/manufacturing emphasis and influence on the subject: all the men listed above thus had some form of chemical, pharmaceutical or medical training and were in related careers. The issue of finding such skilled quinologists in British India continued throughout the latter part of the nineteenth century and may have contributed to the limited success in Indian alkaloid production by the turn of the twentieth century. In comparison, the Dutch went on to dominate global markets. This seems to reflect an efficiently centralised management system with official government botanists, horticulturalists and chemists working together, rather than relying on specialised quinologists, though undoubtedly there may were figures who could be technically classed in as such (Roersch van der Hoogte & Pieters, 2014). Within a search of Dutch Texts, the term *'quinologiste'*, *'quinoloog'* and *'kinaloog'* most often appear in association with non-Dutch scientists such as Delondre, Bouchardat and Howard.

Eventually the Dutch dominated quinine markets and British-Indian cinchona plantations lessened in importance (Goss, 2013; Roersch van der Hoogte & Pieters, 2014). By 1945, Japanese invasion of Indonesia led to quinine shortage for the Allies. This led to the

[106] Clements Markham to the Secretary to Government, Revenue Department, 16th January 1866, *British Parliamentary Paper No. 353*, *East India (Chinchona plant)*, 1863-1866, Section I, Item No. 85, p. 220.

accelerated invention of a new antimalarial, chloroquine (Coatney, 1963; Krafts et al., 2012). Quinine was no longer the primary treatment for malaria. As the older 'quinologists' passed away, it appears that quinology as a defined discipline also died out.

In summary, the emergence of quinology as a term can be traced through complex, international and multidisciplinary factors leading up to its use in English language in the 1850s. The late eighteenth-century Spanish, botanically focused *quinologia* merged with the 1820 French chemical discovery of the isolation of quinine to become the subject of quinology. Practitioners of the discipline, quinologists, were associated with a specialist knowledge combining both chemistry (quinine alkaloids) and botany (cinchona). Around 1856, Howard himself started to define his own work as explicitly quinological, aligning himself alongside the renowned Spanish botanists who had provided the historic foundation for his research, with the addition of contemporary cutting-edge chemistry.

4.4 Access to the British Museum and Howard's first publications

Howard was thus performing the role of quinologist even before the term gained acceptance, though as we have seen in Chapter 3 it was only in his mid-forties that he shifted to a public career in scientific publishing and consulting on cinchona. However, he had been collecting, curating and analysing barks for Howards and Sons since at least 1827 (Slater, 1955).[107] As noted in the opening vignette to Chapter 3, after decades of research at the family factory, a prize-winning display of trade barks and alkaloids at the Great Exhibition of 1851 brought him to wider public notice. This is significant: it was the same year the Dutch established their own cinchona plantations. This event may have stimulated Howard into refocusing his career direction as he was probably aware of the British interests in establishing their own plantation projects. In 1852, the Reporter on the Products of India at the East India Company, John Forbes Royle (1798-1858), suggested India as an ideal site for cultivation.

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[107] See also his early collection notes in Description & Analysis of Specimens of Bark collected by John Eliot Howard from bark imported into England in 1828 and subsequent years, arranged in 1850. With a classification subjoined. (1997.056). Royal Pharmaceutical Society Archives.

Although Howard had enjoyed renown in the pharmaceutical world due to his prize-winning display of barks at the Great Exhibition, he needed to publish in order to establish his expertise as a quinologist. As the vignette at the beginning of this chapter shows, he based his first project and publications on the collections of *La Real Expedición* in the British Museum. On what basis was Howard granted access to such valuable specimens as a relatively unknown figure? It is likely that connections through his well-known father, Luke Howard, helped pave the way. Luke's scientific status as a meteorologist was well-established in the wider scientific world and he maintained business and friendship connections with senior figures in science.[108] By 1852, Howard gained access to view and assess these specimens. Howard's later book on the specimens, *the Illustrations of the Nueva Quinologia of Pavon* acknowledges the help of John Joseph Bennett (1801–1876), curator at the British Museum. Bennett was also Linnean Society Secretary and he is likely to have facilitated Howard's access to the collections (Howard,1862; Jackson, 1885).

Howard undertook the examination of the Pavón specimens in the British Museum with pharmacologist Jonathan Pereira (1804-1853), a founding member of the Pharmaceutical Society, lecturer, journal editor and writer of a fundamental textbook on materia medica (Pereira, 1848). Pereira would have provided additional status, and therefore access, for Howard (Hudson & Boylan, 2013; 'Preface to the eleventh volume', 1851). It is probable that the introduction of the two men to each other was again due to Howard family networks. While Howard himself was not yet a member of the Pharmaceutical Society, Pereira was a founding member of the Society, with whom the Howards maintained close ties in both friendship and business, as well as a co-member of the Meteorological Society alongside Luke Howard ('The Meteorological Society of London', 1881).[109] While Pereira is frequently mentioned by Howard in his account of the British Museum specimens, he suffered an accident and died the same year as publication. He was not given posthumous

[108] For more on Luke Howard's connections, see Chapter 3.
[109] Luke Howard's original business partner was William Allen, another co-founder of the Pharmaceutical Society, see Chapter 1.

authorship (Howard, 1853).

The British Museum specimens contained herbaria, barks and woods collected during *La Real Expedición Botánica al Virreinato del Perú*, 1777-1816. As described above, these had come via Aylmer Bourke Lambert who had purchased them directly from José Pavón. The collection is historically important as it encompasses multiple types of interrelated specimens collected on-site from live cinchona trees. The collection included 50-60 barks, 35 wood sections and 23 seed packets (Miller, 1970).[110] It is likely that Howard also saw the study of these Peruvian *Real Expedición* collections as his own potential research niche. Spanish botanist, Celestino Mutis (1732-1808) had written on Nueva Granada barks; German botanist Hermann Karsten (1809–1877) on Colombian barks; France-based Hugh Algernon Weddell (1819-1877) on the Bolivian (Karsten, 1858; Weddell 1849).

Accessing the British Museum collection provided Howard with a set of primary specimens: field-collected material to compare, and corroborate, his own trade-collected barks. Ruiz and Pavón recorded the trade names associated with the barks and this created a 'key' from which Howard attempted to unlock modern trade bark data. Howard published a series of eight papers on this collection between May 1852 and January 1853 under the title *Examinations of Pavón's collection of Peruvian barks contained in the British Museum*. This was bound as a book in 1853 and a copy of the volume gifted to the Pharmaceutical Society. An appendix was added in 1855 (Howard, 1853; 1855; 'Pharmaceutical Meeting', 1853).[111]

Howard had academic, as well as practical, motivations, in compiling this collection. As he noted: 'there is a pleasure in coming up with the game after such an intellectual chase'. He aimed to publish a full-colour guide in the style of other European quinological publications

[110] Bark numbers are not clear, as Lambert claims to have bought 44 (Lambert, 1821), but Howard (1862) noted more, but gave no exact number.
[111] An in-depth history and management of the *La Read Expedición* cinchona collections to the present day can be read in Walker et al. (2022), including the details of their arrival at Kew between 1979-1982 when the British Museum relinquished many of their botanical collections.

(see Table 7.1) (Howard, 1885, p. 183). However, more work was needed. Regarding his examinations of *La Real Expedición* barks at the Museum, Howard observed:

> ...the subject was left in an incomplete, and there-fore unsatisfactory state; and I could not help surmising that there must remain at Madrid further results of the labours of the Spanish botanists which might throw light on the many questions still left in obscurity. (Howard 1862, p. ii)

In 1858, Howard purchased a further 54 barks from *La Real Expedición* along with an original unpublished manuscript written by Pavón, entitled *Nueva Quinología* (ca. 1826).[112] This discovery further research led to Howard's first full-colour illustrated book, the *Illustrations of the Nueva Quinologia of Pavón* published in 1862 (Howard, 1862). The publication combined detailed descriptions and engravings of the genus according to Pavón, rearranged by Howard alongside additional chemical and microscopical analyses. During the period of writing his book, a government-sponsored cinchona collection project was finally initiated and led by Clements Markham, who consulted with Howard on the best species to collect (See Chapter 1) (Markham, 1862; Veale, 2010).[113]

Howard's 1862 book is further discussed further in Chapter 7 but is highlighted here to show the impact of *La Real Expedición* collections on Howard's trajectory: from that of an industrial analyst to a published scientific author. The highly significant yet neglected Spanish collection provided the means by which he consolidated his knowledge and established his role as an expert quinologist. This in turn enabled wider network building for specimen and knowledge exchange with European and South American experts.

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[112] The *Nueva Quinologia* manuscript now lies in the Howard and Sons business archives, ACC/1037/855, London Metropolitan Archives.

[113] See also Markham's diaries: *Cinchona notebook 1* (CRM/55), *Cinchona notebook 2* (CRM/56). Royal Geographical Society Archives.

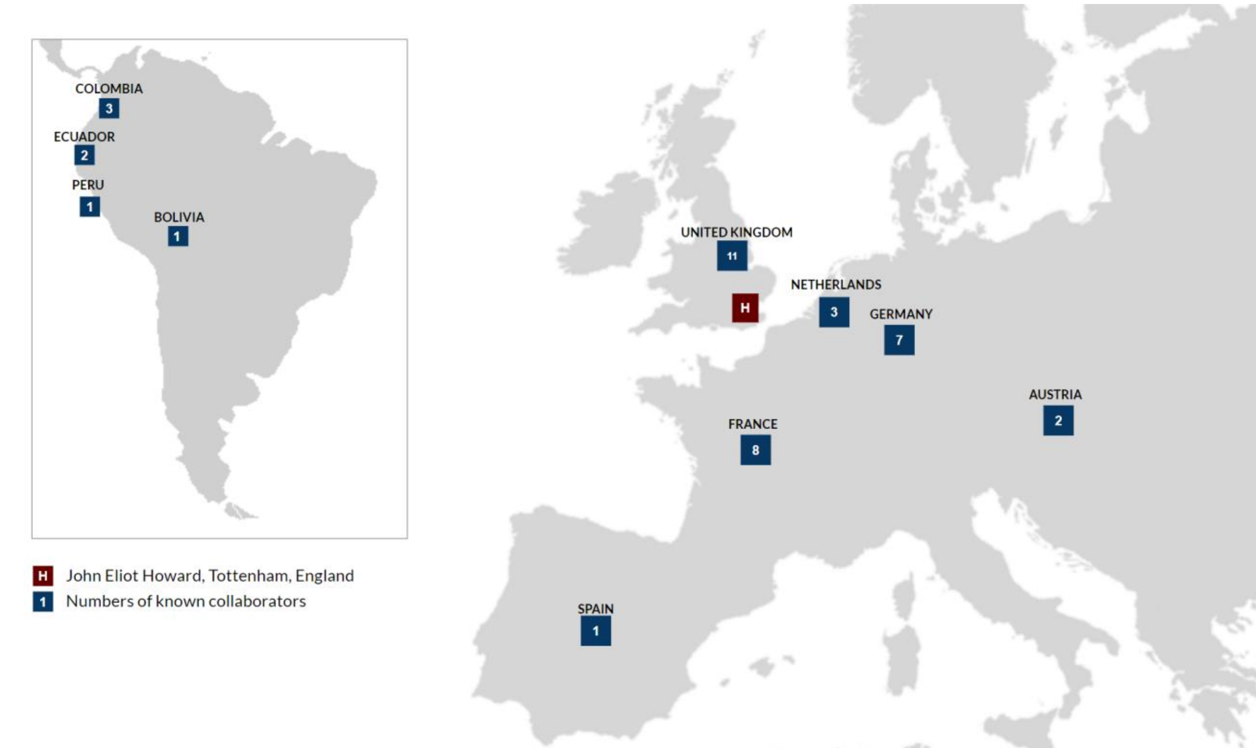

Figure 4.4 Number of known collectors in Europe and America, by country, to whom Howard sent & received cinchona bark specimens, 1823-1883.

4.5 Scientific networks of exchange: circulation and recirculation

> [Thanks] to various scientific gentlemen on the Continent, especially to Dr. Weddell, Professors Guibourt and Schleiden, and to Dr. Karsten, Dr. Junghuhn, Dr. de Vrij, Dr. W. H. de Vriese, Don Francesco T. Riofrio, and others mentioned in this work, I would here record my grateful remembrance for much assistance afforded in various ways in the prosecution of a task in itself pleasant, and rendered more so by their co-operation. (Howard, 1862, p. xvi)

The systemisation of natural knowledge through study of collections was integral to European expansion from the Early Modern period (Bleichmar, 2009; Drayton, 2000; Klemun et al., 2018; Marples & Pickering, 2016; Pearce, 2013; Schiebinger, 2004). Specimens were obtained by travellers and used to build personal collections inspiring wonder, intellectual discussion and status to the possessor (Marples & Pickering, 2016; Pearce, 2013). These specimens were also used as gifts to show or gain favour, later becoming sources for the first museums and as commodities for traders (Delbourgo, 2018;

Egmond, 2018; Findlen & Toledano, 2018; Impey & MacGregor, 1985). By the nineteenth century, the scale of collecting had dramatically increased, many of the products once collected as curiosities were now commercially collected and traded (Osborne, 2000; Penn et al., 2018). Collecting was supported by a greater acceptance of the formalisation of naming with the Linnean binomial system, novel transport technologies and through colonial structures supporting travel (Kohler, 2007; Osborne, 2000).

After the turn of the nineteenth century, cinchona collecting also increased significantly, linked to a surging bark trade as well as the rise in professionalisation of apothecary-pharmacists. Cinchona was a key product in their dispensaries and they relied on their pharmacognostic skills for quality control (Deb Roy, 2017). Pharmacists are noted to have constituted one of the largest groups of artisan-naturalists in Europe (Simmons, 2017; Pugliano, 2018; Wallis, 2012). The extant cinchona collections at Kew and Leiden (as discussed in Chapter 1) show significant amounts of early nineteenth-century specimens originated from trade samples assembled by pharmacists, apothecaries and physicians (many of whom could be classed as quinologsts). This is exemplified by Howard whose bark specimens dominate Kew's collection, constituting the largest sub-collection of the EBC (40%), followed only in number by those collected by botanists Ruiz and Pavón, on *La Real Expedición* (7%). We know this only represents part of Howard's original collection, which was even larger, but much was lost, likely disposed of, in the 1950s during a company reorganisation (Walker et al., 2022; discussed further below). Given what we know of other extant cinchona collections, it is probable Howard had the largest bark collection ever known, remaining the largest extant collection curated by any one person.[114]

Howard's cinchona specimen exchange network was extensive, linking collectors in South America, Europe and later, South Asian and Southeast Asian plantations. Quinological researchers within Europe used the trade network in order to supply exemplary specimens

[114] Compared to the Madrid (Real Jardín Botánico.) and Leiden (Naturalis) collections.

to assemble their secondary (i.e. not collected in the field) collections as well as exchanging specimens to investigate intra-species variation, which Kohler (2007) has highlighted as a trend in wider botanical collection networks.

The types of cinchona specimens exchanged between collectors included ‘duplicates’, which were not always duplicate in the modern sense of the term, i.e. genetically identical specimens taken from the same source (Beentje & Williamson, 2016). Sometimes genetically identical duplicates were circulated: cinchona specimens consisted of multiple slivers of bark, so parts or sections can easily be removed while not devaluing the original sample. However, representative, ideal or unusual types of bark could also be circulated. These ‘twin’ specimens enabled others to compare and contrast their own samples of the same category found in trade, for example. a comparison of Huamalies bark (Walker, et al., 2022). Recent research by Cornish & Driver (2019) has shown the importance of the circulation of non-identical ‘duplicate’ specimens between museums as a pedagogical practice and the cinchona collector-networks support this argument.

A comprehensive review of *all* exchanges within Howard’s collections as a whole is not possible as at least 500 specimens from the collection were lost in the 1950s. However, by combining the evidence in the remaining collection, archives and publications, traces of Howard’s international networks can be revealed. Howard maintained a vast network of collaborators from at least 15 countries with whom he engaged with knowledge and specimen exchange.

Table 4.1 lists names of people with whom he exchanged specimens as evidenced in his collections, as well as references in letters and books. Figure 4.4. shows a map representing these specimen circulations.

Table 4.1 Donors and recipients of bark specimens to and from John Eliot Howard.[115]

Name	[D]onor or [R]ecipient[116]	Country
Batka, Johann Baptista	D	Austria
'Botanist in Madrid'	D	Spain
Beckert, Dr. c/o General Union of Austrian Apothecaries	R	Austria
British Museum	R	England
Buchanan, T.J.	D	Ceylon
Cox, Captain William Trevelyan Hody	D	India
Cross, Robert Mackenzie	D	India
Delondre, Augustus	D	France
Dr. Bureau. Dr. c/o Université Impériale de France	R	France
Guibourt, Nicolas Jean Baptiste Guillaume	D/R	France
'Gutierez'*	D	Ecuador
Hanbury, Daniel	D/R	England
Hasskarl, Dr. Justus Charles	D/R	Java
Hesse, Dr G	R	Germany?
Cranbourne, Lord	R	England
Indian Plantations	D	India
Karsten, Hermann	D	Germany/Austria
King, George, Sir	D	India
King's College, London	R	England
Klotszch, Johann Friedrich	D	Germany
Linnean Society	R	England
López (Via Isaacs)	D	Colombia
Lovegrove, Mr	D	Unknown
Martiny, Julius	D	Germany
Martius, Carl Friedrich Philipp van	D	Germany
Mastenbroek, T	D/R	Netherlands
McIvor, William Graham	D	India

115 Sources for table 4.1 taken from label information from Howard's specimen collections in the EBC and in Naturalis Economic Botany Collection, Leiden. Howard's personal archives (JEH/1/9 & JEH/1/10, Library and Archives, RBG Kew) and his three major publications (Howard, 1853; 1862; 1869-76). In the case of other writers, e.g. Hanbury, their publications were checked for mentions of barks being sent by Howard.
116 Limitations: Some donors may also have been recipients, e.g. Vrijdag-Zijnen likely but evidence has not been traced.

Muséum national d'Histoire naturelle	D	France
Museum of the Jardin des Plantes	D	France
Nantes School of Medicine/Université de France/Académie de Rennes	R	France
Paul, Dr	D	Unknown
Pereira, Jonathan, Dr	D	England
Phoebus, Phillip	R	Germany
Pritchett, Woolcock	D/R	Peru
Rada, Pedro	D	Bolivia
RBG Kew	R	England
Reichel, C.F.	D	Saxony
Restrepo, J.M	D	Colombia
Rijksherbarium	R	Netherlands
Riofrio, T. F	D	Ecuador
Ristolfo, Jose Manuel	D	Colombia
Royal College of Physicians, Edinburgh	R	Scotland
Royal College of Physicians, London	D/R	England
Royal Pharmaceutical Society, London	D/R	England
Société Impériale Zoologique d'Acclimatation	R	France
Vrijdag-Zijnen, T	D?/R	Netherlands
Weddell, Hugh Algernon	D/R	France

However, tracing exchanges is not always straightforward. When identifying collectors, the language on labels can be misleading: a careful reading is needed. Barks may be called, for example, ‘Rusty Crown Bark - the knotty sort of Jussieu’ (EB 52823), or ‘China Flava dura of Bergen’ (EBC 52905), which does not mean it came from the collections of Jussieu (a French botanist) or (von) Bergen, but of a category type that Jussieu or von Bergen described. Many botanists and quinologists had their own personal categorisation system which didn’t always agree, as we will see below. Another issue is with bark recirculation. As Cornish & Driver (2019) have shown, in the nineteenth century, collectable specimens didn’t stop once they reached a destination, but many were circulated and recirculated. An example of this, and the issue of differing author categorisation, can be seen in Howard's first book, *Illustrations of the Nueva Quinologia of Pavón*, where he discusses the identification of *Cinchona purpurea* barks:

> To this origin, then, I refer to the following specimens in my possession, which may all proceed from the same tree, although differing in some respects at first sight.
>
> 1. Sections of a young tree of Huamalies bark, from Bergen's collection, given to me by Reichel.
> 2. Huamalies bark, met in commerce at Hamburg in 1824, from Bergen's collection, given to me by the same gentleman.
> 3. Bark of *Cinchona purpurea*, R. and P., from Pavón's collection, given to me as above, and not so different as mine from the aspect of young Huamalies bark.
> 4. China Huamalies, given to me by Martiny.
> 5. China Huamalies, from Winckler, by favour of Pereira.
> 6. Huamalies bark, given to me by Batka.
> 7. Huamalies bark, from Bergen's collection, given to me by the Pharmaceutical Society.
> 8. Cascarilla boba colorada, C. purpurea, R. and P., Cuchero, as gathered and determined by Poeppig in 1829, —from the collections of Reichel and Martiny.
> 9. "Huamalies ferrugineux, gris terne, blanc A, blanc B, rouge, rougeätre, mince et rougeatre," given to me by Guibourt.
>
> (Howard, 1862, p. 2, *C. purpurea* section).[117]

It is clear from this list collectors not only exchanged their own specimens but would recirculate others of interest. For example, item No. 1 shows Howard received a specimen from von Bergen's collection, but not directly from him. Von Bergen was a notable cinchona collector and publisher who wrote an influential work in 1826 (von Bergen, 1826). Owning a von Bergen bark would provide status for any collection. The specimen was gifted to Howard via. C. F. Reichel, an apothecary at Hohenstein, in Saxony, who at one point 'possess[ed] one of the richest collections of cinchona in Germany' (Poeppig, 1835). The other list items show similar trajectories: non-linear recirculation of important specimens between European collectors.

Trade barks were not the only type of specimen circulated within collector-networks. As item no. 8 in the above list shows, field-collected specimens were also valued. This example shows a cascarilla 'as gathered and determined' by Eduard Friedrich Poeppig

[117] Specimens traced in EBC today: 5. Possibly 52973; 7. Possibly 52851 and/or 52837; 8. 52862

(1798-1868) who had been on an expedition to Peru. These items were exchanged, as a form of 'master specimen'. These specimens, like barks from *La Real Expedición*, were botanically corroborated specimens, having been gathered and named (determined) by an expert on-site in the Andes. Howard's collections contain other examples, such as the Pavón specimens he bought in 1858, as well as others from explorers such as Weddell who also visited Peru. This recirculation of valuable specimens also supported networking through the dispensing (or soliciting) of favours (Cornish at al., 2019; Egmond, 2018). For example, in 1867 Howard sent a bark to the secretary of State for India, writing 'I have a letter from Lord Cranborne to-day, cordially thanking me for the specimen of the first East Indian bark sold in London which I sent him (Howard, 1885, p. 210). This was not because Lord Cranbourne wanted to develop skills as a quinologist but was a political move notifying him of Howard's expertise. In addition, this incident shows bark specimens were not always circulated amongst experts.

It was not only specimens that were exchanged. Correspondence as a means of knowledge exchange was also key, as has been discussed in previous research on correspondence networks (Browne, 2014; Ogilve, 2016; Secord, 1994). Browne (2014) shows how these letters were central to the formation of scientific knowledge, as well as the circulation of it, existing as 'surrogate specimens' and pre-preprints between correspondents. Browne states these provided the 'infrastructure that participated in shaping modern scientific society' (Browne, 2014, p. 169). This is evidenced within Howard's archives too: not only in the direct exchange of information, but also through experts giving opinions on other's specimens, without necessarily expecting a direct exchange, e.g., EBC 52790, Howard annotated 'I had made out this bark as if *C. micrantha* but Dr Weddell could only see likeness in one piece.' In the Naturalis collection of cinchona barks in Leiden, specimens owned by the German botanist, Justus Karl Hasskarl (1811-1894) and Dutch apothecary Theodoor Vrijdag-Zijnen (1799-1863) were identified by Howard.

The Naturalis Economic Botany Collection in Leiden is an important external collection showing the reach of Howard's network. For example, the earliest collections of trade barks at Leiden are those belonging to Vrijdag-Zijnen. It is within this collection that Howard pieces are found. Vrijdag-Zijnen (1835), wrote a book on cinchona identification,[118] as well as producing two publications examining the Rijksherbarium cinchona collections in 1856 and 1860 (Vrijdag-Zijnen, 1857; 1860a). After his death, his personal collections (n=ca. 100) came to the Rijksherbarium, which in turn were absorbed into today's Naturalis collection (Figure 4.5). There is very little evidence of Vrijdag-Zijnen's life, nor is he mentioned in Howard's archives or publications. If it was not for the remains of his collections housed in strikingly beautiful boxes, he would likely have remained a largely unknown author. This, incidentally, is an example of the value of collections-based research for revealing unknown histories and figures.

Amongst Vrijdag-Zijnen's collections, however, are around 24 specimens received from Howard at various points. His archive also includes a short letter dated March 1860 where Howard writes he is sending a selection of 20 cinchona barks he hopes Vrijdag-Zijnen may find interesting (Figure 4.5).[119] Included in the list are adulterants (e.g., *Gordonia fruticosa* (Schrad.) H. Keng (formerly *Laplacea quinoderma* Wedd.) and *Croton* sp.) and some marked '!' and '?', suggesting Howard was not averse to showing his ignorance on some identification and clearly soliciting an opinion. Unfortunately, a reply from Vrijdag-Zijnen to this letter has not been traced. Some of these barks can be cross-referenced to the current Naturalis collection along with further Howard specimens not listed in the 1860 letter, showing this was not a one-off occurrence and the two men must have been in further correspondence. While the Dutch apothecary was only ten years older than Howard, he had been publishing on cinchona for much longer. Howard may have seen him as a model as well as consultant-colleague. Sadly, there is no remaining evidence any barks were sent in exchange from Vrijdag-Zijnen; these may have been lost with the part disposal of Howards in the 1950s.

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[118] De in den handel voorkomende kina-basten pharmacologisch behandeld en toegepast op de soorten welke in de pharmacopoea belgica vermeld zijn. [The commercially available kina-barks, their pharmacology and their sort in the Belgian Pharmacopoeia].

[119] Non-catalogued letter, Economic Botany Collection, Naturalis Biodiversity Collection, Leiden.

As can be seen in

Table 4.1, Howard also collected and sent bark specimens not just to the individual, but also to institutions. Maria Howard recorded her husband's membership of a wide range of international associations, which allowed Howard to stay abreast of industry developments and further his networking and advancement.[120] Howard most frequently donated barks and alkaloids to the museum of the Royal Pharmaceutical Society, founded to educate trainee pharmacists. As well as supporting training, donations would have also promoted the pharmaceutical products and in-house expertise of Howards and Sons. This was not a unique relationship. Howard was frequently asked to provide sets of reference materials for training in other institutes. For example, in 1865, he sent a set of 45 barks to the General Union of Austrian Apothecaries.[121] These still exist in the pharmacognosy department of the University of Vienna.[122] This reveals Howard was considered an expert consultant for many institutes.

Finally, we ask if Howard ever met some of these persons? The answer lies within his archives, where there is letter evidence he travelled to Paris, visiting Weddell in 1852 and Professor Klotszch in Berlin in 1857, where he almost met von Humboldt (Howard, 1885).[123] Figure 4.6 shows he also met with a collection of other European quinologists at the International Botanical Congress in Amsterdam, 1877. Howard's Royal Society election certificate hints at other connections within the wider scientific network. Numerous distinguished supporters added their support from 'personal knowledge' of him. The list includes Kew botanist and Linnean Society president, George Bentham,

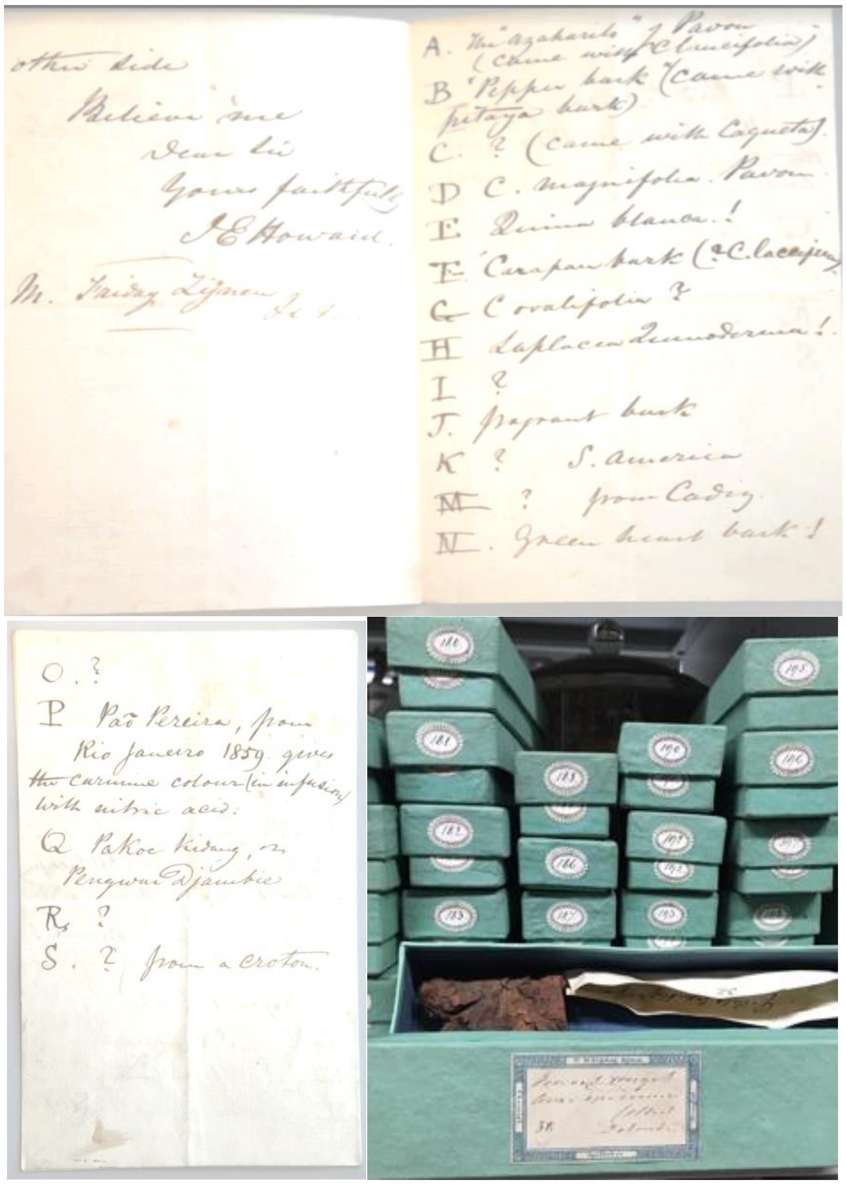
[120] During his career he was elected Fellow of the Royal Society; Fellow of the Linnean Society; Fellow of the Royal Microscopical Society; Member of the Pharmaceutical Society; Foreign Correspondent of the Academie de Medecine of France; Corresponding Member of the Societe de Pharmacie of Paris; Life Member of the Societe Botanique of France; Honorary Member of the Netherlands Industrial Society; Austrian Apotheker-Verein; Philadelphia College of Pharmacy; Societas Physico-Medica of Erlangen; Honorary Correspondent of the Società dei Naturalisti in Modena; Journal de Pharmacie et de Chimie (Howard, 1885)

[121] Beckert to Howard, 6 Nov 1865, JEH/1/9, Library & Archives, RBG Kew.

[122] Personal communications, with thanks to Cornelia Schmidt of Die Bibliothek der Österreichischen Apothekerkammer and Professor Liselotte Krenn of University of Vienna.

[123] 'We were to have visited Baron v. Humboldt, but on the day that Professor Klotszch, I think, took us to his house he was not well enough to receive visitors. This was a disappointment.' (Howard, 1885, p.31)

zoologist Thomas Bell (1792-1880), naturalist John Ball (1818-1899), physician to the Queen, and Quaker relative, Wilson Fox (1831-1887), surgeon and inventor Charles Brooke (1804-1879) and chemist Sir Edward Frankland (1825-1899).[124]


other side
Believe me
Dear Sir
Yours faithfully
J E Howard.
M. Vrijdag Zijnen &c &c

A. The "azaharito" of Pavon (came with C lancifolia)
B "Pepper bark" (came with pitaya bark)
C. ? (came with Caqueta)
D C. magnifolia. Pavon
E Quina blanca.!
F "Carapan bark
G C ovalifolia ?
H
I ?
J. fragrant bark
K ? S. America
M ? from Cadiz
N. Green heart bark!

O. ?
P Paõ Pereira, from Rio Janeiro 1859 gives the carmine colour (in infusion) with nitric acid.
Q PaKoe Kidang, or Pengwari Djambie
R ?
S. ? from a Croton.

Figure 4.5 Letter to Vrijdag-Zijnen & a sample of Vrijdag-Zijnen's collection at Naturalis, Leiden. Image Author's own.

[124]*Candidate Election Certificate for John Eliot Howard (1807-1883)*, Certificates for Election 1874, NA6285. Royal Society Archives, London.

Figure 4.6 Howard (Front row, second from right), with other quinologists at the International Botanical Congress, Amsterdam 1877.

Image from Naturalis Biodiversity Centre, Leiden.

4.6 Kew's 'external' expert

In the digitised copy of Howard's *Examinations* (1853) on Google Books, another article is found, entitled: *Examination of Botanic Specimens at Kew, 1855*. This is a privately printed and circulated paper which focuses on herbarium specimens and does not appear in other versions of this book, nor in Kew's Library and Archives.[125] The origins of the article are unclear. Howard suggests it was privately circulated, rather than published as a journal article, though the article is paginated 9-12, suggesting it is an offprint from a larger work, perhaps a journal (Howard, 1862; 1885).

The Google Books copy was digitised at Harvard University Herbaria but handwriting on the flyleaf shows it came from further afield, originally inscribed '*Monsieur le Professor Guibourt, hommage de l'auteur*' [tribute from the author]. Nicolas Jean Baptiste Guillaume Guibourt (1790-1867), was a French pharmacist and author on an important European pharmacopoeia, *Histoire Naturelle Des Drogues Simples* (Guibourt, 1849). Guibourt had himself examined the Ruiz & Pavón British Museum collection and included his observations in his *Histoire*, and as the last section showed, exchanged barks with Howard. In the *Examinations*, Howard uses Guibourt's categorisations to corroborate and compare his own identification of Ruiz and Pavón's barks. This may be why Howard sent a copy to him: authors regularly circulated published works, known as 'offprints' to flag work of interest (Spoerhase, 2020).

Howard states in the opening lines of the Kew article his herbarium visit was 'enabled, through the permission and with the kind assistance of Sir William J. Hooker.' (Howard, 1853, n.p.). Access to Kew, with the 'assistance' of the Director demonstrates the swift upward trajectory of Howard's botanical reputation within a few short years after the Great Exhibition. Despite the emphasis in the recent literature on Kew as a Latourian 'Centre of Calculation', involved in the production of botanical knowledge vital to imperial expansion, the reality appears more complex (Brockway, 2002; Deb Roy, 2017; Latour, 1987; Endersby, 2008). This challenge to the Latourian model has been

[125] A photocopy has now been deposited at Kew. Two other copies are currently known. at the New York Botanical Garden and the Lloyd Library in Cincinnati.

flagged before in relation to the Economic Botany Collection, which Cornish (2013, p. 257) terms instead an 'Information Exchange' based on Driver's (2001, pp. 36-37) terminology applied to the Royal Geographical Society.

Kew's director, William Jackson Hooker (1785-1865) supported the cinchona collecting project led by the India Office. While Kew undoubtedly played a key role in supporting the cinchona transfer in 1859, it seemed this was more practical than scientific. This was through the supply of trained collectors to South America. The Gardens acted as a stop off point for plants before they were sent on towards India. Kew also provided trained horticulturists to some Indian plantations. There appears to have been no focused cinchona expertise at Kew and this may be key to why Howard was given access to the collections. Markham gives evidence of Howard's expertise over Kew. In a letter to Hooker in 1862, he wrote:

> I think it important that the specimens of C. condaminea should be in the herbarium at Kew and as soon as Mr Howard has examined and compared them, so as to satisfy me of the identity of the species, I will make arrangements for sending them to you.[126]

With cinchona, botanical expertise needed to go hand-in-hand with chemical expertise and Howard appears to have been ideally placed to fulfil this. As he was described in the early search for an expert in the plantations 'an intelligent botanist possessing a knowledge of 'analytical chemistry' will soon settle the value of the bark, a better chemist we could not have'.[127]

This impression that Howard's expertise surpassed Kew's own is supported by the Parliamentary Papers, which collated official correspondence relating to the British Indian Plantation Projects between 1852 and 1875 (See Chapter 2 and 4). A basic text search shows that mentions of Howard far outstrip any of Kew or either of the

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[126] Clements Markham to Sir William Jackson Hooker; from India Office, 24 Feb 1862, p. 2 of the JSTOR PDF viewer. Directors' Correspondence, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas2059.

[127] Captain H.R. Morgan, Officiating Conservator of Forests, to J.D. George, Ootacamund, 1 April 1861, as cited in: *British Parliamentary Paper No. 118, East India (Chinchona Cultivation),* 1852-1863, Item 64, p. 153.

Directors.[128] Another form of evidence is seen in the assemblage of the specimens within Kew's Economic Botany Collection. Although it is one of the world's largest known collections of cinchona bark, wood and seeds, as would be expected in an institute at the centre of such project, most of these were not originally Kew's, only arriving as late twentieth-century accessions from other institutions.

As mentioned in Chapter 2, significant collections were accessioned into the Economic Botany Collection between 1979 and 2013 (n=759), predominantly the Pharmaceutical Society collection containing Howard's specimens and the British Museum collection containing *La Real Expedición* specimens. These constitute a significant majority (70%) of Kew's modern collection. Of the 332 remaining specimens, only ca. 59 South American barks were collected and sent to the Kew Museum before 1860, the date of the initiation of the Indian plantation. Some of these were from Howard. The provenance of herbarium collections at Kew is harder to understand as the structure of curatorial management does not show older accession dates. This means it is often difficult to know precisely when collections were accessioned. In his 1855 paper, Howard mentions only three sets of cinchona in the Kew Herbarium (recently opened in 1854 (Desmond, 2007): one discovered by Matthews in Lima in 1833 left behind by *La Real Expedición*,[129] a set from Aylmer Bourke Lambert and another set from George Bentham (1800-1884). These Kew specimen numbers: <50 herbarium, with at most 60 bark specimens, are remarkably low if Kew was a producer of knowledge on the genus cinchona and point instead to the role of Howard as the presiding expert.[130]

Given this history of Kew's Museum and herbarium collections, it appears Kew acted more as a *facilitator* of expertise, than the *producer* of knowledge one might expect

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[128] The OCR copies used have much corruption, but give a rough idea: *British Parliamentary Paper No. 353*, (1863-66): Howard=152 times, Kew=8 and Hooker=15.; *Paper No. 432*, (1866-1870 Howard=125, Kew=8, Hooker=11; *Paper No. 120*, (1870-1875): Howard=55, Kew=9, Hooker=2; *Paper No. 279:* (1870/1875) Howard=85, Kew=2, Hooker=12.

[129] Howard states these herbarium specimens and illustrations were discovered in Lima by botanist Andrew Mathews (1801-1841) between 1833-1835 who believed them to be those of Ruiz and Pavón, left behind on their return to Spain. Mathews sent these to William Jackson Hooker (1785-1865). However, as stated before, these were collected in the latter part of the Real Expedición, under Tafalla and Manzanilla between 1788-1816 (See Tepe, 2018).

[130] The language in which Howard discusses numbers is obscure for counting confidently and sometimes mentions 'several specimens of this type' indicating there are more than he has listed directly.

from a Latourian model. It seems there was nobody at Kew with the kind of chemical-botanical expertise, combined with such detailed knowledge of cinchona barks, that Howard himself provided. This is perhaps surprising, especially as William Hooker's son, William Dawson Hooker (1816-1840), wrote his medical school thesis on cinchona (Hooker, 1839). He may have had the potential to become a potential in-house expert, but died shortly after in 1840 (Lambert, 2011). Whatever the reason for Kew not developing in-house expertise, an informal, mutually beneficial system was established. Howard's prestige was increased through Kew association, while Kew could delegate cinchona botany to a capable consultant.

4.7 Chemical Consulting

Consultancy has been increasingly recognised as an area of importance in histories of chemical innovation. Until recently, research often emphasised the commercialization of expertise from academic scientists. However, knowledge production shifted in the nineteenth century to include industrial innovation as part of wider changes reflecting the general progress of urbanization and industrialization driven by capitalism (see section 3.2) (Bud & Roberts, 1984; Mackie & Roberts, 2020; Mercelis et al., 2017; Quirke & Reed, 2020; Russel et al. 2017; Simmons 2020; Simmons & Reed, 2022; Wadhwani et al., 2017; Watson, 1995).

Industrial research is less visible in academic literature, but can be detected through knowledge production by chemists and druggists associated with industrial expertise such as drug development, patenting, manufacturing and entrepreneurship (Mercelis et al., 2017; Wadhwani et al., 2017). Within this, chemical consultancy is also a key part of the profession, such as supplying expert witnesses in the courtroom and judging chemical experiments (Mercelis et al., 2017). Simmons (2020, p. 236) explores consultancy as a 'saleable skill' in the nineteenth century noting that the terms 'consulting chemist and 'analytical chemist' become noticeably more popular from around the mid-century. Robert & Mackie (2020) show that in the latter decades of the nineteenth century, around 30% of members registered with the main chemical associations worked as consultants in some form. On an individual basis, the authors also show that while consultancy provided additional work for some chemists, for others it formed their predominant income. It is also noteworthy that as the twentieth century developed, the number of consultants dropped. This is likely due to the rise of running costs of independent laboratories, alongside businesses establishing their own in-house research and development.

Simmons uses Robert Warington, an academic turned commercial chemist, to explore this topic. Warington was the driving force behind the establishment of the Chemical Society of London in 1841 and helped found the laboratories for the Society of Apothecaries in 1842. While not academic institutions, the Societies held roles of authority. Through these, Warington was well placed to provide consultancy on a range of food and drug quality assessment. At points during his career over 60% of his work was the provision of consultation services. Warington is a remarkable example of the changes within the chemical discipline across the century as it shifted to growing commercialization alongside growing pharmaceutical professionalism and standardization.

Alongside Warington, Howard (who incidentally shared the same birth year) illustrates a contemporaneous and contrasting career. Howard's role started within manufacturing for his family's pharmaceutical business, eventually providing in-house quinine specialisation. It was only later that he became more widely known as a chemical researcher, publisher and consultant having spent decades working within commercial production. Howard is an early example of someone with non-academic, non-institutional, origins who became a respected expert and drove research and development within his field of quinine from the mid-1800s onwards.

Mackie and Roberts (2020, p. 214), define consultancy as providing 'chemical services for a fee'. However, the career of Howard shows that in some cases, a fee was not always part of the exchange. Instead, the provision of expertise in association with institutes such as Kew provided another type of transactional, such as credibility and endorsement (Mercelis et al., 2017; Quirke & Reed, 2020). Mackie and Roberts also suggest consultants had unusually varied 'portfolio' careers. Howard's case provides an alternative example. It appears that his ultra-focused niche enabled an advantage over others, elevating his work to the notice of those within the wider scientific field.

4.8 Howard's Influence

Howards and Sons were the largest British quinine suppliers and greatly influenced production and trade. Additionally, references found peppered throughout the *Pharmaceutical Journal* show they were considered a trusted source: Howards and Sons are cited as either supplying pure chemicals for trial or judging the test results of others pharmacists' experiments. The presence of Howard's specimens within the collections of the Museum of Materia Medica of the Pharmaceutical Society and Naturalis (combining many other experts such as Hasskarl) also reflect his influence on pharmaceutical knowledge

Further afield, there is evidence of Howard's influence within Europe. As discussed above and in Chapter 2, many references show Howard's reach and expert networks, for example his existence (via specimens) in the Dutch collections. As will be shown in Chapter 7, regard for his knowledge can be seen in the image of the Koloniaal Museum, Haarlem (Figure 7.7), where curators chose illustrations from Howard's publications to adorn their cinchona displays. And finally, as regards to the deference for his botanical skills, Howard was asked by the Dutch to classify and name the species used to establish their first cultivation project, *Cinchona pahudiana.* Clearly, Howard, was a well-regarded quinologist by scientists both at home and in Europe.

However, to what extent did Howard influence British Indian cultivation, at plantation and government level? Although Howard freely discusses his professional opinions within his own publications, to what extent were these seen and heard? Part of the answer lies within the pages of the British Parliamentary Papers.

Within these are multiple strands of evidence: As mentioned earlier, first is the simple numerical occurrence of Howard's name within these books; both by and about him. Secondly, to provide guidance the British Indian government circulated Howard's analytical reports on the Indian plantations and first book, *Illustrations of the Nueva*

Quinologia of Pavón (Howard, 1862).[131] Secondly, Howard was the professional of choice to assess the outcome of the plantations as soon as it was possible. The British did not want to repeat the mistakes of the Dutch and nurture chemically worthless species (McIvor, 1862). As Markham had complained, the apparent lack of expertise in India meant that there were as yet no others with the relevant skillset who could be appointed. Between 1863 and 1868, Howard made eight official government analyses of the barks grown in the Nilgiris and at least two for private planters (

[131] Many instances of report circulation can be found throughout *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866; In addition, references to the circulation of the *Nueva Quinologia* are as follows; 11 copies sent to libraries and collectors in Madras. Public Despatch to Madras, dated 29 February 1864, Section I, Item No. 10, p. 30; 13 copies distributed, Sir Charles Wood the Government of India, 29, February 1864, Section IV, Item No. 5, p. 306. A copy to Mr. Richardson, Clements R. Markham, Esq., to the Secretary to Government, Revenue Department, Fort St. George; dated Bangalore, 7th February 1866, *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870, Section I, p. 84. At least one of his later *Quinology of the East Indian Plantations* (Howard, 1869-76), From C. B. Clarke, Esq., 31.4., Officiating Superintendent, Botanical Gardens, and in charge of Chinchona Cultivation, *British Parliamentary Paper No. 120, East India (Chinchona Cultivation)*, 1870-1875, p. 12.

Table **4.2**). His commission as official analyst appears on the first page of the 1863-1866 reports. There, a letter sent by William McIvor, Superintendent of the Government Cinchona Plantations, describes the supply of leaves, wood and bark (all under 15 months old) too young for harvesting, but mature enough to '…enable that eminent chemist to… throw much light upon the practical advantage or otherwise likely to be derived from our proposed system of lopping and pruning'.[132]

It is clear that Howard's opinion, all the way from London, was not only important for the bark's chemical value, but influenced assessment of cultivation success or failure, in turn affecting decisions on their future management (Veale, 2010). In response to the report, McIvor proposed that he should plant the cinchona trees closer together.[133] Fortunately for McIvor, the project's 'great success… [was] now placed beyond doubt by the results of Mr. Howard's analysis.'[134]

Deb Roy (2017) explores Howard's role as at once 'judge and competitor', in a position to influence the plantation projects to his own advantage, preventing quinine trade competition, as partly discussed in Chapter 1. As Chapter 7 will discuss, Howard was also accused of withholding practical instruction on what to do with the trees once ready to harvest. It was difficult to produce pure quinine, separate from other chemicals. This remained an issue in India where the trees produced mixed-alkaloids (Deb Roy, 2017; Veale, 2010). Howard gave little hint as to how to resolve the problem. Canny businesses did not give away their industrial secrets.

However, while Howards and Sons may have sought to preserve quinine market dominance and prevent Indian competition, Howard could hardly be responsible for the variety of trees ultimately chosen by various growers or the environmental influence which affected alkaloid content. In addition, he himself donated a quinine-

[132] W.M. McIvor to J.D. Sim, Secretary to Government, Revenue Department, 4 April 1862, *British Parliamentary Paper No. 353*, *East India (Chinchona plant) (1863-1866)*, Section I, Item No. 1, p. 1.
[133] W.M. McIvor to J.D. Sim, Secretary to Government, Revenue Department, 7 July 1863, *British Parliamentary Paper No. 353*, *East India (Chinchona plant) (1863-1866)*, Section I, Item No. 7.1, p. 13.
[134] Sir Charles Wood to the Government of Madras, *British Parliamentary Paper No. 353*, *East India (Chinchona plant) (1863-1866)*, Section I, Item No. 4, p. 8.

rich variety of tree (*C. uritisinga*) to the project which went on to produce 60,000 trees, as discussed in Chapter 6. He also advised the Dutch that their *C. pahudiana* would lead to disappointment due to low quinine and gave advice as to their betterment. The Dutch focus on quinine production could be seen as the biggest threat to Howards and Sons in trade, yet despite this, he still maintained a relationship and advisory role through is contact with the project's players.

Ultimately, as expertise grew within India, Howard's influence was limited. Other quinologists were hired, John Broughton for the Nilgiris plantation in 1866 and C.H. Wood in Rungbee (Mungpoo) in 1873 (Deb Roy, 2017; Veale, 2010). These acted as competition to Howard but failed to successfully produce a profitable product. Development of a failed, unstable mixed-alkaloid, amorphous quinine, led to Broughton resigning in 1873 (see Section 1.6). Wood, the sole remaining quinologist also left in 1879 to be replaced by Sir George King. King was actively opposed to Howard's influence. His main concern revolved around the conflict of interests Howard brought upon India's quinine manufacture:

> Howard of course has a finger in the pie and has written a memorandum hostile to the manufacture in India. When will the I.O. [India Office] learn to think of Howard as a money grabbing Quaker and not a distinguished philanthropist! He wants to squash our factory here of course. But the I.O. can't seem to see the real reason![135]

In addition, Deb Roy suggests that such was Howard's influence through his reports, his judgement meant Indian barks were sometimes made unsaleable within Europe, maintaining lower prices, leading to cheaper bark sales advantageous to Howards and Sons (Deb Roy, 2017). However, as discussed in Chapter 1, Howards and Sons does not appear to have profited by purchasing Indian barks during this period. As Figure 1.9 shows, the company did not use Indian material until 1872.[136] By Howard's death in 1883, however, the case had changed. This was partly related to political

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[135] G.[George] King to Sir Joseph Dalton Hooker; from Royal Botanic Garden, Seebpore, near Calcutta, [Shibpur, near Kolkata, India]; 15 July 1882, p. 6 of the PDF viewer. Director's Correspondence. Library and Archives, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas6468

[136] This uptake is probably related to Howards and Sons production of cheaper, non-quinine alkaloids, despite Howard's previous protestations that the product would be commercially disadvantageous, even if the medical merits had been proven (See Chapter 1, section 1.6).

developments in 1880 whereby Howards and Sons came to an agreement with the Indian Government to receive all the Nilgiris bark and produce quinine for the British Indian market. Despite freight costs, this was considered more efficient. However, the alkaloids led to a stockpile in India and to prevent devaluation, this was discontinued after 1885 (Deb Roy, 2017). Either way, by 1885, Howards and Sons were relying on 88% of production on Indian barks, compared to the 6% in 1875 (Appendix 1). Even after his death, John Eliot Howard's role had provided an advantageous position for the company as a trusted supplier to the government.

During his lifetime however, it appears that Howard's humanitarian beliefs in the accessibility of the medicine and belief in scientific advancement tempered his role as a tradesperson. The failure of the Indian cultivation project owed as much to the lack of expertise and focus of government managers in British India as to any interference by Howard.

Table 4.2 List of analytical reports made by Howard in the British Parliamentary Papers, 1863-1868.

Report No.	Reference & Notes
1	Howard in 1863 analysed the first set of small twigs and barks from British India. This report was not published as a 'report' like the following ones, but is referred to in the following letters of the *r* Letter to Markham, 28 May 1863, Enclosure 2, in. No. 7, p. 14; From the Madras Government to the Secretary of State for India (1863, April 11). Section I, Item No. 1, p.1; McIvor, W. (1863, April 4). Enclosure No. 1. Section I, Item No 2, p. 2; Sir Charles Wood to the Government of Madras. (1863, July 11). Section I, Item No. 4, p.8; From the Government of Madras-to the Secretary of State for India. (1863, August 12). Section 1, Item No. 7, p. 13. etc.
2	Howard, J.E. (1863, December). Report on the Bark and Leaves sent home in October 1863. *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866, Section I, Item No. 16a, p. 30.
3	Howard, J.E. (1864, June 15). Report of an Analysis of the Third Remittance of bark from India, received 20 May. *British Parliamentary Paper No. 353, East India (Chinchona plant) (1863-1866)*, Section I, Item No. 25, p. 48.
4	Howard, J.E. (1865). Report of an analysis of the fourth remittance of bark from India. *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866, Section I, Item No. 51, P. 134.
Report, Non-Gov	Howard, J.E. (1866). Report of an analysis of bark of Chinchona succirubra grown in Wynaad, 1866. *British Parliamentary Paper No. 353, East India (Chinchona plant)* 1863-1866, Section III, Item No. 4, p. 282.
Report, Non-Gov	Howard, J.E. (1866, July 11). Report on Specimens of Chinchona bark grown in Ceylon, 1866. *British Parliamentary Paper No. 353, East India (Chinchona plant)*, 1863-1866, Section VII, Item No. 5, p. 378.
5	Howard, J.E. (1867). Report of an Analysis of the Fifth Remittance of Bark from India, 4 February 1867. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870, Section I, Item No. 15, p.34.
6	Howard, J.E. (1867, August 28). Report of an analysis of the sixth remittance of bark from India. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870, Section I, Item No. 30, p.134.
7	Howard, J.E. (1867, October 7). Analysis of the seventh remittance of bark from India. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870, Section II, Item No. 9, p. 260
8	Howard, J.E. (1868, September 1). Report of an Analysis of the Eighth Remittance of Bark from India. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870, Section II, Item 57. Annual report 1868, In Footnote, p. 211.

4.9 Summary

As Chapters 3 and 4 show, Howard's early career processing quinine in the family factory helped to develop his chemical and pharmacognostic skills. He shifted to the broader discipline of quinology and botany through the analysis of comprehensive Spanish materials after 1851. A decade later, his specialist skillset filled a research gap regarding the cultivation projects in British India which Kew could not provide. This led to the role as an influential consultant and analyst for the government plantations and cemented Howards and Sons success as trusted quinine manufacturers.

However, Howard was a scientist who embodied the idea that 'theory and practice went hand-in-hand' (Strauss et al., 1867, p. 149). He relied on his own trade bark collections as chemical and visual reference aids as a practical foundation from which he developed his expertise. As a sedentary researcher based in London, Howard could not have developed such a broad view of the *Cinchona* genus without these tangible tools. A closer look at these collections in the next chapter will explore his practices and methods in the process of understanding cinchona and their part in his evolution as a quinologist.

Chapter 5 | A Library of Trees: Cabinets, Collecting and Chemical Analysis

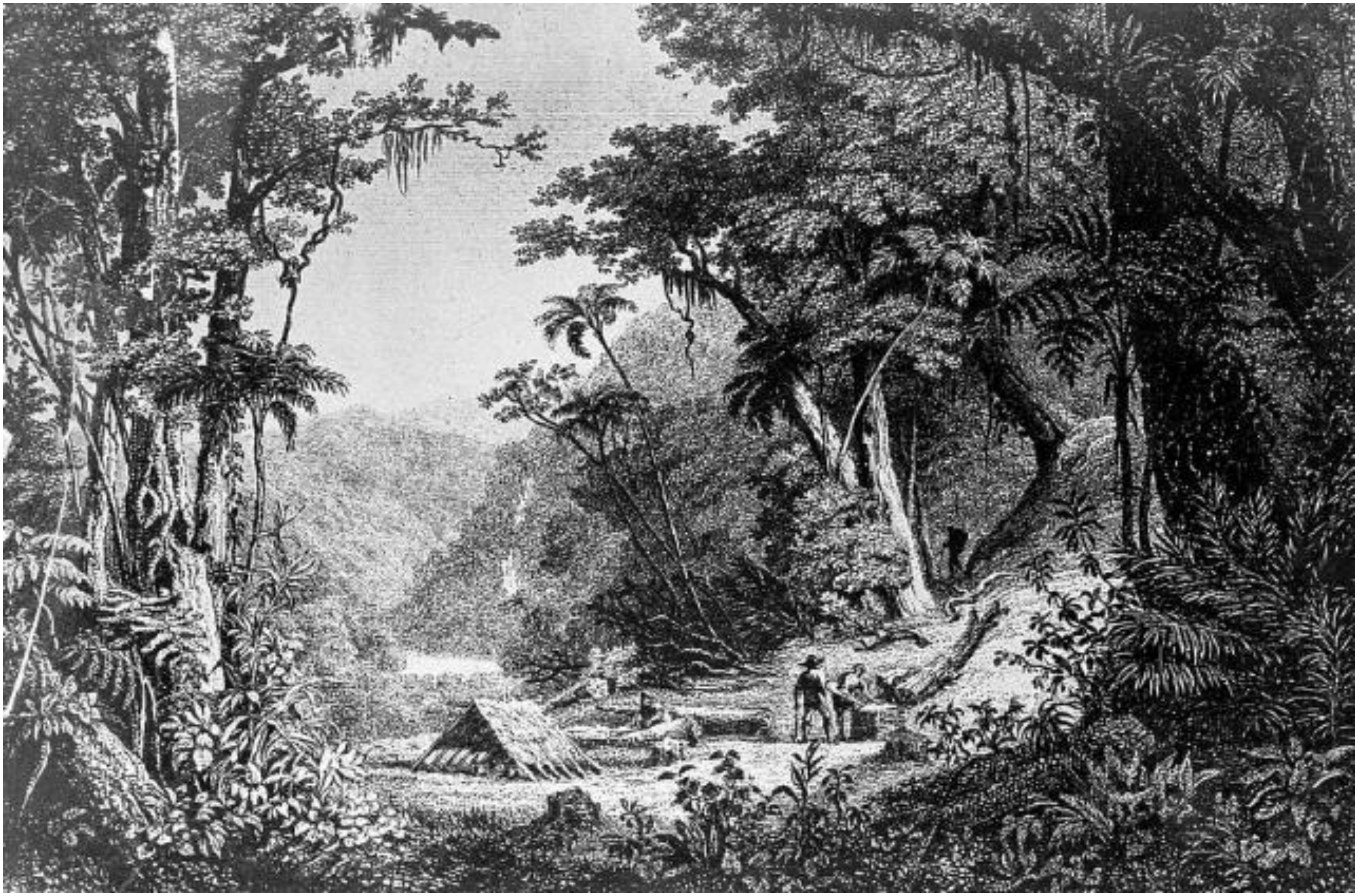

Figure 5.1 Cinchona harvesting, Peru.
From J. Denis, "Vallée de San Juan del Oro", (Weddell, 1849). Wellcome Collection.

5.0 Vignette - The journey of a *cinchona* specimen[137]

1854 - The Andes

In the damp, misty light of an Andean cloud forest, a cinchona tree stands. Soon the muffled clash of mules and footsteps interrupt the peace, lifting the birds from its branches: a group of *cascarilleros*, bark cutters, have arrived to set up a work camp to harvest the valuable fever remedy that will be sent halfway across the world to Europe.

Stripped of bark as high as it can be reached, the cinchona tree is felled and the higher thick, gnarled outer bark beaten off with mallets. The dehusked inner bark is then peeled upwards in sections of 6 to 7 inches wide with the help of machetes, the sap staining the metal purple. The air oxidises the pale creamy, glistening strips into a deep red rust. As the neighbouring trees are felled, the *tendáls* (drying racks) rise, slabs of bark are piled in slatted tiers to allow airflow. A fire is lit to help push out the mists that permeate the forest, the smoke tendrils curling about the barks, darkening them further. The slices taken from the trunks dry into flat slips, then broken apart for transport. The smaller, thinner branch bark curling up into hollow pipes known as 'quills', after their resemblance to the shafts of feathers or porcupine spines.

The *cascarilleros* were descended from both the Spanish colonists and Indigenous groups of the Andes. They camped in the forests in basic conditions, bitten by mosquitoes on the way to find trees, some succumbing to malaria in the process. Despite the abundance of bark, they were often unaware of its use, believing the Europeans used it for dye. For months they chop, cut, dry and sort the barks by size and quality, packing them into transportable pigskin *serons*. At the end of the season the rhythm changes. The *cascarilleros* decamp and the *serons*, weighing 60 to 70 kgs each, are suspended on their backs by strips of cloth bound across their foreheads to be borne across hundreds of miles of the Andes. Later, as the ground became more even, mules take the burden on the final

[137] Vignette sources: Hooker, 1839; Ruiz et al., 1998; Spruce, 1861; Strauss et al., 1867; Wellcome, 1880.

section of the journey to meet traders.

Here, the *cascarilleros* and bark part ways and the cinchona embarks on its long sea journey towards European shores.

1854 - London

Some batches of *serons* were bound for London, the entry point for 95% of Britain's drug trade, to be auctioned off by brokers to the highest bidder (Simmons, 2017). Arriving at London Dock on the Thames, they are transferred to broker's house auction rooms on Mincing Lane. One set of packages is bought by a buyer from a Stratford quinine factory. The corners of the *serons* have been sliced open for sampling during auction, to ensure that the bark is indeed cinchona and hasn't been misidentified or adulterated. The *serons* are then hauled onto carriages, or taken via barge three miles to Stratford via the Limehouse Cut at the foot of the canalised River Lea. Here, they disembark at the Howards & Sons factory, City Mills, destined for unpacking, sorting and grinding to a powder before being boiled in vats in the first steps of alkaloid extraction.

A bearded, bespectacled man pokes into the corners of the packages, sifting and discarding barks, looking for ones that present features of interest to his analytical mind. A few pieces of partially curled bark catch his eye: the abraded cortex is exposed, but enough of the silvery top bark clings on. These he saves from the grinding machines. The man is the quinologist John Eliot Howard, cinchona and quinine expert. He is gathering specimens for his collection, where barks become analytical tools, jigsaw pieces allowing him to trace the bark back to its original cloud forests, to the tree, to its species.

This sliver of bark is examined for its pharmacognostic features and by microscope for its anatomical features, then part removed for alkaloid extraction. A later visitor to the factory workshop described the process of alkaloid extraction:

> The crushed bark is exhausted by several boilings with water, acidulated with sulphuric or hydrochloric acid. The several decoctions are mixed and filtered. When

> cooled, slaked lime is added, until the liquid becomes alkaline and dark in colour. The precipitate formed is collected, drained, pressed, and reduced to powder when dry. It is afterwards digested in rectified spirit and filtered, the spirit being distilled off until the tincture assumes a treacly consistency. Dilute sulphuric acid is now added, and the liquid is again filtered and crystallized; the yellowish sulphate obtained being decolorized by re-solution with animal charcoal and recrystallization. It is finally dried with great care, at a very gentle heat, to avoid the slightest efflorescence. (Strauss, 1867, pp. 144-145)

Howard weighs the resulting alkaloids, essentially assigning a value to the bark. The vial containing the crystals, along with the remaining bark, are then encased together in a glass tube and affixed with a blue and cream label noting the statistics, also recorded in a blue paper record. He then lays the jar in a walnut wood cabinet, where it joins a library of barks that Howard used for analysis, comparison and knowledge production throughout his career. For the next 100 years, this was where the specimen would remain until the collection was broken up in 1952.

The current location of this specimen, in the 167th year since it emerged from the mists of the Andes, is in the Economic Botany Collection at the Royal Botanic Gardens, Kew. It is here that we can use material clues to trace its story back, searching for insights into the practice of science through the acquisition, processing and analysis of collections.

5.1 Introduction

> De verzameling van Howard beschreef hij als de volledigste van alle bestaande; het smaakvolle der inrigting, de zeldzaamheid, volledigheid en uitgebreidheid der exemplaren en hunne kritische bewerking, dat alles, vergezeld van eene kostbare boekenverzameling - schreef Reichel - heeft zijns gelijken niet.
>
> [He described Howard's collection as the most complete of all extant; the tastefulness of the arrangement, the rarity, completeness and extensiveness of the copies and their critical adaptation, all this, accompanied by a precious book collection, has no equal.[138]

Howard, the leading quinologist of his era, devoted his career to the study of cinchona bark from his laboratory bench in the quinine department at the family factory, Howards and Sons. As shown in previous chapters, Howard's research was linked to the success of the company which came to dominate the British quinine trade ('Howard and Sons Ltd', 1903; Deb Roy, 2017; Slater, 1955). It was his leading position in the company that enabled Howard to gather data from the pieces of Andean barks entering the drug trade at London ports and journeying along canals to the industrial hub of Stratford.

As noted previously, due to morphological variability between species, cinchona is a difficult genus to understand (Maldonado et al, 2017b). In the nineteenth century, the plant part predominantly reaching Europe was the bark, lacking the classical botanical features of flowers and leaves that best enable determination to species. As each species varies in alkaloid richness, identifying efficacious and profitable raw barks was important to physicians and pharmacists of London. This was of particular interest to nineteenth-century pharmaceutical manufacturers. From 1820, the profitability was not based on bark weight alone, as was previously the case, but on how much of the precious white alkaloid crystals could be distilled from it. The alkaloid content of barks was thus important information (Deb Roy, 2017; Howard, 1853; Wellcome, 1930).

[138] C. F. Reichel, an apothecary from Saxony, as cited by Vrijdag-Zijnan, 1860, translation by Google Translate.

It seems that Howard's interest in cinchona was initially sparked through collecting the lichens which grew on them (Howard, 1885).[139] As discussed in Chapter 3, his acquaintance with cinchona bark came through his work in the family factory, extracting quinine. HIs biological and chemical interests combined and formed his work as a bark collector and quinologist. The vignette at the beginning of this chapter shows how Howard, situated far from the source origins of the tree in the Andes, used material clues from bark trade samples to 'reverse botanise'. Using clues such as trade data, macroscopic, microscopic and chemical analysis, he could infer pharmacologically important species and their origins. With this, he went on to build a biological reference collection, a library of trees that formed a reference collection in principle enabling the identification of newly acquired barks. Howard's collections came to be considered one of the most extensive and complete (Strauss et al., 1867; Vrijdag-Zijnan, 1860; Vorwerk, 1868). Not only did his collections-based research improve company profitability: it also later informed key decisions about the best species for cultivation in British India.

The bulk of Howard's cinchona collections now lie within the Economic Botany Collection (EBC), Royal Botanic Gardens, Kew (n=ca. 438), a substantial proportion having arrived from the Royal Pharmaceutical Society (RPS), London, in 1982/3. The collection is composed of specimens directly donated to both Kew and the RPS during his lifetime, then his own personal collections donated by his descendants to the RPS in 1952 (see Figure 2.3 for trajectory of these). Howard's personal collection also included around 17 Spanish-collected *La Real Expedición barks.*

This chapter takes a closer look at a particular sub-collection of Howard barks, his 'personal collection', once 290 specimens strong and housed in a walnut cabinet, now dispersed through Kew's collections. Through a collection 'reassembly', Howard's

[139] The lichen collection is now lost but Howard mentions them occasionally in relation to identifying bark quality. For example, 'elegantly marbled with white and yellowish Lichens on a blackish or silvery ground' indicated good quality in *Cinchona chahuarguer*a (syn. *C. chahuraguera* Pav. syn. *C. officinalis* L.) (Howard, 1862, *C. chahuarguera* section, p.4). Lichen and bark quality is a theme found throughout many quinological works beyond Howard's.

practices, collecting trends and purposes are revealed. Reconnecting this cinchona collection to the archives for data enhancement was not always possible due to historic specimen loss: research within the paper archives revealed that much of Howard's collection was disposed on in the 1950s. However, partial mapping of some the collection as well as an analysis of collection and curation methods gives insights into the overall collection history, including questions of provenance and trajectory as well as an understanding of his methods of curation, which, when combined with publication data aid interpretation. In addition, the tracing of the biographies of these objects over time reveals the change in collection value to different users, discussed later.

Figure 5.2 Howard’s cabinet, and contents of one of the drawers.[140]

EBC Archives, File 88, RBG Kew.

[140] Pharmaceutical Society Howard Files in the Economic Botany Collection (No accession no.).

5.2 Howard's collection cabinet

> We commenced our inspection of Messrs. Howards' works with an examination of an interesting series of barks, consisting of typical specimens of every year's importation, from 1821 to the present time. They are all labelled with name, locality, and per-centage of alkaloids, and form a complete history of the British bark trade for the last thirty-nine years. (Strauss et al., 1867, p. 144)

Within the EBC archival files for the Howard cinchona bark collection at Kew are two black and white photographs (Figure 5.2). The first shows a walnut, glass-fronted cabinet for books set atop a set of 18 matching drawers. The second image shows one of the drawers removed, revealing a filing system containing 16 test tube-shaped glass jars. This image shows Howard's collection of cinchona barks, lauded across Europe as 'unique' and 'unrivalled' ('Great Exhibition', 1851, p. 15; 'Paris Exhibition' 1867, p. 81).

These images picture Howard's 'personal' cinchona collection as it was assessed for accession into the RPS Museum in the spring of 1952. The cabinet had been offered to the RPS by Geoffrey Howard, Chairman of Howards and Sons, after the death of A. G. Howard, who had maintained it.[141] The decision to pass it on to the RPS was likely due to resolving his estate, alongside an upcoming company restructure after a general post-war decline (Richmond et al., 2003). The 1952 museum curator's report notes a 'munificent' donation of the cabinet 'comprising 292 authenticated specimens of bark with records of their analyses and with samples isolated from these barks'.[142] As well as this donation, in the October of the same year, the RPS accepted another '120 specimens of cinchona barks, their allies and substitutes, which are not represented in the J. E. Howard [personal] collection'.[143] These came from the collection mentioned in the quote at the beginning of this chapter: a larger, more general collection from Howards and Sons, representing British

[141] Copy of letter to Mr Adams Ref JCF/JMR, File 88, Cinchona shelves, Economic Botany Collection, Royal Botanic Gardens, Kew

[142] Despite the RPS Curator's report that 292 specimens were donated, only 290 appear on the inventory lists.

'Annual Report 1952', second page; Copy of letter to Mr Adams Ref JCF/JMR; Curator's Report, December 1952, RPS, all File 88, Cinchona shelves, Economic Botany Collection, Royal Botanic Gardens, Kew

[143] 'Annual Report 1952', second printed page. File 88.

trade barks started around 1824 and curated by Howard during his working life. These trade barks have been described in Walker et al. (2022). It is suggested that the selection made by the RPS was intended to complement and 'fill gaps' in their own museum collections in a what has been described as 'intercalation' (Cornish, 2013, p. 248). It is not known what happened to the rejected barks. These were likely either disposed of or broken up between other unknown collectors. Some samples may have been included in a donation to the Wellcome Medical Museum, London in 1958 (Walker et al. 2022).

The cabinet itself, however, cannot be traced. It was referred to in a note located by the RPS archivist which states 'not taken to Lambeth'.[144] Lambeth was the new location of the RPS museum when it moved from Bloomsbury Square in 1976. The RPS collections had been moved to Bradford University in 1965 and the cabinet must have been left with the Society. On the move to Lambeth, the cabinet was likely sold or rehomed due to its size.

Another loss from the collection is of the 'samples isolated' from each bark. Today, only five of the barks still have associated chemical samples (See four of these in Figure 5.3). The samples do not appear to have been absorbed separately into the RPS chemical collection, which also came to Kew. They remain an unexplained loss.

The specimens in the cinchona cabinet were organised in 18 drawers, as shown in Figure 5.2. Three inventories of this cabinet collection have been located in the Kew archives (alongside the RPS card catalogue). An overview of the cabinet and its related archives can be seen in Figure 5.4, and an overview of detailed data Table 5.1. However, an overview of each is given here:

A - Howard's Blue Catalogue.[145]
Figure 5.5/A and example in Appendix 4
Location: Kew Library and Archives

[144] Email from Briony Hudson to Mark Nesbitt, 2013, personal communications, File 88.
[145] JEH/1/21, Library and Archives, Royal Botanic Gardens, Kew

Barks date between 1845-1853[146]

A catalogue of the first 9 (of 18) drawers written on blue paper in Howard's hand.

Organised by:

a) Drawer number (geographical origin)

b) 'Line' number (i.e. placement in drawer)

c) Includes data on origin, date, broker, vernacular name, species and chemical analysis.

Description: Howard's blue catalogue shows that the personal collection barks were not ordered from oldest to newest, rather, the focus was on geographical origin.

B - Typewritten Inventory[147]

Figure 5.5/B and image in Appendix 4

Location: Economic Botany Collection Archives

Dates ca. 1930s-1950s?

Organised by:

1) drawer number (1-18)
2) Howard specimen number.

   See Table 5.1

C - RPS Accession Inventory[148]

Figure 5.5/C and images in Appendix 4

Location: Economic Botany Collection Archives

Written 1952

An accession inventory for the cabinet created by the RPS.

Organised by:

1) drawer descriptor (by Geographical origin)
2) Howard specimen number

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[146] Reconciliation of specimens number to the other lists show that other barks date up to 1880, however, these barks may have been in the other 'missing nine draws list.

[147] Typewritten inventory, 1952, File 88, EBC, RBG Kew.

[148] RPS Accession Inventory List, File 88, EBC, RBG Kew. A note preceding the typewritten inventory written by the RPS accessioner notes that he did not check the Accession Inventory © against the typewritten list (B) and is therefore newer.

See Table 5.1

D - Economic Botany Collection Specimens

Figure 5.4/D

Location: Economic Botany Collection

Howard collected between 1827-1883

Specimens collected by Howard, dating between around 1777 to 1883.

Now organised by:

1) Genus
2) Species
3) EBC Collection number

See Table 5.1

Description: Howard originally labelled the specimens using a handwritten slim cream slip with a blue, geometric-patterned border attached to the jar. This label can be seen in the original RPS cabinet photograph, Figure 5.2, as well as a colour image in Figure 5.4/D where echoes of the jar curvature is discernible in the bend of the dismounted label.

Visually, the specimens are now far removed from their original form of matching glass tubes and labels. At some point at the RPS, the barks were decanted and repackaged into new jars, or possibly at the University of Bradford where the collection was housed between 1965 and 1983 (this jar style can be seen in Figure 5.3/B). Additional repackaging occurred at Kew in 1983, where many items were placed in black cardboard boxes or clear polythene bags for larger items.

The only original jar that remained in the EBC with its specimen is Catalogue No. 52726 (Figure 5.6). It exists in a smashed state, likely put aside for later safe repackaging but forgotten. Ironically, the jar's partial destruction was its saving. The wooden-topped glass tube maintains its original Howard labels plus an RPS museum label, showing that some of the collection had been kept in their original packaging at RPS. Why some were rebottled is unrecorded. On 12 January 2023, one of the empty jars came up for sale on eBay, confirming that some of these had been historically sold or given away by Kew (Figure

5.7). The jar bears a later annotation in blue ink of the Kew family number for Rubiaceae (84/1) showing that the disposal of the jar (minus its contents) was after arrival at Kew in 1983. The label data has allowed it to be reconnected to its contents, Catalogue Number, 52809.

Many labels attached to the original jars were ‘lost’ on disposal of said jars, the information transcribed onto pieces of ‘replacement’ white card, an occurrence which seems to have happened at the RPS, due to the fact they are found in both the RPS style packaging, as well as Kew’s. An example card replacement can be seen in Figures 5.3/D. In the case of this image, there is also an original label as well. This card has replaced another label, but it is common to find a white card as the only remaining record of a label. At Kew, where a label was ‘lost’, a replacement was not made, rather a note on the database of ‘missing label’ followed by a transcription can be found (around 40 specimens). The transcriptions at both RPS and Kew have led to clear errors in data transfer, as occasionally dates seem out of place where a specimen almost matches the blue catalogue, there may be inconsistencies, such as, e.g., 7/1 vs. 1/7, or 1880, vs. 1850. Due to Howard’s handwriting, it is suspected that number interchanges have also occurred e.g., 3, 5, 6 and 8 in dates and specimen numbers can be hard to read and may have been incorrectly transcribed. This has resulted in obscured data and careful consideration is needed when reconnecting the data on the archives to their specimens.

E - RPS Card Catalogue

Figure 5.4/E

Location: Economic Botany Collection

See Table 5.1

Description: On arrival at the RPS in 1952, the cinchona specimens from Howard’s cabinet were recorded in the museum’s card catalogue, with an orange dot sticker denoting Howard’s ‘personal collection’ was placed on the cards. This differentiated items from Howard specimens already in the collection. In the time since then, some of the dots may have fallen off, meaning more personal items may be unrecorded.

Matching the cabinet to the archives

The drawer descriptor in the RPS inventory and Howard's blue catalogue do not correspond. Unusually, Howard's catalogue does not record his specimen numbers. By comparing the lists, A (Howard's Blue Catalogue) & C (The RPS Inventory), it is clear the original order of these drawers has been mixed, as have the drawer contents. In the 69 years from Howard's death in 1883 to the moment the cabinet is captured on photograph, the drawers were switched, barks moved around and the order broken. The connection of the specimens to their original order and purpose, was further obscured as they moved locations within the RPS and later to Kew. Only around half of the specimens are left of Howard's cabinet collection of barks. It is through these, working backwards to the cabinet again, that some order and understanding of Howard's purpose can be revealed.

Tables 5.1 discusses the information that each of the archives A-E contain. Table 5.2. shows the traced cross-references between A-E, with numbers of traced extant specimens in the EBC. Table 5.3 shows how many of Howard's 'personal collection' remains and are discussed in the following sections.

Figure 5.3 The remaining four specimens from Howard's personal collection that still retain their chemical isolations.
A: EBC52827; B: EBC 52880; C: EBC 5290; D: EBC 52972. Images Author's own.

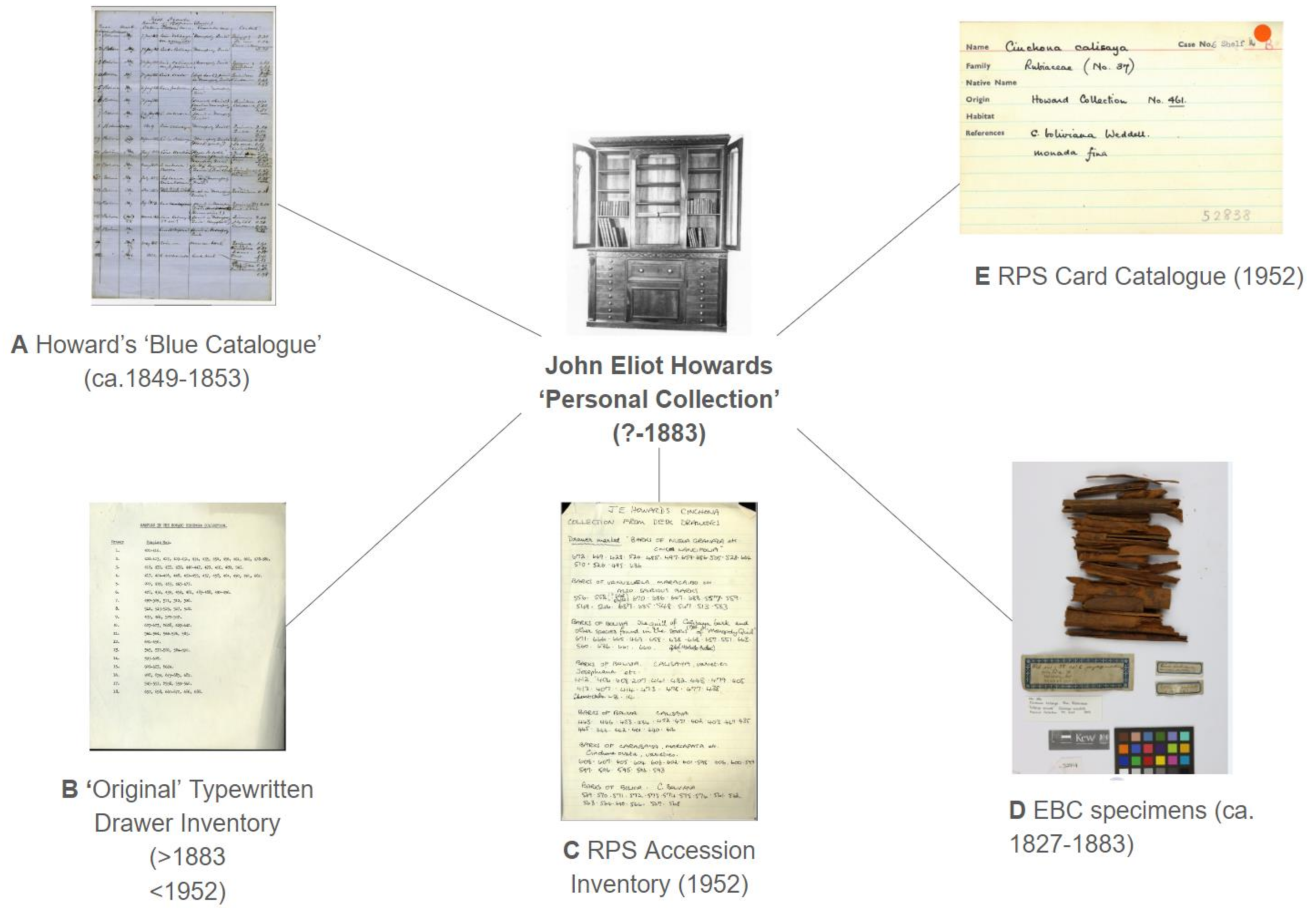


Figure 5.4 Reconnecting the data: Description of the items involved in reconnecting the specimen data. This can be linked to Table 5.1 and Appendix 4. Images Author's own.

Table 5.1 Archives related to the Howard Personal Collection and the data they contain. Letter codes are in relation to Figure 5.4.

Key	Item Description	Date created	Howard specimen no.?	Drawer no.?	Drawer descriptor[149]	Date?	Trade supplier?	Geographical origin?	Species name?	Vernacular name?	Alkaloid analysis?
A	Howards 'blue catalogue' (n=145)	Barks 1849-Ca. 1854? (List written before 1883?)		✓	✓*	✓ Month + Year	✓	✓	✓	✓	c.70%; more detail than D
B	Typewritten Inventory (n=290)	Ca. 1930 - 1952?	✓	✓							
C	RPS accession inventory (n=290)	1952	✓		✓*						
D	EBC Specimens (n=127) (Not including his Pavón specimens n=17)	1827 -1883	Rare			c.75%, often year only	Some	17%	✓	c.60%	45%
E	RPS Card Catalogue (n=ca.127)	1952	✓			c.75%, often year only	Some	Some	✓	c.60%	Some

[149] *Please note, the drawer 'descriptor' given in **C** and **E** do not fully match.

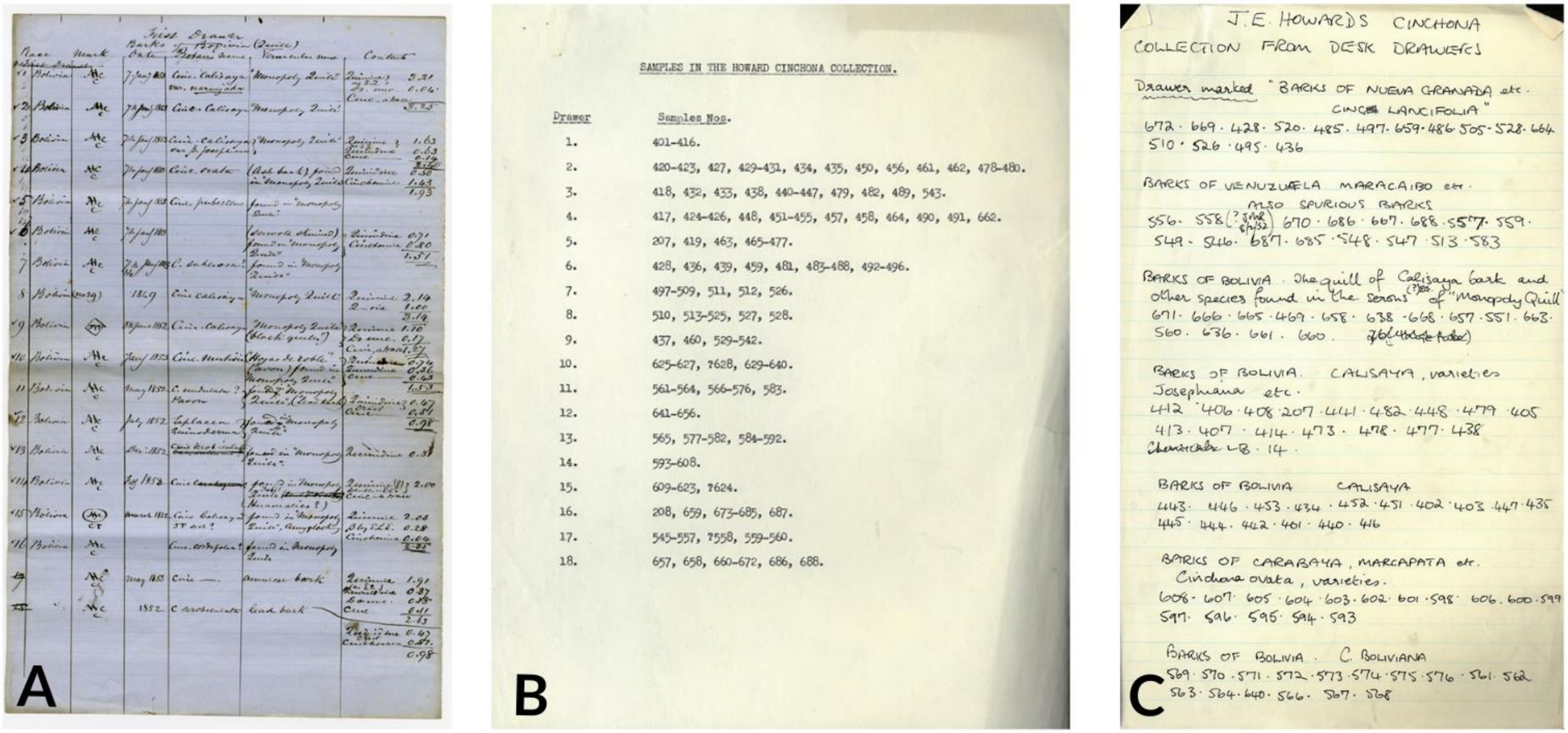
Table 5.2 Reconnecting and cross referencing the specimens and archives. Letter codes are in relation to Figure 5.4.

Step	**No. specimens connected**
[D] Specimens + [E] Card Catalogue = EBC Database which contains the combined data from a 2006 project	127 EBC specimens
[D + E] EBC Database + [A] Howard's Blue Catalogue. Because the catalogue does not use specimen numbers, items matched through label data: e.g. matching quinine analysis and/or species name and/or date etc.	Ca.25 EBC Specimens with varying confidence
[B] Typewritten inventory + [C] RPS accession inventory matched via Howard specimen number. From this, a combined table was produced. It must be remembered that these lists represent the full original collection, of which only half now exists.	290 EBC Specimens
[D+ E] EBC Database + [B] Typewritten inventory.	114 EBC Specimens
[D + E] EBC Database + [A+B+C] The three catalogue/inventory lists *Drawer number order agreement between the two lists: 6 (Drawers 9, 11-15)* *Drawer number order agreement on the two lists: Blue catalogue: 2 (Drawer 1 & 3)* *Drawer content (specimen) order agreement is rare. E.g. Specimen no. 401 appears in drawer 1 of the typewritten and blue catalogue, but not in the same order, i.e. it comes first in the typewritten list but 7th in the blue catalogue. Many other drawer contents disagree.*	*18 EBC specimens that appear on all three lists.*

Table 5.3 Connections between Howard's existing EBC 'Personal Collection' specimens and the 3 inventories.

Specimen Category	No.
Kew EBC Specimens that exist marked as 'personal collection'	127 individuals[150]
Matched to Inventory list (n=290) *(some appear twice, some are connected to more than one bark)*	114 (40%)
No. not traced in list due to lack of number	6
Not traced in list due to non-corresponding number	12
Not traced to Howard's blue catalogue (n=145)	23 (16% of Blue Catalogue 7% original no.)
Marked as 'personal collection' but in reality, belonging to the Ruiz & Pavón Collection (Different specimen No.) Originally stored separately from the main 'personal collection'. See Walker et al. (2022)	17

[150] The reasons for these numbers not adding to 127 include:
Some items in EBC have had their labels mixed as they were originally housed in one single jar, EBC 52983 contains 4 separate labels associated with four other samples (these samples include 7983 & 7984, the others are unknown).
2 specimens appear in the typewritten inventory twice (Howard specimen 479 & 662), likely a mistranscription.
2 specimens appear twice in the RPS accession inventory. (Items 583 and 643), likely a mistranscription by the RPS accessioner.
The non-corresponding numbers (n=12) are found on specimens at Kew but do not occur on either list. These may be down to mistranscriptions of specimen numbers occurring at Kew in 1983. These may include items from the first two points. Nine of these misnumbered items start with a '1' and roughly match the unmatched '5' section, e.g. '110' may have been '510', but this is conjecture.
A selection of additional barks are marked as 'personal collection' on the RPS Catalogue cards but appear not to be part of the original cabinet collection. Instead, these belonged to Howard personally as part of the Pavón specimens he purchased in 1858 (n=17) (Also discussed in Walker et al., 2022).



SAMPLES IN THE HOWARD CINCHONA COLLECTION.

Drawer	Samples Nos.
1.	401-416.
2.	420-423, 427, 429-431, 434, 435, 450, 456, 461, 462, 478-480.
3.	418, 432, 433, 438, 440-447, 479, 482, 489, 543.
4.	417, 424-426, 448, 451-455, 457, 458, 464, 490, 491, 662.
5.	207, 419, 463, 465-477.
6.	428, 436, 439, 459, 481, 483-488, 492-496.
7.	497-509, 511, 512, 526.
8.	510, 513-525, 527, 528.
9.	437, 460, 529-542.
10.	625-627, ?628, 629-640.
11.	561-564, 566-576, 583.
12.	641-656.
13.	565, 577-582, 584-592.
14.	593-608.
15.	609-623, ?624.
16.	208, 659, 673-685, 687.
17.	545-557, ?558, 559-560.
18.	657, 658, 660-672, 686, 688.

Figure 5.5 The three cabinet collection inventories.
A) The first page of the blue catalogue list (JEH/1/21 Library Art and Archives, RBG Kew); B) The typewritten inventory (collated between 1883 and 1952); C The first page of the RPS accession inventory (both File 88, *Cinchona* shelves, EBC, RBG Kew). See Appendix 4 for large-scale images.

Figure 5.6 EBC 52726 contains a broken jar from Howard's original packaging.
Image Author's own.

Figure 5.7 Howard's original cabinet jars. No 566, *C. coccinea,* matched to EBC 52809 on the right.

5.3 Reassembling the collection

This section lays out the history of the specimens after they were removed from the cabinet, their relation to the above archives, the steps to reconnect the data. Reassembling the collection allows the reconnection of additional data from the archives to enrich the specimens. The main archives relevant to the cabinet include the three catalogue/inventory lists (A-C) previously discussed, the specimens and the RPS card catalogue (Figure 5.4).

Relatively few of the specimens could be linked to the original inventory (A - Howard's Blue Catalogue) due to lack of catalogue numbers on the paper catalogue itself, despite their use on the jars (Tables 5.1-5.3). This highlights the nature of Howard's curation practices, different from contemporary collection standards which require a unique catalogue referencing system between specimens and their archives, as well as original packaging preservation where possible. As mentioned above, repackaging of item and loss of material clues at various points in the collection's history has led to difficulty in reconnecting objects.

The lack of such a connected system in historic botanical collecting has led over time to disjointed, diasporic collections that lead to difficulties reconnecting related items, as has been noted in similar collections (Punzalan, 2014; Walker et al., 2022). However, even without a full reconnection of all items, each of the archives represents the changing value and purpose of the collection over time and provides important overlapping information that enhances collection analysis.

At Kew, around 127 (43%) of the original 290 Howard personal cinchona specimens were traced. The rest were destroyed by a beetle infestation of unknown date at the RPS.[151]

[151] A note at the beginning of the RPS cinchona catalogue cards. Cinchona shelves, Economic Botany Collection, Royal Botanic Gardens, Kew

5.3.1 Repackaging & data loss

There are a range of reasons why repackaging and relabelling occurred historically, often due to standardization of both labels themselves and for overall collection presentation. In botanical collections, the reorganisation or redetermination of families, genus and species can render older labels 'obsolete'. Other reasons include damage to original packaging or for (re)display at exhibition.

Today, as part of standard museum practice, specimens receive a unique alpha and/or numerical collection reference record which is also adjoined to associated records such as archives, so that related items can remain connected (Collections Trust, 2019). In addition, as far as is reasonably possible, original packaging and labelling should be preserved, as these may have material clues that can be later decoded. The purpose of these actions is to preserve material as well as archival data, e.g., glass style, label types and handwriting that can show relationships between objects, be traced to certain collectors or restrict time periods (Griffenhagen & Bogard, 1999; Longair & Hannan, 2017; Salick et al., 2014). When data is lost, the specimens lose these connections and obscure the provenance.

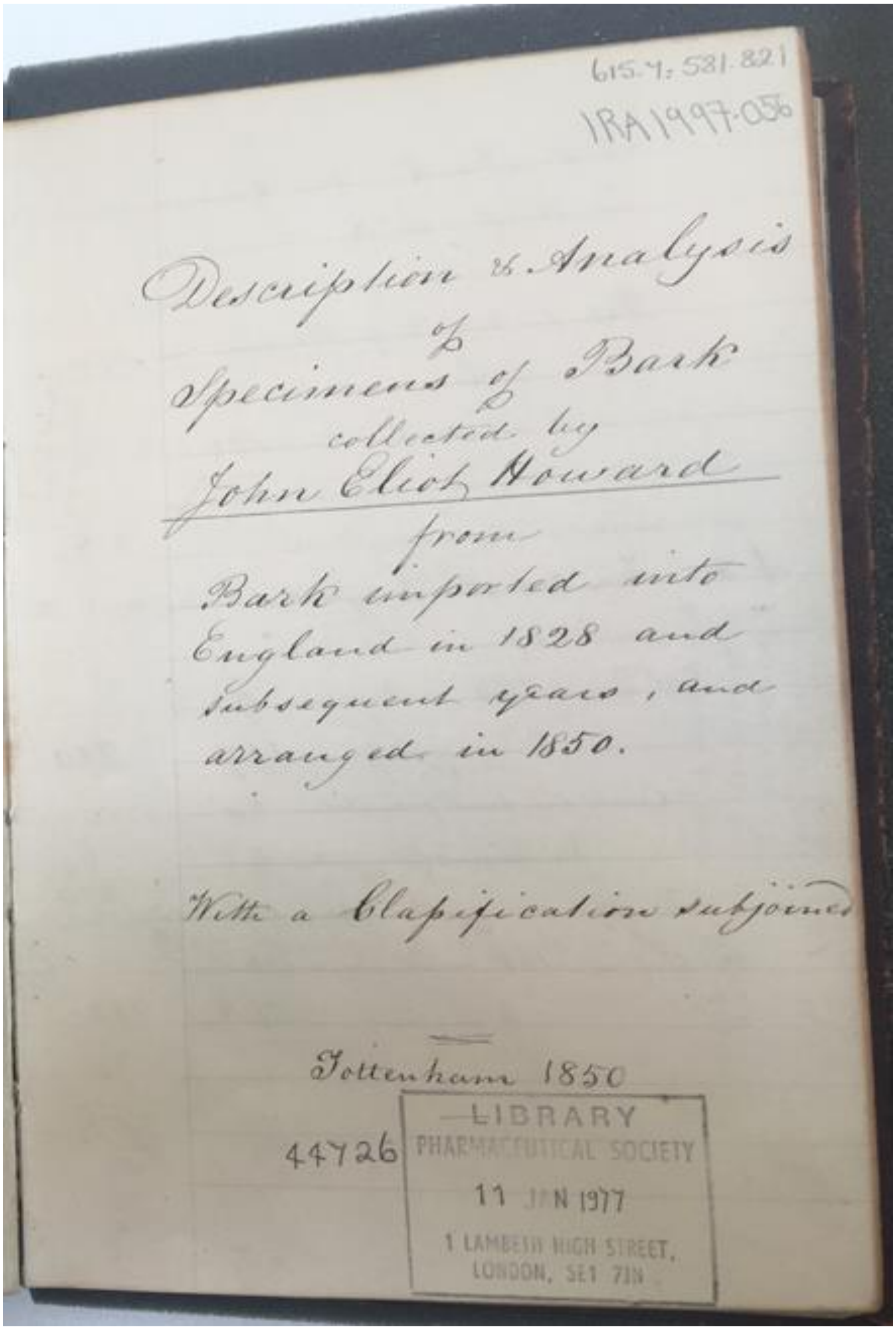
On transfer of economic botany collections to new ownership in the nineteenth and twentieth centuries, it was not uncommon for items to be repackaged and relabelled. This frequently occurs with cinchona, as seen at Kew and Naturalis Biodiversity Centre in Leiden. However, in contrast, this does not often happen with herbarium sheets, where preserving original labels is a key protocol to show changing identification or nomenclature over time (Cook, 1995; Rabeler et al., 2019).

The RPS collection came to Kew in 1982/3 at a time when the Economic Botany Collection was undergoing change. A purpose-built store was being created to consolidate the four museums that had previously existed around the gardens (Cornish, 2013). This move to a new location provided the chance for a digitisation project, with computer database and new standardised labelling. In her examination of the wood collections at Kew, Caroline

Cornish noted some curation practices that affected the materiality of original specimens. For example, some woods were cut down to a size to fit the new space (Cornish, 2013, p. 378). The Kew collections have historically had a role as biological reference and sampling collection which, in some cases, has taken precedence over its heritage value.

The decision to repackage the whole of Kew's cinchona collection on relocation to the new store reflected various factors. One was the sheer size of the collection (Cinchona represents one of the largest genera in the EBC at 1,091 items), with some specimens measuring over 30cm to 1m. As well as introducing a standard approach to housing samples, there may thus have been considerable space saving. In addition, safety factors based on the weight of the glass of the combined collection and the new rolling compactor shelves could have played a part, as suggested by anecdotal evidence from collections staff.[152]

[152] Personal communication.



615.4: 581.821
1RA1997.056

Description & Analysis
of
Specimens of Bark
collected by
John Eliot Howard
from
Bark imported into
England in 1828 and
subsequent years, and
arranged in 1850.

With a Classification subjoined

Tottenham 1850

44726

LIBRARY
PHARMACEUTICAL SOCIETY
11 JAN 1977
1 LAMBETH HIGH STREET,
LONDON, SE1 7JN

Figure 5.8 The title page of Howards and Sons collection handbook.
Description and analysis of specimens of bark collected by John Eliot Howard from bark imported into England in 1828 and subsequent years and arranged in 1850. A bookplate states accession in 1952. The 1977 stamp relates to the move to Lambeth. Image author's own, by permission of The Royal Pharmaceutical Society Museum.

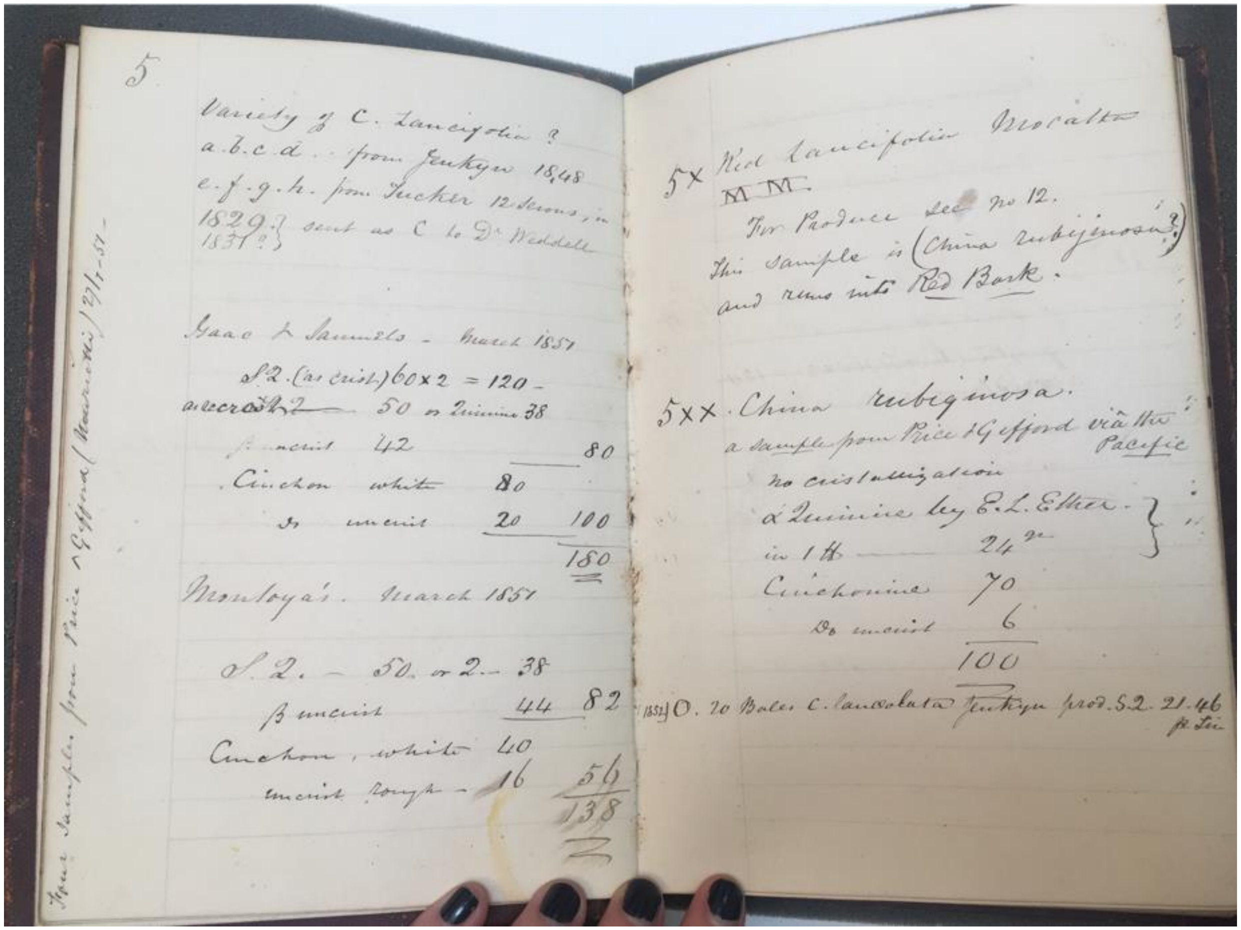


Figure 5.9 Page 5 of the of Howards and Sons collection handbook
This appears to be a register of an older, larger collection found at Howards and Sons factory. (IRA 1997.056), Image Author’s own permission of The Royal Pharmaceutical Society Museum.

5.3.2 Reconciling the data

Of the 127 surviving specimens from Howard's personal collection currently at Kew, all except 6 have an original unique three-digit reference number based on that assigned by Howard (e.g., 410). This is evidenced on the original label or, more often where the original label was lost to repackaging it was noted on the relevant RPS catalogue card. Howard's specimen reference numbering system is not consistently consecutive, showing that perhaps over time he removed specimens from the collection. An alternative hypothesis is that a larger collection of trade specimens was kept at Howards and Sons, serving as a record of trades. Howard may have selected representative barks from this for what became his personal collection. However, the catalogue for this larger collection, made by Howard and dated 1828 to 1850, does *not* contain any unique specimen numbers, the sequence appears instead to be based on page numbers (Figure 5.8 and Figure 5.9).[153] In addition, the notes within appear to be meaningful mainly for the author and evidently were not intended for wider readership or others to understand the collection curation. It may also be that the numbers on Howard's personal collection specimens represented a third system, perhaps a stock purchase number, for which direct evidence has been lost.

These three-digit numbers of Howard's specimens, as recorded on the later inventories, range in a non-consecutive order between 207 and 688. While they roughly follow a date pattern from oldest collected to newest (300 & 400s in 1830s - 1840s; 500s in 1840s-1850s; and 600s in the 1850s) there are wide overlaps and odd occurrences obscuring any obvious pattern. As mentioned, Howard's cabinet organisation focused on geographical origin. While the organisation of the cabinet roughly represents lowest to highest specimen number generally across the drawers, it is not a rule, the numbers and dates are sometimes non-consecutive. Therefore, while in theory using specimen numbers should allow a neat reconstruction of the data, this is not always possible.

[153] *Descriptions and analysis of specimens of bark collected by John Eliot Howard*, IRA 1997.056, Archives of the Royal Pharmaceutical Society, London.

Clearly, from Howard's blue catalogue (Figure 5.5/A), a unique number system was not the main key used by Howard, who curated using an *in situ*, physical location practice. The lack of a unique reference reconnecting all three lists and specimens therefore makes the project of mapping specimens onto archives more difficult. Clearer label data and a 'key' to the curation using a handbook would be the ideal scenario to unlocking the items. It is possible that Howard had a handbook for his personal collections, that used the numbers, but this has not been traced.

On the specimens themselves, it is rare that labels contain standardised information of a sort comparable to Howard's blue catalogue list, e.g., origins or trade names. On these, the focus always seems to be on chemical analysis and species. In contrast to modern collection management, Howard's bark collections were not for public display, instead curated for his personal use, unless sent out for exhibition. The barks were kept in a particular order in a particular space that made sense to him. Once taken from that space, they no longer maintained their sense of relationship and value. A parallel case is that in many households, there is a precise space in the kitchen for the corkscrew, the tin opener and tea towels. Their location can often make sense to the owner but make little sense to the stranger trying to locate them. Howard's barks likewise lack the key person that could decode the barks in their entirety: Howard himself. The lack of handbook and meaningful labels mean that a more difficult 'reading' of the objects is required. However, by triangulating the archives, some inferences can be drawn.

An overview of the cabinet and archives can be seen in Figure 5.4. The data they contain, showing absences and overlaps can be seen in Table 5.1. Only part of the manuscript of the blue catalogue now survives, giving details of the contents of the first nine drawers, representing half of the original collection. As only around half of the specimens from the 18 drawers have survived this means that relatively few specimens can be reconnected with the catalogue.[154] Reconciling the data as represented through the relationships in Table 5.1 and connecting these is described in the steps in Table 5.2 The results of these steps are given in Table 5.3.

[154] Due to insect damage, half the collection was disposed of. See note in File 88.

The steps reconnecting the specimens and the archives show that while there are some overlaps between archives (where they are connected to EBC specimens), there are just as often disagreements, see the discussion in the final row of Table 5.2. The collection appears to have been rearranged or disordered more than once, likely each time the collection moved locations. The disagreements and data selection of each list also shows the different purposes and aims of their authors, which further explains the decision-making process regarding collection curation and assessment.5.3.3 Curation of the cabinet over time.

Each archival list and catalogue reflect each author's specific purpose and the collection's value at different points in its history. Howard's handwritten blue catalogue contains data that expanded beyond the barks and the labels themselves: a record of their provenance tracing their journey back to the Andes, through trade routes and reported geographical origins. Howard added his own species determination and chemical analysis to create a comprehensive quinological reference library of trade barks for aiding in their identification. This library also provided a data set for Howard's comparisons to other collections.

The later inventories reflect moments when the collection was reassessed and are thus snapshots of the cabinet at various points. The RPS inventory was created at a period when cinchona was no longer a critical part of the pharmacopoeia, nor were botanical specimens of central importance to medical training in Britain, therefore a full and extensive analysis was not required (Houghton, 2021). The cabinet in 1952 likely represented a curiosity, albeit an educational one, accessioned because of its acknowledged historical importance.

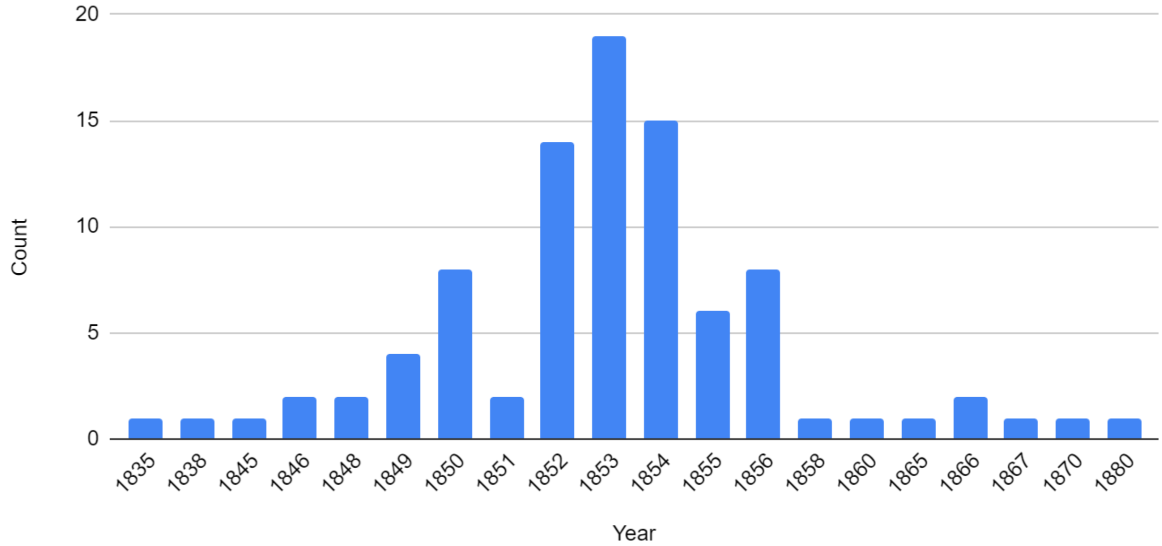


Figure 5.10 Howard's collection date from reconnected species to the 3 inventory lists (n=92 that included a date).

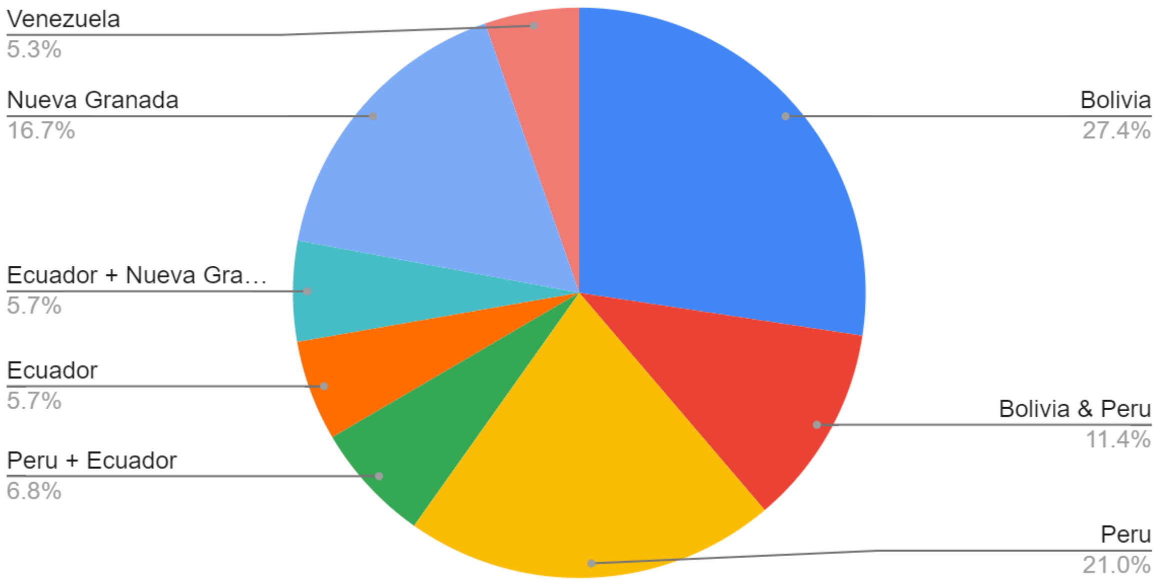


Figure 5.11 Howard's personal cabinet collection: Drawer classification ratio by country of origin according to the RPS accession inventory.[155]

[155] The inventory was chosen as the data set because, unlike Howard's blue catalogue, it shows the origins/name of all 18 drawers.

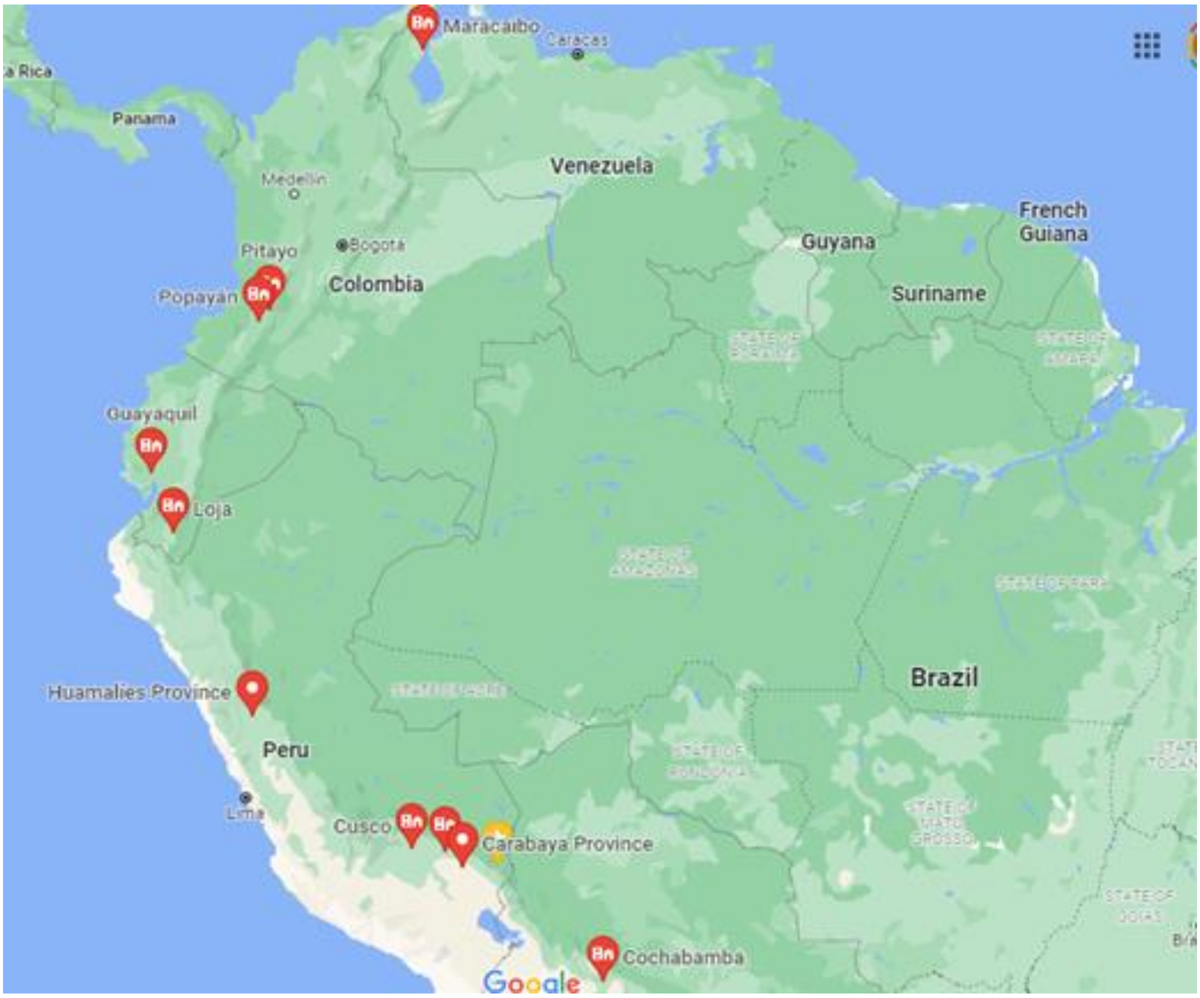


Figure 5.12 Drawer geography: the origins of cinchona according to Howard's blue catalogue drawer descriptions.

This includes trade port towns, e.g., Guayaquil, Ecuador and Maracaibo, Venezuela. Produced using Google Maps.

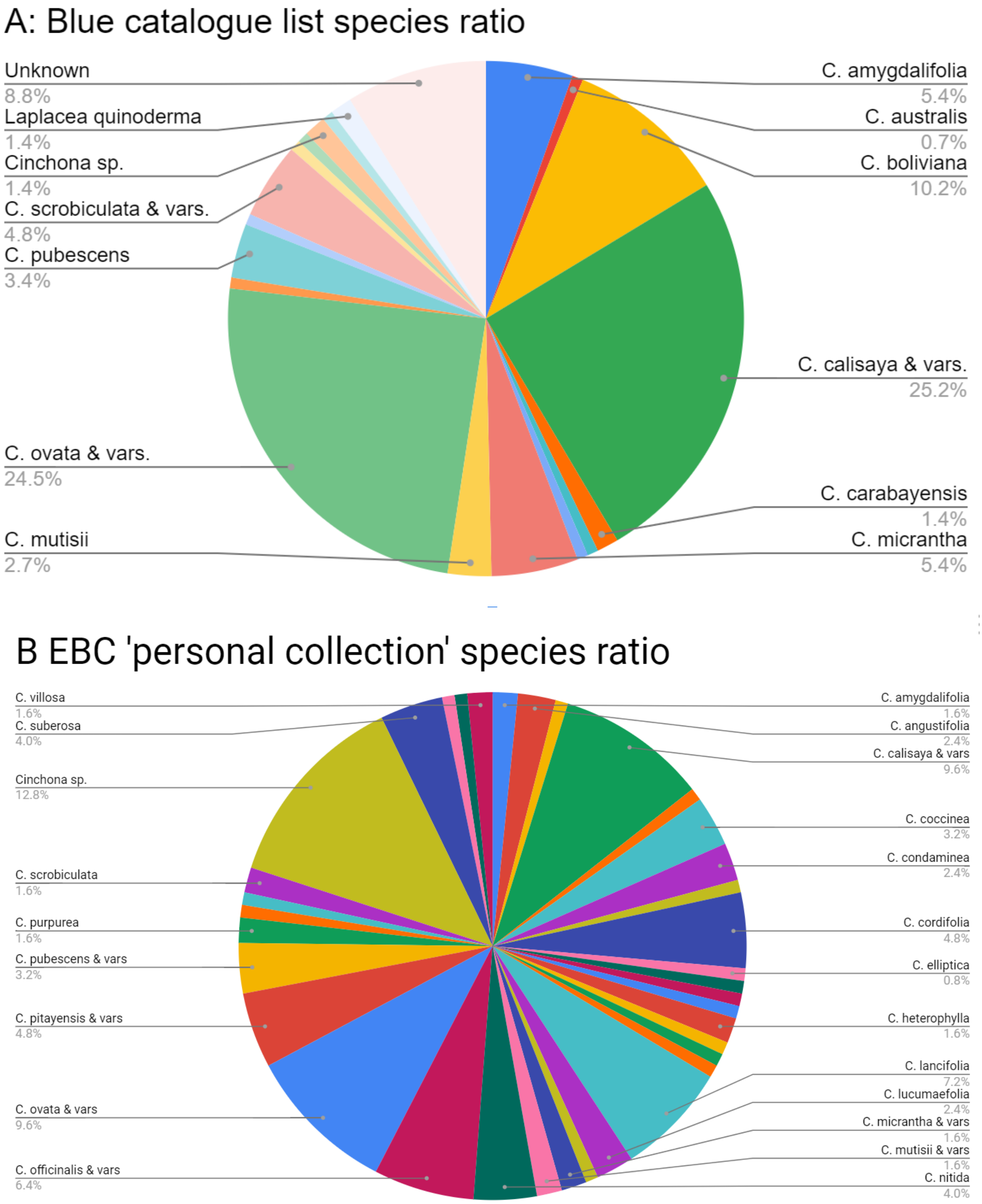


Figure 5.13 A comparison of [A]: Species in Howard's blue catalogue (n=145); [B] Species of extant EBC 'personal collection' specimens (n=127).
Both sets of species listed are by Howard's designations.

5.4 Data from the collection

Data from the cabinet collection has been analysed by date, geographical origin and species.

Dates

Figure 5.10 shows the collection dates from surviving specimens in the cabinet. The small number of specimens (n=92) may be unrepresentative. However, the patterning of dates does align with Howard's timeline, from 1825 to 1880 (i.e. the start of his career to shortly before his death). There was an increased collection rate over a seven-year period between 1849 and 1856, peaking around 1853. As discussed in Chapter 4, the period between 1851 and 1853 was an important period in Howard's career. He displayed his award-winning set of cinchona barks at the Great Exhibition of 1851, the moment he first engaged with the wider scientific community. Howard subsequently published his first scientific articles in 1852 and book in 1853 (Howard, 1852; 1853). Therefore, this increase in collection rate reflected Howard's new research focus and collection practices.

After 1856, additions to his personal collection reduced in number, possibly because the cabinet was fuller and Howard regarded his dataset as complete. Archival evidence also shows that from the 1850's Howard started sending small 'complete' collections of specimens to other individuals and institutes. This may be where incoming new specimens were being directed, rather than to his own cupboard.[156]

After this date, Howard also focused on obtaining further Peruvian field-collected specimens from *La Real Expedición* (1777-1816). He eventually purchased these in 1858 from Madrid (discussed below in Chapter 7) and published a major book on it, the *Illustrations of the Nueva Quinologia of Pavon* (Howard, 1862), also discussed in Chapter 7. In addition, in the 1860s the British established cinchona plantations in India. In response to this, Howard shifted his research focus - the subject of the next chapter.

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[156] Evidence for this lies in various sources: the dates for thank you letters the file JEH/1/9, Library and Archives, Royal Botanic Gardens Kew; RPS Pharmaceutical Journal acknowledgements and also within other collections such as the Austrian Apothecaries Association (dated around 1865) and the Economic Botany Collection, Naturalis, Leiden (dated between the 1850s and late 1870s) where this author found Howard barks.

Geographical origins

Figure 5.11 shows bark origins based on the geographical drawer descriptors as given in the RPS Inventory, Figure 5.12 shows these mapped. South America bark trade origins shifted along the Andes as supplies were discovered, then exhausted and the specimens partially reflect these markets. In 1859, Howard explained these changes in a letter to Clements Markham, describing the consecutive exhaustion of certain bark types from Nueva Granada between 1849 and 1855, with barks mainly arriving from Peru and Bolivia, but with continuing worries over the vagaries of continued supply.[157]

Though conclusions based on such small data are tentative, this analysis appears to corroborate the pattern mentioned by Howard in his letter to Markham. The barks of Bolivia and the area of Carabaya (Peru) are amongst the first collected and predominate throughout, as reflects the main growing areas and the markets. In 1849 barks from Nueva Granada (now the area of Colombia) appeared, between 1849 to 1852, then faded out until its reappearance in the 1860s. However, despite predictions of market collapse due to overharvesting, Howard later stated that cultivation had helped prevent the exhaustion of the wild cinchona forests and that new wild sources had stabilised the market (Howard, 1876).

Indian barks do not appear in Howard's personal collection, the purpose of which was for identifying trade samples with little data. Though Howard later analysed Indian barks for the Government, publishing these in his 1869 book, *The Quinology of the East Indian Plantations* (Howard, 1869), it does not appear that he kept many himself, though this may be because they formed part of the lost general factory collection discussed in section 5.2. The collection data shows too, that he sent some of these on to Kew instead.[158]

Species

Figure 5.13 shows that Howard's Blue Catalogue contained 28 different species from

[157] Howard to Markham 13 July 1859 as cited p. 166, *Cinchona notebook 1*, (CRM/55), Royal Geographical Society Archives.
[158] For example EBC 52305, 11021, 52311 & 52398, Economic Botany Collection, RBG Kew.

Bolivia and Peru (Figure 5.13/A). The collection currently in the EBC represents 36 species according to Howard's own assessment (Figure 5.13/B). Because each of these two sources shows a different sub-sample of Howard's original collection, a comparison of the species numbers is of limited utility. However, in both samples, C. *calisaya* (n=37) and *C. ovata* (n=36) were the most common species collected between 1835 and 1880. When the original binomials assigned by Howard are updated to modern determinations then the two largest categories are *Cinchona calisaya (n=46) and C. pubescens* (n=32).[159] Both species are recorded as native to Bolivia by Andersson (1998). Both are alkaloid-rich varieties common to Bolivia and Peru, the main suppliers of the bark trade and this may well explain why they are highly represented in the collection. Howard's cinchona collection reveals his collecting habits and preferences in terms of species and origins of trade barks in the nineteenth century. However, as a pharmaceutically interesting species, Howard may have selected these out as barks of interest and introduced a collection bias. However, analysis of the collection statistics gives some insights into the history of the global cinchona trade. Comparison with other collections remains an area of potential further research.

5.5 Analytical tools & reverse botanising

> It has been my object to begin in each case de novo, and to attain, as far as possible, clear and certain information as to individual forms of the Cinchona and the barks which are their products, and thus to trace out (following the guidance of authentic specimens) the produce of each sort or variety as it now occurs in the importations from Peru. (Howard, 1862, p. iv)

Howard's detailed and intricate publications make clear the complex knowledge required to understand cinchona, explaining why he devoted his career to the specialist study of a single genus.[160] Howard's collection of reference materials was a way to manage knowledge of an aggregate set of specimens that would allow a comparison and contrast of incoming data. In this way, he could use a specimen's trade clues such as origin and vernacular name and by comparing material features, microscopic and

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[159] Using Andersson, 1998 and https://powo.science.kew.org/

[160] Only two other articles *not* on cinchona have been traced: on the growing of datura in Howard's garden, published in the *Gardeners' Chronicle* (Howard, 1879); and 'Notice of a floating island in Derwentwater Lake, formed by *Lobelia Dortmanna*, Linn.' read out at the Linnean Society Meeting of 5 November 1874. (SP/572), Library of the Linnean Society of London.

chemical analysis, then 'reverse botanise' in order to extrapolate species and their chemical value.

The difficulty in identifying specimens based on trade information, such as origin or vernacular name, was noted by Howard: 'It would fatigue the reader to study even a portion of the difficulties which arise from this practice.' (Howard, 1853, p. 43). Depending on the geographical origin of the barks, what could be classed as 'red bark' in one place, could be yellow bark elsewhere. Howard believed that part of the error in colour assignations originated partly with José Celestino Mutis, the eighteenth-century cinchona expert based in Ecuador, whose terminology of Nueva Granadian barks was based upon earlier terms for Peruvian barks, though both types of red bark were actually different species as mentioned in Chapter 1 (Howard, 1853; 1862).[161] Understanding that the region of origin could help trace the correct species and assess the value of the bark. he also noted that the 'origins' assigned to specimens were often incorrect, their 'appellation is taken from the place of shipment, where never grew a cinchona tree, in all probability, since the creation' (Howard, 1853, p. 43).

To expand upon and decode the incoming patterns of place and name, Howard was also comparing and contrasting trade barks with other known and established collections, starting from his first assessment of *La Real Expedición* (1777-1816) collections at the British Museum and herbarium at Kew Gardens as discussed in Chapter 4 (Howard, 1853; 1855). The British Museum collection was important for Howard as its bark specimens had been collected in the field and came with corroborating botanical data: related herbarium sheets and species descriptions. This allowed Howard to connect patterns directly between different species and their barks. This data set enabled him to 'reverse botanise', tracing trade barks found at London docks back to their potential origins and trees in the Andes and helped understand their connections with different species. As Howard noted in his Kew herbarium and bark examinations:

I am glad to find that these varied sources of information will enable me to

[161] It is unclear if the terminology used was based on Indigenous terms.

> supply many lacunae which existed in my previous examination… the examination of the *barks* must not be without importance in the discrimination of the *plants* themselves. (Howard, 1855, p. 1)

It is around the time of accessing the British Museum and Kew collections that Howard appears to have established his own personal cabinet (Figure 5.2), changed the way he analysed trade barks and added a more botanical aspect to his work.

As discussed in Chapter 4, Howard also corroborated trade knowledge with analysis of specimens from other collectors, including those who had visited the tree in its native habitat. For example, in Howard's Great Exhibition display, the *Pharmaceutical Journal* explicitly noted the trust that could be placed in the bark classification due to the company's consultation with cinchona collector Hugh Algernon Weddell (1819-1877) ('Great Exhibition', 1851, p. 15). This mention of Weddell shows that Howard's international networks were already established as early as 1851. It also shows that the taxonomic conundrum of cinchona was a well-known issue in the botanical and pharmaceutical world and opinion from botanists was vital to manufacturers, no matter how long experienced they were in trade or the laboratory. Weddell's collection experience in the forests of South America earned respect as first-hand knowledge. This was often valued more highly than collections-based knowledge like Howard's. These themes - the taxonomic uncertainty, the position of tradesmen in the botanical world, the value of different types of knowledge and the importance of knowledge networks - appear frequently throughout Howard's career.

Medicinally valuable barks existed in multiple categories. As Howard states:

> It is well known that from a therapeutic and pharmaceutical point of view, the value of a specimen of bark does not coincide with the amount of quinine it may contain. Other ingredients, and among them the alkaloid commonly known as *uncrystallizable quinine*… no doubt contribute largely to the medicinal qualities of the bark… (Howard, 1870a)

The barks that were useful for quinine extraction in industry, producing an output of crystallised, bottled alkaloids, were not always the same as those that could be used in whole bark preparations by physicians. Barks containing higher amounts of quinine were privileged over others and this should be remembered when using his texts to evaluate species 'value'. This is discussed throughout the British Indian plantation project where other alkaloids were considered as potential medicine and were touched upon in Chapters 1 and 4 (Howard, 1869; 1876). This categorisation of value is also relevant when looking at Howard's approach to botanical assessment, explaining his approach to handling trade and species naming as well as medicinal content.

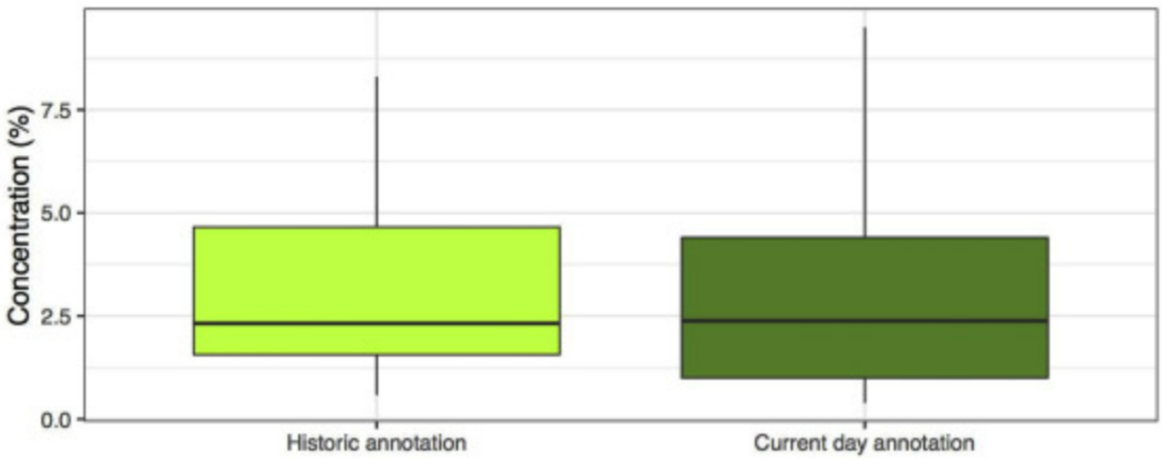

Figure 5.14 Boxplot comparing total alkaloid content between historic and current day annotations of cinchona specimens, including Howard's (using HPLC). Comparisons between historic and current annotations were calculated using Spearman's rank correlation coefficient, while linear relationships were drawn on significantly correlating alkaloids for illustrative purposes only. Reproduced from Canales et al. (2020).

5.4. Reassessing Howard's chemistry and species identifications

A recent paper (Canales et al, 2020) reviewed the chemical analysis of historic cinchona collections including Howard's own specimens. The investigation showed that quinine alkaloids remain relatively stable over time, even within historic samples, and present-day analyses of chemical content are comparable to Howard's analyses (Figure 5.14). In this case, the alkaloid extraction and measuring processes used by Howard to analyse samples at the time were found to be reliable.

However, while Howard's chemical analysis has withstood modern chemical analysis, his species determinations have not. This highlights the different value he placed on names compared to modern standards today. While technically 'botanically' incorrect, he recognised differences that were of value to pharmacy (chemotypes) that have the potential for further research. That is, Howard described more varieties than are recognised today. Of the 26 species and varieties Howard named, all are now recognised as synonyms and grouped together or into other species (Table 5.4). For example, he has recognised *C. officinalis* correctly but split it into varieties not now recognised. For other specimens, these have now been moved to different species such as *C. peruviana*. This difference in naming is partly due to the difficulty of *Cinchona* determination, but also due to uncertainty within the contemporary understanding of what a species was. In addition to this, and perhaps most importantly, can be explained by Howard's approach to identification:

> '...the consideration of the Cinchonaceous plants more from a practical than from a technically botanical point of view and thinks that much remains yet to be done by careful study of the plants themselves, to reduce Botanical terms to harmony with Pharmaceutic requestions, and thus to discriminate between forms which, in a therapeutic point view, produce wholly different products and which have been thrown by systematic arrangement founded on insufficient data.' (Howard, 1866, p. 11)

Howard's assessment of the genus came from a distinctly pharmaceutical perspective, classifying barks on their chemical value, or chemotype in a form of pharmaceutical taxonomy. However, there is great chemical variability within species, likely due to genotypic factors as well as environmental influences, as shown by recent research by Maldonado et al. (2017b). As a practical chemist, Howard was looking at the plants beyond simply their botanical features, attending to their chemical profiles too. Howard recognised the variation that came with *Cinchona* varieties in relation to his determinations. He was what is considered a 'splitter' rather than a lumper: recognising and differentiating small differences within populations (Bonneuil, 2002; Endersby, 2009). While his understanding may now be considered limited from a contemporary plant science viewpoint, from a pharmaceutical and cultivation perspective his understanding of relevant and important differences in varieties remains relevant. As Howard stated:

> The questions of "Species" and "Varieties" thus tempt us almost irresistibly to some hypothetical solution of the reason of their existence, but it is quite beyond the compass and foreign to the scope of the present work to enter largely upon any such abstruse discussion. It is with the different *forms* of

> Cinchona that present themselves to our notice that I have to deal; and that with the purpose of pointing out to the cultivator those which will be most likely to further his wishes. (Howard, 1876, p. 75)[162]

These chemical variations within species however, were responsible for uneven rates of success in historical attempts at cultivation. A chemically weak species, such as *C. pahudiana* first cultivated by the Dutch in 1851, is now known to be a synonym of *C. calisaya*. Cultivation of this plant initially hindered quinine production by the Dutch. However, despite this slow start, the Dutch later dominated quinine trade with cultivation of *C. ledgeriana*, which produced plants with remarkably high quinine content. This was later shown to sit within *C. calisaya* (Andersson, 1998; Roersch van der Hoogte & Pieters, 2014). The focus on chemical variation within species was a feature of pharmaceutical botany and can be seen within many of the labels of the Pharmaceutical Society specimens beyond cinchona. For example, similar species variations and debates can be seen, for example on coca (*Erythroxylon* spp.) and opium poppy (*Papaver* spp.), the source of cocaine and morphine respectively. This is an area of potential further research to be taken up with chemical and genetic assessment.

Table 5.4 Howard's published species and modern day synonyms[163]

Species/variety name	Synonym
Cinchona calisaya var. *ledgeriana* Howard	*C. calisaya* Wedd.
Cinchona cordifolia var. *macrocarpa* Wedd. ex Howard	*C. pubescens* Vahl.
Cinchona crispa Tafalla ex Howard	*C. officinalis* L.
Cinchona forbesiana Howard ex Wedd.	*C. calisaya* Wedd.
Cinchona ledgeriana (Howard) Bern.Moens ex Trimen	*C. calisaya* Wedd.
Cinchona obovata Pav. ex Howard	*C. pubescens* Vahl.
Cinchona officinalis var. *bonplandiana-colorata*	*C. officinalis* L.

[162] Howard is referring to Darwin's theories of natural selection and this aspect is discussed further in Chapter 7.
[163] Table updated names taken from Plants of the World Online (2022).

Howard	
Cinchona officinalis var. *Bonplandiana-lutea* Howard	*C. officinalis* L.
Cinchona officinalis var. *condaminea* (Bonpl.) Howard	*C. officinalis* L.
Cinchona officinalis var. *crispa* (Tafalla ex Howard) Howard	*C. officinalis* L.
Cinchona officinalis var. *uritusinga* Howard	*C. officinalis* L.
Cinchona pahudiana Howard	*C. calisaya* Wedd.
Cinchona pallescens var. *ovata* (Ruiz & Pav.) Howard	*C. pubescens* Vahl.
Cinchona peruviana Howard	*C. calisaya* Wedd.
Cinchona peruviana var. *micrantha* (Ruiz & Pav.) Howard	*C. micrantha* Ruiz & Pav.
Cinchona peruviana var. *nitida* (Ruiz & Pav.) Howard	*C. nitida* Ruiz & Pav.
Cinchona peruviana var. *reicheliana* Howard	*C. micrantha* Ruiz & Pav.
Cinchona peruviana var. *vera* Howard	*C. calisaya* Wedd.
Cinchona reicheliana Howard	*C. micrantha* Ruiz & Pav.
Cinchona robusta Howard	unresolved.
Cinchona rosulenta Howard ex Wedd.	*C. pubescens* Vahl.
Cinchona subcordata Pav. ex Howard	*C. pubescens* Vahl.
Cinchona suberosa Pav. ex Howard	*C. officinalis* L.
Cinchona umbellulifera Pav. ex Howard	*C. scrobiculata* Humb. & Bonpl.
Cinchona undulata Pav. ex Howard	*C. glandulifera* Ruiz & Pav.
Cinchona uritusinga Pav. ex Howard	*C. officinalis* L.

5.6 Summary

Howard's place at the lab benches of the Howards and Sons pharmaceutical manufacturers meant he was able to exploit the potential of trade barks flowing into the extraction vats of the quinine department. Collection and pharmacognostic assessment of these allowed him to build up a biological reference collection for future assessments and the quinological knowledge and expertise based on its analysis. Although acts of collecting occurred throughout his life, this chapter has focused on a period of intense research around his personal cabinet of cinchona barks, collected predominantly between 1849 and 1856. A collections-based approach, linking specimens and archives, has provided rich additional data. This reading of the material tools which Howard used has aided an understanding of his curatorial and analytical practices, as well as his geographical and pharmaceutical bias, in the production of knowledge about cinchona.

As discussed in chapter 4, it was during this same period that Howard recognised the cultivation potential of the cinchona tree. In 1859, at the same time Markham set off for South America, he started to grow his own trees in glasshouses next to his Tottenham home. The shift from cabinet collections to living collections helped keep his expertise relevant as the focus on cinchona went from identifying obscure barks in trade to how to grow it best. This shift within Howard's research is the subject of the next chapter.

Chapter 6 | Howard in the Garden

6.0 Vignette - Tottenham Trees[164]

Tottenham, 1862

A spindly sapling grows in the warmth of a stove-heated glasshouse. Its thick, shiny leaves reflect the afternoon sun and it has just come into bloom. The pink, tubular flowers scent the air with lilac as John Eliot Howard adjusts them gently, untwisting the stems. It is the first cinchona ever to flower in England. The botanical artist Walter Hood Fitch has visited to record the moment in watercolour for *Curtis' Botanical Magazine* and now it is about to be captured on camera and pressed as a specimen (Figure 6.1, Figure 6.2 andFigure 6.3). Howard is particularly proud of this plant. It is the first species he has planted from seeds collected in the *Cerro Uritusinga* range of the Ecuadorian Andes by a Peruvian contact, Don Francisco T. Riofrio. Its bark is highly valued but has been overharvested and is now rarely seen in trade. Howard has been experimenting with growing this variety because of its high alkaloid content of 7.5 % by weight. Howard has named it *Cinchona uritusinga* (syn. *Cinchona officinalis*) after its mountain home.

Tottenham is far removed from the lofty Andean cloud forests but Howard has carefully controlled the environment. He has built a glasshouse at the bottom of his garden as an extended research laboratory, growing live plants for taxonomic investigation. The glasshouse and the plants within form part of his plan to expand his botanical knowledge in the face of a changing research field. As the British embark on colonial projects cultivating the profitable fever tree for quinine production, Howard has shifted research from the laboratory bench and into his garden.

The photograph capturing the moment the spindly uritusinga bloomed can be found within the archives of the Royal Pharmaceutical Society, along with images of another twenty varieties Howard cultivated. The image is captioned in Howard's hand, noting an important fact in which he evidently had taken pride: 'The *Cinchona* in flower is the sister to the one sent to India'. From Riofrio's carefully raised seeds, Howard sent a

[164] Sources for this vignette are from Howard (1870b; 1885) as well as photographic specimens in the archives of RBG Kew and the Royal Pharmaceutical Society.

single plant measuring 5 feet high to India via a Southampton steamship on 4th March 1862. From these, further cuttings eventually produced a plantation of 60,000 trees in Ootacamund in the, Nilgiris.[165] Along with the photograph, a pressed herbarium specimen of the Tottenham tree, as well as ones of Indian-grown descendants, also survive. These specimens can be found in the Kew Herbarium and Economic Botany Collection. Paired with Fitch's watercolour printed in *Curtis's Botanical Magazine*, they form a rare set of related specimens collected from the same plant. Reconnecting these allows a glimpse into Howard's scientific and horticultural practices, showing how a nineteenth-century London scientist located roughly halfway between the Andes and India was able to research a distant plant and influence how it was used.

[165] Howard also donated living specimens of *C. calisaya* and *C. anglica* to the Royal Pharmaceutical Society, Letter of Thanks to Howard, 7 February 1878, JEH/1/10; and 3 species of living tree to the Royal Botanic Society in Regent's Park, Letter of Thanks to Howard, 22 January 1879 JEH/1/10, Library and Archives, RBG Kew.

Figure 6.1 *Cinchona uritusinga* Pav. ex Howard (syn. *Cinchona officinalis*) drawn and engraved by William Fitch for Curtis' Botanical Magazine from a live specimen in J.E. Howard's glasshouse. (Hooker, 1863).
Image from the Biodiversity Heritage Library. Contributed Missouri Botanic Gardens.

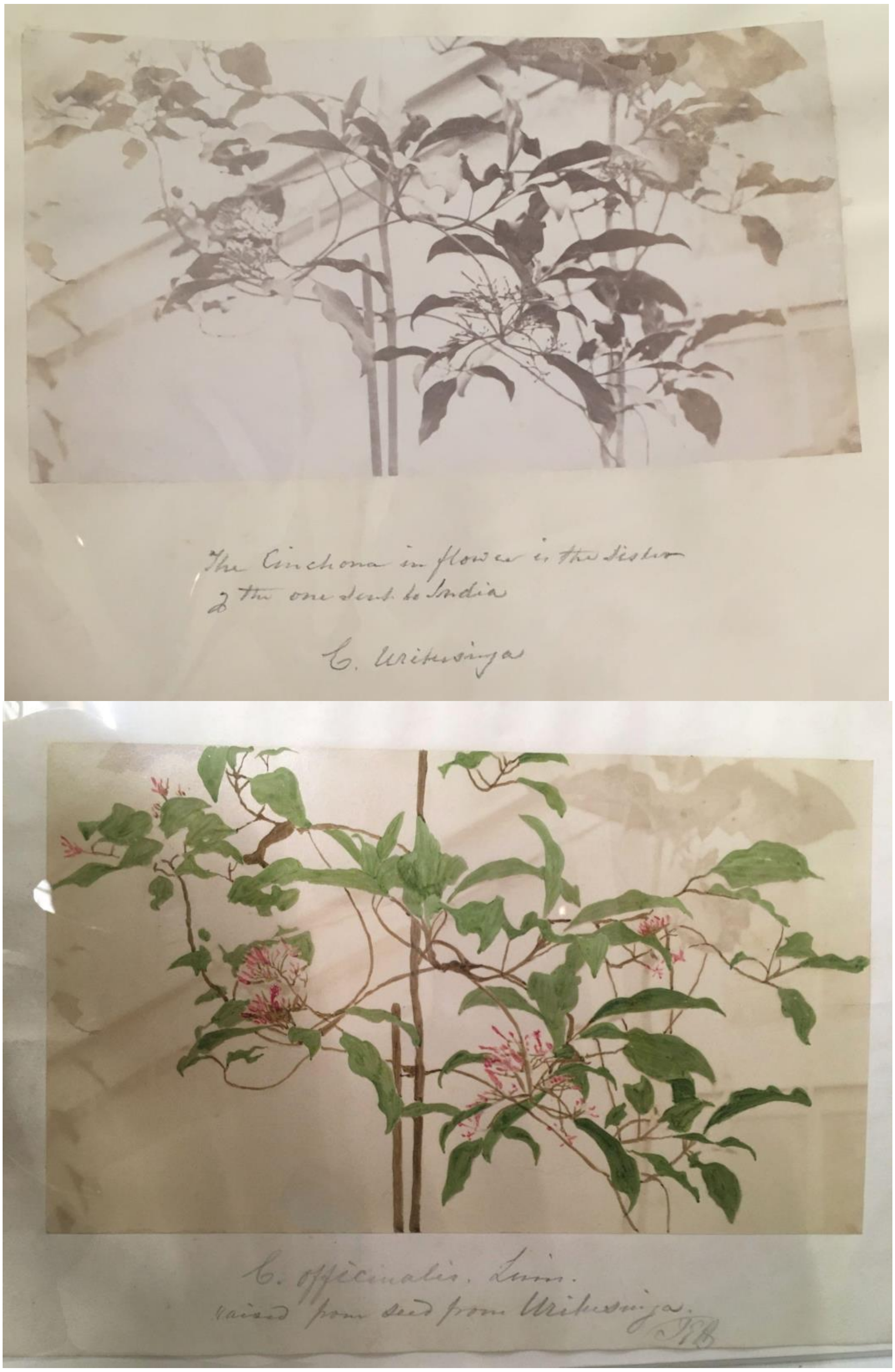

Figure 6.2 *Cinchona officinalis* (syn. *C. uritusinga*) growing in John Eliot Howard's Glasshouse.

The caption to the photo reads: 'The Cinchona in flower is the sister to the one sent to India'. The image below shows a second version of this photo, crudely (water)coloured by an unknown person, possibly Howard. Permission of Royal Pharmaceutical Society Museum.

Figure 6.3 Herbarium specimen of *Cinchona officinalis* (syn. *C. uritisinga*) grown in Howard's Tottenham Glasshouse.
K001337771, Herbarium, Royal Botanic Garden, Kew.

6.1 Introduction

> The possession of living plants gives the opportunity of observing many things not apparent in dried specimens (Howard, 1870b, p. 388)

The philosopher Francis Bacon (1561-1624) describes in his *Gesta Greyorum* four 'principal Works and Monuments' that are cultivated by 'Men in Knowledge': a cabinet, a still-house, a library and a garden (Bacon & Canning, 1594, p. 34-35; Impey & MacGregor, 1985). As we have seen thus far, John Eliot Howard had access to three comparable facilities: his famous cinchona cabinet, a factory workshop (the nineteenth-century equivalent of a 'still-house') and a specialist library.[166] By 1859, he had completed the quartet by adding the final piece: a garden.

This chapter explores how Howard adapted his research methods to further bolster his credentials as an experimental botanist and maintain his expertise in the face of a rapidly changing field. The scientific aspirations of middle-class botanists have been shown to have been developed through the practice of scientific horticulture (Lustig, 2000). As British cinchona science expanded from Andean Forest to colonial plantation, Howard further expanded his expertise by shifting the focus of his work from the laboratory into the garden through the cultivation of 'living' collections. He critiqued others who relied solely on dried specimens and 'urged the study of the whole plant in its living state, not disregarding either the microscopical or chemical examination of the bark' (Howard, 1875, p. 157). The shift towards horticultural experiment meant that Howard was able to expand his knowledge of cinchona, particularly on questions of environmentally driven botanical and chemical variability. This allowed him to maintain influence through consultation work and the provision of genetic material to enhance the medical and pharmaceutical projects of the British Empire. In addition, his shift to the study of living plants enabled Howard to better combine his religious and scientific interests as discussed in chapter 3 above.

As the British Government dispatched a team of collectors to South America to take cinchona to Indian plantations in 1859, Howard procured cinchona seeds from his own

[166] The scientific part of the library was donated to the RPS in 1952.

personal Andean contacts in order to cultivate the plant within his London home. In 1859, he constructed glasshouses in his garden to make observations, cultivating around twenty different forms of cinchona, eventually supplying plants for the British project in India.

In 1869, Howard gave a talk and discussion entitled ‘On the cultivation of cinchona plants under glass in England’ to the Royal Pharmaceutical Society, which was printed in the *Pharmaceutical Journal* shortly after (Howard, 1870b). In the paper, Howard described over a decade’s worth of experiments and observations on these living collections and gifted a set of photographs and stereoscopic photographs of his trees to the Society’s Museum. These images still exist in the Society’s archives today.[167] The lecture and photographs of Howard’s cinchona garden provide further valuable evidence of his scientific practice, especially when combined with their associated archives, illustrations, herbaria and barks found in the collections of the Royal Botanic Gardens, Kew. Through his garden, Howard created a ‘proxy’ field for experimentation with cinchona varieties beyond his laboratory.

6.2 Tottenham trees: Collection data

Through an assessment of surviving specimens and archives, links to Howard’s living collection at Tottenham have been traced. Table 6.1 gives the varieties grown, Table 6.2 breaks down the current archive specimens by type, Table 6.3 shows specimen locations. Examples of the photographs and herbarium images can be seen in Figure 6.2 and Figure 6.9. The primary focus of the analysis presented here is on the species and varieties Howard grew in Tottenham. Therefore, the illustrations and descriptions in and Table 6.3 include both journal illustrations and plants mentioned in publications but not illustrated.

Howard grew around 20 forms of cinchona covering at least 14 species (by his

[167] These are now in the illustration files of the Royal Pharmaceutical Society. Another set, from his own personal collections, exists in the archives of the Royal Botanic Gardens, Kew. A few more are attached to herbarium sheets in the RPS herbarium which is now at the Royal College of Physicians. Howard appears to have sent other sets too, one was sent to botanist Alphonse Planchon, as evidenced in a letter of thanks dated 20 February 1869, JEH/1/9 Library & Archives, RBG, Kew.

designation), a larger number than cultivated at Kew.[168] Modern botanical determination reduces these to 7 separate species, as some species names are now classified as synonyms (names no longer in use). It is clear however, that Howard continued with his research ‘from a practical rather than from an abstractedly botanical point of view’ (Howard, 1875, p.157). As discussed in the last chapter, this was also a classification objective within his bark collections: a form of pharmaceutical taxonomy that focused on varieties with alkaloid production potential, but which are now not considered distinct. The varieties grown by Howard include those being grown in the Dutch Indonesian and British Indian plantations: *C. officinalis* (3 forms) and *C. calisaya* (4 forms).

Howard did not carry out chemical analyses of the trees he cultivated. We know this because of a lack of surviving records of analyses and because he notes an unusual incident where an accidental destruction of a tree gave him the rare opportunity for analysis, as discussed below (Howard, 1866). The lack of analysis of the growing plants may reflect the simple fact that they were too valuable as living material. It also may be due to the fact that Howard could not control for all variables and so the plants were of value for their growth as specimens and not for their alkaloids, also discussed in the following sections.

It is likely that the photographs of living specimens reproduced in this chapter were taken by Howard’s first son William Dillworth Howard. It was noted that ‘Dillworth was very busy with photography’ during the same period, as well as having a role within the Howards and Sons business, part of which involved helping his father prepare quinine displays for exhibition (Howard, 1885, p.25).

[168] Although Kew held plants for acclimatisation before sending on to India, they only appear to have formally grown Weddell’s specimen in 1854. Currently only one species remains at Kew: *C. pubescens*, donated in the twentieth century from an African plantation.

Table 6.1 *Cinchona* varieties grown by Howard in Tottenham.

Howard's nomenclature	2022 nomenclature*
C. anglica	unknown
C. angustifolia	*C. lancifolia* Ruiz
C. calisaya/C. calisaya vera	*C. calisaya* Wedd.
C. calisaya var. *josephiana*	*C. officinalis* L.
C. calisaya var. *ledgeriana*	*C. calisaya* Wedd.
C. calisaya 'Schukraft calisaya'	*C. calisaya* Wedd.
C. cordifolia	*C. pubescens* Vahl
C. forbesiana	*C. calisaya* Wedd.
C. glandulifera	Accepted
C. grandiflora	*Cosmibuena grandiflora* (Ruiz & Pav.) Rusby
C. micrantha	*C. micrantha* Ruiz & Pav.
C. nitida	*C. nitida* Ruiz & Pav.
C. officinalis alpha *uritusinga*	*C. officinalis* L.
C. officinalis var. *bonplandia*	*C. officinalis* L.
C. officinalis var. *condaminea*	*C. officinalis* L.
C. pahudiana	*C. calisaya* Wedd.
C. peruviana	*C. calisaya* Wedd.
C. robusta	Unknown
C. tucujensis	*C. pubescens* Vahl
Pitayo barks	Unknown
Undetermined/Unknown	Unknown

*According to *Plants of the World Online* (https://powo.science.kew.org/)

Table 6.2 Records & archives of cinchona grown by Howard in Tottenham, by type

Specimen type	No. of items
Archival photograph	39
Herbarium specimens	7
Bark specimens	2
Publication illustration or description	16
Total	**64**

Table 6.3 Records & archives of Howard's Tottenham-grown cinchona, by type & location.

Description	Archive/Location	No. of specimens
Photographs	Royal Pharmaceutical Society Archives (Photographic Collection)	31
	Royal College of Physicians (photographs as part of the RPS Herbarium)	6
	Economic Botany Archives, Royal Botanic Garden, Kew	1
	Illustrations, Royal Botanic Garden, Kew	1
Herbaria	Royal College of Physicians (Herbarium previously belonging to the RPS, transferred in 2013)	3
	Royal Botanic Gardens, Kew (Herbarium)	4
Bark specimens	Royal Botanic Gardens, Kew (Economic Botany)	2
Published Descriptions/Illustrations	Howard's publications	14
	Curtis's Botanical Magazine	2
TOTAL		**64**

Figure 6.4 *C. palalba* (*C. pubescens* Vahl), 'sent over with a specimen of bark by Mr Riofrio in 1862'.
K001337012 Herbarium, RBG Kew.

Figure 6.5 'Crespilla of Riofrio from Cuenca' Cinchona rugosa (*C. pubescens* Vahl.). EBC 52770.
Image Author's own.

Figure 6.6 A specimen or uritisinga bark (*C. officinalis* L.) 'the seeds of the accompanying specimens vegetated and are now flowering in JEH's hothouse'. Specimen sent by Riofrio to Howard, passed on to Justus Karl Hasskarl, 1861.
L2110219, Economic Botany Collection, Naturalis Biodiversity Centre.
Image Author's own.

6.3 Between the cabinet and the field: *in situ* and *ex situ* botany

> I wish particularly to receive the specimens Mr R. provided me from the Eastern side of the mountain Uritusinga and also from the Western, shewing the effects of the morning and afternoon sun. The bark should be accompanied by the leaves of the tree to shew that it is the <u>same tree</u> in both situations (Howard to Riofrio, 1857).[169]

Howard's scientific enquiry into the influence of the environment on the variability of cinchona botany and chemistry was important. As he did not know the growing conditions of trade-collected barks, he could not rely solely on his cabinet collection for data. Since trade barks had provided the sole source of cinchona up until this point, knowledge gleaned from these specimens had been sufficient when combined with herbaria and specimens collected on older field-collecting trips such as the *Real Expedición*, as discussed in the last chapter. As cinchona cultivation loomed, grappling with the seemingly endless variety of cinchona forms led to Howard thinking beyond the laboratory to a broader view on the biology of the plants. This shift was essential because environmental factors were known to affect the morphology of plants and their production of chemicals, but no one knew precisely how (Howard, 1862). Unable to visit the 'field' himself, Howard cultivated contacts in South America to, firstly, answer his enquiries about how cinchona was affected in different locations/environments, as well as requesting herbarium and barks. As Chapter 4 showed, we know Howard had at least seven contacts (Table 4.1) across South America in Colombia, Ecuador, Peru and Bolivia.[170] In June 1855, for example, he received reply from Guayaquil-based 'contact' (of which we only have the translation):[171]

> The Commission which you send to procure for you a piece of the trunk of the larger branches and of the roots of a red bark tree packed in 1 seron, then pieces of the smaller branches, with leaves, flowers and fruit or seeds in another seron, has my particular attention. So soon as I shall receive these objects from the interior, it will give me much pleasure to forward them to you. But I warn you I

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[169] Letter dated 30 December 1857, It is written about 'Mr R' as it was to be translated into Spanish and forwarded by translator, Bruce on 4 January 1858, JEH/1/17, RBG Kew Library and Archives.

[170] Correspondents included Charles Ledger, on whose behalf the famous quinine-rich *C. ledgeriana* seeds had been collected. Correspondence from the 1880s show that Howard was asking Ledger about his friend, Manuel Icamanahí's knowledge of Cinchona. JEH/1/42, Library and Archives, RBG Kew. See Chapter 1.

[171] The translator was G. Jenkins, of Jenkins & Phillips, drug and bark traders who supplied Howards and Sons.

> shall not be able to do so for a considerable amount of time for the only [illegible] who can execute a commission of this kind for me are too lazy to take any pains about it and although I have endeavoured to interest several of the bark collectors in the matter and they have all promised to attend to it, I do not put much faith in their promises.[172]

The archives show that Howard corresponded in particular with Loja-based bark dealer Don Francisco T. Riofrio[173]. Little is known about him other than his origin, role and that Howard made acquaintance with him while preparing his first book for publication, through Howard's 'managing agent in South America' around 1855.[174] Howard also records a visit by Riofrio to London where he provided his opinions on his bark collection (Howard, 1862). Howard's letters to Riofrio show his interest in answers to botanical questions from someone with direct access to the cinchona-containing forest of the Andes, as well as requests for sketches, herbarium and bark samples.[175]

Only a single herbarium (Figure 6.4) received from Riofrio remains at Kew, *C. pelalba* (syn. *C. pubescens* Vahl) labelled 'sent with a specimen of bark by Mr. Riofrio, in 1862, J.E. Howard'.[176] In the EBC, only one of Riofrio's bark specimens has been traced (Figure 6.6) - if any others exist at Kew, they no longer have any reference. In addition, other barks he sent may have been part of Howard's collection disposed of after the 1950s (Walker et al., 2022).

Further Riofrio specimens survive in the Naturalis Biodiversity Centre, Leiden, with 4 barks sent via Howard: 3 barks to German botanist Justus Karl Hasskarl (1811 – 1894) and one that came via the Rijksherbarium.[177] One of these bark specimens has a label

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[172] Translation by Jenkins, London, 13 August 1855 of Letter dated 30 June 1855, Guayaquil, JEH/1/17, Library and Archives, RBG Kew.

[173] Howard describes Riofrio as Peruvian, though he was based in Ecuador, and at this point the borders between the two countries were in dispute, resulting in the Ecuadorian–Peruvian War (1857–1860).

[174] Report by Dr. Royle on the Introduction into India of the Quinine-yielding Cinchonas, and of the means which have hitherto been adopted for the purpose, March, 1857, British Parliamentary Paper No. 118, East India (Chinchona plant) (1852-1863), Item No. 16. p. 18. Also see series of letters to and from Riofrio, with translations by Bruce. In particularone where Bruce describes Riofrio as 'my friend is very zealous, though not very sanguine of success', letter Dated 2 [November?] 1856, JEH/1/17, Library and Archives, RBG Kew.

[175] See also letters and translations of queries and responses between Howard and Riofrio, JEH/1/17, Library and Archives, RBG Kew.

[176] K001337012, Herbarium, RBG, Kew.

[177] L 2110217, L 2110219, L 2110413 and L 2903589 of the Economic Botany Collection, Naturalis Biodiversity Centre.

which states ''Bark of *Cinchona uritusinga* Pavón … the seeds of the accompanying specimen vegetated and are now flourishing in JEH's hothouse' (Figure 6.6). Howard's correspondence with Riofrio, as well as frequent mention of him throughout his publications, highlights his awareness of the different knowledge types gleaned from cabinet collections, versus those collected in the Andean field.

Dorinda Outram has discussed the contrasting spaces occupied by, as well as the tensions between 'cabinet' and expeditionary or 'field' naturalists in the eighteenth century, still visible in the nineteenth. She quotes naturalist Georges Cuvier (1769-1832), who argued for cabinet knowledge: 'it is really only in one's study that one can freely roam throughout the universe' since the accumulation of numerous specimens, sourced from a wide range of origins allowed a proper comparison, analysis and classification of nature. This contrasted with the 'field botanist,' who Cuvier explained, while well-travelled and absorbing a breadth of information, could not capture the depth of understanding which could be achieved when having hundreds of specimens at one's fingertips (as cited in Outram, 1996, pp. 260-261). In contrast, explorers like Alexander von Humboldt (1769-1859), felt that only by travel could nature's intricacies and connectedness be observed (Gerassi-Navarro, 2017). As Cuvier acknowledged himself, this latter type of explorer had the advantage of 'observ[ing] [plants] in their natural surroundings, in relationship to their environment' (as cited in Outram, 1996, pp. 260-261). However, there are only a few examples of figures during Howard's time that had the resources to successfully combine both field and cabinet collecting with global travel, notably Humboldt himself and Charles Darwin.

The tensions between the two forms of practice and different ways of knowing are particularly vivid in cinchona studies due to its confounding botany. One of the earliest European explorers of cinchona forests, Humboldt himself noted:

> Indeed I hardly know any one tree varying more in the shape of its leaves than the Cinchona. Whoever determines single specimens of dried collections, and has no opportunity to examine them in their native forests, will, as is the case with the [Broussonetia] papyrifera, be led to discover different species by leaves which are of one and the same branch (Humboldt, n.d., as cited in Lambert, 1821, p. 35).

Robert Kohler (2002) discusses the overlapping nature of the borders between laboratory and field in the modern period and the places that combine elements of both. Kohler prefers the term 'border' rather than 'boundary' as this space can be permeable, crossed by field and laboratory scientists, a 'zone of mixed practices' (p. 18). While Kohler is referring to the modern period, his approach is applicable to Howard's nineteenth century and his movement between the different spaces of laboratory and garden. Howard seemed to be aware of the drawbacks of being solely a cabinet botanist and developed ways to work around the issue (Howard, 1855, 1862). Unable, or unwilling to travel himself, he first studied the collections of other field botanists (i.e. Hipólito Ruiz & José Pavón), then cultivated contacts in the tropics to incorporate a form of second-hand 'field knowledge'. Howard then devised ways to recreate the 'field' nearer to home. This was a space in-between, a 'hybrid place' (Kohler, 2002, p.169), bolstered by knowledge exchange flowing in from other 'fields', such as the natural Andean space and the other 'in-between' space of the plantation.

Howard's shift into experiments in cultivation reflects wider cultural trends. After the invention of the glass Wardian case in the 1830s, successful mass-transportation of colonial and other tropical plants became possible (Brockway, 2002; Keogh, 2020). Large glasshouses were being built as spaces to recreate controlled tropical environments to maintain plants long-term (Alcorn, 2021; Valen, 2016). This technological development aided the study of the botany and horticulture of the thousands of plants flowing in from Imperial places and beyond (Brockway, 2002; Drayton, 2000; Elliot, 1992; Schoenefeldt, 2010; 2011; Teltscher, 2020).

In Britain, as part of the imperative to understand potentially profitable plants such as cinchona, wider government projects relied on knowledge produced from Latourian 'centres of calculation' to provide information enabling the control of economically important plant-based products. A main site for this knowledge production was the Royal Botanic Gardens, Kew (Brockway, 2002; Latour, 1987; Parry 2004). However, as discussed in Chapter 4, Kew's role was mainly as a botanical knowledge repository, in the provision of trained horticulturists and as a 'stop-over' for propagating plants heading to India after 1860 (see Kew's cinchona glasshouse in Figure 6.7) (Desmond, 2007). In contrast, Howard acted as an external consultant for the British Indian government giving the final judgement on the success or failure of horticultural practices.[178] It is no surprise then, that Howard anticipated the British Imperial cinchona project and specially constructed his own glasshouse in the garden of his home in Tottenham in readiness to perform these roles. Howard was well placed to become a small but vital cog in the machine of the Empire.

Nineteenth-century glasshouses 'served as sites where nature was subjected to the laws of reason and where foreign bodies and climates were domesticated on English soil' (Valen, 2016, p. 403). The application of scientific methods to create artificial environments was a feature of the burgeoning knowledge about plants, particularly economically interesting ones (Alcorn 2021). Within these spaces, 'scientific gardeners' aided in the production of 'profitable landscapes' (Valen, 2016, p. 404). Cinchona is a key example of a plant that, informed by Howard as a scientific gardener, domesticated the tree on English soil to aid the British to place it within a profitable, colonial, landscape. As historians such as Brockway (1979; 2002) and Drayton (2002) have shown, botanical science burgeoned during nineteenth-century colonial expansion, intersected with parallel technological advancements.

As highlighted at the above, Howard was interested in wider botanical knowledge of cinchona beyond his cabinet collections, through contacts in collecting networks such as those mentioned in Chapter 4, including agents in the field such as Riofrio. Eventually requests for information from the field evolved into requests for the plants themselves. The received trees became the first of many species grown in his garden, a space that formed a new laboratory and 'proxy field' that allowed Howard to occupy the space somewhere between *ex situ* (cabinet) and *in situ* (field) botanical science.

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[178] See numerous letters throughout Miscellaneous Reports (MR/144) India. Economic Products. Cinchona c. (1859-1888), e.g. p. 199: Letter to William Turner Thiselton-Dyer, 8 May 1878; p. 224 Letter to Thiselton-Dyer from Joseph Hooker, 10 August 1880. as well as the British Parliamentary Papers discussed in Chapter 4.

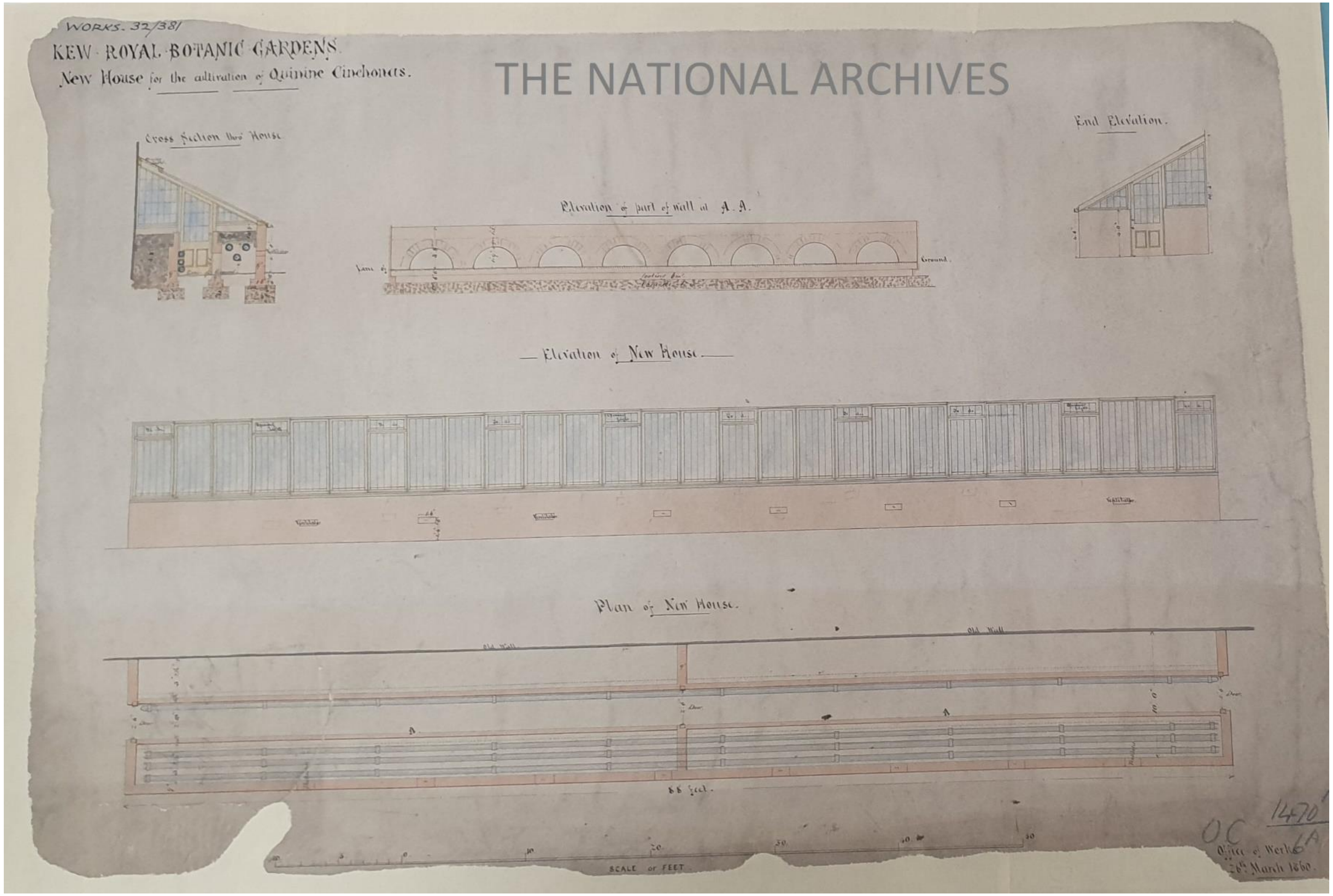

Figure 6.7 A new house for the cultivation of Cinchona, Royal Botanic Gardens Kew, 1860.
WORK 32/381, Permission of The National Archives.

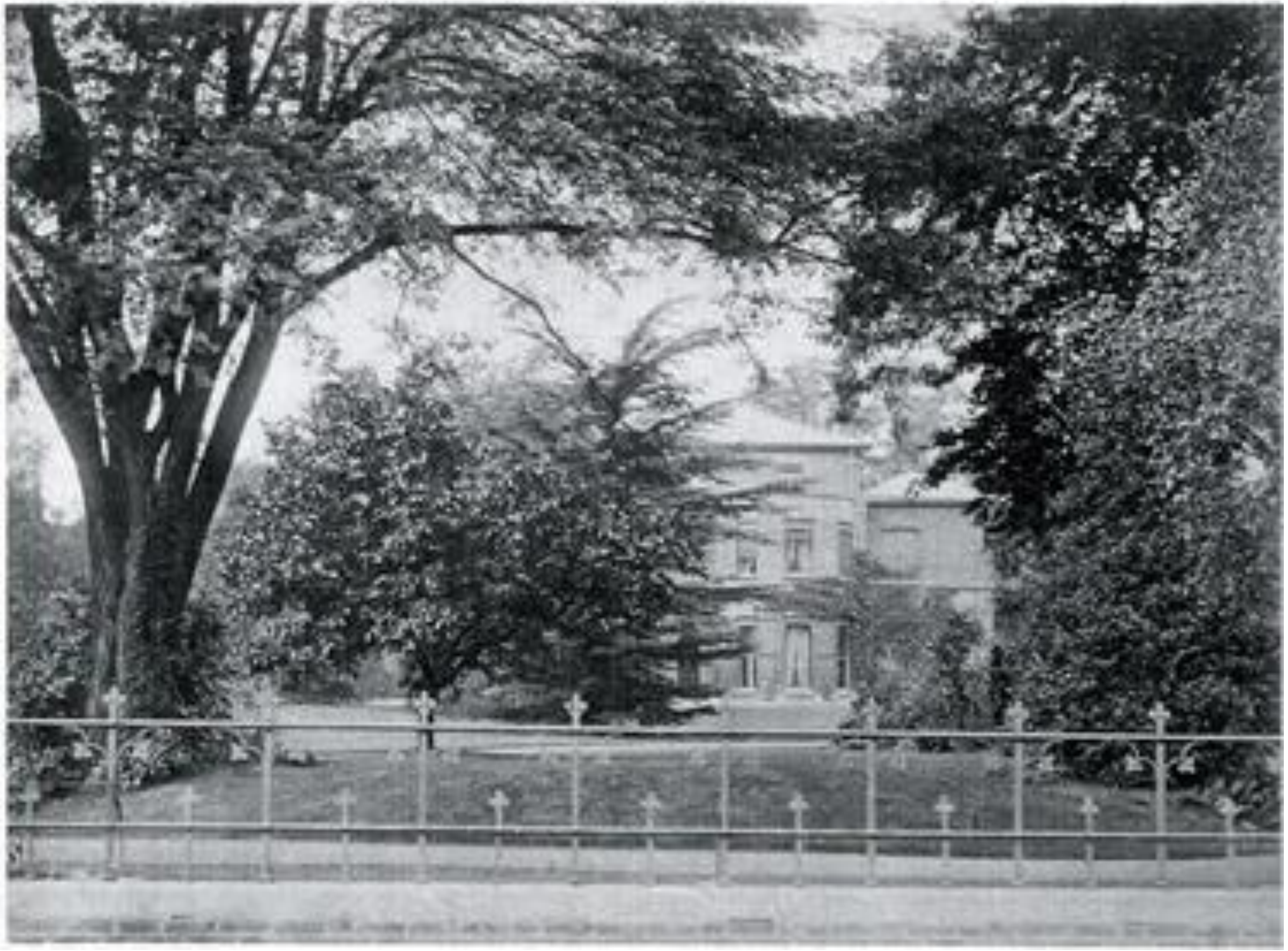

Figure 6.8 The front of Howard's house, Lord's Meade, Tottenham.
Image with kind permission from the Howard family.

Figure 6.9 A backdrop to a *Cinchona officinalis* (syn. *C. officinalis* var. *bonplandia*) provides a view of the inside of one of Howard's glasshouses, 1880.
Image with Permission of the Royal Pharmaceutical Society Museum.

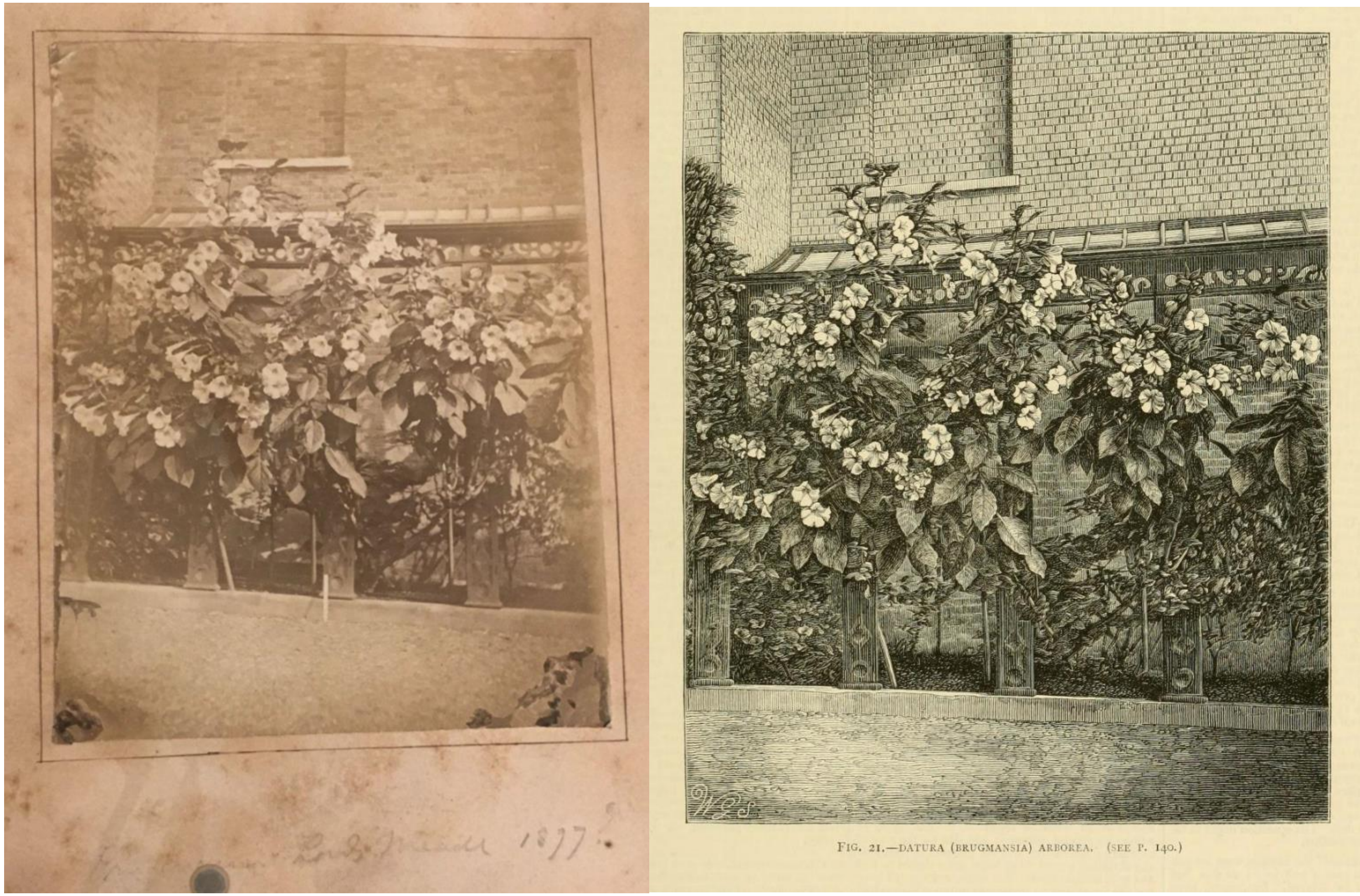

Figure 6.10 Howard's *Brugmansia arborea* (syn. *Datura arborea*) growing in the glasshouse with removable glass doors, built against Howard's home, 1877. The second image shows the sketch made from the photo for Howard's piece on the plant in the *Gardeners' Chronicle* (Howard, 1879).
Image Permission: (L) The Royal Pharmaceutical Museum & (R) Biodiversity Heritage Library.

6.4 Constructing the field: building glasshouses in Tottenham

To recreate his slice of cinchona forest in England, environmental control was required. Howard erected a series of glasshouses in the garden of his family home at Lord's Meade, Tottenham (Figure 6.8). These glasshouses can be partially seen in the background in some of the cinchona photographs donated to the RPS, showing a gabled conservatory that Howard describes as 'constructed for purpose' 1859 (Figure 6.9) (Howard, 1870b, p. 388). Later, in November 1871, his wife Maria Howard recorded that a new cinchona house had been added (Howard, 1885). These were in addition to another lean-to at the back wall of his house used for growing *Brugmansia arborea* (l.) Sweet (syn. *Datura arborea*) which he discussed in the pages of the *Gardener's Chronicle*, which shows him gardening for pleasure as well as science (Figure 6.10) (Howard, 1879).

Howard stated in his 1869 talk at the RPS that he worked under the doctrine of *Ne quid nimis* [nothing too much], suggesting that he kept a light touch towards his horticultural activities (Howard, 1870b, p. 391). Howard's note in the *Gardeners' Chronicle* also reveals another important factor: the role of a gardener, who in this case was the one who applied manure to his *Brugmansia*. Cinchona collector Clements Markham (1830-1916) sent £5 and £3 'gratuity' to Howard's gardener for taking cuttings for the Indian plantations.[179] Though this shadowy figure is little mentioned elsewhere, his presence means that we cannot be sure of the level of Howard's involvement with day-to-day growing of the cinchona plants. However, Howard's practical personality and systematic experimentation in the pursuit of knowledge would suggest that after the trouble of sourcing cinchona from the Andes, he would be unlikely to leave his delicate horticultural experiments entirely to someone else, as shown by his detailed knowledge of the variables involved with his cinchona growing such as light, soil, water and temperature, discussed later.

Howard maintained three glasshouses in total, two of which were devoted to cinchona.

179 Clements Markham to John Eliot Howard, 11 November 1868. JEH/1/12, Library and Archives, RBG Kew.

These constructions appear on an ordnance survey of the area of 1863-69, and are confirmed as glass: they were still in existence in a map of 1895 (Figure 6.11 and Figure 6.12). The glasshouses, as well as Howard's house, no longer exist, having been absorbed by streets of terraced houses. Visitors to the street, Lordsmead Road, named after Howard's house, Lord's Meade, can stand in the location of the glasshouses in front of no. 30 Lordsmead Road, N17 (Figure 6.13).

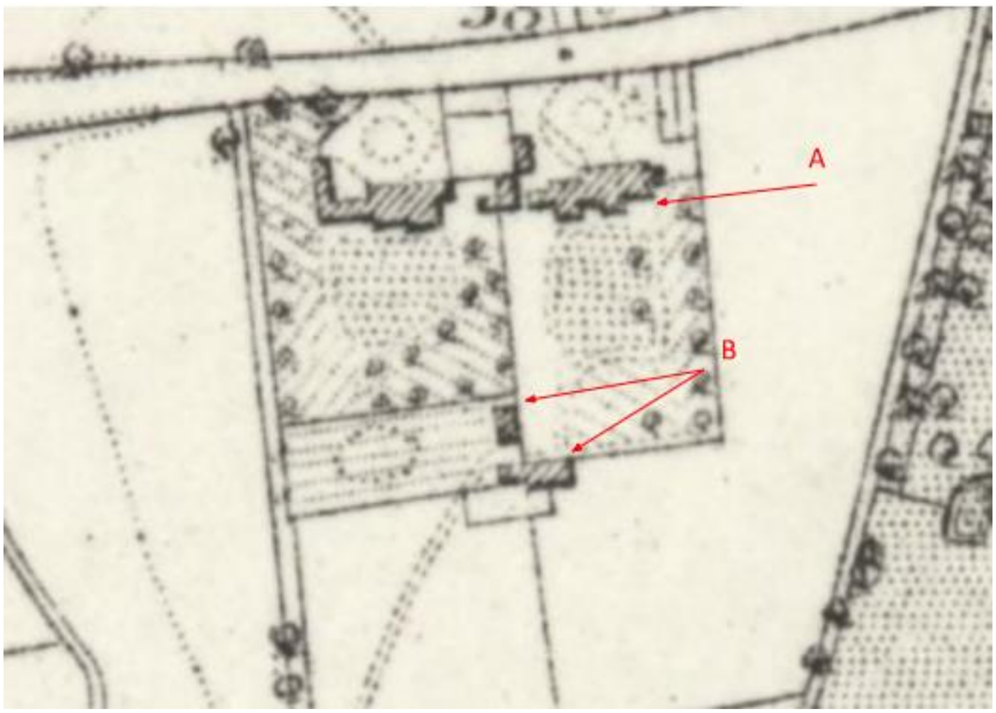

Figure 6.11 Map of Howard's home and garden.
OS Six-Inch England & Wales, Middlesex Sheet XII, 1873 (Surveyed 1863-69). Howard's house is the building located on the right (A). At the bottom of the garden appear buildings (B) which are labelled as glasshouses in an 1895 map (See next figure). National Library of Scotland.[180]

[180] Reproduced with the permission of the National Library of Scotland, Middlesex Map XII. https://maps.nls.uk/view/102345952

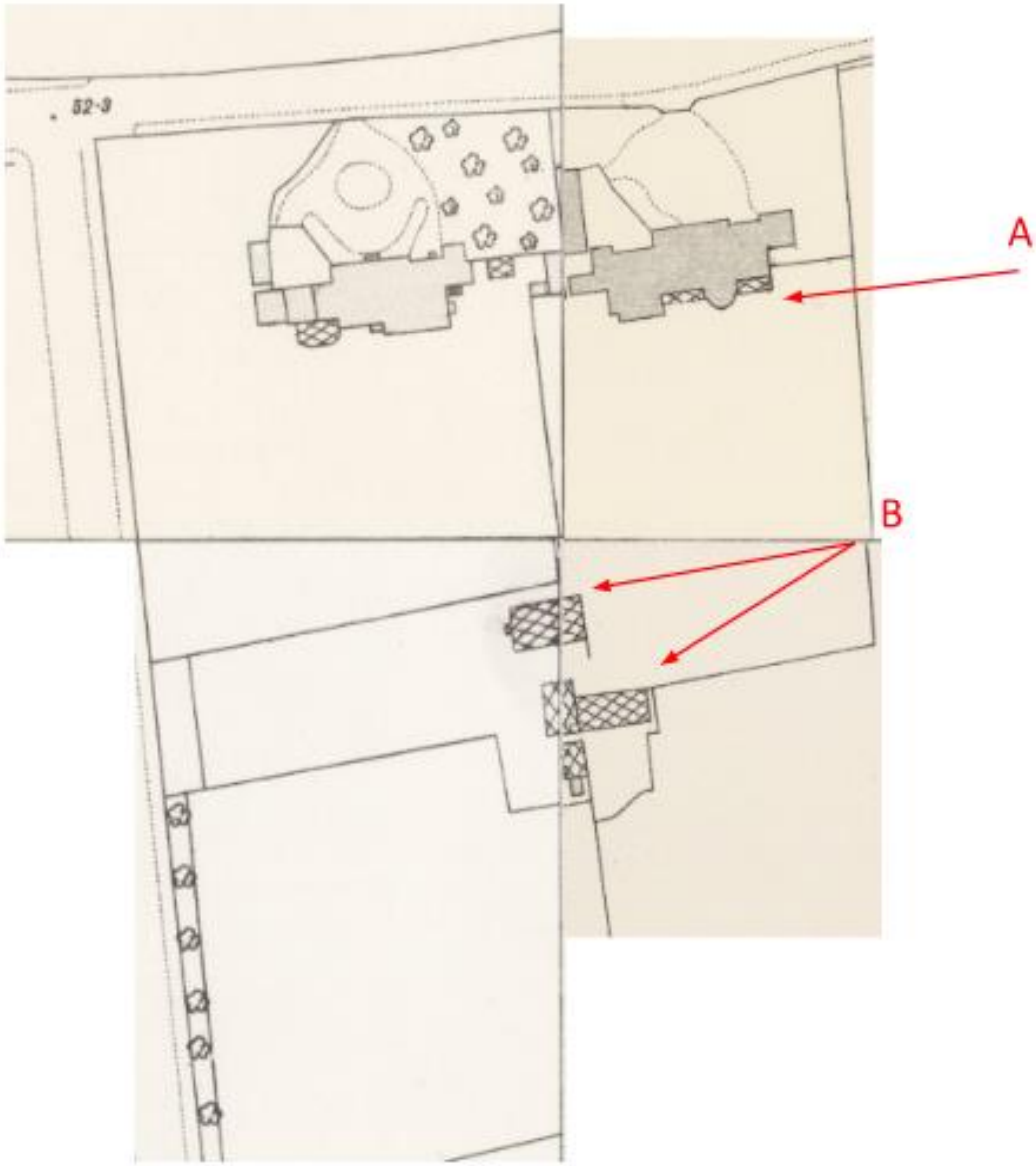

Figure 6.12 Map of Howard's house and garden, published after his death.
The map key clarifies glass constructions. A: the *Brugmansia* glasshouse located on the South side of the house and B: the Cinchona glasshouses. Reconstructed from OS London 1:1,056 Sheets III.16, III.17, III.26 & III.27. of Scotland, 1895.[181]

[181] Reproduced with the permission of the National Library of Scotland. OS London. Top left: Sheet III.16 https://maps.nls.uk/view/101200824; Top Right: Sheet III.17 https://maps.nls.uk/view/101200827; Bottom Right: Sheet III.27 https://maps.nls.uk/view/101200851; Bottom Left: Sheet III.26 https://maps.nls.uk/view/101200848

Figure 6.13 The 1895 map (previous figure) overlaying a current Google Maps snapshot showing the location of Howard's glasshouses.

It is possible for someone to stand 'in' the glasshouses in current day Lordsmead Road, Tottenham, N17. National Library of Scotland.[182]

[182]Image created using National Library of Scotland Georeferenced Maps resource , Retrieved 20 February 2022, CC BY. https://maps.nls.uk/geo/explore

In his influential treatise on growing delicate hothouse plants, botanist and landscape designer John Claudius Loudon (1783–1843), categorised four variables in control of the environment: soil type, water, atmosphere, temperature and light (Loudon, 1826). Though these categories are the same as those required outside a hothouse, Loudon's list calls attention to careful attention and control that must be given to them in a glasshouse. In fact he also gives brief advice on the cultivation of cinchona, which should be 'grown in loam and peat, but not very freely, and ripe cuttings in sand under a hand-glass, in moist heat, will strike root' (Loudon, 1826, p. 1180).

Though Howard does not mention Loudon specifically, these factors are at the core of cinchona growing project. Soil could thus be managed 'according to species' using various ratios made of Reigate sand, rich loam, bog earth and broken brick, which allowed good drainage (Howard, 1870b, p. 389). This suggests Howard experimented with soil types to encourage best growth. This has borne out: sandy-mixes have recently been shown to be the ideal type of general seedling soil for cinchona (Barrutia et al., 2020). Ensuring good drainage meant that soil moisture could be controlled, likewise atmospheric humidity, through spraying the leaves twice daily with tepid water. Howard also emphasised proper air circulation: 'It must be remembered that these are mountain plants, loving free air and alternate mist and sunshine, while the hot, close atmosphere of the lower valleys is always injurious to their perfection as quinine-producing plants, and generally fatal to their growth' (Howard, 1870b, p. 390). The *type* of water was also important: Howard considered rainwater superior and recorded that during a period where it was unavailable, the use of spring water affected the plants badly. This may be because cinchona prefers an acid soil, better suited to rainwater than an alkaline spring water (Howard,1870b; Evans & Evans, 2009).

Double glazing with four inches of airspace between the two panes provided insulation and Howard advised an 'ideal' temperature of 65°F (18 °C) in summer. With the addition of warm water pipes buried in the soil, a minimum winter temperature of 55°F (13°C) protected against sudden damaging frosts (Howard, 1870b). Of the *Brugmansia* house, Howard explained how he created a 'sort of Madeira climate' by utilising the South face of his house and enclosing an existing veranda with removable glass doors (Figure 6.10) (Howard, 1879, p.140) The veranda shared the homes' kitchen wall and the residual warmth from the ovens kept the plants in a temperature they were more accustomed to, though during colder frosts paraffin lamps were added (Howard, 1879).

However, not everything could be controlled. In the *Nueva Quinologia of Pavon*, published in 1862, Howard regularly mentions the effect of sunlight versus shade on the appearance of the bark and production of alkaloids. In England levels of light were lower in winter and higher in summer compared to the Andes. Unfortunately, this meant he had 'no perfect observations, at present, of the extent of the action of light' to give those attending his 1869 RPS lecture (Howard, 1870b, p. 391). During the construction of the Palm House at Kew during the mid-1840s, scientist Robert Hunt (1807-1887) was hired to resolve the issue of plant scorching due to the intensity of light increasing while passing through the glass. Hunt experimented with tinted glass to prevent this and to stimulate growth (Schoenefeldt, 2011). During Howard's RPS lecture, in response to an audience question, Howard confirms that he also experimented using coloured glass, but generally controlled light intensity through using manually lowered blinds. All he could do was minimise damage on sunnier days.[183]

Another key factor which could not be controlled was altitude. This, as well as light, were widely believed to have the greatest influence on alkaloid production in cinchona (Bergen, 1826; Delondre & Bouchardat, 1854; Howard, 1862, 1869, 1876; 1883; von Humboldt et al, 1850). Indeed Howard frequently mentions this throughout his works. However, Tottenham is only 20 metres above sea level, a sharp contrast to the high native Andean range of 5-8,000 feet (Howard, 1862).

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[183] See examples of discussion on this in Howard (1862): *C. micrantha* section, 5; *C. chaharguera* section, 5; *C. uritusingha* section, 2.

These two issues may ultimately explain why Howard was unable to use his glasshouses as a site for more extensive alkaloid experimentation, assessing the influence of the environment on chemical strength. Instead, he grew cinchona for horticultural purposes in order to advance his knowledge of the trade barks and help with queries about cultivation (Howard, 1870b, p. 388: this issue is discussed further below in the section 6.6 on species determination). In order to assess the impact of factors such as light and elevation, Howard thus relied on samples with detailed environmental information sent from the Andes and later India (Howard, 1869, Howard, 1862, Howard 1869; Veale, 2010). For example, government quinologist, John Broughton wrote to Howard about his observations of the materials while making his analyses:

> The typical individuals of each variety are very distinct, but there are trees which would, I think, puzzle even you to assign them their places. Of course I am not competent to speak with any authority on this subject, but as it has in the course of work so frequently struck me, I here mention it… I have made a series of analyses on the influence of elevation. The statement of the richness of the Red Barks increasing with the altitude inaccurate. Above 7,500 feet it yields little more than 2 per cent, and that nearly destitute of quinine.[184]

Howard's desire for regulation of the field environment was only partially successful. Although he could, to a certain extent, control soil, temperature, humidity and water, light could not be controlled well and elevation not at all. However, to Howard's scientific mind, cultivation would still provide answers for botanical determinations and how forms and varieties changed between generations. As cinchona was being transported across the world into a variety of new settings, his knowledge produced from the garden contributed towards an understanding and that 'the very difficulties to be overcome in imitating, as far as possible, the climate and soil of the mountain regions of the Andes, present many subjects of not unfruitful consideration' (Howard, 1870b, p. 388)

6.5 Chemical queries

Throughout Howard's work in monitoring his cultivated trees, chemical analyses were

[184] John Broughton to J.E. Howard, 28 July 1867, as cited in Appendix C, p. 110, Howard (1876).

rarely undertaken. There is one exception where an RPS attendee noted: ‘having had occasion to cut down one of his plants, in consequence of an accident, he availed himself of the opportunity of stripping off the bark and extracting the alkaloids’ (Howard, 1870b, p. 392). Howard clarified this was due to an ‘irruption of smoke’ which killed the specimen (Howard,1866, p. 15). He rarely undertook chemical analysis on the barks of his own plants except under exceptional circumstances such as these and this is supported by a lack of such analytical data in the collections and archives. For his chemical analysis, Howard relied on samples flowing in from a range of Indian plantations, which, as had the addition of detailed descriptions of their environment from their horticulturalist managers (Howard, 1869; 1876).[185] The plant destroyed by smoke and cut down for analysis happened to be one of the uritusinga trees, the same variety as discussed in the vignette and later sent to the Indian plantations. Howard records its analysis, along with a comparison of its three generations of Indian-grown descendants:

[185] Also see correspondence in the JEH files, in particular, JEH/1/16, JEH/1/36, JEH/1/37 JEH/1/44 JEH/2/6, Library and Archives, RBG, Kew.

The original bark of the first generation, from the mountains of Uritusinga, near Loja (Peru), was sent to me, with the flowering branches and ripened seeds, by Don T. Riofrio, and from these I raised plants in 1859. This was fine-looking, but very much weathered Crown Bark, with few adherent lichens, it gave me:

No. 1.
First Generation.

Oxalate of Quinine	*1.87*
Cinchonidine	*1.20*
Cinchonine	*0.04*
Total	***3.11***

No. 2.
Second Generation
raised from the above seed.

No. 2 a.
Grown in England

Sulphate of Quinine	*1.36*
Cinchonicine (with. merely a trace of Cinchonine)	*0.57*
Total	***1.93***

No. 2 b.
Grown partly in England, partly in India

Oxalate of Quinine	*1.40*	
(Quinine uncrystallized	*0.17)=*	*1.57*
Cinchonidine		*0.79*
Total		***2.36***

No. 3. Third Generation
descended from No. 2 b.

Sulphate of Quinine	*1.75*
Sulphate of Cinchonidine	*1.50*
Cinchonine	*0.08*
Total	***3.33***

In the third generation it is easy to remark a sort of atavism, the produce having returned almost exactly to the first; and having, in the Neilgherries, in India, rather surpassed the quantity of alkaloid yielded by the first generation grown on the mountains of Uritusinga, its native habitat. This is so far very satisfactory, as showing that at least there is no deterioration in this species through the so great change of its acclimatisation. (Howard, 1869, p. 3)

The above analysis shows that a comparison between two 'sister' plants of the second generation, grown in parallel in England and India, showed increased alkaloids in the Indian-grown tree. Howard concluded that this showed transfer to India had improved alkaloid production by the third generation, partially related to atavism (reversion to an ancestor type). Yet he also believed that the variation in light, constant in the equatorial Andes and India, as opposed to being under glass in England, was also a critical factor: 'the variation of soil, temperature, and elevation united (all these being of the greatest extent) did not equal the effects of the altered character of *light* on the plant' (Howard, 1869, p. 4). He observed that the plants in the first and third generation had the same level of light, but the ones grown under glass (2a), and partially under glass (2b) had reduced access to the sun's 'actinic power',[186] and was what he assumed had affected the alkaloid content (p.5). Figure 6.14 shows an *uritusinga* bark sample harvested from a 4th generation plant.

The view that morphology and alkaloid expression in cinchona is influenced by environmental factors such as climate and altitude is supported by recent research (Moore et al., 2014). Altitude is correlated with alkaloid production: the trees with the highest content were found in a narrow band of altitude between 1,100 to 1,350 m, above or below this related to reduced concentrations (Maldonado et al., 2017b). However, the research also showed that the biggest driver in chemical expression is related to phylogeny, particularly between geographically distinct populations. The subject of diversity is covered in the next section.

[186] The contemporary understanding of this is the chemical changes induced by 'solar beams', now known to be caused by sunlight's electromagnetic radiation involved in photosynthesis and other chemical reactions within plant tissue (Paxton, 1848, p. 129).

Figure 6.14 Bark of *Cinchona officinalis* (syn. *C. uritisinga*), grown in the Ootacamund plantation and collected from 4th generation trees.
52994, Economic Botany Collection, Royal Botanic Garden, Kew.

6.6 Infinite diversity: Determining *Cinchona* species

> It is with reluctance that we touch here upon the much-vexed question of the nomenclature of this species [cinchona], but we must adopt some name, and as there are, according to authors, seven or eight to choose from, we are compelled to vindicate our choice. To begin: in this, as in so many other cases, when once the law of priority is departed from without perfectly good cause, the door is opened to endless future change, and consequent confusion. (From text accompanying Figure 6.1, Hooker, 1863)

> ...nature is more rich and more inexhaustible in realization than our imagination is in conceptions and in ideas of the possible modes of life. Far from following only a straight line in her creations, she creates in every sense; far from having only one model, she is infinite in diversity. (Howard, 1862, p. v)

As discussed above, understanding cinchona diversity was a complex challenge. It was long known that the morphology and chemistry varied between and within species, even within closely related plants from one generation to the next. The reasons this happened were much debated but believed to be environmental as well as inherited. Howard's effort to understand these variables intersected with Wallace and Darwin's theories on how species evolved over longer periods of time, as famously expounded in their papers read to the Linnean Society in 1858 (see below). Howard's specific thoughts on Darwin's theories can be seen in the pages of his first book:

> I have no doubt that the principle of natural selection, as illustrated by Darwin, fills up a most important part in the general economy of the world, but am very far from thinking that it will bear the stress attempted to be laid upon it, and I do not see that it throws more than a feeble light on the prevalence of species in particular localities, as it seems to me that the result must have been very different if all the Cinchona, for instance, had been derived from a single species, and allowed to develop differences which by degrees usurped the situations most favourable to them. I cannot but conclude that the variety would have been much less marked, and that we should scarcely have found the most dissimilar sorts growing side by side, as appears now to be the case, and as will be found recorded, for instance, in the reports of different journeys to obtain plants of the Calisaya for transplantation to India.' (Howard, 1862, introduction, p. vii)

Howard and Darwin were direct contemporaries and amongst their many differences, there are some striking similarities. They were born and died just a year apart, both were interested in botanical variations and relationships and both built glasshouses in the garden of their homes for botanical and horticultural experimentation. Howard, slightly ahead of his contemporary, constructed his in 1859, followed by Darwin in 1863.[187]

However, the differing approach to studying nature is reflected in the careers the two men cultivated. Darwin had the family wealth and opportunity to take a broad (as well as in-depth) view of science, as an expeditionary naturalist, travelling widely and gaining much experience in the field, the study and the garden. He also collected extensively, building the cabinet specimens of the home scientist. In contrast, Howard, though of a wealthy middle class, had business and family duties in London preventing travel beyond Europe. This business focus led to a niche specialism, creating a career revolving around a single genus and its alkaloids.

Another similarity between Howard and Darwin and their explorations of form can be found in the plants they focused on. Darwin was interested in the cross-fertilisation between different forms of flowers within the same species, performing hundreds of fertilisation experiments within his glasshouse. This was initiated with a study of primroses (*Primula vulgaris* Huds.), published in *The different forms of flowers on plants of the same species* (Darwin, 1862). Darwin notes that he first saw the similarity of *Primula's* heterostyly to that of *Cinchona* in an illustration from Howard's *Nueva Quinologia.*[188] The image and example of heterodistylous flowers can be seen in Figure 6.15.

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[187] Charles Darwin to Thomas Rivers ca.15 January 1863, Darwin Correspondence Project, "Letter no. 3918," accessed on 15 February 2022, https://www.darwinproject.ac.uk/letter/?docId=letters/DCP-LETT-3918.xml

[188] Darwin, date unknown, mentions Howard and notes that he saw this plate reproduced in Markham's (1862) *Travels in Peru*. Note by Darwin, Personal Papers CUL-DAR110.B106. Accessed from van Whye, J. (Ed.) (2002). *The complete work of Charles Darwin online*. http://darwin-online.org.uk/

Figure 6.15 *C. micrantha* Ruiz & Pav from *Illustrations of the Nueva Quinologia of Pavon*.
It is in this image that Darwin noted the similar floral heterostyly (top right) that he was working on in *Primula*. Image Wellcome Collection, (Howard, 1862).

Primroses are polymorphic, displaying their style and stamen arrangement in two heterostyled forms: either long- or short-styled flowers.[189] Darwin noted that florists long knew this under the respective terms of 'pin-eyed' and 'thumb-' or 'thrum-eyed', and observed that local village children made primrose garlands with the 'pin' form: The long stigma allowed the blooms to be strung together in a row. Darwin's experiments on primrose breeding showed that each form's pollen structure differed and 'cross-fertilisation' (between opposite forms, i.e. pin x thumb) were more fertile than between the same forms. This showed, he argued, that heterostyly to be an adaptation to reduce self-pollination, though he could at that point not explain why (Darwin, 1862).

Cinchona is one of the other few genera that also displays heterostyly and the adaptation is now known to encourage genetic variation to enable, amongst many reasons, increased fertility, healthier offspring and increased variation which may be better adapted to future changes in the environment (Barrett, 2019). In Howard's '*Addenda et corrigenda*' of his *Illustrations of the Nueva Quinologia of Pavon*, he draws the reader's attention to his own observations about these two forms of *Cinchona* in relation to Darwin's work. These, he said, were already recognised in the Andes as *macho* [male/pin] and *hembra* [female/thrum] flower varieties (Howard, 1862). Howard hypothesised that the existence of two flower forms explained some of the earlier confusion in earlier author's descriptions of species and that they produced different bark structures (Howard, 1862). He also believed that this tendency to cross-fertilise was why some generations appeared so different to parents, which we now know to be true - *Cinchona* species easily hybridise between species and lead to much botanical variation (Andersson, 1998). This was a particular problem in India where different species planted together, normally geographically separate in the Andes, tended towards hybridisation (Howard, 1876). The natural Andean geographic separation reduces the incidence of this in the wild (Andersson, 1998; Maldonado et al, (2017b).

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[189] Styles are the long part of the ovary found in flowers. The style receives the pollen, which travels down to fertilise the ovum which subsequently produces the fruit.

However, in contrast to Darwin, Howard maintained orthodox Christian views throughout his life. As discussed in Chapter 3 Howard had a dual career, being a church leader and publishing extensively on religious topics (Howard, 1885; West et al., 2016). Ultimately, he believed that whatever scientific theories there were, divine power was always at the root (Howard, 1862, 1869, 1876; Mathieson, 2020). Throughout Howard's scientific works, however, he rarely mentions his religious philosophy, preferring to keep his scientific works free of religion beyond introductory comments on the divine and occasional mild debate with Darwinism, perhaps conscious of the audience. In contrast, within his religious works, science had a prominent place as in titles such as *Seven Lectures on Scripture and Science* (Howard, 1865a) and these increased in frequency towards the end of his life (Figure 2.5). Howard was an active member of the Victoria Institute, or Philosophical Society of Great Britain, which was established in 1865. He authored numerous lectures and articles in the publications of the Society and later sat on its Council. The Institute's purpose was to defend the 'great truths revealed in Holy Scripture against the oppositions of science, falsely so called' ('Victoria Institute', 1867, p. vi; 1872). Howard's lectures covered subjects such as *Scientific facts and Christian evidence* (Howard, 1874a) and *Creation and providence, with especial reference to the evolutionist theory* (Howard, 1877).

The history of the Victoria Institute, including Howard's role within it, is the subject of a recent PhD thesis by Stuart Mathieson. As he notes, Howard was particularly concerned to delimit the authority of science in relation to religion and he took part in some of the most famous controversies of the time. The Irish physicist and materialist, John Tyndall (1820 - 1893), gave a famous lecture now known as the 'Belfast Address', which strongly promoted Darwin's theories. In response, Howard acidly noted that Tyndall's criticism was 'always instructive when he describes that which he understands' (Hesketh, 2020; Howard, 1874a, p. 332; Mathieson, 2020). His own critique of the Belfast Address challenged Tyndall's views on both philosophical and chemical grounds (Howard, 1874b). As Mathieson (2020) points out, Howard was one of the few members of the Institute with the specialist knowledge to engage with specific scientific theories (such as Tyndall's) rather than making broader philosophical arguments against general concepts in science. Howard's booklet was positively reviewed in the pages of the *Pharmaceutical Journal*, showing that Howard was not alone in his beliefs within the pharmaceutical world. ('Review', 1875).

Cinchona species remain to this day notoriously difficult to distinguish due to phenotypic variation leading to intra- and inter-species variability, often only settled with genetic analysis (Andersson, 1998; García et al., 2022). This was noted by Howard: 'the opportunity… of raising the seeds proceeding from the same bunch of capsules, and observing thus, as I am doing at the present moment, the amount of variation to be observed in the children of one parent plant' (Howard, 1870b, p. 388). He believed that God had created cinchona with 'permanent features' and cited as evidence his own observations of 'historic' collections:

> Whatever may have been the history of the *past*, there can be no question of the absolute permanence of all the forms of Cinchona which meet our view in the well-balanced *present*. It is interesting to observe the exact way in which every minute feature of the barks gathered by Pavon nearly a century since, are reproduced in those now brought from the same districts. (Howard, 1862, p. vii)

Any variation, Howard, believed, was down to a tendency to 'diverge into other forms, or to *sport* as the gardeners call it,' influenced purely from environmental factors (Howard, 1862, p. v).[190] He argued that each form with distinguishable features distinct from others should be classed as a species 'without being compelled to rest our classification on hypothetical conjectures as to the past', an implicit allusion to Darwin (Howard, 1862, introduction, p. vii). Howard recorded his views on the use of the terms 'species' and 'variety', believing instead in forms creating 'successive links in a chain' because he was 'unable to find in any instance one single marked typical form from which the others can be considered divergent' (Howard, 1876, p. 78). Elsewhere he describes further how he viewed tendencies to 'sport':

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[190] 'Sporting' here relates to a natural, spontaneous forms differing from the parent plant, now understood to be caused by genetic mutation.

> It will be seen from what precedes, that when I use the term *species*, it is only as the expression sanctioned by use, which I retain to express a group of *forms* more or less intimately allied, but not passing absolutely one into the other, since, as far as can be seen, every one form is as permanent as every other. The word *variety* might conveniently express such alteration as we know to be produced by the influence of surrounding circumstances. *Mixtures* and *hybrids* of an evanescent character are apparently produced in great number where the different *forms* of the Cinchona are allowed freely to mingle, and amongst these some may be permanent enough to claim the character of *races*. Such is the manner in which I am at present disposed to regard the phenomena before us in this genus.
>
> Nature seems spread out like some magnificent poem composed in separate books and in lines not capable of being displaced without injury to the whole. The reader may have very little idea of the art of poetry, but he will at once understand that such a composition *is not prose*. So in studying nature, I am convinced that, notwithstanding the multiplicity of forms, and their apparent blending with each other, there is after all a fixity connected with the very design and purpose of the whole. In other words, that *heredity* or the produce of like from like is the most unchangeable amongst the laws which govern the reproduction of organized beings, and *permanence* rather than insensible variation and the gradual transformation of species is that which meets our view. (Italics Howard's own, Howard, 1869, p. 82)

As a consequence of these beliefs, Howard was liberal with naming. In contrast John Broughton, Government quinologist for the British Indian plantations, while also observing that cinchona displayed 'innumerable gradations, took the opposite view. As he wrote in 1868, 'I greatly fear, Mr Howard will, when he sees the specimens, affix more distinctive names as a sort of protest against the notion of the mutability of characters'.[191] In the long run, Broughton's naming has proven the more correct, his judgement perhaps helped by the much larger data set available within the plantations: Today, there are far fewer species than Howard believed. The ones he officially named are no longer considered separate species, having been absorbed into other established types (Chapter 5). Ultimately, due to the unusual botanical features found within *Cinchona* genus, Howard concluded that:

> We thus find it difficult absolutely to isolate any part of creation; and when, on the

[191] John Broughton to the Royal Botanic Gardens, Kew; from Ootacamund [Udagamandalam, India], 14 Sep 1868 <https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas855>1; See also letter 23 Jan 1869 <https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas8551>.

> other hand, we resolve to look upon the many, we are constrained, by connection of type and structure, to revert back to some one common type of the whole, so wondrously the infinitely diversified harmonies of the creation are blended into one hymn of praise to the infinitely varied Wisdom which has planned, built, and still upholds the whole. (Howard, 1862, p. vii).

The contrast in the breadth of Darwin and Howard's research topics contributed towards their very different understandings of species and evolution. As cinchona forms are so variable depending on environmental factors, the species are difficult to unpick without modern genetic insight. Determining species, varieties and forms was no simple task. Cinchona is far more complex than the patterns Darwin's island-isolated finches represent, for example. Hence, Howard's obscure views on natural selection and the evolution of, and relationship between, species are understandable. Concepts of species relationships only began to be standardised in the latter half of the nineteenth century (Bonneuil, 2002). If Howard was studying a less complex genus, his opinion on natural selection and species variation might have been different. As a staunchly religious person, perhaps not, but he may have found a more complementary integration for his religious and scientific interests. With the limited tools available to him at the time, resolving the cinchona conundrum satisfactorily was difficult and prompted Howard's to reflect that 'There are in nature mysteries beyond the domain of science' (Howard, 1869, p. 19).

In a remarkable coincidence, Howard's paper on the *Nueva Quinologia* was read at the Linnean Society on the 1st July 1858, a special meeting called to elect a new vice-president and the very same occasion that Wallace and Darwin's joint papers were first read, presenting their ideas of natural selection.[192] However, neither Howard nor Darwin and Wallace were in attendance (Darwin's son had just died and Wallace was travelling in Indonesia) (Guerrero, 2008).[193] This event occurred just at the point Howard was about to embark upon his own growing projects in an attempt to better understand cinchona

[192] *General Minute Book No. 7*, (GM/7), p. 386-389. Library of the Linnean Society of London.
[193] At the same meeting, Howard's *Examinations* where formally accepted for donation (Howard, 1853), (GM/7), p. 386. Library of the Linnean Society of London; Howard had been elected a Fellow of the Linnean Society, 3 February 1857 (Proceedings of the Linnean Society, 1857).

cultivation. It is clear throughout Howard's publications however, that he rejected these new discoveries, which he criticised as 'mechanical theories' and was unable to fully reconcile them with his religious views (Howard, 1870b, p. 388). This affected how he later sought to understand *Cinchona* varieties and forms. After the July 1858 meeting, Howard's *Nueva Quinologia* paper was duly submitted for official publication in the Society's Journal. However, the reviewer, botanist and pharmacologist Daniel Hanbury (1825-1875), rejected the paper, writing:

> [Howard's] object being to endeavour to connect each commercial variety of Cinchona bark with the particular [Pavon assigned species] affording it… [however] In adopting the views of Pavon, several forms regarded by the most recent botanical authorities as mere varieties, would assume the place of species. Some species that have been transferred to other genera, would again be described as Cinchona; - while others which, even according to Mr. Howard, are of very questionable distinctness – and many that are known only from Pavon's specimens at Madrid, would now appear under new and precise names. Considering the undesirability of multiplying the number of imperfectly known species; - and that Pavon's species at Madrid have not been examined by the author of this communication, or by any botanist competent to determine their value and what relation they bear to species already described, (a step, I conceive is highly desirable to take), I am of opinion that this communication had better not be published at present.[194]

Howard and Hanbury were on good terms, Hanbury having 'urged' Howard to join the Pharmaceutical Society in 1853, so it is unclear if Hanbury is implying Howard is *not* a 'competent botanist' or if he simply needs to view them before making assumptions (Howard,1885, p. 282).[195] Howard's response to the rejection came in 1862, when he self-published his first monumental guidebook to cinchona in the *Illustrations of the Nueva Quinologia of Pavon* (Howard, 1862). This work reproduced Fitch's illustrations of Pavón's Madrid herbaria, based on first-hand examination of them (as discussed in Chapter 7). Howard excluded nine species from the final text, avoiding those which as Hanbury had pointed out had been 'transferred to other genera'. There is a note to the effect that these

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[194] Howard, J.E, Reviewer's Report, (SP/571), Archives of the Linnean Society.
[195] In 1883, Howard was awarded the Hanbury Medal from the Pharmaceutical Society ('Obituary', 1883a). This is given every 5 years to an individual for remarkable services towards pharmacy, rather than botany.

were ‘excluded by present arrangements’, suggesting perhaps that Howard continued to regard the current official taxonomy as in a state of flux (Howard, 1862, p. iii).

6.7 Summary

As discussed in Chapter 5, quinologist John Eliot Howard was an established expert in the identification of cinchona barks and assembled one of the largest known cabinet reference collections. This chapter has shown that as the British transferred cinchona from the Andes to mass-cultivation in India from 1859, he likewise shifted his expertise from cabinet-based knowledge to horticultural experiment. Howard was interested in exploring how environmental impacts affected alkaloid production and morphological variation within species. By building glasshouses in his garden and growing a specialist collection of cinchonas, he was able to make novel observations that helped inform practice in India. The project also allowed him to engage with emerging theories of natural selection from a practical and experimental point of view.

While Chapter 4 presented Howard’s extensive influence on pharmaceutical world and cultivation practices in British-India, it is clear this influence had its limits. Due to his pharmaceutically perceived classifications and his reluctance to accept wider developments in the understanding of what constituted species, Howard would not be regarded as a radically progressive thinker in scientific terms. His career was however, devoted to promoting his classifications of dried and living specimens as he understood them, from a practical point of view. This led to a series of books through which he communicated his ideas, further promoted his quinological expertise and aimed to influence cinchona cultivation. These publications and their significance for Howard’s scientific practice and reputation are the subject of the next chapter.

Chapter 7 | Communicating Quinology: Howard's Book Production, Illustration, Distribution and Reception

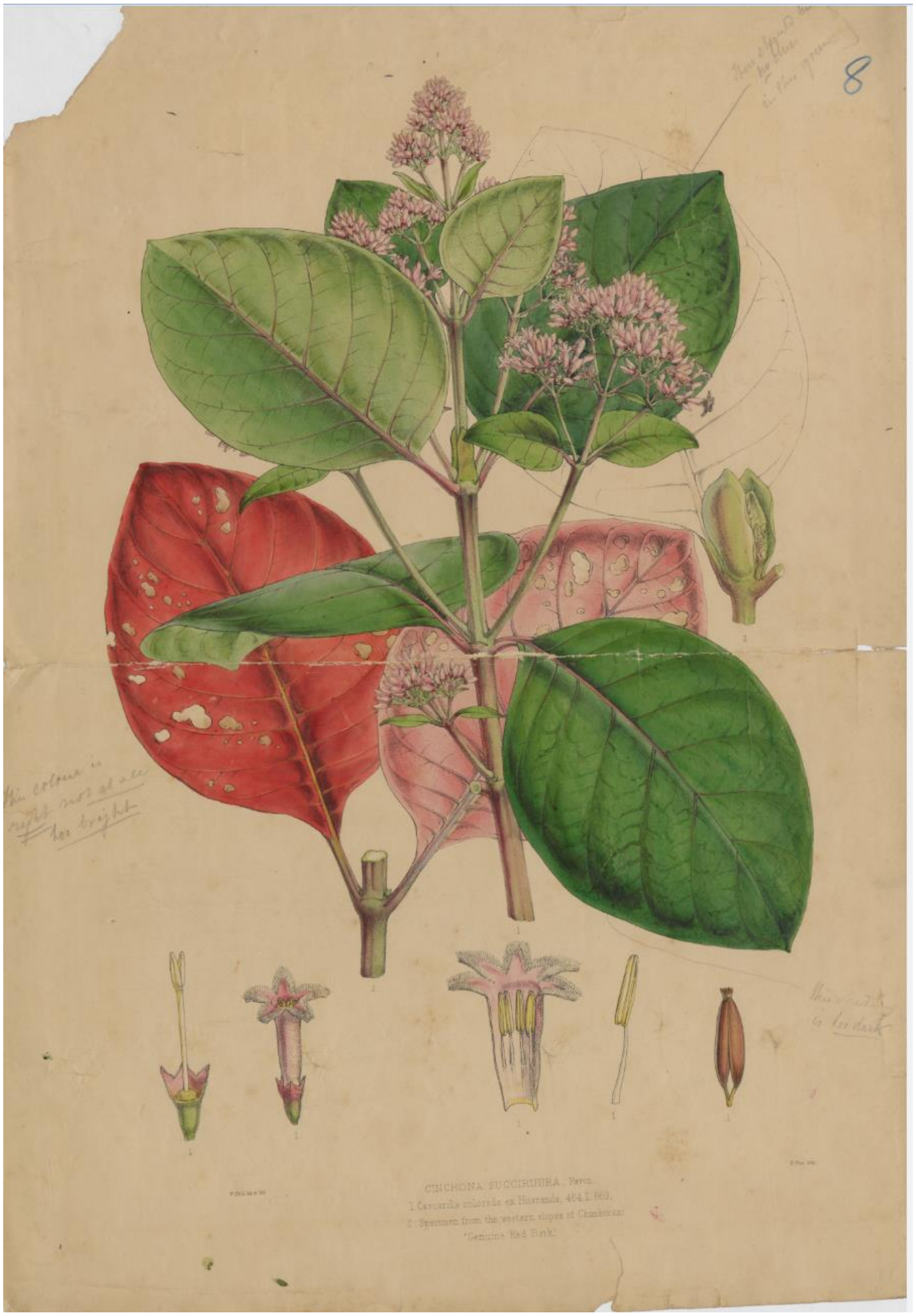

Figure 7.1 ***C. succirubra*** **(syn.** ***C. pubescens*** **Vahl) pattern block for Howard's** ***Nueva Quinologia*** **(1862).**

Handwritten notes. Top right: 'There should be <u>no</u> blue in the green'; Middle left: 'This colour is <u>right</u> not <u>at all too bright</u>.' From publishing house archive of Lovell Reeve (LRP/4/10), Library and Archives, RBG Kew.

7.0 Vignette: A parcel of pictures, Tottenham, 1861[196]

Untying the string on the parcel, quinologist John Eliot Howard unfolds the brown paper, revealing the illustrations he has been waiting for. Walter Hood Fitch's depictions of *Cinchona*, commissioned for each species chapter in Howard's first formal book, *The Nueva Quinologia of Pavón*, to be published the following year (Figure 7.1). Howard has seen the pictures build from rudimentary pencil sketches to watercolour drafts, but these pattern blocks are the printer's master copies representing the final stage before publication, showing how they will appear within the book's pages. Tiny lines fleck the green leaves, depicting the veins and pores, palest mauve suffuses the flowers, so life-like he can almost smell the lilac-scent he has heard they release. He takes up his magnifier and examines the first image closely, he notices a slight flaw. He picks up his pencil and scrawls across the background, taking care not to scratch the paint, annotating it here and there: this part looks correct, but that part needs adjustment to the hue. Placing the pencil down, he then shifts to the next picture, working methodically through the pile, checking his notes to confirm colouring and shade. Other than the few he has recently grown, he has seen few of these plants in real life, none yet fully grown, but he has researched enough to believe the result is life-like, or near enough.

These illustrations are as much his work as Fitch's, a culmination of 35 years of work. Both men have examined the coffee-coloured, desiccated specimens of *Cinchona* in the herbarium, which are all that most botanists get to see of the tree. Howard has also recently grown a couple of specimens, fledglings yet, but expected to enhance his future research. He has built a reputation in pharmacy for his expertise on the identification and chemical analysis of the alkaloids within bark traded into the London docks. Now he hopes to put his name to the forefront of the wider botanical and scientific community with his monographic publication on Peruvian species. Times are changing and Howard senses the shift: the year before he advised a Peru-bound Clements Markham on collecting cinchona.

[196] Sources taken from Lovell Reeve Archive, LRP/4/10, RBG Kew, Howard, 1862, Markham, 1862.

The British government has finally decided that the bark supply needs to be brought under control. A guaranteed supply is required for Imperial projects in India and beyond. By now, Markham has seen the great tree in the wild, getting closer than Howard ever will. He stops to imagine the great trees spreading across a jungle canopy, the green and ruby leaves glistening in the damp air. Markham has already collected saplings; they briefly settled at Kew and were now bound for plantations in India. Howard hopes the project will be a success, and with his expert advice, enhanced by contacts in South America and the trees growing in his own glasshouses, he will be in an ideal position to consult further.

Howard plans to send the book out to key contacts in the world of quinology and beyond. With this quality of production and illustration, it will take its place alongside other great works such as those of Humboldt, Mutis, Ruiz & Pavón and von Bergen. However, it will be the first richly coloured guide devoted to the *Cinchona* genus that also includes illustrations of bark, chemical analyses and microscopical figures.

7.1 Introduction

As discussed in Chapters 4 and 5, John Eliot Howard's career shifted towards scientific publishing with his first series of articles in the *Pharmaceutical Journal* on the British Museum's cinchona collections. These *'examinations'* were collated and privately bound to become his first book in 1853 (Howard, 1853). This was the start of a career consulting and publishing on cinchona supported by two further major, full-colour reference guides, published across his career. The first, published in 1862, was the *Illustrations of the Nueva Quinologia of Pavón* (hereafter called *Nueva Quinologia*); the second was *The Quinology of the East Indian Plantations* (hereafter called *The Quinology)*, completed in two parts, between 1869 and 1876.

The differences between the two books reflect changes not only Howard's career, but also in quinology at large, from wild-traded barks to cultivated trees in Dutch and British colonies, from 1851 and 1860 respectively. The circulation of these publications helped establish, then confirm, Howard's position at 'the front rank of living quinologists' ('Reviews', 1870, p. 658). Outranking all his peers in the extent of his detailed knowledge of cinchona, Howard became an expert consultant for the British Indian government, as discussed in Chapter 4, which in turn gave him unrivalled access to information for his publications. This chapter describes and compares Howard's books in detail, the importance of the illustrated sections, his publication and distribution strategies and their reception.

7.2 Howard's quinological books

Copies of Howard's two book-length publications can be found in the library of the Royal Botanic Gardens, Kew in the form of leather-bound, elephant folios each measuring over 50cm tall. The size of the books is significant. These are not pocketbooks to be opened in the field, nor compiled for a quick read. They were created as monuments to cinchona research: illustrated reference guides that require a commitment to study. They also form a representation of 'living' herbaria: instead of dried, pressed, poorly captured specimens, these contain life-size, life-like illustrations presented as richly coloured plates to accompany their textual analysis.

Each book follows a similar pharmacognostic and botanical format aimed at guiding identification of the various *Cinchona* species. As discussed in Chapters 5 and 6, Howard's focus was on the medicinal viability of different forms, so although debate existed between experts on the botanical taxonomy, their pharmaceutical taxonomy was given equal importance. The books were published by Lovell Reeve (1814-1865), a leading London-based naturalist and publisher, also responsible for printing Kew's *Curtis's Botanical Magazine* (Petit, 2007). The Lovell Reeve price lists and advertisements show that Howard's two cinchona volumes were costly: the *Illustrations of the Nueva Quinologia* cost £5 5s in 1862, £6 6s in 1867 and *The Quinology of the East Indian Plantations*, £6 6s in 1879. These were some of the most expensive books on the Lovell Reeve list, others selling for shillings (Willis & Southeran, 1862).[197] The prices for Howard's books are around £300-400 in 2022 values, around 3-6 times more than current average academic book prices.[198] In its review of the *Quinology*, the *Pharmaceutical Journal* noted that 'The expensive character of the work renders it probable that many of our readers may be precluded from seeing much of the valuable information contained in it; we propose, therefore, to extract rather freely from its pages', which it subsequently does.

While we do not know how many copies of these works were sold, we do have evidence of how some were circulated. Currently there are nearly 100 copies of Howard's two books available in institutional libraries worldwide, as discussed below (section 7.4). No profit was made on the publication by Howard, rather he subsidised their production. The archives show he gifted many of these institutional books as donations, though at least a couple of dozen were purchased by the British Indian Government to distribute to

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[197] Lovell Reeve & Co. (1879). *List of works on botany, entomology, conchology etc.* Lovell Reeve & Co. Held at: LRP/8 Library & Archives, Royal Botanic Gardens, Kew.
[198] The National Archives. (2018). *Currency converter: 1270–2017*. https://www.nationalarchives.gov.uk/currency/#currency-result

cinchona planters (Howard, 1885).[199] Since Howard's and Sons were by this time making their own large profits from quinine sales the publication may have been seen partly as a marketing strategy to promote the expertise within the company and quality of products. As a review in the *Gardener's Chronicle* stated, it was noted that *The Quinology* had been:

> produced at the cost of the author, regardless of any expense that could render it worthy of its subject, and has been distributed largely to scientific institutions and individuals. Such books originating as they do in a pure zeal for science and a desire for its diffusion and from no love of fame or popularity are noble monuments no less to their authors' liberality than to their good taste. (*Journal of Botany*, 1866, rear advertising pages)

Table 7.1 shows a chronological list of quinological works in which Howard's works can be placed. In Howard's first book, the 1862 *Nueva Quinologia*, he cites some works as particular influences. This is important to note as a comparison can be made about the themes he then chose to continue, or not within his own work. In his opening lines, he refers to three books to which his can be placed alongside: the 1826 *Versuch einer Monographie der China* by German drugmaker Heinrich von Bergen (von Bergen, 1826), and more contemporary works by German botanist Hermann Karsten writing on Colombian Cinchona and Weddell's work on the Bolivian (Karsten, 1858; Weddell 1849). While von Bergen's work is an earlier pharmacognostic tome written from and for the pharmaceutical perspective, the later works come from the botanical, though all include bark identification to greater or lesser degrees. It is these last two, however, that Howard fills in a geographical Peruvian gap between the works:

> I trust therefore that these three works, taken together, may give, not indeed a complete representation of the whole of the species comprehended in this widely spread genus, but at least an extensive and accurate diagnosis of by far the greater number of its members. (Howard, 1862, p. i)

A look at the table shows that Howard's work is most comparable to Delondre and Bouchardat's 1854 *Quinologie*, with a pharmaceutical perspective, alkaloid, analysis colour botanical illustrations and bark descriptions, although it lacks and microscopical diagrams.

[199] See Chapter 4, section 4.8.

As discussed in Chapter 4, Delondre's influence on the mid-century quinological discipline is apparent, with multiple references by Howard to his descriptions, analysis, and illustrations. Most notably for Howard, however, is the lack of bark illustrations in his own work compared to other authors, and this is discussed in the Illustrations section below.

Howard's *Quinology of the East Indian plantations* followed the style of his earlier book, with an equally large size, full-colour botanical-microscopical illustrations and chemical analysis. This publication signalled the change in career path by Howard towards analysis of cultivated barks which included more in-depth analysis on the influence of environment on breeding.

Table 7.1 Major cinchona publications: A content comparison.[200]

Year	Author	Book	Alkaloid analysis	Illustrations: Colour	Illustrations: Botanical	Illustrations: Bark	Illustrations: Microscopic
1792	Ruiz López, Hipólito	*Quinologia*	N	N	N	N	N
1797	Lambert, Aylmer Bourke	*A description of the genus Cinchona*	N	N	N	N	N
1801	Ruiz López, Hipólito & Pavón Jiménez, José Antonio	*Suplemento á la quinología*	N	N	1	N	N
1816 (1957 publication)	Mutis y Bosio, José Celestino	*Quinas de la Real Expedición Botánica del Nuevo Reino de Granada* (Vol 44)	N	Y	62 (Colour with black & white outlines)	N	N
1821	Lambert, Aylmer Bourke	*An illustration of the genus Cinchona*	N	N	N	N	N
1826	von Bergen, Heinrich	*Versuch einer monographie der china*	N	Y	N	7 plates (84 specimens)	N

[200] Books selected from text search, author knowledge and a list from Flückiger & Hanbury (1874). Excluded are books on plantation techniques. Some smaller botanical books have been excluded if cinchona was not a focus. Karsten's *Florae Columbiae* was not cinchona focused but was included as it was recognised and cited by Howard at the time as it contained a section within it as best guide for Columbian cinchonas.

				Illustrations			
Year	Author	Book	Alkaloid analysis	Colour	Botanical	Bark	Microscopic
1828	Mutis y Bosio, José Celestino	*El arcano de la quina*	Mention of alkaloid variations, not quantitative	N	N	N	N
1835	Vrijdag-Zijnan, Theodoor	*De in den handel voorkomende kina-basten pharmacologisch behandeld en toegepast op de soorten welke in de Pharmacopoea Belgica vermeld zijn*	Y	N	N	N	N
1849	Weddel, Hugh Algernon	*Histoire naturelle des quinquinas*	Y	Partly	27 B&W	3 colour plates showing 34 barks	2 B&W plates of 43 micro/macro scopic
1853	Howard, John Eliot	*Examination of Pavon's collection of Peruvian barks contained in the British Museum*	Y	N	N	N	N

				Illustrations			
Year	**Author**	**Book**	**Alkaloid analysis**	**Colour**	**Botanical**	**Bark**	**Microscopic**
1854	Delondre, Augustus & Bouchardat, Apollinaire	*Quinologie: Des quinquinas et les questions qui dans l'état présent de la science et du commerce s'y rattachent avec le plus d'actualité*	Y	Y	N	23 plates containing 123 illustrations of 33 bark types	N
1858	Karsten, Hermann	*Die medicinischen chinarinden-Neu Granada's*	N	N	N	N	2
1858	Karsten, Hermann	*Florae Columbiae terrarumque adjacentium specimina selecta.* Vol. 1	N	Y	7 plates	3 botanical plates include bark examples	N
1862	Howard, John Eliot	*Illustrations of the nueva quinologie of Pavon*	Y	Y	27	N	3 plates; 44 illustrations of 38 bark cuttings, 6 germinating seeds
1864	Phoebus, Philipp	*Die Delondre Bouchardat schen china rinden*	N	N	N	N	N

				Illustrations			
Year	**Author**	**Book**	**Alkaloid analysis**	**Colour**	**Botanical**	**Bark**	**Microscopic**
1864	Planchon, Gustave	Des quinquinas	Y	N	N	N	N
1865	Berg, Otto	*Chinarinden der pharmakognostischen sammlung zu Berlin*	N	N	N	N	10 plates
1867	Vogl, August	*Chinarinden des Wiener grosshandels und der Wiener sammlungen*	N	N	N	N	N
1870	Triana, José	*Nouvelles études sur les quinquinas*	N, brief mention	N	33 plates	N	N
1870	Weddell, Hugh Algernon	*Notes sur les quinquinas*	Y	N	1	N	N
1869-76	Howard, John Eliot	*Quinology of the East Indian plantations*	Y	Y	12 [10 colour + 2 B&W]	2 small B&W	3 plates: 27 bark cuttings

7.2.1 *Illustrations of the Nueva Quinologia of Pavón*

The works in the early part of Howard's publishing career, though botanical in nature, were written from a pharmaceutical manufacturing perspective: they were concerned with identification of valuable trade species for alkaloid extraction from poor-quality barks or adulterated specimens. Howard's first journal and book publications, *Examination of Pavón's collection of Peruvian barks contained in the British Museum*, published between 1852-1853, were based on his research examining the important cinchona bark collection in the British Museum sourced from *La Real Expedición Botánica al Virreinato del Perú* (1777-1816), collected predominantly by Spanish botanists, Hipólito Ruiz López and José Antonio Pavón Jiménez. As discussed in Chapter 4, these Peruvian forest-collected specimens allowed Howard to compare 'known' barks to those arriving in trade.

The title of Howard's *Nueva Quinologia* reflected its presentation as an update to Ruiz's *Quinologia* of 1792, based on his purchase of Pavón's unpublished manuscript on 35 *Cinchona* species, along with a further set of 54 bark specimens from the *Expedición*.[201] Some mystery surrounds this purchase as the seller is not named and the sale was organised through a scientific book publisher, Hippolyte Baillière.[202] The specimens may originally have been sold outside Madrid's botanic gardens by Pavón himself, therefore eventually becoming available for purchase by Howard. The provenance of this collection is traced in Walker et al. (2022), though their trajectory between the date of Pavón's sale and Howard's purchase remains a mystery: one researcher suggests botanist and later Madrid Director Miguel Colmeiro (1816–1901) (Estrella, 1995). Howard's purchase formed the basis for his *Nueva Quinologia* publication, as well as playing an important role in developing his expertise and positioning himself as a successor to Ruiz and Pavón's knowledge (Howard, 1853; 1862).

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[201] Some of these barks are now in the Economic Botany Collection, Kew. Pavón's *Nueva Quinologia* manuscript is in Howard's and Sons archives, (LMA ACC/1037/855), London Metropolitan Archives.
[202] Hippolyte set up a London based branch of the company of his Parisian-based brother, Jean-Baptiste Baillière (1795-1885). The company eventually became the well-known Baillière Tindall Ltd publishing company https://archiveshub.jisc.ac.uk/search/archives/934e0880-aa89-3a14-a272-4b926642fbd9

Howard may have been spurred to develop this work by the establishment of Dutch Indonesian cinchona plantations in 1851. A decade of career building and publishing prior to the founding of British Indian plantations in 1860 had established his role as a key consultant to the British Government's cinchona expeditions in 1859 and then the Indian cinchona projects for the remainder of his career (See Chapter 1) (Howard, 1876; Markham, 1862).[203] The *Nueva Quinologia* was completed just as the British plantations were established. It demonstrated Howard's extensive knowledge in the botanical, chemical and commercial aspects of cinchona both to inform growers and establish his own expertise.

In the *Nueva Quinologia*, 39 of Pavón's botanical descriptions of *Cinchona* from the *Nueva Quinologia* were published, restructured to Howard's taxonomic organisation, omitting those he did not consider part of the genus (Howard, 1862). These 39 chapters are listed in Table 7.2. To these he added enhanced notation. Howard's own additions to the work include:

- 27 colour plates showing 30 species illustrated by Walter Hood Fitch.
- 3 colour plates of 44 microscopical bark and seed observations by Tuffen West.
- Additional text for each of Pavón's descriptions with Howard's notes on bark identification compared to those found in trade and a synthesis of other literature.

Regarding the species classifications, Howard suggested that Ruiz and Pavón had described *Cinchona* with great 'accuracy and fidelity' (Howard, 1862, p. iv). By Howard's time (and remaining the case today) around 11 species were no longer accepted within *Cinchona*, having moved to other species such as *Ladenbergia*. Notably, however, Howard wrote the book connecting barks. Ruiz and Pavón had listed a trade bark type, *Cascarilla crespilla* (*chica* and *grande)*, as falling within *C. ovata*. Howard disagreed. Hasskarl had

[203] See also Markham's diaries, *Cinchona notebook 1* (CRM/55), and *Cinchona notebook 2* (CRM/56), Royal Geographical Society Archives.

gathered plants for the Dutch plantations and Howard considered *these* as the trees that produced this particular bark type. Howard published the Dutch-collected species, describing it as *Cinchona pahudiana* How. This is significant as it shows Howard's confidence in his own botanical credentials alongside those of the two Spanish botanists and therefore his own 'accuracy and fidelity' as a botanist and not just a pharmacist. Today, however, *C. pahudiana* is no longer considered a species, it is instead classed as Weddell's *C. calisaya*.

Table 7.2 Species listed in the Illustrations of the Nueva Quinologia of Pavón (Howard, 1862) and relation to trade names and illustrations.

Species as listed	Modern determination (powo.science.kew.org)	Main trade names	Colour illustration	Microscopical illustrations
C. chahuarguera Pav.	*C. officinalis* L.	Cascarilla Colorada del Rey; Cascarilla Amarilla del Rey; Select Crown Bark.	Y	Plate 1: fig. 1, 2
C. crispa Tafalla ex. How.	*C. officinalis* L.	Quina pina de Loja; Loja Bark.	Y	-
C. coccinea Pav.	*C. macrocalyx* Pav. ex DC.	Cascarilla serrena acanelada	Y	-
C. palalba Ruiz & Pav. [sic] should be *C. pelalba* Pav. Ex DC.	*C. pubescens* Vahl.	Cascarilla con hojas de Zambo	Y	-
C. micrantha Ruiz & Pav.	Accepted	Cascarilla Provinciana Blanquilla	Y - and in *Flora Peruviana* (Ruiz & Pavón, 1799)	Plate 1: fig 3; Plate 3: fig. 37, 38
C. reicheliana How.	*C. micrantha* Ruiz & Pav.	Cascarilla Provinciana Negrilla; Grey bark	Y - (with *C. micrantha*)	Plate 1: fig. 4
C. villosa Pav.	Accepted	Cascarilla peluda; Dark Jaen bark.	Y	-
C. macrocalyx Pav.	Accepted	Cascarilla con hojas redondas; Ashy crown bark	Y	Plate 1: fig. 6
C. succirubra Pav.	*C. pubescens* Vahl.	Cascarilla colorado; Red bark	Y	Plate 2: fig. 11, 12a, 12b, 13; Plate 3: fig. 44;
C. ovata Pav.	*C. pubescens* Vahl.	*Cascarilla de pata de Gallareta*	Y- and in *Flora*	Plate 2: fig. 14;

Species as listed	**Modern determination (powo.science.kew.org)**	**Main trade names**	**Colour illustration**	**Microscopical illustrations**
			Peruviana (Ruiz & Pavón, 1799)	Plate 3: fig. 39, 41, 42
C. magnifolia Pav.	*Ladenbergia oblongifolia* (Humb. ex Mutis)	Cascarilla flor de Azahar; Spurious red bark	Y – and in *Flora Peruviana* (Ruiz & Pavón, 1799)	Plate 2: fig. 17
C. purpurea Pav.	*C. pubescens* Vahl.	Cascarillo morado; Huamalies bark	Y- and in *Flora Peruviana* (Ruiz & Pavón, 1799)	-
C. pubescens Vahl.	*C. pubescens* Vahl.	-	N - in *Flora Peruviana* (Ruiz & Pavón, 1799)	-
C. erythrantha Pav.	*C. macrocalyx* Pav. ex DC.	-	Y	-
C. palton Pav.	*C. officinalis* L.	Cascarilla con hojas de Palton; Carthagena bark.	Y	Plate 3: fig. 22
C. lutea Pav.	*C. pubescens* Vahl.	Cascarilla amarilla; Pale Jaen bark	Y	Plate 1: fig. 10
C. conglomerata Pav.	*C. villosa* Pav. ex Lindl.	Cascarilla colorada	Y	-
C. parabolica Pav.	Accepted	Cascarilla crespilla con hojas rugosas	Y	-
C. microphylla Pav.	*C. mutisii* Lamb.	Cascarilla crespilla con hojas de roble	Y (with *C. rugosa*)	Plate 3: fig. 18

Species as listed	Modern determination (powo.science.kew.org)	Main trade names	Colour illustration	Microscopical illustrations
C. rugosa Pav.	*C. pubescens* Vahl.	Cascarilla crespilla de Cuenca	Y (with *C. microphylla*)	-
C. heterophylla Pav.	*C. macrocalyx* Pav. ex DC	Cascarilla negrilla o negra; Negrilla bark	Y	Plate 3: fig. 25
C. uritusinga Pav.	*C. officinalis* L.	Cascarilla fina; Original Loja bark	Y	Plate 3: fig. 20
C. nitida Ruiz & Pav.	*Ladenbergia oblongifolia* (Humb. ex Mutis)	Quina cana legitima; Grey bark	Y (and in *Flora Peruviana*, Ruiz & Pavón, 1799)	Plate 1: fig. 5; Plate 3: fig. 27, 28, 29, 30, 31, 32, 33, 34, 35, 36,
C. pahudiana How.	*C. calisaya* Wedd.	Cascarilla crespilla chica	Y	Plate 3: fig. 23, 24
C. umbellulifera Pav.	*C. scrobiculata* Humb. & Bonpl.	Cascarilla crespilla de Jaén	Y	Plate 3: fig.19
C. decurrentifolia Pav.	*C. pubescens* Vahl.	Cascarilla crespilla ahumada	Y	Plate 2: fig. 15; Plate 3: fig. 43
C. obovata Pav.	*C. pubescens* Vahl.	Cascarilla con hoja de oliva	Y	-
C. stupea Pav.	*C. officinalis* L.	Cascarilla estoposa	Y (with *C. lanceolata*)	Plate 2: fig. 16
C. lanceolata Ruiz & Pav.	Accepted	Cascarilla boba amarilla	Y (with *C. stupea*)	-

Species as listed	**Modern determination (powo.science.kew.org)**	**Main trade names**	**Colour illustration**	**Microscopical illustrations**
C. glandulifera Ruiz & Pav.	Accepted	Cascarilla negrilla	Y	-
C. peruviana How.	*C. calisya* Wedd.	Cascarilla pata de Gallinazo	Y	Plate 1; Fig. 7
C. violacea Pav.	*C. macrocalyx* Pav. ex DC.	-	-	-
C. tarontaron Pav.	Unknown.	-	-	-
C. obtusifolia Pav.	*C. officinalis* L.	-	-	-
C. viridiflora Pav.	*Pimentelia glomerata* Wedd.	-	-	-
C. hirsuta Ruiz & Pav.	Accepted	-	N - in *Flora Peruviana* (Ruiz & Pavón, 1799)	-
C. subcordata Pav.	*C. officinalis* L.	-	-	Plate 3: fig. 21, 40
C. suberosa Pav.	*C. officinalis* L.	-	-	-
C. lucumaefolia Pav.	Accepted [as *C. lucumifolia* Pav.]	-	-	Plate 1; fig 8

7.2.2 *Quinology of the East Indian Plantations*.

> I hope that the present volume will guide the cultivator in his choice, and thus secure him from loss, or at least suffice to show that it needs much cautious discrimination in commencing plantations of cinchona (Howard, 1876, p. ix)

As discussed above, Howard's first series of publications helped to establish his reputation as Britain's leading quinologist and led to consultation work for the Indian government cultivation projects. Howard first undertook the role of analytical quinologist for the Indian plantations at Nilgiris between 1863 and 1867 until John Broughton was officially appointed, though Howard continued to give his analytical opinions well into the 1870s (King, 1876; Veale, 2010).

Over the next two decades, Howard produced official reports for the government and articles for the pharmaceutical profession on cinchona species, hybrids and alkaloid analysis of the Indian plantation experiments. This list of reports, published in the official Parliamentary Paper Blue Books, can be seen in

Table **4.2**. These reports were well discussed and their influence is explored in Chapter 4. This involvement with the plantations, giving access to sampling material, culminated in his final work, *The Quinology of the East Indian Plantations* (Howard, 1869; 1876). This came in two parts, often later bound as one, again published through Lovell Reeve, positioned as a continuation and development of his previous works (Howard, 1876). Like Howard's *Nueva Quinologia*, Howard described species with their chemical analysis while reporting on 'intelligent culture', advising on cultivation choices and practices (Howard, 1869, p. 30). This time, however, fewer species were discussed: the focus was on those grown in the British and Dutch colonial plantations. In the preceding years, barks from British India had been supplied to Howard for analysis with further evidence on the importance of elevation, shade and other environmental factors such as bark renewal (a sustainable growing practice) gathered through correspondence with gardeners within the plantation project, including William McIvor and Robert Mackenzie Cross (Cross, 1871; McIvor, 1862; 1863; Veale, 2010).[204] These filled the gap that Howard felt in his previous works: detailed knowledge of environmental variables that affected the relationship between cultivation and alkaloid manufacture. This information augmented the observations Howard had made on cinchona grown in his own garden (as discussed in Chapter 6). This sort of additional 'ecological' knowledge is highlighted in his discussion of microscopical observations, where Howard provides 27 images showing the differences in barks grown in forest vs. open space, as well the effect bark renewal using a technique known as mossing. This was a method developed by McIvor who had observed that the best wild barks were covered in moss and lichen. Alternate strips of bark were harvested from the trunk and allowed to regrow for sustainable cropping. While this increased alkaloid content, Howard thought due the moss excluding light, it did not increase the quinine content notable. Some tension lay between Broughton, who preferred cropping, and McIvor who promoted the moss technique. This further complicated the story of alkaloid purity as discussed in Chapter 2 (Howard, 1869; Veale, 2010)

[204] See correspondence files, particularly JEH1/44 JEH/2/6 for McIvor and JEH/1/16, JEH, 1/36-38, Library and Archives, Royal Botanic Gardens, Kew.

Howard was not paid for his plantation analyses or advice. Rather, his work was 'gratuitously given', in return receiving what he sardonically called '*grandis et verbosa epistola*' [grand and wordy letters] (Howard, 1885, pp. 226, 316). He commented further on this work in an 1867 letter to his son Henry:

> I read a paper last evening before the Linnean society, which formed the chief business of meeting, and led to rather spirited discussion, in which I got a good deal complimented, which indeed in some sense I deserve, having been hard at work for the government' (as cited in Howard, 1885, p. 210)

The Quinology of the East Indian Plantations was published in three parts: the first in 1869, on microscopical and chemical observations; two and three in 1876, on the condition of the Indian plantations, updated horticultural and botanical observations and additional microscopical observations. Today these three parts are typically found bound together as one text, with both dates on each flyleaf. The species Howard discussed can be found in Table 7.3. Images from the complete works include:

- 10 colour and 2 black and white illustrations by Walter Hood Fitch.
- 3 microscopical plates showing 27 images by Tuffen West.
- 3 photographs of plantation scenes.
- 2 pen sketches of barks, artist unknown.

Table 7.3 Species chapters in *The quinology of the East Indian plantations* (Howard, 1876) and relation to trade names and illustrations [205]

Species as listed	Modern determination (Powo.science.kew.org)	Main trade names	Colour illustration	Microscopical illustrations
C. calisaya var. *ledgeriana*	*C. calisaya* Wedd.	-	Y x 3 forms	-
C. calisaya javanica	*C. calisaya* Wedd.	-	Y x 2 [Hasskarl & Schuhkraft]	-
C. josephiana var. *glabra*	Probably *C. calisaya* Wedd.	-	Y	-
C. calisaya anglica (hybrid)	hyrbid between *C. calisaya* Wedd. and *C. pubescens* Vahl.	-	Y	-
C. officinalis **γ** *bonplandia* var. *lutea*	*C. officinalis* L.	Amarilla del Rey	Y	Y – renewed (mossed) and unrenewed
C. pitayensis Wedd.	Accepted	Anaranjada fina; Roja del Pinon de Pitayo; Quina anaranjada from La Cruz; Amarilla del huevo	Y (also showing barks)	-
C. grandiflora	*Cosmibuena grandiflora* (Ruiz & Pav.) Rusby	-	Y	-
Calisaya de St. Fe		*Calisaya de St. Fe*		-
C. calisaya **β** *macrocarpa*	*C. calisaya* Wedd.	-	Y (b&w)	-
C.succirubra	*C. pubescens* Vahl	-		Showing grown in open forest, as well as renewed (mossed). Both Indian & Ceylon

[205] Howard also discusses in passing other species from Dutch plantations not placed in this table.

Figure 7.2 *C. anglica* (*C. officinalis* L. x *C. pubescens* Vahl), by Walter Hood Fitch for Howard's *Quinology of the East Indian Plantations* (Howard, 1876).
Library & Archives, RBG Kew. Image Author's own.

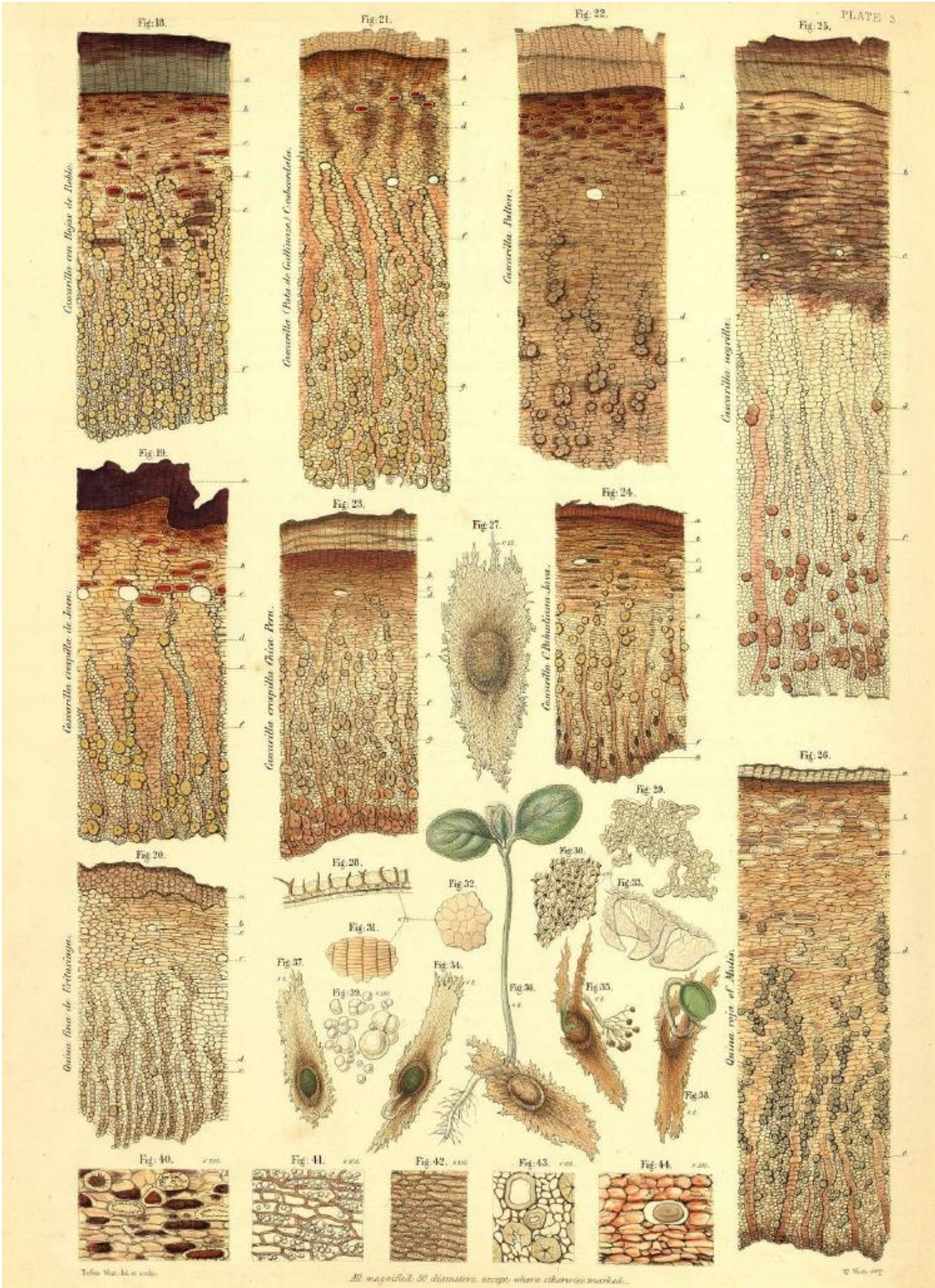


Figure 7.3 Microscopical observations by Tuffen West for Howard's *Nueva Quinologia of Pavon* (Howard, 1862).
Wellcome Collection.

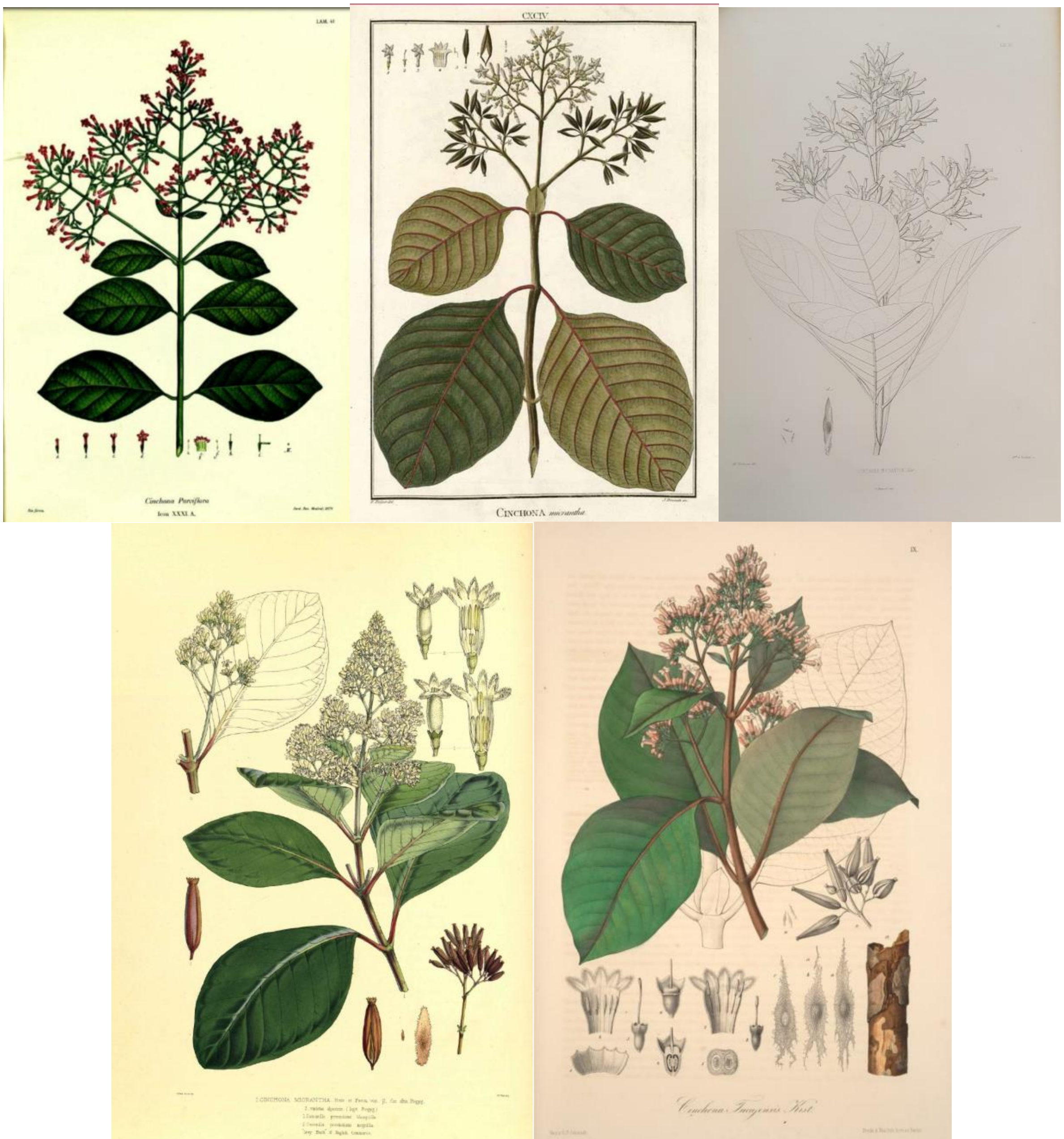


Figure 7.4 Illustrating *Cinchona*

Artists from top left, clockwise: *Cinchona parviflora* (syn. *C. micrantha* Ruiz & Pav.), by an Unknown artist, from Mutis' *Quinas de la Real Expedición Botánica del Nuevo Reino de Granada* (c.1816); *C. micrantha* Ruiz & Pav., by José Brunete Casto Dubua from Ruiz & Pavón's *Florae Peruvianae* (1799); *C. micrantha* Ruiz & Pav., From Weddell's *Histoire naturelle des quinquinas (*1849); *C. tucujensis* (syn. *C. pubescens* Vahl) by Carl Friedrich Schmidt from Hermann Karsten's *Florae Columbiae* (Karsten, 1858*); C. micrantha* Ruiz & Pav., by Walter Hood Fitch from *Howard's Illustrations of the Nueva Quinologia of Pavon* (1862). Images from Plant Illustrations or Author's own.

7.3 Illustrations

Howard's botanical illustrations represented the morphological and taxonomic aspects of the work (Figure 7.2), while the microscopic images reflected the analytical aspects (Figure 7.3). Combined, this created a quinological work rather than simply a botanical one.

Howard's illustrations are comparable to the engravings in eighteenth-century, botanically focused cinchona publications by travellers who commissioned illustrations from living specimens, including those of José Celestino Mutis and those from Ruiz and Pavón (Bleichmar, 2006; 2009; Ruiz & Pavon, 1794, 1799; Mutis, 1783-1816). As can be seen in the first image in Figure 7.4, Mutis commissioned artworks in a flat style, similar to a herbarium specimen, seemingly against the wider trend to follow the advice of Linnaeus, whereby botanical illustrations were designed to capture the size and structure of a plant before it was pressed flat as a specimen (Bleichmar, 2009; Rose, 2020). Artists accompanying Ruiz and Pavón normally depicted the Peruvian flora with a more realistic style, though with some cinchona they revert to a flatter style, perhaps to echo the first depictions of cinchona which circulated from herbarium specimens and to compete with Mutis. In contrast, the nineteenth-century quinological publications, such as Howard's, were presented in more natural, three-dimensional images, representing branches cut from a tree. Ironically unlike artists in the field of the living plant, Howard's depictions were reconstructed from flat herbarium specimens to reimagine the living.

As discussed, above, Howard explicitly acknowledged the works of Von Bergen (1826), Weddell (1849), Karsten (1858) and Delondre and Bouchardat (1854). However, in contrast to his own, these other works presented colour plates representing examples of commercially-collected bark types, while Howard's work does not, Ruiz and Pavón having collected the barks alongside the herbaria and woods (Figure 7.4 and Figure 1.2) (Walker et al., 2022). It is not clear why Howard did not present trade barks in illustrations, perhaps he felt that these antecedents had covered them sufficiently, or perhaps it was because he organised these works by species rather than bark types. He may also have intended the illustrations and descriptions to be used by readers when examining a physical bark specimen. Howard frequently sent out sets of barks to other collectors and institutes (as discussed in Chapter 4) and there is occasional evidence he sent both books and barks to the same places and so these may have meant to have aided side-by-side examination.[206]

Another influence on Howard's visual presentation of the specimens, notably in Tuffen West's work (see Figure 7.3 and discussed below), were microscopical illustrations first found in Weddell's *Histoire naturelle des quinquinas* (1849). Howard himself wrote that 'The microscope reveals to sight much which chemical analysis cannot follow' (Howard, 1869, p.29). Perhaps he felt the microscopic analysis of barks was more useful than macroscopic images. However, this meant that only those with microscopes, an expensive item, would be able to benefit from the information, if using the books to analyse their own collection. A look at von Bergen and Delondre and Bouchardat's charts show how visually variable specimens were dependent on the age of tree, part cut (twig, branch, bark), drying method (pressed, quilled, smoked), and so on (Compare the red barks of Figure 7.5).

The influence of Alexander von Humboldt, especially his *Geographie des plantes equinoxales* of 1807 (von Humboldt et al., 2008), is also evident in works on cinchona. Humboldt's famous *Tableau physique*, a form of topographical map showing Andean plants, including cinchona, their growing regions related to elements such as elevation and soil type, is a case in point. In 1826, von Bergen created a similar diagram of the biogeography of the *Cinchona* species as discussed within his *Monographie* which was clearly inspired by Humboldt (the two diagrams are compared in Figure 7.6) In addition, Delondre and Bouchardat replicated the *Tableau* in its entirety alongside their bark descriptions (Delondre & Bouchardat, 1854). As mentioned in Chapter 4, Delondre was a direct contemporary of Howard, a pharmaceutical manufacturer with botanical and chemical skills who, unlike Howard, had visited the cinchona forests of South America (Jaussaud,

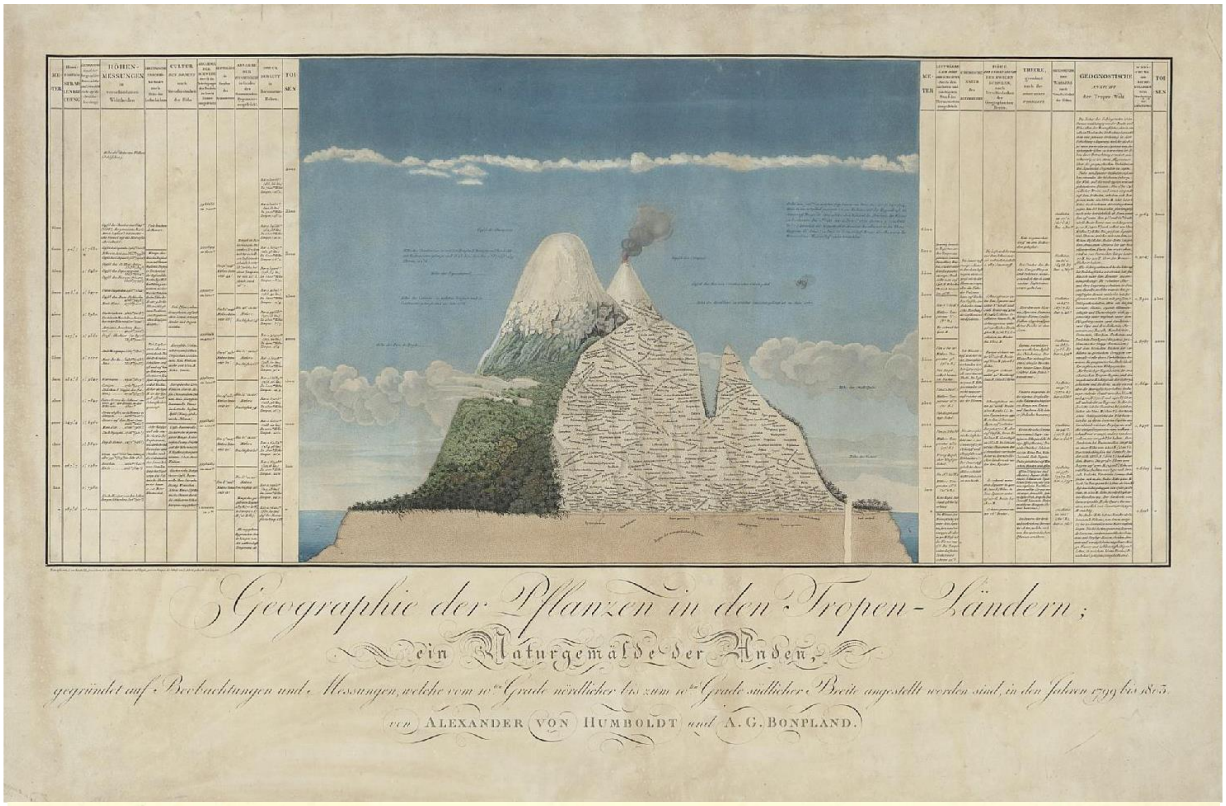
[206] From Howard's records, it is clear he sent these to institutes and collectors, e.g., France-based quinologist Hugh Algernon Weddell, the Royal Pharmaceutical Society Museum and the General Union of Austrian Apothecaries these can be seen across JEH/1/9 and JEH/1/10, Library and Archives, RBG Kew.

2018). The subject of ecological influences on cinchona was clearly still of contemporary interest in the mid nineteenth century - particularly because of the effect on alkaloid content, which would directly affect the business of chemical production, an important theme in Howard's work as well. Yet Howard, lacking Andean experience, held back from reproducing similar topographic diagrams, instead drawing the ecological into his textual descriptions.

Hermann Karsten's 1858 *Florae Columbiae* is notable in its aesthetic similarities to Fitch's illustrations for Howard (compare the two in Figure 7.4). Karsten's figures were illustrated by botanist and lithographer, Carl Friedrich Schmidt (1811- 1890), sharing commonalities of style, perspective and colouring with the Howard-Fitch work. There is no evidence that two artists, Schmidt and Fitch, met though they must have been aware of each other's work. More broadly, the similarity in their works clearly reflects the naturalistic European style of the time (Bleichmar, 2009). However, again, one significant difference is that Schmidt's illustrations include barks.

Howard used his illustrations not only in his books and in exhibitions, but also in displays at society lectures and conversazione in order to enhance the verbal aspects of his work ('Conversazione', 1867; Hanbury, 1862; Howard, 1870b). Caroline Cornish has noted the lasting importance of such displays of the ideal specimen in pedagogic and museum settings, supplementing texts, objects and pressed herbaria (Cornish, 2017). The Howard-Fitch illustrations were themselves used in museum contexts, as is clear from a photograph of the cinchona collection at the Koloniaal Museum, Haarlem (Figure 7.7) (van Someren Brand, 1906). The space is filled with traditional glass cabinets displaying barks, bottles and boxes with a ring of illustrations crowning the room. The fact that such images from *The Quinology of the East Indian Plantations* were being used in such a context over forty years after their publication indicates their continued significance as ideal depictions of cinchona.

Figure 7.5 Red bark illustrations across publications.
Top: China rubra [red bark] trade examples. Bergen's *Monographie* (1826), Real Jardín Botánico-CSIC; Bottom: Red barks with their chemical analyses, Delondre & Bouchardat's *Quinologie* (1854), Library & Archives, RBG, Kew.



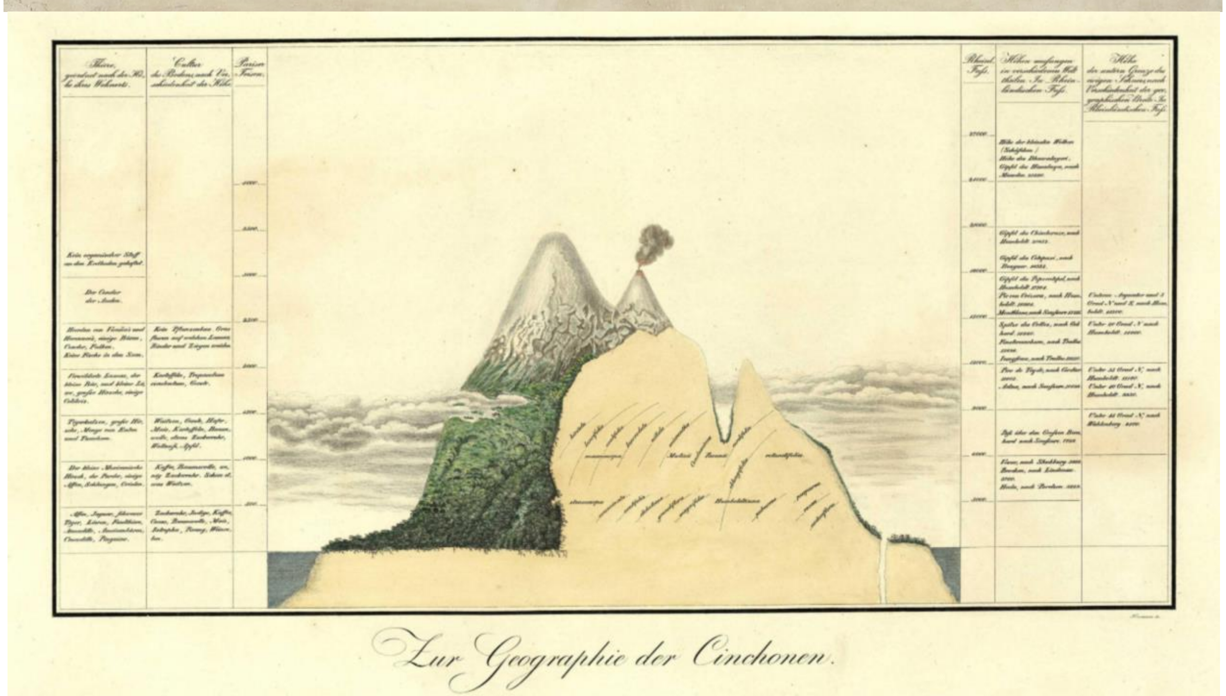


Figure 7.6 Humboldt-inspired maps.
Top: Humboldt and Bonpland’s map of plants (including cinchona) growing regions, with an analysis of ecological variables. von Humboldt et al., 2008), Wikimedia Commons. Bottom: A Humboldt-inspired cinchona map from Bergen’s *Monographie* (1826), Real Jardín Botánico-CSIC.

De meest uitgebreide kinacollectie ter wereld, in het Koloniaal Museum te Haarlem.

Figure 7.7 The Koloniaal Museum, Harlem

The Howard-Fitch illustrations from the 1876 *Quinology of the East Indian Plantations* can be seen displayed above the exhibition cabinets. The caption reads: ‘der meeste uitgerbreide kinacollectie ter wereld in het Koloniaal Museum te Haarlem’ [the most extensive cinchona collection in the world at the Koloniaal Museum, Harlem [Netherlands]]. Image taken from Groot *Kultures of der Wereld* (van Someren Brand, 1906).

7.3.1 Walter Hood Fitch Illustrations

Walter Hood Fitch (1817-1892) was a Scottish botanical artist and lithographer. He was employed aged 17 when working as a fabric printer by Kew Director William Jackson Hooker (1785-1865), at the time Regius Professor of Botany in Glasgow. Soon after, in 1834, Hooker as editor of *Curtis's Botanical Magazine* commissioned Fitch's first botanical illustration. When Hooker moved to the directorship of Kew in 1841, he brought Fitch with him. Fitch went on to illustrate many Kew articles and publications, creating around 12,000 images over his career (Desmond, 1992; Hemsley, 1915; King, 1992). The most likely route for the meeting of Howard and Fitch was through Howard's work assessing the herbarium at Kew (Howard, 1855).[207]

Fitch's first project for Howard was illustrating the *Nueva Quinologia* specimen images (Figure 7.1, 7.2, 7.4, 7.8-7.11). Howard's correspondence archives reveal that along with his 1858 purchase of *La Real Expedición* manuscript and barks, he also tried to obtain the accompanying herbarium. However, as the herbarium specimens were part of the *Real Jardín Botánico*, Madrid, he was told by Baillière they '<u>are not</u> to be sold and therefore cannot be <u>got'.</u>[208] As Howard could not then visit himself, Fitch was dispatched to Madrid to capture their essence through sketches of the herbarium and copies of the few illustrations that existed.

Fitch combined data from the Madrid herbaria, specimens at Kew and the British Museum, living plants in Howard's hothouses and descriptions from text to create an idealised drawing: not from life, but life-like (Howard, 1862; 1869; 1876).[209] The quality of these

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[207] See correspondence with Hooker throughout Howard manuscripts JEH/1, and Miscellaneous Reports, Library and Archives, RBG Kew.

[208] Underlining by Baillière. Letter attached to flyleaf of the folder holding the *Nueva Quinologia* of Pavón: Hippolyte Baillière (a scientific book dealer) to John Eliot Howard, 2 February 1858, London Metropolitan Archives (LMA ACC/1037/855). At this point Miguel Colmeiro was not yet Director and may have sold the barks separately.

[209] For example, in the *Nueva Quinologia*, Howard says Fitch drew the *C. chahuarguera* from 'Seeman's' specimens (Howard, 1862, *C. chahuarguera* section, p. 5). This is presumed to refer to Berthold Seeman, German botanist and traveller closely associated with Kew.

composite drawings were commented on by another quinologist who had visited and collected from cinchona forests in the 1840s. In 1860, just before publication, Hugh Algernon Weddell stated:

> '...it occurred to me that if Pavón could take a peep at them, how mightily pleased he would be… Fitch has [put?] off in a strikingly correct manner the general tint of inflorescences in several of your plates. Less so in others, in C. ovata he has given a violet tint to the flowers which I am confident exists in no species of this genus. (Weddell to Howard, 1860)[210]

In response, it appears, an annotation was made on the pattern blocks which survive in the publisher's archives indicating 'flowers too blue, more pink'.[211]

This form of production of natural history images has been discussed by historians of botanical illustration. Where an artist could not capture an image from life, especially in all important stages – notably, flowering and fruiting - multiple sources were drawn upon, including consultation with botanical experts. Historian Danielle Bleichmar thus refers to these illustrations as 'composite portraits' (Bleichmar, 2006, p.87) and 'composite mosaic[s] of those multiple observations' (2009, p. 457). This seems to have been particularly true for cinchona due to the swift deterioration of pigmentation on dried plant specimens. Herbaria take on an all over yellow-brown hue and original colouring, such as pink-lilac flowers, is quickly lost and becomes impossible to decipher. Interestingly, Howard occasionally refers to this in his text: thus in one case describing a specimen as 'represented in the branch with capsules and the coloured leaf showing the tints acquired in decay (and marked 2 in our Plate)' (Figure 7.10) (Howard, 1862, p. 2 *C. uritusinga* section).

Of the difficulty of identification using herbarium specimens, George King (1840-1909), Director of Bengal Cinchona Plantations, argued that 'Forms that appear quite distinct as

[210] Hugh Algernon Weddell to John Eliot Howard, 15 May 1860, JEH/1/15, Library and Archives, RBG, Kew.
[211] *Chinchona ovata* LRP/4/10, Library and Archives, RBG Kew.

growing trees here are quite indistinguishable in dried specimens'.[212] In addition, the variable flowering times of cinchona meant that sometimes only 'imperfect' specimens without flowers or fruit, crucial to identification, were gathered. Therefore, images of specimens became composites to form an idealised version with complete information. Aylmer Bourke Lambert discusses examples in the case of cinchona:

> Few botanists have seen it, and all that we know of it is confined to what Mons[ieur]. Condamine has related. The various figures we are in possession of are all borrowed from him, though his representation cannot be esteemed a perfect one, and has the appearance of being in some points a little artificial. From what I shall proceed to mention, it will be evident that Linnaeus never saw it, but availed himself of Condamine's description and figure to establish the characters of the genus. (Lambert, 1797, p. 9)[213]

Henry Trimen (1843-1896) also commented on the issue. Trimen was a British economic botanist and editor of the *Journal of Botany* and from 1880 the Director of the Royal Botanic Gardens, Ceylon (Veale, 2010). He had a lengthy and heated debate with Howard over cinchona taxonomy (discussed below in section 7.5), adding his critique on Howard's illustrations:

> As to the magnificent pictures illustrating or forming the basis of Weddell's diagnosis of var. Ledgeriana, they are no doubt fine examples of Fitch's work, and one cannot but admire the skill which can produce such restorations from dried mummies in an herbarium. But it is risky work, and the botanist is but too familiar with the want of that sort of accuracy which he particularly needs, so often to be seen in the works of even the best botanical artists… the points missed are just such as would be likely to escape an artist unless his attention were drawn to them, and they were not then known to Howard himself. Nor has the artist caught the *facies* or habit of the plant any better… whilst the gaudy and inaccurate colouring makes them still less like reality. (Trimen, 1883b, p. 1078)

This opinion reflects a tension between botanists and artists. It echoes Daniel Hanbury's 'competent botanist' comment regarding Howard's *Nueva Quinologia* publication attempt at the Linnean Society (Section 6.6). Hanbury also questioned the role of botanical art in

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[212] George King to Sir William Thiselton-Dyer; from Government Cinchona Plantation, Mungpoo near Darjeeling, [India]; 4 June 1880, p.5 of pdf viewer. Director's Correspondence. Library and Archives, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas6415

[213] Charles-Marie de La Condamine, (1701-1774) was an important early collector of cinchona.

taxonomic identification, no matter the quality of the artist, despite this being a common form of botanical communication in magazines such as the *Kew Bulletin* and *Curtis's Botanical Magazine*. [214]

Within RBG Kew's illustration archives lie original pencil sketches which either match or bear strong similarities to the plates in Howard's *Nueva Quinologia* (1862), suggesting that these were Fitch's original sketches. On further analysis, similarities can be traced between these drawings and the arrangement of plants on *Real Expedición* herbarium specimens at Madrid, Kew and the Natural History Museum. Some of these sketches and herbarium specimens can be matched visually, with some also having the *Expedición* collection number noted by Fitch on the sketches. However even where this number is noted, there is still room for doubt: for example, in some instances the same *Expedición* collection number appears on specimens at both Kew and Madrid. It thus seems likely that Fitch combined details from specimens in more than one herbarium to compose an idealised image including all plant parts, not all of which were present in individual herbarium specimens. In both *Nueva Quinologia* and *The Quinology*, Howard also mentions another source for the illustrations: Fitch's observation of Howard's own grown specimens, as an aid to understanding the growth, form and colouring. An example of this process can be seen in the images Figure 7.8 to Figure 7.11 (Howard, 1862, 1876).

Figure 7.8 thus shows a clear match between the top specimen on the herbarium sheet to Fitch's sketch and then to the final illustration in Howard's Book. Figure 7.9 meanwhile shows a specimen said to have been inspired by a specimen in the Madrid herbarium combined with evidence from a living plant in Howard's own collection: as Howard puts it, the specimen was 'carefully drawn by Mr. Fitch from fruit-bearing branches in Pavón's collection at Madrid, the flowers being added from a specimen of Pavón now in my collection', this refers to the final plate shown in Figure 7.9 (Howard, 1862, *C. magnifolia* section, p. 2). While there are similarities between the final sketch and the herbarium

[214] Howard, J.E, Reviewer's Report, (SP/571), Archives of the Linnean Society.

specimen, there are enough differences to show that Fitch was combining his experience, skills and creative licence to produce the final image. In Figure 7.10 , again, Fitch drew from herbarium samples, alongside observation of the growing plant in Howard's glasshouse (Hooker, 1863). In that Figure, Fitch's shows an image of the flower labelled as taken from 'Howard's specimen' which is most likely from the living plant.

The precise provenance of Fitch's pencil sketches in Kew's archive are unknown but they are unlikely to have been absorbed from John Eliot Howard's own archives, accessioned at Kew in 2002 as it would have been clearly noted in the catalogue. It possible they were originally part of Fitch's own archives. After the death of William Hooker, his son, Joseph Dalton Hooker (1817-1911) took over Kew's directorship and the two men fell out over rights to Fitch's sketches for *Curtis's Botanical Magazine*. Fitch alleged that William Hooker had promised him an allowance in return for his permission for the illustrations to become part of Kew's collections, which would have returned a significant income for Fitch. The younger Hooker denied this, insisting they were the property of Lovell Reeve (publisher of the magazine) who had in turn donated them to Kew. In protest, Fitch submitted his final picture for *Curtis's* in 1877. A reconciliation eventually took place when Joseph obtained Fitch a Civil List pension (Desmond, 1992; Hemsley, 1915). Kew's illustrations were traditionally kept in the herbarium as part of a form of 'working collection', alongside dried herbarium sheets, representing idealised living specimens (Mills, 2009, p. 188). However, in recent years many have been moved to the Illustrations section of Kew's archives. The *Curtis' Botanical Magazine* illustrations, which included many Fitch works were moved between 20 and 30 years ago. This is another possibility of where the Fitch's pencil sketches originally came from.[215]

The final proof images for Fitch's plates of the *Nueva Quinologia* also survive in the archives at Kew (Figure 7.1). These items, originally described as 'pattern blocks', are part of a

[215] A later project to relocate illustrations, initiated around a decade ago, is still ongoing (Information from personal communications with Julia Buckley of Illustrations department, and Anne Marshall, Library and Archive department, RBG, Kew).

collection of the natural history publisher Lovell Reeve.[216] They are loose sheets printed in full-colour with handwritten annotations by Howard on adjustments to the shading colouring. However, interestingly, some of these suggested edits do not seem always to have been followed (Figure 7.10 and Figure 7.11). For example, in Figure 7.10, Howard notes that the red leaf colouring is correct, but ultimately it was printed much duller. There are similar examples on other plates, for reasons which are not exactly clear. Such archival materials shed new light on the stages of production between Fitch's illustrations and the final printed product, a rare survival in the archives of nineteenth-century printing.

[216] Lovell Reeve archive, (LRP/4/10), Library and archives, RBG Kew. More on Lovell Reeve Pattern Blocks in Johnson (1970).

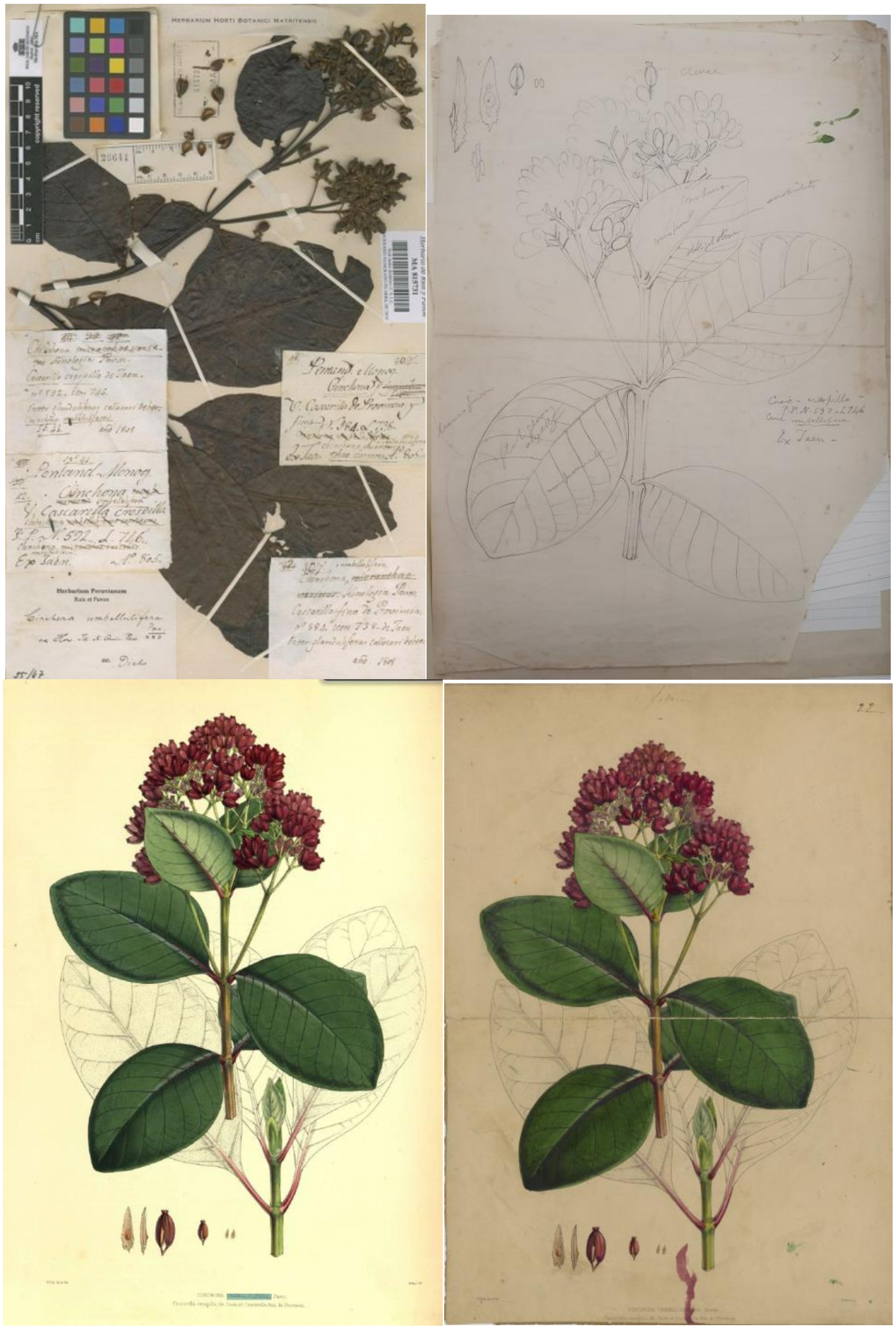

Figure 7.8 From herbarium to book.

A matching herbarium specimen and illustration. *C. umbellulifera* (syn. *C. scrobiculata* Bonpl.) (Clockwise from top left): Specimen (see top example on paper) from the *Real Expedición*, *'F.592 L.746'*; Fitch's sketch with matching *Expedición* numbers, Illustrations, RBG Kew; Lovell Reeve pattern block plate (LRP/4/10), RBG Kew; Final print of the *C. umbellulifera* in Howard (1862), Wellcome Collection.

Figure 7.9 Fitch Illustrations, *C. magnifolia* (syn. *Ladenbergia oblongifolia* (Humb. ex Mutis)) from *Illustrations of the Nueva Quinologia of Pavon* (Howard, 1862).

A less exact match of specimen and illustration. Howard specified that the image was taken by Fitch from a Madrid specimen. The sketch & herbarium states no. 586 L. 740 (Howard, 1862, *C. magnifolia* section, p. 2). Images L-R: Natural History Museum; Library and Archives, RBG Kew; Wellcome Collection.

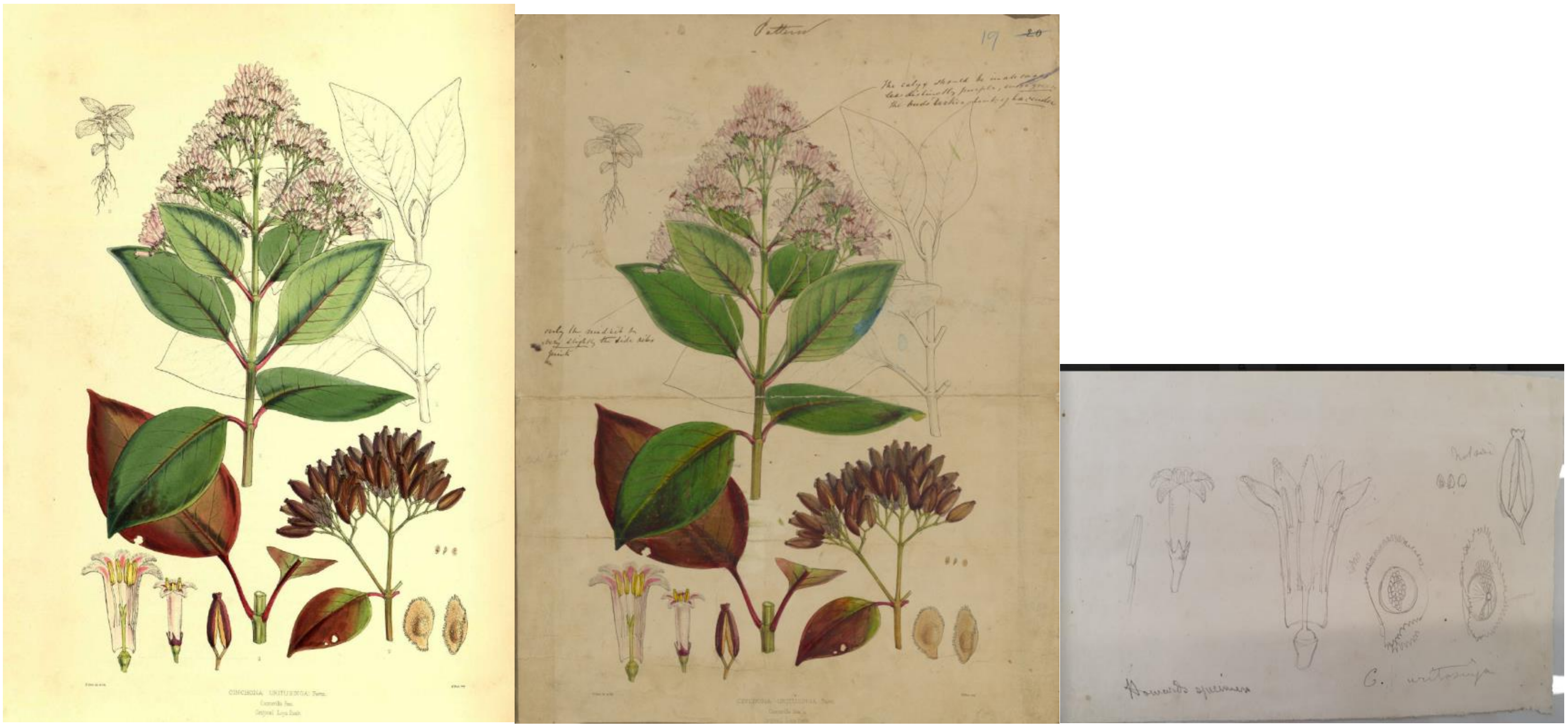

Figure 7.10 Fitch's *C. uritusinga* (syn. *C. officinalis* L.) from the *Nueva Quinologia* (Howard, 1862).
Left: final plate from *Illustrations of the Nueva Quinologia* (Howard, 1862). Middle: pattern block. Right: Fitch Sketch. The two-colour images show the colour of the leaf once it has been dried on a herbarium sheet (reddish-brown leaf bottom left of image). Unlike the others in Howard's book, these images represent different stages of growth, drawn from Howard's Tottenham glasshouse plants. The pattern block has notes on colourings: starting from the left of image, clockwise: (by left leaf) 'Only the midrib and very slightly the side ribs pink'; (top) 'The calyx in all cases less distinctly purple, more green. The buds darker, hint of lavender.' These 'edits' were not changed.
Images from; L-R: Wellcome Collection; LRP/4/10. Library and Archives, RBG Kew; Illustrations, RBG Kew.

Figure 7.11 Fitch's Pattern Block (L) and final illustration (R) of *C. succirubra* (*C. pubescens* Vahl) from the *Illustrations of the Nueva Quinologia of Pavon* (Howard, 1862).

On the left is the matching Pattern Block with notes on colourings. Notes, clockwise starting from the lef: (by red leaf) 'This colour is right, not at all too bright'; (by top right leaf) 'There should be no blue in this green'; (by lower right leaf) 'This shading is too dark'. (L) (LRP/4/10), Library & Archives, RBG Kew; (R) Wellcome Collection.

7.3.2 Tuffen West illustrations

Tuffen West (1823-1891), was a naturalist, microscopist, artist and lithographer who was elected a Fellow of both the Linnean Society (FLS) and the Royal Microscopical Society (FRMS). Born in Leeds, it is likely that he crossed paths with Howard through connections between their Quaker chemist and druggist fathers. West's father, William West, was a founding member of the British Association for the Advancement of Science. In 1834 both William and Luke Howard represented the Chemistry Committee at a meeting John Eliot also attended (BAAS, 1834; Dolan, 2021; 'William West (1792-1851)', 2014). Correspondence in Howard's files show friendliness between the two men, West often addressed Howard as his 'dear friend' and mentions looking forward to seeing him at a Linnean 'conversazione' the following week,[217] and this may also have been a route for both men to have continued their friendship: Howard was elected a Fellow that same year (1857), West later in 1860. West illustrated both Howard's works with beautiful, colour 'microscopical observations' (Howard, 1862, Microscopical observations section, n.p.) (Figures 7.3 & 7.12)

Relatively little has been written about West. John R. Dolan has analysed his illustration production and gives a short biography. West was widowed early and left with a young son who later died around the age of 18. Throughout his career he suffered from unspecified mental health issues, frequently becoming a long-term patient in institutions (Dolan, 2021). His obituary in the *Journal of the Royal Microscopical Society* for 1891 euphemistically described 'severe bodily illness [which] had for the last twenty years secluded him from contact with his fellow-workers' ('The late Mr Tuffen West', 1891, p. 529).

Howard owned his own microscopes, of Powell & Lealand make, which included a *camera lucida* for projection, allowing tracing of the image. In some cases, his son, John Eliot

[217] Tuffen West to J. E. Howard, 30 April 1857, JEH/1/33. Library and Archives, RBG, Kew.

Howard Jnr. (1836-1866), illustrated the microscopical slides (Figure 7.13).[218] Howard stated that although he would consult West in the first instance, he wanted to ensure that multiple observations on the barks were made (Howard 1864).

Howard considered West's microscopic work 'unrivalled' (Howard, 1862, *microscopical observations section*, p. 8). Interestingly, Maria Howard suggests that Howard himself mounted the specimens (Howard, 1885), and West's letters seem to confirm this: 'the three new sections of bark reached me safe on Saturday morning, I at once set to work to secure figures of the two containing crystals'.[219] Letters in Howard's archives show other discussions about displaying the illustrations at the Royal Microscopical Society ('your drawings were there and excited much interest') and instructions on colour adjustment for the printer.[220] The 1891 obituary of West also highlighted 'the importance which was attached to securing [West's] services in the production of any work requiring illustrations' due not to his skilled draughtsmanship but also to his scientific understanding of what he was commissioned to draw. (Anon, 1891, p. 529). Tuffen West was also commissioned to write scientific educational pieces titled 'Half an hour at the microscope with Mr Tuffen West' (West, 1885). Evidence in the few surviving letters of correspondence between the men suppors the claim of Howard receiving West's scientific insights, with the latter offering analytical commentary on the barks.

For the *Illustrations of the Nueva Quinologia of Pavón*, West provided 44 microscopical bark and seed illustrations (Figure 7.3) (Howard, 1862). For *The Quinology of the East Indian Plantations*, he provided 3 plates of 28 illustrations (Howard, 1869). The original watercolours for the latter publication survive in the Illustrations collections of the Royal Botanic Gardens, Kew. An example of an original illustration can be seen in Figure 7.12.

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[218] Nine original illustrations by Howard Jr are in the illustrations collection, RBG Kew.
[219] Tuffen West to J.E. Howard, 6 May 1867, JEH/1/33, Library and Archives, RBG Kew.
[220] Letters from Tuffen West to Howard dated 6 May 1867, JEH/1/16 and a series of others in JEH/1/33 referring to plates published in part 1 of Howard (1869). The RMS display and colour notes are in the letter dated 25 April 1867, JEH/1/33. There are further letters to Howard in the Royal Pharmaceutical Society Archives, IRA.1996.091-094.

Figure 7.12 Tuffen West's microscopical observations.
(L) image from *The Quinology of the East Indian Plantations* (Howard, 1869); (R) image watercolour original for Fig. 5, 5a & 5b, Illustrations, RBG Kew.

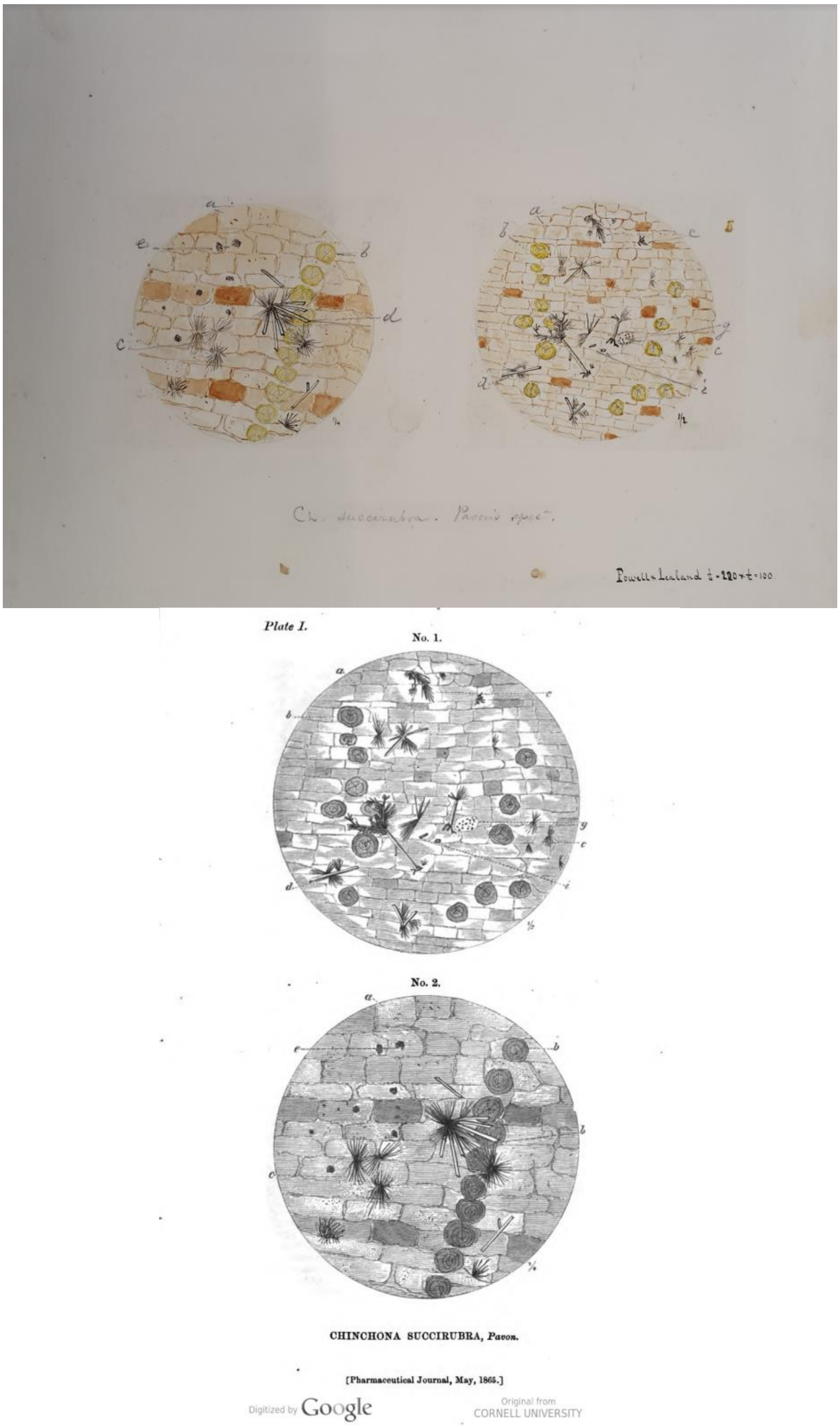

Figure 7.13 Microscopic illustrations by John Eliot Howard Jr.
Upper: Original sketch, Illustrations, RBG Kew; Lower: As reproduced in the Pharmaceutical *Journal*, (Howard, 1865b). Digitised by Google Books.

7.4 Distribution

Howard's files of thank you letters show that he distributed books (as well as sets of barks) widely to peers and institutions. This manner of circulating the work would have signalled his role as a man of science, through the long-standing tradition of gift-economy between gentlemen scientists (Rose, 2020). More specifically, distributing his books widely would have helped signal, then later secure, his role as an expert quinologist.

Evidence from Howard's correspondence shows that at least 50 books were sent to 37 institutes and individuals living in at least eight countries (UK, Ireland, France, Switzerland, Germany, Netherlands, Russia and Dutch Java). Of these, around 40% were donated to individuals, including notable quinologists, chemists and scientists across Europe. The remainder went to scientific and chemical institutions, medical schools, universities and libraries. The recipients can be seen in the tables below (Table 7.4 for individuals and
Table 7.5 for institutions, excluding the 'unknown' category). Some of these copies may subsequently have been acquired by other museums and libraries: the global distribution of copies identified in contemporary library and museum catalogues is provided in Appendix 5.

Table 7.4 A list of individuals to whom Howard gifted books

Name	Location	Description (if known)
Alphonse Louis Pierre Pyramus (Pyrame) de Candolle (1806-1893)	Switzerland	French-Swiss botanist
'Brady' probably Henry Bowman Brady (1835-91)	England	Laboratory and chemical equipment maker, Newcastle-Upon-Tyne
Dr Bureau	Austria	An apothecary
Clarke, James	England	Unknown, likely a chemist
Flückiger, Friedrich August (1828-1894)	Switzerland	Pharmacist & botanist
Griffin, J.W,	England	Chemistry lecturer, Bristol School of Chemistry

Hanbury, Daniel (1825-1875)	England	Botanist and pharmacologist
Ince, W. H	England	Pharmacist, student at School of Pharmacy in 1883
Phoebus, Phillip (1804-1880)	Germany	Physician and pharmacologist
Planchon, Jules Émile (1823 – 1888)	France	Botanist
Vry, Johan Eliza de [also Vrij, Johan Eliza de] 1813-1898	Dutch-Indonesia	Dutch Chemist, Director of the Government Cinchona Estates, Java
Weddell, Hugh Algernon (1819-1877)	France	British botanist and quinologist based in France

Table 7.5 Institutions to whom Howard donated books

Institute	Location
Académie Royale des Sciences, Lettres et Beaux-Arts de Belgique	Belgium
Amsterdam City Library	Netherlands
Botanical Society of Edinburgh	Scotland
British Museum	England
King's College, London	England
Linnean Society	England
London Hospital	England
Nederlandsche Maatschappij Ter Bevordering Van Nijverheid [Dutch Society for the Promotion of Industry]	Netherlands
Quekett Microscopical Club	England
Royal Microscopical Society, King's College	England
Royal Society of London	England
Royal Pharmaceutical Society, London	England
Société Impériale des Naturalistes de Moscou [Imperial Society of Naturalists of Moscow]	Russia
Société Impériale Zoologique d'Acclimatation [Imperial Zoological Society of Acclimatization]	France
Trinity College, Dublin	Ireland
Université de Paris	France
Université impériale de France. Académie de Rennes	France
Victorian Institute or Philosophical Society of Great Britain	England

Most of the surviving letters show that the *Quinology of the East India Plantations* was the book most frequently donated. Interestingly, the letter dates show that in most cases, it was the 1869 volume (Part 1 of the publication) must have been sent out. It is not recorded if Howard later sent the second part to the same recipients, or alternatively, if this was a cunning marketing ruse by Howard: sending out only the first part, to encourage the purchase of the second, more costly and illustrated part. In the case of the *Royal Pharmaceutical Society*, it is recorded in their Journal that Howard sent the work in multiple separate chapter parts, which must later have been bound together (RPS, 1869).

A survey of online library catalogues shows that, today, there are at least 102 copies of Howard's three books around the world, predominantly in Britain and Europe, though at least 4 are available in India (Appendix 5).[221] *The Quinology of the East India Plantations* is the most common work found (c. 63%), likely due to Howard's fame by that later date plus, undoubtedly, his wide distribution strategy. In many cases, it is likely that copies acquired by individuals in this way were subsequently bequeathed to or purchased by national and university libraries. However, some direct connections can be traced, including copies surviving at the Linnean Society, British Museum (Now Natural History Museum Library), the Royal College of Physicians (both London and Edinburgh branches), RBG Kew, King's College, London, Trinity College, Dublin, *Muséum national d'Histoire naturelle*, Paris and Amsterdam City Library. As mentioned in Chapter 4, the British Indian government purchased a series of the books for distribution to planters. This is probably how they found their way into Indian libraries today.

The distribution of these books did not merely disseminate Howard's work, they helped to promote his role as a botanical authority and a chemical consultant (See section 4.7).

[221] A survey of WorldCat. Hathi Trust, Biodiversity Heritage Library, British Library, Jisc Library Hub Discover, India Cat, National Library of India and The Indian Culture Portal, Archive.org, Google Books, as well as the catalogues of institutes not represented on these: the Royal College of Physicians, Linnean Society, Biodiversity Heritage Library. Correct as 15th June 2022.

In the following section we examine the reception of these works, especially in the context of attitudes to Howard's position in the worlds of commerce, science and imperial policy.

7.5 Reception

Reviews of Howard's two books show that there was a generally positive reception (*Journal of Botany*, 1866; 'Reviews', 1870; 'Review', 1876). Unsurprisingly, reviewers praised the 'beautiful' works and 'rich' illustrations of value to all scientists (*Journal of Botany*, 1866, rear pages). In addition, as mentioned above, the Indian Government respected the information enough to purchase multiple copies for planters. However, in the complex research science of cinchona, there was much room for disagreement. Howard's combined role as a government advisor and one of Britain's leading quinine manufacturers raised concerns over a conflict of interests. Towards the end of his career, criticism became more heated. Those experimenting with cultivation first-hand in India were concerned with more than gentlemanly science.

Despite positive reviews from other quinologists such as Weddell and Karsten, doubts about the validity of Howard's opinions were frequently aired (Howard, 1855; Journal of Botany, 1866). As shown by Daniel Hanbury's sceptical review of Howard's notes on the *Nueva Quinologia* (discussed above in section 6.6), the need for precise botanical observation and experiment led even his friends to express doubt about some of his ideas, especially those based on herbarium specimens alone. Other botanists went much further in their criticism of Howard's reliance on such collections in the face of the increasingly complex picture of cinchona which was emerging in experimental science. George King (1840-1909), superintendent of the Indian Bengal Kolkata (Calcutta) Garden, was particularly sharp in his critique. In 1880, King wrote to Kew's Assistant Director, William Turner Thiselton-Dyer (1843-1928):

> It is about time that Howard had ceased writing from herbarium material. A good deal of what he does write is unintelligible and most of the balance is, I suspect, rubbish. I defy anybody to make anything satisfactory out of herbarium material or even out of living plants of Cinchona calisaya or officinalis from the constituents. Forms that appear quite distinct as growing trees here are quite indistinguishable from dried specimens and on the other hand you can from the

> same tree gather specimens that, as far as leaves are concerned, look quite distinct when dried. Then the chemistry of the barks is quite as perplexing as the botany of the trees.[222]

The botanist Henry Trimen, Director of the Royal Botanic Gardens at Peradeniya, Ceylon, was also critical of Howard. In public, he wrote: 'It is to my friend, Mr. J. E. Howard, who is ever most liberal in helping to advance our knowledge of quinology' (Trimen, 1883a, p. 461). In private however, Trimen also complained about Howard's shortcomings, particularly his 'muddle headed' articles.[223] Perhaps the comment on Howard's 'liberal' help was less about his generosity and more a veiled comment about Howards broad-ranging handling of cinchona. In 1883, he wrote to Thiselton-Dyer:

> I see old Howard has broken out in a new place. One does not like to say hard things in print about the old boy, but I wish someone would stop him writing about the botany of cinchona. His greenhouse barks, his specimens, his barks and latterly T. Christy[224] have, I fear completely muddled him. I have not seen his last paper at the Linnean Society only Christy's reprint of it which is utterly absurd.[225]

It should be noted that Howard was not the only subject of Trimen's complaints: his letters to Thiselton-Dyer are peppered with colourful descriptions of many figures, some favourable, many disparaging. It is clear few people pleased him and that even the genus itself inspired revulsion. In the same letter, Trimen states 'How I loathe cinchona!' remarking that he considered the inheritance of the cinchona a '*noblesse oblige*'.[226] Cultivation of cinchona in Ceylon was ultimately unsuccessful. There was much disagreement on the Indian and Sri Lankan taxonomy (due to confusing hybridity)

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[222] George King to Sir William Thiselton-Dyer; from Government Cinchona Plantation, Mungpoo near Darjeeling, [India]; 4 June 1880, p.5-6 of JSTOR PDF viewer. Director's Correspondence. Library and Archives, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas6415

[223] Regarding the 'muddle-headed article' in the *Pharmaceutical Journal* in: Henry Trimen to Sir William Thiselton-Dyer; from Peradeniya, [Sri Lanka ex-Ceylon]; 28 Sep 1883. Director's Correspondence. Library and Archives, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas1455. Trimen also describes writing a response for the *Pharmaceutical Journal*, but as it 'was rather rough on Howard' he did not expect it to be published: Henry Trimen to Sir William Thiselton-Dyer; from Peradeniya, [Sri Lanka ex-Ceylon]; 29 Oct 1883. Director's Correspondence. Library and Archives, RBG Kew. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas1457

[224] Thomas Christy, F.L.S (1831-1905), nineteenth-century London-based drug importer, and pharmaceutical manufacturer who analysed cinchona long after Howard's death. He was also the author of *New Commercial Plants* (1882) ('London's pharmaceutical industry', 1933). His eldest son, born 28 May 1866, was named Thomas Howard Christy (Baptisms Register, St. Saviour, Pimlico, via Ancestry.com).

[225] Henry Trimen to Sir William Thiselton-Dyer; from Peradeniya, [Sri Lanka ex-Ceylon]; 6 June 1883. p. 6 of JSTOR PDF viewer. https://plants.jstor.org/stable/10.5555/al.ap.visual.kdcas1450

[226] Trimen to Thiselton-Dyer, 6 June 1883, p. 2 and 6 of JSTOR PDF viewer.

with Trimen and Thiselton-Dyer on one side and Robert Cross and Howard on the other. In an article on 'The disputed identity of the red bark of the Nilgiris' published in the *Pharmaceutical Journal* in 1884, Thiselton-Dyer stated:

> '[Cross's] recollections of plants seen no less than twenty years before seem to have misled him. Unfortunately, his views were to a certain extent adopted by the eminent quinologist Mr Howard, and it therefore became necessary to critically examine them, as such gigantic errors in nomenclature could not but very seriously affect the future policy of administration of the Madras cinchona plantations (Thiselton-Dyer, 1884, p. 482)

Thiselton-Dyer closed the subject by stating that Trimen's position 'may be taken as the last word in the matter', by which point Howard was dead and unable to argue his case further (Howard, 1883; Trimen 1883a; Thiselton-Dyer, 1884, p. 482; Veale, 2010).

Returning to the reception of Howard's books during his lifetime, a particularly pertinent point had been raised in 1870 within an official government report by Charles Baron Clarke (1832-1906), superintendent to the Bengal Botanic Gardens:

> The title of Mr. Howard's book *The Quinology of the East Indies* [sic] might lead one to expect much from it, but I challenge any person to point out a passage in that great book from which the slightest hint about manufacture can be gleaned.[227]

Howard's own copy of Clarke's report survives in Kew's archives and annotations in the margins reveal his response. Whether these notes were purely for himself or to show someone else is not known. Annotating Clarke's statement, quoted above, Howard wrote one word: 'amusing' (p. 12). Clarke goes on to make a still more serious criticism:

> Now, my object is not to make any complaint about this. Mr. Howard is by trade, a quinine manufacturer, and he is fully justified in keeping the results of his vast experience to himself. But the moral which I desire to draw is, that upon this question of local manufacture the higher departments of Government ought

[227] Howard's own annotated copy of 'C.B. Clarke's Report to the Secretary the Government of Bengal, 1 July 1870.' JEH/1/12 Kew Library and Archives. See also Clarke discussing Howard's geographical limitations in From C. B. Clarke, Esq., Officiating Superintendent, Botanical Gardens, and in charge of Chinchona Cultivation in Bengal, to, the Secretary to the Government of Bengal, 10 February 1870, p. 12 *British Parliamentary Paper No. 120, East India (Chinchona Cultivation),* 1870-1875.

> not, under these circumstances, to pay the slightest regard to the opinion or advice of manufacturers. I make this point very distinct, because I have good reason to believe that interested persons have already commenced attempts by surreptitious influence to pamper the local manufacture in India, even if they cannot hope to stop it altogether.[228]

Howard annotated this statement with a spelling correction: 'pamper' becomes 'hamper' with the addition of a simple exclamation mark. One wonders if by correcting the error, he is reinforcing the point.

Other pithy marginal comments by Howard include the words 'no!' (p. 4), 'rubbish'., (p. 7), as well as a further sprinkle of exclamation marks. He also indulges in sarcasm: to Clarke's statement that barks give up alkaloids in 'charming readiness', Howard states 'and see the charming result', which seems to imply a lack of confidence in Clarke's analytical skills. Alongside notes on Clarke's errors and omissions, Howard also ticks and compliments parts he agrees with or finds of interest, as if he were a teacher marking an errant student's work.

Others were quick to defend Howard against Clarke. In Kew's archives there is a letter from George Douglas Campbell (Duke of Argyll), Secretary of State to India between 1868 and 1874 (Veale, 2010). Markham appears to have forwarded this to Howard, as an attached letter states 'You will see, by the enclosed, that the Duke of Argyll disapproves of the way in which Mr. Clarke spoke of you in his reports'.[229] Campbell's public letter to the Governor of India concludes by censuring Clarke's 'disparaging' remarks and an acknowledgement of Howard's useful advice for which the government is 'indebted'.[230] Clarke himself left the cinchona project the same year, perhaps coincidentally, though he later went on to have a distinguished career including working on the *Flora of British India* with Sir Joseph Hooker. He eventually became president of the Linnean Society, 1894-1896 (JSTOR Global Plants, 2013; Veale 2010).

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[228] C. B. Clarke, Esq., Officiating Superintendent, Botanical Gardens, and in charge of Chinchona Cultivation in Bengal, to, the Secretary to the Government of Bengal, 1 July 1870, In: *British Parliamentary Paper No. 120, East India (Chinchona Cultivation),* 1870-1875, Section I, Item No. 2.5, p. 22.
[229] Markham to Howard, n.d., attached to: Duke of Argyll, Secretary of the State to India to the Governor of India in Council, Public Letter no. 28, 4 April 1870. JEH/1/12 Kew Library and Archives.
[230] Duke of Argyll, Secretary of the State to India to the Governor of India in Council, Public Letter no. 28, 4 April 1870, p.2. JEH/1/12 Kew Library, Art and Archives.

Yet Clarke had a point. As discussed in Chapter 1, there were disagreements over the best location for alkaloid manufacture, pitting Britain against India. In his annotation on Clarke's report, which made the case for Indian-based alkaloid production, Howard noted: 'the argument carried out would shew that the manufacture should be in Europe' (p. 2). However, the charge against Howard concerning conflict between his commercial interests and the need for sharing details of the process of quinine production was one which was serious. Although details of the original isolation of the alkaloids had been published by Pelletier and Caventou in 1821 and therefore could be found in contemporary chemistry books, the method for transforming it to a more usable salt form, the extraction of the other quinoline alkaloids more common to Indian barks and scaling-up to an industrial standard, seem to have been more elusive (Pelletier & Caventou, 1821; van Gorkom, 1883). Plant collector Karel Wessel van Gorkom (1835-1910) recorded in 1883 that only 15 factories existed because the method was still only known to a few and was an industrial secret kept close by manufacturers (van Gorkom, 1883). For Howard's and Sons, competitive manufacture from a cheaper and more readily available source would threaten to drive down quinine prices and topple their dominance. In this context, as Clarke pointed out, Howard had been unforthcoming about the practicalities of alkaloid extraction.

There are other possible explanations for Howard's failure to publish details of the extraction process used by his firm. For example, did he avoid 'shop-talk' in his books, in order to position himself more as a man of science than a man of trade? Other studies of mid-Victorian science indicate a growing tension between academic and manufacturing chemistry (Bud & Roberts, 1984). Howard's publications achieved his objectives in the sense that they circulated his interpretation of cinchona from a botanico-pharmaceutical point of view and promoted his role as the leading British quinologist. They specifically did not position the author as a leading British manufacturer: indeed, in his books Howard never mentions the Stratford factory or the nature of his own business.

Notwithstanding his pre-eminence in the field of quinology, Howard was not immune to criticism in his lifetime, especially as the wider adoption of cinchona led to competing expertise and the Indian quinine projects slowly struggled to become established. Clarke, King and Trimen's criticisms came during this troubled period, towards the end of Howard's life (he died in 1883) and after two decades of plantation experiment with uneven results. Mark Harrison (2010) has shown that British-Indian colonies were transformational spaces producing new medicinal knowledge influential back home. It appears that medical-botanical field was also becoming well-established in its knowledge production. Howard's expertise could no longer compete with those at the forefront of the cultivation projects in the tropical 'field'.

In December 1876, shortly after publishing his final book, Howard finally retired from Howards and Sons with the comment 'Finished up my work at Stratford, thankful to be liberated, I trust, for the Lord's service.' (Howard, 1885, p. 53). While continuing to collect cinchona, the focus of his remaining publications was on the relations between religion and science (Figure 2.5).

7.6 Summary

Published at great expense, Howard's two illustrated books were monuments to cinchona study and to his dedicated collections-based research. The addition of 'idealised' botanical and microscopical illustrations alongside detailed chemical analysis positioned his books as cutting-edge, much discussed within the pages of the *Pharmaceutical Journal*. These two major works reflect the shift in cinchona knowledge gleaned from trade barks and field exploration towards cultivation after the middle of the century. However, while Howard's publications became influential treatises about cinchona barks and chemistry from a pharmaceutical perspective, especially during a time when little was known about the difficult genus, his botanical opinions were less respected.

As the leading quinine manufacturer in England, the barks flowing through Howard's factory represented years of data upon which he built both expertise and profit. These profits enabled Howard to purchase one of the most significant assets of bark collected in the field and to produce a comprehensive text on Peruvian cinchona bark identification and chemical analysis in *Illustrations of the Nueva Quinologia of Pavón* in 1862. This book signalled Howard's symbolic role as a successor in cinchona expertise to Ruiz and Pavón and established his authority as the pre-eminent quinologist in Britain, if not Europe. This first book came as Howard was advising Clements Markham on the species and varieties he should collect in South America in 1859 to initiate the grand British Indian cinchona project. Concurrently, Howard was supplementing his trade-collection based expertise towards aspects of cultivation in his own glasshouses, and as discussed in Chapter 6, this renown then meant that he was the expert of choice as the official analyst on the progress of the cinchona experiments in India. This led to the publication of his *magnum opus* in *The Quinology of the East Indian Plantations*, between 1869 and 1876. However, Howard's role did not go unchallenged and there was, understandably, critical reception of his opinions on taxonomy and on the influence on Indian alkaloid production. Nonetheless the Indian government continued to rely upon this expertise as the consultant of choice in the absence of others up until his death in 1883.

Chapter 8 | Conclusions

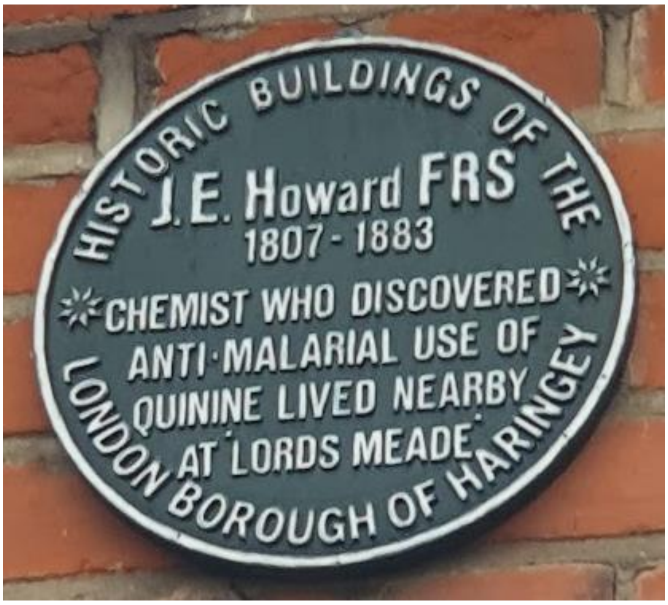


Figure 8.1 Howard's memorial plaque, 2 Lordsmead Road, Tottenham, N17. The wording is inaccurate as Howard did not discover quinine's anti-malarial properties. Image Author's own.

8.1 Introduction

This thesis has explored four main questions (raised in Chapter 1) concerning the making of a quinologist, John Eliot Howard, and his practice of science focused on the historically important antimalarial tree, cinchona. Howard's collection of cinchona barks, his publications and his archives formed the core material for this research. As well as playing a significant role in his career as a man of science, his collections were also central to revealing enhanced histories of both the person and the plant. This concluding chapter explores the overarching themes as they have emerged across the thesis, considering where these fit with other research and the wider implications of the findings reported in previous chapters.

8.2 Research themes and questions

Theme 1: How did Howard develop his expertise and sustain his scientific networks?

It is clear from the evidence examined in this thesis that Howard's professional development drew on his place within industry, on how he adapted to a changing research field and most importantly, on how he cultivated and exploited his correspondence networks. Combined, these were fundamental in providing the information from which he built his knowledge and expertise.

Howard was the foremost British expert working on both the botany and chemistry of cinchona in the middle decades of the nineteenth century. His leading role within the family firm, Howards and Sons, meant few European rivals were so well placed to answer the same questions. The 1820 isolation of quinine occurred at the start of his career. It was embraced by Howard not only as a tool for alkaloid production but as a tool for quantification and bark assessment. The factory also provided streams of data in the form of cinchona bark flowing into vats for mass-alkaloid production.

Over his career, Howard built bark collections and used innovative chemical analysis to enhance botanical assessments of cinchona in novel and practical ways. These skills enabled him to contribute to the understanding of the morphological and chemical variability of cinchona as well as the development of 'quinology' as a discipline.

Howard first displayed the factory cinchona bark collections after nearly thirty years' work on the genus, curating an award-winning display at the 1851 Great Exhibition. As discussed in Chapter 4, this both displayed and promoted his role as an expert to the wider scientific community. His recognition as a quinologist was built upon these foundations.

Recognition of Howard's expertise, alongside family connections, enabled access to assess the historic collections of barks and herbaria at the British Museum and Kew. His assessments of these specimens boosted his career, enhancing his reputation amongst botanists in addition to confirming his bark-identification expertise. In the case of the British Museum, the collections were created by plant collectors in the Andean forests, linking the botanical (herbaria) with bark specimens and associated trade names. This 'enhanced' data accelerated his research and Chapter 5 shows it was around this date he increased his collecting rate, established a specialised cabinet collection combining barks both from trade and exchanged with other experts.

Howard's expertise combined detailed knowledge of cinchona with analytical chemical skills. These were key to assessing the genus. This set him apart even from the botanists at Kew Gardens, confirming his reputation as the key British expert and chemical consultant (Chapter 4). However, the tension between cabinet collections made by a tradesperson versus botanists who had visited the Andean field resulted in Howard adapting his skillset from cabinet collecting (Chapter 5) to cultivation of living specimens (Chapter 6).

In terms of his public reputation, Howard came to the wider quinological scene just as cinchona science was transferring from reliance on South American, wild-collected trade barks to cultivated varieties in Dutch and British colonies. Howard recognised that his expertise needed to diversify from analysis of trade barks alone. Using contacts in the Andes he sourced plants to grow in glasshouses in his Tottenham garden. This novel knowledge gave Howard an edge over rivals: no one else in Britain was growing trees for this type of research. Through sourcing and cultivating a variety of species - again beyond Kew's scope - he developed a detailed knowledge of ecological influences on cinchona morphology. This meant he became the obvious choice for consultation on the British-Indian cinchona cultivation projects from 1860. This position helped maintain his influence, further cementing his role as the pre-eminent British quinine expert.

Limitations of travel meant Howard's specialised knowledge relied on the extensive global networks he maintained, as shown in Chapter 4. This was both from sourcing South American specimens and in the circulation and exchange of trade specimens and knowledge between other experts across at least 15 countries in Europe, the Americas and the Colonies. These networks were a significant part of his expertise building, providing a rich resource both for gleaning information and material and for circulating his own ideas. Data circulated included bark specimens, herbaria, seeds, saplings, correspondence, offprints and books (Chapter 7). The importance of his networks is also expanded on in the following sections.

Howard was an active, industry-based, practical scientist who had the time, funds and tools to devote a career to one genus. In these ways, he eluded the stamp of a commercial chemist to move into the more academic, and gentlemanly, science of botany. However, his understanding of species from a strongly biblical point of view. His approach to classification was influenced by both this and pharmaceutical considerations and led to tension with other botanists, prompting challenges to his expertise (Chapter 6).

Situating Howard's career as a botanist and pharmacologist within the context of wider studies of expertise in the history of nineteenth-century science has added nuance to the account of his role as a knowledge producer, bridging the worlds of commerce, science and policy. This study has shown the significance of industrial practice and commercial experience for the development of new knowledge, specifically in the case of pharmacy, as well as wider contributions to empire-building. These issues are discussed further below.

Theme 2: How did Howard practice his science, located distant from the cinchona habitats, wild in the Andes and cultivated in Asia?

Howard's industrial background influenced the development of his practical and systematic approaches to understanding cinchona. Hands-on, material-based collection analysis with a basis in pharmacognosy was the foundation of his approach. Placed in-between the two geographical centres of the cinchona story, between South America and Asia, he developed methods to study the distant tree by bringing it in to his laboratory and garden. These included the cultivation of networks through which knowledge and specimens could circulate through correspondence and exchange.

Of central importance to Howard's work were the cinchona barks themselves. These tangible objects gave him insight to cinchona, despite being located far from the spaces in which it grew. Using the material clues and chemical analysis Howard practised a form of 'reverse botany'. From these jigsaw pieces, he extrapolated types and origins back to the Andes, linking them through pharmacognostic assessment to known species.

Pharmacy and religion were the two major influences on Howard's approach to scientific research. His botanical determinations followed a form of pharmaceutical taxonomy, assessments based on alkaloidal richness and therefore medicinal/economic usefulness and value (Chapters 4 and 5). However, these categorisations were not liable to be disputed by more classically trained botanists. His understanding of the genus was also complicated by his evangelical views which led him to resist theories of natural selection (Chapters 6 and 7). This affected his perception of what constituted 'species', 'variety' and 'forms' and led to tension with other scientists and horticulturalists.

Theme 3: How was Howard's knowledge communicated and circulated?

While active in the worlds of commerce and religion, Howard was a prolific publisher of articles and books with at least 107 known works over a 44-year period (Figure 2.5). Alongside lectures and correspondence, his published works were widely used to promote his ideas. He often circulated his books and papers to others in his network to ensure his findings were widely known. Sharing such ideas reinforced his role as expert. This process went beyond the written word for he also circulated sets of representative cinchona bark to museums, schools and other institutions.

Although Howard published widely, his work was also subject to criticism especially within botanical circles, such as the Linnean Society, due to his handling of cinchona species (Chapter 6). However, within the pharmaceutical world, his perspectives on cinchona species were more widely accepted. His favoured publication outlet therefore became *the Pharmaceutical Journal and Transactions.* This was an important space for communicating his ideas. Pharmacists were trained in both botany and chemistry and thus better appreciated his pharmaceutically inclined categorisations of cinchona. Not only did the journal provide an appreciative audience, but it also promoted and established his expertise and this translated into confidence in Howards and Sons' products.

Howard's public reputation was sealed through the publication of expensively produced, full-colour guides on the identification of cinchona between 1862 and 1876. These acted as bulwarks for his expertise as a quinologist, notably combining the botanical, the chemical and the horticultural (Chapter 7). The place of these books within the lineage of other 'quinological' works indicates his preference for traditional botanical works illustrated with herbarium-style images, based on a variety of evidence including his own 'living' trees. However, these texts were also brought up-to-date through the addition of detailed alkaloidal analyses and microscopical observations. Howard's detailed, colour microscopical plates intended for identification of trade barks were novel in quinology and replaced the previous trend to represent macroscopical barks.

These books were widely distributed, often gratis, across Europe, further cementing the reputation of their author. Howard became the consultant of choice for the British-Indian government who circulated his books to libraries and planters as the most up-to-date guides available. This, therefore, disseminated his ideas to influence further colonial fields.

Theme 4: What does a collections-based approach, which combines evidence from scientific collections and from textual sources, contribute towards pharmaceutical history?

This thesis has demonstrated the advantages of combining a collections-based approach with research in conventional historical archives, including printed works and manuscripts. The collections-based analysis produced quantitative data from which qualitative insights have been drawn. It has also demonstrated the usefulness of collections-based methods for study the history of nineteenth-century pharmacy, which has until now been predominantly based on textual research, despite rich extant specimen collections. The focus on collections has also been useful in mapping the development of the discipline of quinology, which hitherto has been a little-studied subject. The importance of specimens and investigative material-analysis to quinologists is clear and it is reflected in the methodology of this project.

Decoding the material clues in the form of medicinal objects and mapping them to the archives, shows how collection assemblages can be traced. This in turn enhances data interpretation, allowing a variety of stories of the collections and their curators to emerge. Nineteenth-century materia medica collections, historically used for education and analysis, are commonly found within national and international museum collections. These repositories have the potential to offer rich insights into the history of other fields in medicine, chemistry and botany. Cinchona's colonial associations, medical significance and botanical complexity make it a particularly suitable subject for this kind of study, especially given the richness of its collections, as exemplified at Kew, Leiden and Madrid. This provides a large data set for new perspectives in the history of the tree, its treatment and colonial implications. The same methodology could well be transferred to other plants.

8.3 Implications and future research

This project has examined collectors and collection assemblages through a material perspective, seeking to enhance historical narratives and add value to the many rich collections of economic botany found across global institutions. In particular, it has focused on colonial-era collections, such as those at Kew, containing plants like cinchona which were prominently involved in empire-building. Many of these collections were gathered by privileged white, male Europeans, raising wider questions about their role in a broader global history and the potential of alternative sources of knowledge (Ashby & Machin, 2021; Das & Lowe, 2018; Roque, 2011; Thorpe, 2019). These debates over Indigenous agency and forms of knowledge are important. It is this that I explored with co-author and Quechua scientist, Nataly Allasi Canales in a chapter of a *This book is a plant*, published as part of an exhibition with the Wellcome Collection, 'Rooted Beings' discussed further at the end of this chapter (Walker & Canales, 2022). However, the first essential steps in unlocking the evidence within these collections comes from understanding how they came to be, including the tracing of collection practices and motivations.

Assembling and comparing different forms of collections data is a crucial step in enhancing the knowledge of collections and specimens, providing a starting point from which other investigations can be made. The 'collections-based' approach in this thesis has involved working with multiple forms of data – in the shape of barks, herbarium specimens, inventories, drawings, prints, taxonomic and chemical analyses – in order to demonstrate the ways in which these different kinds of evidence were combined by quinologists in the nineteenth century and can be reconnected today. This approach has the potential to open new avenues of research with the enhanced data, including the provenance and trajectory of other kinds of biocultural collection. Over time this will give greater insight to the actual and potential uses of such collections. For example, material analysis of Kew's wild-collected barks could reveal new information concerning the practices of bark collectors (*Cascarilleros*) and other stories of Indigenous knowledge. Also, further knowledge of the Andean provenance of specimens could help map old-forests and drug trade routes with potential impact on conservation and sustainability today. Without first having contextualised and corroborated the data they contain by understanding when, how and why they were gathered and curated, such research would be of limited potential.

In addition, material analysis of specimens can enhance data relevant to the ecology of plants. This kind of information-gleaning is often undertaken with herbarium specimens in order to understand climate, conservation and distribution data, both historical and contemporary (Dierig et al., 2014; Harris, 2021; Lang et al, 2019; Willis et al, 2017). Its potential application in relation to economic botany collections has by comparison received much less attention yet has significant potential – for example in analysis of the lichens which grow abundantly on cinchona trees and are preserved on many Kew specimens. Each lichen species has unique growth requirements and can be used to understand the environments in which it, and its cinchona host, grew.[231] Research on isotope analysis of timber specimens to identify trade product origins provides another example (Blockley et al., 2018; Deklerck, 2022). This technique has potential to trace with more accuracy the origins of cinchona barks, not only to further enhance ecological and geographical understanding, but also to give insight into historical trade routes. In the case of trade specimens of cinchona, for example, it is clear that the attribution of source region was often obscured by port origin and so does not reflect the true geographical source. Improving the accuracy of provenance

[231] Communication with Holger Thüs, Curator for Algae, Fungi and Bryophytes, State Museum of Natural History Stuttgart.

would answer many questions.

The contribution of historical interpretation to the understanding of scientific data has also been demonstrated throughout this thesis. Verifying specimen data in archival terms can contribute significantly to the precision of sampling strategies, for example in chemical and phylogenetic research. This is of particular interest to Economic Botany Collections which often have objects designated with botanical determinations from older periods, no longer recognised. However, due to lack of botanical features, these are not always accurately updated, detailed provenance study is required to unpick potential species. Archival research can also help direct scientific research focus through the targeting of important specimens, i.e. those that were historically significant (2020; 2021a; 2021b; 2021c).

Turning to the wider implications of the historical arguments advanced in this thesis, the story of Howard's role both as consultant and as industrialist has complicated the standard account of Kew's role as a 'centre of calculation' for botany and empire. While Howard's work and publications were undoubtedly part of the wider British-Indian cinchona cultivation project, the account in this thesis has shifted the emphasis to experts *external* to Kew and their role in knowledge production. Howard appears to have been the primary cinchona expert in Britain, pre-eminent even over Kew's experts. It was Howard, not the botanists of Kew, who was invited to write reports on cultivation management which influenced species selection and practice in the early plantation years. More generally, the way botanical, chemical, commercial and horticultural evidence was combined in pursuit of a scientific understanding of cinchona has been revealed as a more contingent and complex process than often allowed by a Latourian framework (Jons, 2014; Latour, 1987). There is evidence the story of external expertise is also shared with other commodity plants, e.g. rubber (*Hevea brasiliensis*) and is an area of further research (Loadman, 2009).

The account of Howard's role as a chemical manufacturer in this thesis raises wider questions about the influence of pharmaceutical industry both on medical practice and wider scientific research. This is an issue that remains prominent in ethical debates today (Bourcier-Bequaert et al.,2022; Komesaroff & Kerridge, 2002; Lasco & Yu, 2022). Early twentieth-century histories of cinchona have already highlighted the role of quinine and the production of the first pharmaceutical cartels (Roersch van der Hoogte & Pieters, 2015a; Goss, 2013). This thesis adds to literature on the earlier influence of the pharmaceutical industry over drug production, development and marketing, a subject also highlighted by Deb Roy (2017).

The discussion of Howard's attempts to reconcile his botanical knowledge with a fundamentally biblical understanding of creation clearly has a resonance in the context of wider debates over nineteenth-century science and religion. While Howard did not reject Darwin and Wallace's ideas of natural selection outright, he was unable to fully integrate them in his own work. This was not merely a matter of his religious faith, which was widely shared by his contemporaries, including eminent men of science: Howard, while scientifically progressive, balanced this with religious conservativism. It was also due to his specialist research focus: *Cinchona* is a particularly difficult genus to study because it does not appear to play by the rules of what it means to be a species (Chapter 6). It has taken twentieth and twenty-first century developments in genetic science to start unpicking its taxonomy and even today many questions remain unanswered (Andersson, 1998, Maldonado et al., 2017b). Howard's grappling with this complex genus goes some way to explaining his resistance to overarching theories on natural selection and the evolution of species.

Although examining Howard's descriptions of cinchona species through the lens of modern science reveals their shortcomings, his categorisations followed a structure that clearly made sense to him. As a pharmaceutical manufacturer, Howard recognised varieties or forms of cinchona of value to chemical production. Plant scientists now understand that a single species can produce various chemotype subspecies which are only recognisable through chemical analysis. This adds nuance to the 'splitters' vs. 'lumpers' species debate much discussed in the history of botany literature (Bonneuil, 2002; Endersby, 2009). The skillset of a nineteenth-century pharmacist included pharmacognosy: the ability to assess drug quality of natural origins, such as cinchona through the visual and non-visual senses (such as taste, smell, chemistry etc.) (ASP, 2016). These skills were highly refined in those who used them daily and, on this basis, Howard clearly recognised and categorised the cinchona subtypes of interest to him. The same process was at work in relation to other medicinal genera at Kew, as evidenced in specimens donated by other pharmacists (Chapter 5). This pharmaceutical recognition of chemotypes may be a fertile area for future research linking epistemology, history of pharmacy and drug discovery (Chassagne et al, 2021; Cragg & Newman, 2009; Lautie et al., 2020).

A final thread running thread throughout this thesis is the use of exhibitions and the display of useful plants to present and promote medical and other applications of science. Howard first established his name in the public world of science through his company's displays at the Crystal Palace Great Exhibition of 1851 (Figure 3.1). His barks represented nature as a commodity, part of the transformation of crude drugs into refined, pure, alkaloid chemicals. This exhibit was clearly part of a wider mid-Victorian narrative concerning industry, technology and progress.

Eighty years later, long after Howard's death, his barks were once again displayed in London at the Wellcome Tercentenary Exhibition of 1930 (Figure 8.2). This exhibition was organised by the curators of Henry Wellcome's historical medical museum to honour the approximate anniversary of the date that cinchona was first noticed by Europeans. Quinine was of considerable importance to the pharmaceutical business of Burroughs, Wellcome & Co. The museum exhibit celebrated a heroic narrative of cinchona collection in South America (culminating in Wellcome's own journey to Ecuador in 1879)[232] while highlighting the importance of medical research on plants. Its angle was thus progressivist, reflecting themes of exploration, 'discovery', human dominion over nature and power over disease. Though this exhibition lies outside the main frame of this thesis, it provides a fitting end point, as hundreds of barks exhibited came from John Eliot Howard's collection (Wellcome, 1930). These exhibits originated in his personal specimen collections, books and manuscripts loaned for the occasion by Howards and Sons, but also from other institutions, many of which had received

[232] Highlighted in the "Chronology of the principal explorations and personal investigations of the native cinchona forests since 1700" (Wellcome, 1930, p. 11).

donations from Howard during his lifetime. Although nearly fifty years had passed since Howard's death, the exhibition relied heavily on his work to illustrate cinchona's legacy in science, commerce and medicine.

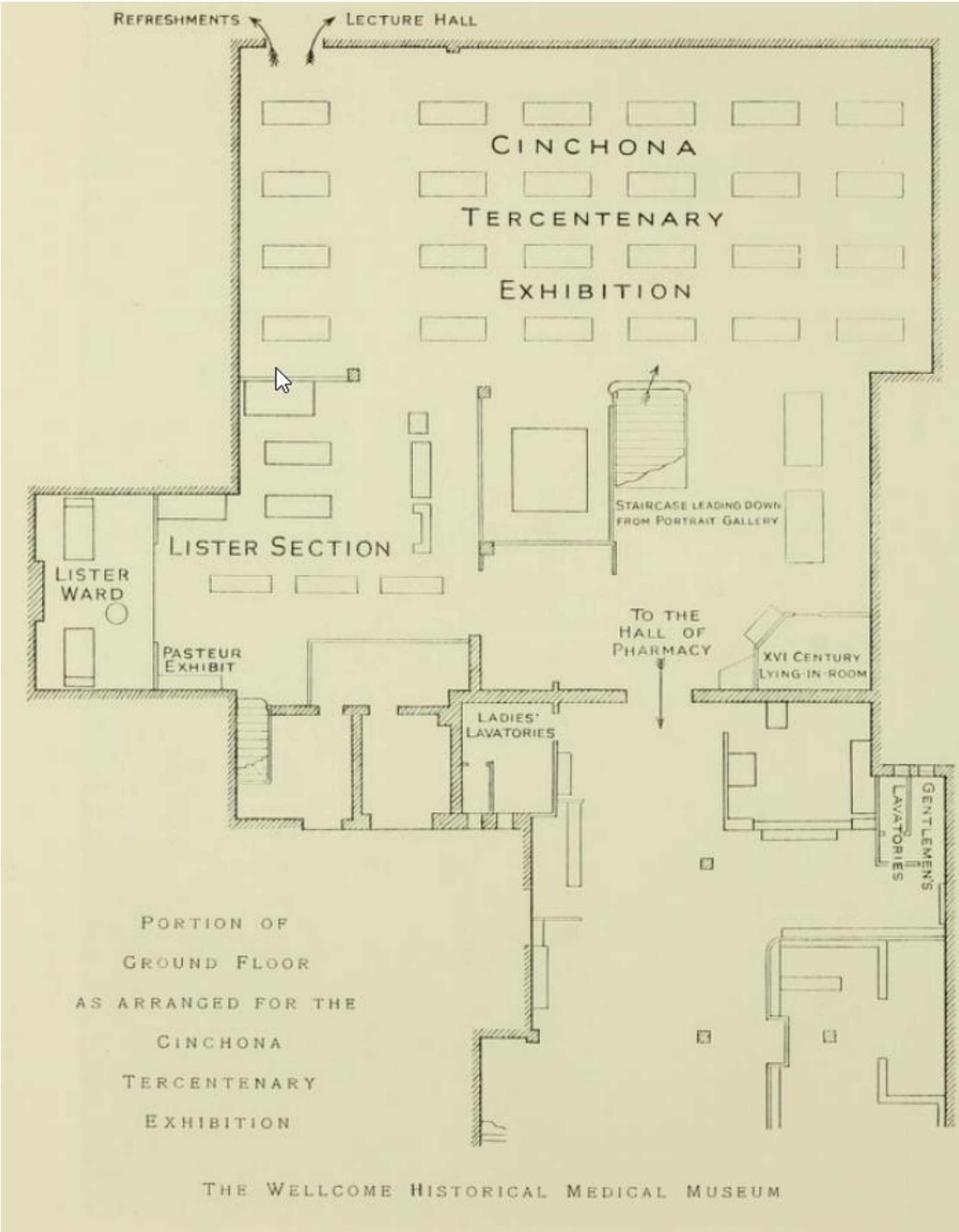


Figure 8.2 Floor plan of the 1930 Wellcome Cinchona Tercentenary Celebration and Exhibition, 1930. (Wellcome, 1930, p. 16).

During 2022, the Wellcome Foundation in Euston Road was the home for a third, very different kind of exhibition, 'Rooted Beings', which explored human-plant relationships. This time, it was ecological rather than medical knowledge which took centre stage, the progressivist narratives of a former age were notable by their absence. Instead, stories of plant intelligence and behaviour were highlighted, with attendees asked to meditate on what we might learn from nature's ways of being (Wellcome Collection, 2022). Humans appeared in the display chiefly as exploiters of the plant world. Part of this theme was represented through a set of altars by artist Patricia Domínguez, one devoted to cinchona. Once again, the genus was recognised as highly significant for the story of human-plant interactions. Domínguez highlighted the role of cinchona in colonial expansion, the exploitation of indentured labour in its cultivation and the ecological impacts that mass-harvesting and mass-growing had on Andean and Asian landscapes. The artist selected items from the Wellcome and Kew collections for their representational and historical significance and these were used as counterpoints to her altars - pieces of history to which she responded in her artistic form (Figure 8.3). Included in the altar was a Howard-Fitch print from *Illustrations of the Nueva Quinologia of Pavon* as well as one of the *Real Expedición* barks that Howard himself had examined (also seen in Figure 4.1).

1851, 1930 and 2022: three exhibitions, each with cinchona held symbolically at the heart, but each representing very different moments and reflecting different approaches and beliefs. As the quatercentenary of cinchona's first Western use approaches in 2030, how will its story be told and its legacy continue to be used? What further lessons can we learn from this history? Over the last few centuries, cinchona has been written about in many different ways by many different authors. The rich worldwide cinchona collections continue to show the plant's significance and invite further examination.

Figure 8.3 Cinchona displayed at the Wellcome Collection exhibition 'Rooted Beings'.
The central image is from Howard's *Illustrations of the Nueva Quinologia of Pavon* (Howard, 1862). The lower display includes barks from the *Real Expedición* that Howard published on. Image with permission of the Wellcome Collection.

Appendices

Appendix 1: Table showing Howards and Sons bark sources for quinine manufacture by geographical origin (%) 1859-1885.[233]

Year	South American	East Indian
1859	100	0
1860	100	0
1861	100	0
1862	100	0
1863	100	0
1864	100	0
1865	100	0
1866	100	0
1867	100	0
1868	100	0
1869	100	0
1870	100	0
1871	100	0
1872	99.2	0.8
1873	98.7	1.1
1874	97.3	2.7
1875	94.2	5.8
1876	93.9	6.1
1877	86.9	13.1
1878	88.4	11.6
1879	91	9
1880	76.2	23.8
1881	83.6	16.4
1882	69.1	30.9
1883	24	76
1884	11	89
1885	11.7	88.3

[233] Data adapted from Laboratory Calculations Book, 90/360/E2/A5, Redbridge Archives.

Appendix 2 Howards and Sons Quinine sales 1862-1902 with 2022 equivalent values.[234]

Year	Home	Foreign	Government	Total	Modern value[235]
1862	£ 99,849.00	£ 66,846.00	£ 1,809.00	£ 168,503.00	9,963,506.72
1863	£ 108,760.00	£ 72,940.00	£ 1,995.00	£ 183,695.00	10,861,738.39
1864	£ 105,808.00	£ 67,432.00	£ 2,465.00	£ 175,705.00	10,389,296.09
1865	£ 142,417.00	£ 64,176.00	£ 2,681.00	£ 209,273.00	13,102,435.87
1866	£ 122,180.00	£ 93,738.00	£ 4,509.00	£ 220,427.00	13,800,713.04
1867	£ 123,707.00	£ 99,849.00	£ 8,013.00	£ 231,570.00	14,498,366.13
1868	£ 115,826.00	£ 70,269.00	£ 52,893.00	£ 238,988.00	14,962,799.69
1869	£ 117,201.00	£ 44,312.00	£ 48,808.00	£ 210,321.00	13,167,987.49
1870	£ 130,181.00	£ 94,151.00	£ 38,253.00	£ 262,585.00	16,440,183.37
1871	£ 137,641.00	£ 130,572.00	£ 41,316.00	£ 309,529.00	19,379,301.16
1872	£ 150,483.00	£ 182,067.00	£ 16,253.00	£ 348,805.00	21,838,332.25
1873	£ 141,946.00	£ 143,453.00	£ 79,562.00	£ 364,961.00	22,849,843.25
1874	£ 149,190.00	£ 142,133.00	£ 55,000.00	£ 346,323.00	21,682,999.32
1875	£ 159,507.00	£ 117,072.00	£ 22,143.00	£ 298,723.00	19,770,892.14
1876	£ 138,099.00	£ 135,958.00	£ 15,333.00	£ 289,391.00	19,153,256.52
1877	£ 84,651.00	£ 115,693.00	£ 21,458.00	£ 221,803.00	14,679,965.01
1878	£ 135,218.00	£ 160,457.00	£ 13,790.00	£ 309,465.00	20,481,848.19
1879	£ 109,069.00	£ 187,672.00	£ 8,000.00	£ 304,741.00	20,151,321.79
1880	£ 125,795.00	£ 178,800.00	£ 19,853.00	£ 324,448.00	21,473,493.55
1881	£ 132,499.00	£ 262,136.00	£ 7,532.00	£ 402,167.00	26,617,302.24
1882	£ 106,466.00	£ 154,982.00	£ 66,597.00	£ 328,045.00	21,711,559.91
1883	£ 101,245.00	£ 243,422.00	£ 38,743.00	£ 383,410.00	25,375,875.83
1884	£ 193,768.00	£ 329,212.00	£ 7,313.00	£ 530,293.00	35,097,349.30
1885	£ 232,573.00	£ 371,377.00	£ 10,825.00	£ 614,776.00	50,441,940.46
1886	£ 144,946.00	£ 316,003.00	£ 10,406.00	£ 471,355.00	38,672,706.82
1887	£ 114,860.00	£ 365,597.00	£ 15,885.00	£ 496,342.00	40,724,513.66
1888	£ 129,748.00	£ 429,723.00	£ 15,939.00	£ 575,411.00	47,212,069.76
1889	£ 126,865.00	£ 334,692.00	£ 23,367.00	£ 484,923.00	39,787,673.75
1890	£ 128,709.00	£ 449,105.00	£ 14,261.00	£ 592,075.00	48,579,339.30
1891	£ 130,069.00	£ 498,076.00	£ 10,186.00	£ 638,331.00	52,378,713.18
1892	£ 147,043.00	£ 556,650.00	£ 1,520.00	£ 705,213.00	57,862,233.00
1893	£ 106,147.00	£ 477,861.00	£ 38,777.00	£ 622,785.00	51,099,073.30
1894	£ 127,386.00	£ 501,592.00	£ 36,546.00	£ 665,523.00	54,605,778.33
1895	£ 104,333.00	£ 577,777.00	£ 42,996.00	£ 725,107.00	56,683,209.43
1896	£ 119,333.00	£ 495,921.00	£ 50,803.00	£ 666,057.00	52,067,141.02
1897	£ 170,983.00	£ 617,793.00	£ 47,002.00	£ 835,778.00	65,334,603.97
1898	£ 89,780.00	£ 479,863.00	£ 52,501.00	£ 622,145.00	51,761,331.37
1899	£ 85,242.00	£ 457,548.00	£ 77,403.00	£ 620,193.00	48,481,929.41
1900	£ 113,876.00	£ 524,445.00	£ 75,155.00	£ 713,476.00	55,773,988.57
1901	£ 88,299.00	£ 440,312.00	£ 71,481.00	£ 600,092.00	46,910,511.84
1902	£ 80,482.00	£ 520,432.00	£ 51,818.00	£ 652,732.00	51,025,496.45

[234] Laboratory Calculations Book, Redbridge Archives, 90/360/E2/A5
[235] Equivalent values in Sterling calculated to the nearest decade. The National Archives Currency Converter 1270-2017. (TNA, 2018)

Appendix 3: A list of John Eliot Howard's major publications by year and type

Apart from his books, Howard's major scientific works were published in the *Pharmaceutical Journal & Transactions*, the journal of the Royal Pharmaceutical Society. Selected other publications have been included here.

Year	Genre: (R)eligious, (S)cientific (C)ombined Or (L)iterature	Type	Government Reports Reprinted?	Reference
1839	R	Book		Howard, J.E. (1839). *The Inward light*. T. Ward & Co.
1843	R	Book		Howard, J.E. (1843). *'New views' Compared with the Word of God*. Groombridge.
1845	R	Book		Howard, J.E. (1845). *Eight lectures on the scriptural truths most opposed to Puseyism.* Longman, Brown, Green and Longmans.
1850	R	Book		Howard, J.E. (1850). *Hymns for Christians*. James Nisbet & Co. & John J. Campbell.
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 11*(11), 489-498,
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 11*(12), 557-564.
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 12*(1), 11-16.
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 12*(2), 58-62.
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 12*(4), 173-180.
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 12*(5), 230-235.
1852	S	Article		Howard, J.E. (1852). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 12*(3), 125-129.
1853	S	Article		Howard, J.E. (1853). Examination of Pavon's collection of Peruvian barks contained in the British Museum. *Pharmaceutical Journal and Transactions 12*(7), 339-342.
1853	**S**	**Book**		**Howard, J.E. (1853).** ***Examination of Pavon's collection of Peruvian barks contained in the British Museum*****. C. Whiting.**
1854	S	Article		Howard, J.E. (1854). Observation on the specimens of Peruvian bark presented to the museum of the Pharmaceutical Society, May 17th 1854. *Pharmaceutical Journal and Transactions 13*(12), 671-672
1854	S	Article		Howard, J.E. (1854). Observation on some additional specimens of Peruvian barks presented to the museum of the Pharmaceutical Society. *Pharmaceutical Journal and Transactions 14*(2), 61-63
1854	S	Article		Howard, J.E. (1854). On the bark of Gomphosis chlorantha, Wedd., occurring mixed with quilled calisaya bark. *Pharmaceutical Journal and Transactions 14*(7), 318.

1854	S	Article		Howard, J.E. (1854). On copalchi bark. *Pharmaceutical Journal and Transactions 14*(7), 319.
1854	R	Unknown		Howard, J.E. (1854). *The Protestant in Ireland*. Unknown publisher.
1855	R	Book		Howard, J.E. (1855). *'The island of saints'; or, Ireland in 1855.* Seeley, Jackson and Halliday.
1855	S	Pamphlet		Howard, J.E. (1855*). Examination of botanic specimens at Kew, 1855*. Privately circulated.
1855	S	Unknown		Howard, J.E. (1855). *Appendix to the Examination of botanic specimens at Kew, 1855.* Privately circulated (cited by Maria Howard but never traced)
1855	S	Pamphlet		Howard, J.E. (1855). *Appendix to examination of Pavon's collection of Peruvian barks contained in the British Museum.* Privately circulated
1856	S	Article		Howard, J.E. (1856). On the tree producing red cinchona bark. Pharmaceutical Journal and Transactions 16(4), 207-212; *Journal de Pharmacie 31*, 142-149.
1857	R	Book		Howard, J.E. (1857). *The shepherd, the stone of Israel.* (1st Ed.). W. Yapp.
1858	R	Book		Howard, J.E. (1858). *Christ crucified—the one meeting-point between God and the sinner. W*. Yapp,
1862	**S**	**Book**		**Howard, J.E. (1862*). Illustrations of the Nueva Quinologia of Pavon.* Lovell Reeve & Co.**
1863	S	Article		Howard, J.E. (1863). Cinchonine, its value in medicine. *Pharmaceutical Journal and Transactions 4*(12), 561-562
1863	S	Report 1	Yes	Howard, in 1863 analysed the first set of small twigs and barks from British India. This report was not published as a report to the government in the British Parliamentary Papers, but is referred to in the following letters: *British Parliamentary Paper No* 353: Letter to Markham, 28 May 1863, Enclosure 2, in. No. 7, p. 14; From the Madras Government to the Secretary of State for India (1863, April 11). Section I, Item No. 1, p.1; McIvor, W. (1863, April 4). Enclosure No. 1. Section I, Item No 2, p. 2; Sir Charles Wood to the Government of Madras. (1863, July 11). Section I, Item No. 4, p.8; From the Government of Madras-to the Secretary of State for India. (1863, August 12). Section 1, Item No. 7, p. 13. etc.
1863	S	Report 2	Yes	Howard, J.E. (1863, December). Report on the Bark and Leaves sent home in October 1863. *British Parliamentary Paper No. 353*, *East India (Chinchona plant)*, 1863-1866, Section I, Item No. 16a, p. 30.
1863	S	Report & Article	Report 1 PJ Reprint	Howard, J.E. (1863). Report on the bark and leaves of Cinchona succirubra grown in India, sent 23 May 1863. *Pharmaceutical Journal and Transactions 5*(2), 74-75.
1863	S	Article		Howard, J.E. (1863). Quinine, quinidine, cinchonine and cinchonidine in the leaves of Cinchona succirubra. *Pharmaceutical Journal and Transactions 5*(2), 76-77.
1863	S	Article		Howard, J.E. (1863). New features in the supply of Peruvian bark. *Pharmaceutical Journal and Transactions 5*(6), 248-249.
1863	S	Article		Howard, J.E. (1863). Note on the root bark of Cinchona calisaya. *Pharmaceutical Journal and Transactions 5*(8), 342.
1864	S	Report 3	Not reprinted	Howard, J.E. (1864, June 15). Report of an Analysis of the Third Remittance of bark from India, received 20 May. *British Parliamentary Paper No. 353*, *East India (Chinchona plant)*, 1863-1866, Section I, Item No. 25, p. 48.
1864	S	Report & Article	Report 2 PJ Reprint	Howard, J.E. (1864). Report on the above bark and leaves sent home in October 1863 for examination by J.E. Howard Esq. Letter reprint from Howard to the Under Secretary of State for India, December 1863. *Pharmaceutical Journal and Transactions 5*(8): 368-369.
1864	S	Article		Howard, J.E. (1864). On the red variety of Pitayo bark. *Pharmaceutical Journal and Transactions 6*(2): 48-50.

1864	S	Article		Howard, J.E. (1864). On the root bark of the Cinchonae *Pharmaceutical Journal and Transactions 6*(1), 19.
1865	S	Article		Howard, J.E. (1865). Microscopical researches on the alkaloids, as existing in Cinchona bark. *Pharmaceutical Journal and Transactions 6*(11), 584-588.
1865	C	Book		Howard, J.E. (1865). *Seven Lectures on scripture and science*. Groombridge and Sons.
1865	S	Report 4	Yes	Howard, J.E. (1865). Report of an analysis of the fourth remittance of bark from India. *British Parliamentary Paper No. 353*, *East India (Chinchona plant)*, 1863-1866, Section I, Item No. 51, P. 134.
1866	S	Report, Non-Gov	n/a	Howard, J.E. (1866). Report of an analysis of bark of Chinchona succirubra grown in Wynaad, 1866. *British Parliamentary Paper No. 353*, *East India (Chinchona plant)*, 1863-1866, Section III, Item No. 4, p. 282.
1866	S	Report, Non-Gov	n/a	Howard, J.E. (1866, July 11). Report on Specimens of Chinchona bark grown in Ceylon, 1866. *British Parliamentary Paper No. 353*, *East India (Chinchona plant)*, 1863-1866, Section VII, Item No. 5, p. 378.
1866	S	Report & Article	Report 4 PJ Reprint	Howard, J.E. (1866). Report of an analysis of the fourth remittance of bark from India. *Pharmaceutical Journal and Transactions 7*(8), 419-421
1866	R	Book		Howard, J.E. (1866*). A caution against the Darbyites, with remarks on heresy and schism.* Printed for Private Circulation
1867	S	Article		Howard, J.E. (1867). Observations on the present state of our knowledge of the genus Chinchona. *Pharmaceutical Journal and Transactions 8*(1), 11. According to Howard (1885), this was given as a talk at the Report of the International Horticultural Exhibition and Botanical Congress, London, 1866;
1867	S	Report 5	Report 5	Howard, J.E. (1867). Report of an analysis of the fifth remittance of bark from India, 4 February 1867. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870, Section I, Item No. 15, p.34.
1867	S	Report & Article	Report 5 PJ Reprint	Howard, J.E. (1867). Report of an analysis of the fifth remittance of bark from India. *Pharmaceutical Journal and Transactions 8*(10): 592-595.
1867	S	Report 6	Yes	Howard, J.E. (1867, August 28). Report of an analysis of the sixth remittance of bark from India. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870. Section I, Item No. 30, p.134.
1867	S	Report & Article	Report 6 PJ Reprint	Howard, J.E. (1867). Report on an analysis of the sixth remittance of bark from India 1867. *Pharmaceutical Journal and Transactions 9*(5), 243.
1867	S	Report 7	Yes	Howard, J.E. (1867, October 7). Analysis of the seventh remittance of bark from India. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870. Section II, Item No. 9, p. 260
1867	S	Report & Article	Report 7 PJ Reprint	Howard, J.E. (1867). Report on an analysis of the seventh remittance of bark from India 1867. *Pharmaceutical Journal and Transactions 9*(5), 243.
1868	S	Article		Howard, J.E. (1868). Fresh exploration of the Calisaya-yielding districts of Easter Bolivia by Senor Pedro Rada. *Journal of Botany* 6, 323-326.
1868	S	Report 8	Yes	Howard, J.E. (1868, September 1). Report of an Analysis of the Eighth Remittance of Bark from India. *British Parliamentary Paper No. 432 East India (Chinchona Cultivation)*, 1866-1870. Section II, Item 57. Annual report 1868, In Footnote, p. 211.
1868	S	Report & Article	Report 8 PJ Reprint	Howard, J.E. (1868). Report on an analysis of the eighth remittance of bark from India 1867. *Pharmaceutical Journal and Transactions 10*(5), 317-320.

1869	S	Article		Howard, J.E. (1869). The calisaya barks of eastern Bolivia. *Journal of Botany* 7, 1-3.
1869	S	Article		Howard, J.E. (1869). On the cultivation of cinchona in the East Indies 1867. *Linnean Society Journal of Botany* 10, 15-18.
1869	**S**	**Book**		**Howard, J.E. (1869). *The quinology of the East Indian plantations* (Part I). Lovell Reeve & Co.**
1870	S	Article		Howard, J.E. (1870). Note sûre une espèce nouvelle de Cinchona (C. rosulenta) de la province d'Ocana, dans la Nouvelle-Grenade. *Bulletin de la Société botanique de France* 17, 228-231.
1870	S	Article		Howard, J.E. (1870). Introductory remarks to Mr Broughton's paper on hybridism among Cinchonae. *Linnean Society Journal of Botany* 11: 474.
1870	S	Article		Howard, J.E. (1870). On the cultivation of cinchona plants under glass in England. *Pharmaceutical Journal and Transactions*, *11*(7), 388–392.
1870	S	Article		Howard, J.E. (1870). Cinchona cultivation in Java. *Pharmaceutical Journal and Transactions*. 3rd series (vol 1): 441-444
1872	S	Article		Howard, J.E. (1872). Ueber Cinchona tucurensis, Karst. *Flora* 55, 348-349.
1872	S	Article		Howard, J.E. (1872). Cinchona trees grown in India. *Pharmaceutical Journal and Transactions 3*(2), 361-363.
1872	S	Article		Howard, J.E. (1872). A note on the sale of Java bark at Amsterdam, on 14th March 1872. *Pharmaceutical Journal & Transactions*, 3rd Series, 945.
1872	R	Book		Howard, J.E. (1872). *Pros Hebraious. The epistle to the Hebrews.* (1st ed.). Unknown publisher.
1873	S	Article		Howard, J.E. (1873). Sur l'origine du quinquina-Colombie mou (Angel. soft columbian bark) du commerce. *Bulletin de la Société Botanique de France* 20, 291-294.
1873	S	Article		Howard, J.E. (1872). Report on the Cinchona bark grown in Jamaica. *Pharmaceutical Journal and Transactions*, 3rd series, 3rd August, 83.
1873	S	Article		Howard, J.E. (1873). Examination of the leaves of Cinchona succirubra. Pharmaceutical Journal and Transactions. 3rd series, 11th January, 541-542.
1873	S	Article		Howard, J.E. (1873). Cinchonas. *Pharmaceutical Journal and Transactions*, 3rd series, 10th May, 881.
1873	S	Article		Howard, J.E. (1873). The cinchona plantation in Java. *Pharmaceutical Journal and Transactions*, 3 (4): 21-25.
1874	S	Article		Howard, J.E. (1874). Presumed hybrid between Cinchona calisaya and C. succirubra. *Pharmaceutical Journal and Transaction*, 3rd series, 1, 42
1874	S	Article		Howard, J.E. (1874). On coppicing Chinchonas. *Gardeners' Chronicle*, 418.
1874	C	Article		Howard, J.E. (1874). On scientific facts and Christian evidence. *Journal of the Transactions of the Victoria Institute* 7, 324-354.
1875	S	Article		Howard, J.E. (1875). Sur l'origine du quinquina de Ste Fe. *Bulletin de la Société Botanique de France* xxii
1875	S	Article		Howard, J.E. (1875). On the Genus Cinchona. *Journal of the Linnean Society* (14), pp. 156-179.
1875	C	Article		Howard, J.E. (1875*). An examination of the Belfast address from a scientific point of view.* Robert Hardwicke. Also reprinted in 1877 as: Howard, J.E. (1877). An Examination of the Belfast Address from a Scientific Point of View. *Journal of the Transactions of the Victoria Institute* 10, 104-134.
1875	R	Article		Howard, J.E. (1875). Remarks on Buddhism. *Journal of the*

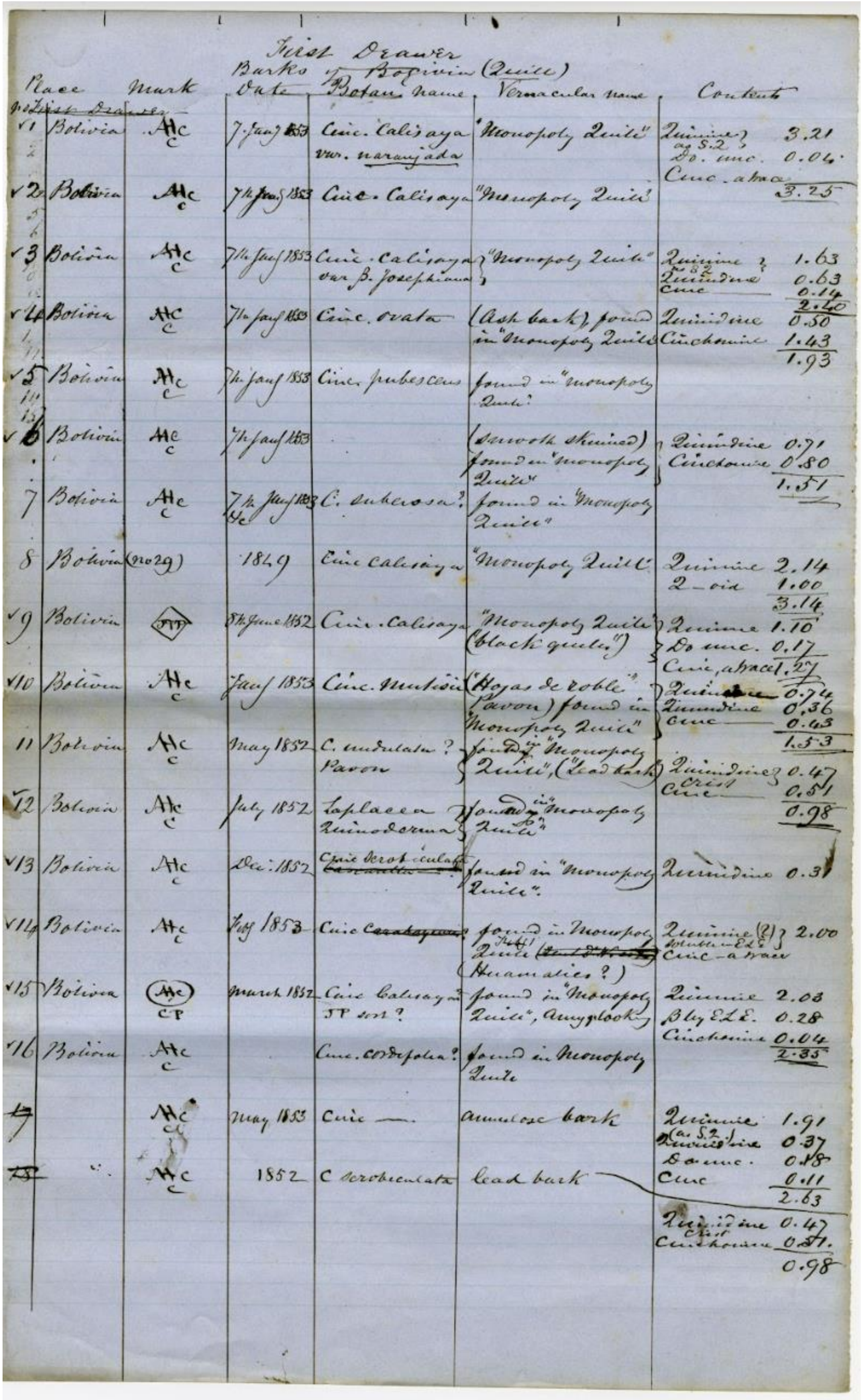
				Transactions of the Victoria Institute 8, 167-171.
1875	C	Article		Howard, J.E. (1875). On contrast between crystallization and life. *Journal of the Transactions of the Victoria Institute* 8, 173-210.
1875	C	Article		Howard, J.E. (1875). The early dawn of civilization considered in the light of scripture. *Journal of the Transactions of the Victoria Institute* 9, 239-270.
1876	**S**	**Book**		**Howard, J.E. (1876).** ***The quinology of the East Indian plantations*** **(Parts II & III). Lovell Reeve & Co.**
1877	R	Article		Howard, J.E. (1877). On Egypt and the bible. *Journal of the Transactions of the Victoria Institute* 10, 340-385.
1877	S	Article		Howard, J.E. (1877). The supply of cinchona bark as connected with the present price of quinine. *Pharmaceutical Journal and Transactions*, 3rd series, 15th September, 207. Also reprinted In *Yearbook of pharmacy*, 1877. (1877). John Churchill & Sons
1878	S	Article		Howard, J.E. (1878). The fast-growing variety of Chinchona called pubescens. *Pharmaceutical Journal and Transaction*, 3rd series, 20th April, 825.
1878	S	Article		Howard, J.E. (1878). Analysis of barks brought by Mr. Cross. *Pharmaceutical Journal and Transaction*, 3rd series, 17th August, 140.
1878	C	Article		Howard, J.E. (1878). The influence of true and false philosophy on the formation of character (Annual Address*). Journal of the Transactions of the Victoria Institute* 12, 164-188.
1878	L	Book		Howard, J.E. (1878). *Essay on Elizabeth Barrett Browning's sonnets from the Portuguese.* G.E. Waters.
1879	S	Article		Howard, J.E. (1879). East India Homemade Alkaloids. *Pharmaceutical Journal and Transaction*, 3rd series, 18th January, 611.
1879	S	Article		Howard, J.E. (1879). Note on the Cinchona alkaloids. *Pharmaceutical Journal and Transaction*, 3rd series, 24 May, 972.
1879	S	Article		Howard, J.E. (1879, May 17). Chinchona in India. *Gardeners' Chronicle*, 1879, 622.
1879	S	Article		Howard J.E. (1879). A note on aricine. *Pharmaceutical Journal and Transactions*, 3rd series, 27th September, 249-250.
1879	S	Article		Howard, J.E. (1879, October). Chinchona ledgeriana. Gardeners' *Chronicle*, 457.
1879	C	Article		Howard, J.E. (1879). Creation and providence. *Journal of the Transactions of the Victoria Institute* 12, 191-242.
1879	R	Book		Howard, J.E. (1857). *The shepherd, the stone of Israel*. (2nd Ed.). Unknown Publisher.
1879	S	Article		Howard, J. E. (1879). Datura arborea. *Gardeners' Chronicle* & New Horticulturist 11(266), 140–41.
1879	R	Unknown		Howard, J.E. (1879). *Two apostles and one church*. Unknown Publisher
1880	S	Article		Howard J.E. (1880). Origin of the Calisaya ledgeriana of commerce. *Pharmaceutical Journal and Transactions*, 3rd series, 13th March, 730.
1880	S	Article		Howard, J.E. (1880, April 3). Chinchonas. *Gardeners' Chronicle*, 427.
1880	C	Article		Howard, J.E. (1880). The caves of South Devon and their teaching. *Journal of the Transactions of the Victoria Institute* 13, 163-210.
1880	R	Article		Howard, J.E. (1880). The Druids and their religion. *Journal of the Transactions of the Victoria Institute* 14, 87-134.
1881	S	Article		Howard J.E. (1881). Cultivation of Calisaya. *Pharmaceutical Journal and Transactions*, 3rd series, 18th September, 244.
1881	R	Book		Howard, J.E. (1881). *Pros Hebraious. The epistle to the Hebrews*. (2nd ed.). James E. Hawkins.
1882	C	Article		Howard, J.E. (1882). The early destinies of man. *Journal of the*

				Transactions of the Victoria Institute 15, 159-190
1882	C	Article		Howard, J.E. (1882). What are scientific facts? *Journal of the Transactions of the Victoria Institute* 15, 221-235.
1883	S	Article		Howard J.E. (1883). Effect of altitude on the alkaloid in red bark. *Pharmaceutical Journal and Transactions.* 3rd series, 9th June, 1013.
1883	S	Article		Howard, J.E. (1883). What is the source of Ledger bark? [lecture notes]. *Pharmaceutical Journal & Transactions 14.* 111-113
1883	S	Article		Howard J.E. (1883). Brief note on Calisaya ledgeriana [Letter]. *Pharmaceutical Journal and Transactions.* 3rd series, *14* 1st September, 178.
1883	C	Article		Howard, J.E. (1883). The supernatural in nature. *Journal of the Transactions of the Victoria Institute* 16, 291-319.
1884	C	Article		Howard, J.E. (1884). On certain definitions of matter. *Journal of the Transactions of the Victoria Institute* 17, 171-193.

Appendix 4: Inventory Lists A-C

A - Howard's Blue Catalogue (1st Page only).

JEH/1/21 Library Art and Archives, RBG Kew



First Drawer
Barks of Bolivia (Quill)

Place	Mark	Date	Botan. name	Vernacular name	Contents
1 Bolivia	AHC	7 Jany 1853	Cinc. Calisaya var. naranjada	"Monopoly Quill"	Quinine 3.21; Do. unc. 0.04; Cinc. a trace; 3.25
2 Bolivia	AHC	7th Jany 1853	Cinc. Calisaya	"Monopoly Quill"	
3 Bolivia	AHC	7th Jany 1853	Cinc. Calisaya var β. Josephiana	"Monopoly Quill"	Quinine 1.63; Quinidine 0.63; Cinc 0.14; 2.40
4 Bolivia	AHC	7th Jany 1853	Cinc. ovata	(Ash bark) found in "Monopoly Quill"	Quinidine 0.50; Cinchonine 1.43; 1.93
5 Bolivia	AHC	7th Jany 1853	Cinc. pubescens	found in "monopoly Quill"	
6 Bolivia	AHC	7th Jany 1853		(smooth skinned) found in "monopoly Quill"	Quinidine 0.71; Cinchonine 0.80; 1.51
7 Bolivia	AHC	7th Jany 1853	C. suberosa?	found in "Monopoly Quill"	
8 Bolivia	(no 29)	1849	Cinc Calisaya	"Monopoly Quill"	Quinine 2.14; Q-oid 1.00; 3.14
9 Bolivia	JTP	8th June 1852	Cinc. Calisaya	"Monopoly Quill" (black quill)	Quinine 1.10; Do unc. 0.17; Cinc, a trace .27
10 Bolivia	AHC	Jany 1853	Cinc. Mutisii	("Hojas de roble" Pavon) found in "Monopoly Quill"	Quinine 0.74; Quinidine 0.36; Cinc 0.43; 1.53
11 Bolivia	AHC	May 1852	C. undulata? Pavon	found in "Monopoly Quill", ("lead bark")	Quinidine 0.47; Cinc cryst 0.51; 0.98
12 Bolivia	AHC	July 1852	Laplacea Quinoderma	found in "monopoly Quill"	
13 Bolivia	AHC	Dec: 1852	Cinc scrobiculata	found in "Monopoly Quill"	Quinidine 0.31
14 Bolivia	AHC	July 1853	Cinc	found in Monopoly Quill (Huamalies?)	Quinine (?) soluble in EL 2.00; Cinc - a trace
15 Bolivia	AHC CP	March 1852	Cinc Calisaya JP sort?	found in "Monopoly Quill", Amyglooking	Quinine 2.03; Sly ELE. 0.28; Cinchonine 0.04; 2.35
16 Bolivia	AHC		Cinc. cordifolia?	found in Monopoly Quill	
17	AHC	May 1853	Cinc —	annulose bark	Quinine 1.91; Quinidine (a. S2) 0.37; Do unc. 0.18; Cinc 0.11; 2.63
18	AHC	1852	C scrobiculata	lead bark	Quinidine 0.47; Cinchonine cryst 0.51; 0.98

B - Typewritten Inventory (Entire).

File 88, Cinchona shelves, Economic Botany Collection, RBG Kew.

SAMPLES IN THE HOWARD CINCHONA COLLECTION.

Drawer	Samples Nos.
1.	401-416.
2.	420-423, 427, 429-431, 434, 435, 450, 456, 461, 462, 478-480.
3.	418, 432, 433, 438, 440-447, 479, 482, 489, 543.
4.	417, 424-426, 448, 451-455, 457, 458, 464, 490, 491, 662.
5.	207, 419, 463, 465-477.
6.	428, 436, 439, 459, 481, 483-488, 492-496.
7.	497-509, 511, 512, 526.
8.	510, 513-525, 527, 528.
9.	437, 460, 529-542.
10.	625-627, ?628, 629-640.
11.	561-564, 566-576, 583.
12.	641-656.
13.	565, 577-582, 584-592.
14.	593-608.
15.	609-623, ?624.
16.	208, 659, 673-685, 687.
17.	545-557, ?558, 559-560.
18.	657, 658, 660-672, 686, 688.

C - RPS Accession Inventory (Entire).

File 88, Cinchona shelves, Economic Botany Collection, RBG Kew.

J.E. HOWARDS CINCHONA
COLLECTION FROM DESK DRAWERS

Drawer marked "BARKS OF NUEVA GRANADA etc.
CINC. LANCIFOLIA"
672 · 669 · 428 · 520 · 485 · 497 · 659 · 486 · 505 · 528 · 664
510 · 526 · 495 · 436

BARKS OF VENUZUELA MARACAIBO etc.
ALSO SPURIOUS BARKS
556 · 558 (? JMR 8/2/52) 670 · 686 · 667 · 688 · 557 · 559 ·
549 · 546 · 687 · 685 · 548 · 547 · 513 · 583

BARKS OF BOLIVIA · The quill of Calisaya bark and other species found in the serons (?)EE. of "Monopoly Quill"
671 · 666 · 665 · 469 · 658 · 638 · 668 · 657 · 551 · 663 ·
560 · 636 · 661 · 660 · ~~461 (large tube)~~

BARKS OF BOLIVIA. CALISAYA, varieties
Josephiana etc.
412 · 406 · 408 · 207 · 441 · 482 · 448 · 479 · 405
413 · 407 · 414 · 473 · 478 · 477 · 438
~~Characteristics~~ 2B · 14 ·

BARKS OF BOLIVIA CALISAYA
443 · 446 · 453 · 434 · 452 · 451 · 402 · 403 · 447 · 435
445 · 444 · 442 · 401 · 440 · 416

BARKS OF CARABAYA, MARCAPATA etc.
Cinchona ovata, varieties.
608 · 607 · 605 · 604 · 603 · 602 · 601 · 598 · 606 · 600 · 599
597 · 596 · 595 · 594 · 593

BARKS OF BOLIVIA · C. BOLIVIANA
569 · 570 · 571 · 572 · 573 · 574 · 575 · 576 · 561 · 562
563 · 564 · 640 · 566 · 567 · 568

BARKS OF BOLIVIA COCHABAMBA etc.
643 · 649 · 650 · 651 · 652 · 654 · 655 · 656 · 647 · 646 · 645 · 644 · 648 · 641 · 642 · 653

BARKS OF BOLIVIA and of CARABAYA
CINCHONA OVATA, varieties.
580 · 584 · 585 · 587 · 588 · 590 · 591 · 592 - 565 · 577
578 · 579 · 581 · 582 · 586 · 589.

BARKS OF PERU.
626 · 627 · 628 (? JMR 8/2/52) 662 · 643 · 629 · 491 · 489
472 · 476 · 456 · 458 · 457 · 461 · 475 · 480

BARKS OF PERU, HUAMALIES etc.
CINCHONA PUBESCENS.
554 · 633 · 553 · 635 · 552 · 625 · 541 · 634 · 632 ·
583 · 637 · 542 · 630 · 631 · 540 · 639.

BARKS OF PERU, LOXA. CINC CONDAMINEA varieties
504 · 423 · 422 · 421 · 430 · 431 · 427 · 432 · 418
470 · 462 · 433 · 471 · 455 · 474 · 468

BARKS OF NUEVA GRANADA. CINC LANCIFOLIA
494 · 498 · 492 - 439 · 506 · 501 · 488 · 514 - 503 · 496
484 · 493 · 487 · 512 · 481 · 459

BARKS OF BOLIVIA & CARABAYA, C. GLANDULIFERA AMYGDALIFOLIA.
622 · 621 · 620 · 619 · 618 · 610 · 611 · 609 · 678 · 623
617 · 615 · 614 · 613 · 612 · 616.

JE Howards Collection. (2)

BARKS OF CARABAYA CUZCO etc
CINC SCROBICULATA, AMYGDALIFOLIA
555 545 · 550 · 682 · 681 · 680 · 679 · 624 (? JMR 8/4/52)
684 · 683 · 208 · 673 · 675 · 676 · 674

BARKS OF GUAYAQUIL. RED BARKS + WHITE BARKS.
429 · 410 · 426 · 420 · 464 · 460 · 463 : 490
417 · 409 · 411 · 425 · 424 · 419 · 454 · 467

BARKS OF ECUADOR and NEW GRANADA GUAYAQUIL + PITAYO.
529 · 523 · 524 · 535 · 537 · 460 · 538 · 437
465 · 530 · 531 · 532 · 525 · 534 · 536 · 533

BARKS OF NUEVA GRANADA of POPAYAN and PITAYO
500 · 519 · 511 · 509 · 507 · 522 · 502 · 527 · 499 · 518
517 · 508 · 515 · 516 · 521 · 539

Appendix 5: Table showing modern locations of Howard's Books in Libraries and Museums[236]

Book	Country	Location
The Quinology of the East India plantations, (1869-1876)	Australia	State Library of NSW
Die Nueva Quinologia [German Edition/Allgemeiner Österreichischer Apothekerverein]	Austria	Österreichische Nationalbibliothek
The Quinology of the East India plantations, (1869-1876)	Canada	Université du Québec à Chicoutimi
The Quinology of the East India plantations, (1869-1876)	Canada	University of Victoria Libraries
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	France	Institut de France, Paris
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	France	Bibliotheque Central du Museum National History Naturelle, Paris
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	France	Bibliotheque Central du Museum National History Naturelle, Paris
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	France	Muséum national d'histoire naturelle, Paris
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	France	Guibourt, Nicolas-Jean-Baptiste-Gaston [via Google Books]
Illustrations of the Nueva Quinologia of Pavon (1862)	France	Institut de France, Paris
The Quinology of the East India plantations, (1869-1876)	France	Muséum national d'histoire naturelle, Paris
The Quinology of the East India plantations, (1869-1876)	France	University Louis Pasteur, Strasbourg
The Quinology of the East India plantations, (1869-1876)	France	Université de Strasbourg
Die Nueva Quinologia [German Edition/Dt. Übers. des Textteiles der engl. Ausgabe]	Germany	Universität Mainz, Zentralbibliothek
The Quinology of the East India plantations, (1869-1876)	Germany	Deutsche Nationalbibliothek Frankfurt am Main
The Quinology of the East India plantations, (1869-1876)	Germany	Niedersächsische Staats- und Universitätsbibliothek Göttingen
The Quinology of the East India plantations, (1869-1876)	Germany	Universitätsbibliothek der Eberhard Karls Universität, Tübingen
The Quinology of the East India plantations, (1869-1876)	Germany	Deutsche Nationalbibliothek Leipzig
The Quinology of the East India plantations, (1869-1876)	Germany	Universitätsbibliothek Regensburg
Illustrations of the Nueva Quinologia of Pavon (1862)	India	Andhara University, Visakhapatnam
Illustrations of the Nueva Quinologia of Pavon (1862)	India	National Library of India
The Quinology of the East India plantations, (1869-1876)	India	National Library of India
The Quinology of the East India plantations, (1869-1876)	India	National Library of India
The Quinology of the East India plantations, (1869-1876)	Ireland	Trinity College, Dublin
The Quinology of the East India plantations, (1869-1876)	Malaysia	Asia Pacific University of Technology and Innovation

[236] Data Sources:
World Cat; Hathi Trust; Biodiversity Heritage Library; British Library; Jisc Library Hub Discover; India Cat; National Library of India; The Indian Culture Portal; Google Books, as well as the catalogues of institutes not represented on the above catalogues: the Royal College of Physicians, Linnean Society, Biodiversity Heritage Library.

Die Nueva Quinologia [German Edition/Dt. Übers. des Textteiles der engl. Ausgabe]	Netherlands	Bibliotheek Universiteit van Amsterdam [Library University of Amsterdam]
Illustrations of the Nueva Quinologia of Pavon (1862)	Netherlands	Naturalis, Leiden
Illustrations of the Nueva Quinologia of Pavon (1862)	Netherlands	Universiteitsbibliotheek Leiden [Leiden University Library]
The Quinology of the East India plantations, (1869-1876)	Netherlands	Erasmus University Rotterdam
The Quinology of the East India plantations, (1869-1876)	Netherlands	Naturalis, Leiden
The Quinology of the East India plantations, (1869-1876)	Netherlands	Universiteitsbibliotheek Leiden (Leiden University Library)
The Quinology of the East India plantations, (1869-1876)	Netherlands	Bibliotheek Universiteit van Amsterdam (Library University of Amsterdam)
The Quinology of the East India plantations, (1869-1876)	Netherlands	Universiteitsbibliotheek Utrecht (Utrecht University Library)
The Quinology of the East India plantations, (1869-1876)	Netherlands	Wageningen University and Research Library
Illustrations of the Nueva Quinologia of Pavon (1862)	Spain	Biblioteca Digital del Real Jardin Botanico de Madrid
Die Nueva Quinologia von Pavon. Erläutert durch illuminirte Tafeln von W. Fitsch, F.L.S., und Bemerkungen über die beschriebenen Chinarinden von J. E. Howard ... In deutscher Uebersetzung herausgegeben vom Allg. österr. Apotheker-Vereine.	UK	British Library, London
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	UK	King's College, London
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	UK	Wellcome Collection, London
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	UK	Royal College of Physicians, Edinburgh
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	UK	RBG, Kew
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Wellcome Collection, London
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	British Library, London
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	RBG, Kew
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	British Library, London
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	University of Liverpool
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	University of Edinburgh Library
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Royal Horticultural Society Library
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Royal College of Physicians, Edinburgh
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	University of Birmingham
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	University of Glasgow
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Natural History Museum Library, London
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Royal Society Library, London
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	National Library of Scotland
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	University of Cambridge
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Linnean Society, London
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Univeristy of Oxford
Illustrations of the Nueva Quinologia of Pavon (1862)	UK	Queen's University Belfast

The Quinology of the East India Plantations (1869-72)	UK	Royal College of Physicians, London
The Quinology of the East India Plantations (1869-72)	UK	RBG, Kew
The Quinology of the East India plantations, (1869-1876)	UK	University of Birmingham
The Quinology of the East India plantations, (1869-1876)	UK	Wellcome Collection, London
The Quinology of the East India plantations, (1869-1876)	UK	British Library, London
The Quinology of the East India plantations, (1869-1876)	UK	University of Cambridge
The Quinology of the East India plantations, (1869-1876)	UK	Univeristy of Oxford
The Quinology of the East India plantations, (1869-1876)	UK	University of Aberdeen, Scotland
The Quinology of the East India plantations, (1869-1876)	UK	Linnean Society, London
The Quinology of the East India plantations, (1869-1876)	UK	Natural History Museum Library, London
The Quinology of the East India plantations, (1869-1876)	UK	Royal Horticultural Society Library
The Quinology of the East India plantations, (1869-1876)	UK	Royal Society Library, London
The Quinology of the East India plantations, (1869-1876)	UK	University of East Anglia
The Quinology of the East India plantations, (1869-1876)	UK	Univeristy of Birmingham
The Quinology of the East India plantations, (1869-1876)	UK	University of Liverpool
The Quinology of the East India plantations, (1869-1876)	UK	University of Edinburgh
The Quinology of the East India plantations, (1869-1876)	UK	National Library of Scotland
The Quinology of the East India plantations, (1869-1876)	UK	University of Aberdeen
The Quinology of the East India plantations, (1869-1876)	UK	Queen's University Belfast
Examination of Pavon's collection of Peruvian barks contained in the British Museum (1853)	USA	Harvard University, Cambridge, MA
The Quinology of the East India plantations, (1869-1876)	USA	Yale University Library, New Haven, CT
The Quinology of the East India plantations, (1869-1876)	USA	Muhlenberg College Library, PA
The Quinology of the East India plantations, (1869-1876)	USA	Princeton University Library, NJ
The Quinology of the East India plantations, (1869-1876)	USA	Academy of Natural Sciences, PA
The Quinology of the East India plantations, (1869-1876)	USA	Saint Joseph's University Libraries, PA
The Quinology of the East India plantations, (1869-1876)	USA	University of the Sciences in Philadelphia
The Quinology of the East India plantations, (1869-1876)	USA	Wilmington University Library, DE
The Quinology of the East India plantations, (1869-1876)	USA	Library of Congress, DC
The Quinology of the East India plantations, (1869-1876)	USA	Patrick Henry College Library, VA
The Quinology of the East India plantations, (1869-1876)	USA	University of Michigan, MI
The Quinology of the East India plantations, (1869-1876)	USA	Duke University LIbraries, NC
The Quinology of the East India plantations, (1869-1876)	USA	University of North Carolina at Chapel Hill. University Libraries, NC
The Quinology of the East India plantations, (1869-1876)	USA	Virginia Tech, VA
The Quinology of the East India plantations, (1869-1876)	USA	Chicago Botanic Garden XWH, IL
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