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Cambridge University Herbarium: rediscovering a botanical treasure trove

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Abstract

The Cambridge University Herbarium has a rich history of over 300 years of plant collection, inventory, production of taxonomic literature, and teaching of botany. The herbarium of some 1.1 million dried, pressed plant specimens includes collections made by some of the great British botanists including Charles Darwin, Alfred Russel Wallace, Nathaniel Wallich, and Richard Spruce. Over its history, the Herbarium has experienced various stages of evolution, expansion, changing research focuses, and threats, and over the last 100 years was particularly important in European and British taxonomy and floristics. Currently the collections are relatively poorly known and have virtually no visibility outside the physical building in which they are housed. The historic specimens represent a treasure trove of unstudied material and are especially rich in nomenclatural type specimens. This paper aims to provide an overview of the history of the collection, and to raise awareness of its existence. Now with a new Curator, in an era of collections digitisation and interdisciplinary research, the potential to open this Herbarium up via collaborative research, teaching, and engagement is huge.

Keywords: Collections, Darwin, flora, herbaria, Lemann, Lindley, plants, species discovery, Rackham, Sell, Spruce, Wallace, Wallich

The Cambridge University Herbarium: location and context

The Cambridge University Herbarium, CGE (international herbarium code, Thiers 2018), is the University of Cambridge's main herbarium. Based historically and administratively within the Department of Plant Sciences (previously known as the Botany School), CGE is physically located within the Sainsbury Laboratory Cambridge University, a research institute itself based within the grounds of the Cambridge University Botanic Garden.

A major collection of dried, pressed plant specimens collected over more than 300 years, with enormous scientific and historical value, CGE has an important place in the history and development of scientific thinking about the natural world, and botanical discovery and description. Many of the specimens in the collection appear to have never been studied, or even properly documented, since they were originally collected.

Of the 552 herbarium codes for the UK listed on Index Herbariorum (Thiers, 2018), only 74 have been

updated within the last 15 years and are recorded as holding more than 100 specimens. The three huge herbaria of the Royal Botanic Gardens, Kew (K), Natural History Museum (BM), and Royal Botanic Garden Edinburgh (E), each hold between 3-7 million specimens. CGE is currently recorded as the fourth largest collection in the UK, with a similar number of specimens as the University of Manchester (MANCH), the Oxford Herbaria (OXF and FHO), and the National Museum Wales (NMW).

Overview of the collections at CGE

CGE contains an estimated 1.1 million specimens, and is thought to house some 50,000 nomenclatural type specimens, a very high proportion and comparable to the major collections of the world. These type specimens are currently the focus of most research enquiries from outside Cambridge. In part due to the research focus of CGE during the 20th century, the collection is especially rich in Great Britain and Ireland (c. 300,000) and mainland Europe (c. 200,000) vascular specimens. CGE also has extensive and historically important vascular collections from the rest of the world, accounting for some 400,000 specimens, and where many of the as yet undesignated type specimens are to be found. These 'World' (i.e. non-European) collections have been little studied, and many have remained in their original papers since their arrival in Cambridge, in some cases nearly 200 years ago.

Some 148 images of CGE type specimens are available on JSTOR Global Plants., These were imaged during the Mellon Foundation African Plants Initiative (Smith and Figueiredo, 2014) in 2007, and only include those African specimens which were known to be types in the collection already plus four type specimens from Europe (Portugal). Anecdotally, these records on JSTOR Global Plants are quite misleading to researchers. Rather than encouraging them to look in CGE for further types, researchers have commented they had assumed that all of the CGE type collections must have been imaged and made available via JSTOR Global Plants. With some 12,000 type specimens physically curated into red paper folders at CGE, and new types being identified regularly by visiting researchers working on the 'World' collections, the 148 types available on JSTOR Global Plants is a tiny proportion of the likely total.

The bryophyte collections at CGE are substantial, perhaps accounting for over 80,000 specimens, and incorporate important collections made by William Edward Nicholson (1866-1945), Thomas Laflin (1914-1972), and Harold Leslie Keer Whitehouse (1917-2000). The algae, fungi, and lichen collections at CGE are smaller in number but similarly appear to have received very little attention since specimens were deposited. Based on the history and type-richness of the vascular collections and discussions with colleagues at other institutions, the non-vascular collections are likely to also contain many types and historically and scientifically important material, but the degree to which this is the case remains to be ascertained.

CGE is revealing itself to contain an enormous number of hitherto undocumented specimens from important collections and collectors over the last 300 or more years. These specimens have not yet been catalogued or imaged as part of the various projects to bring such specimens together internationally. Such specimens include those from important 19th century expeditions such as the H.M.S. Challenger Expedition (1872-1876), and the Ross Antarctic Expedition of H.M.S. Erebus and Terror (1839-1843) on which Joseph Dalton Hooker (1817-1911) (later the second Director of the Royal Botanic Gardens, Kew) collected. There appear to be a least one, if not more sets of specimens from the Herbarium of the British East India Company. The main set of this collection - also frequently referred to as the 'Wallich Herbarium', for Nathanial Wallich (1786-1854) who produced and distributed a list of the material along with the specimens - is at Kew, but multiple sets were distributed to other institutions and individual collections. Several separate sets appear to have come to Cambridge, in the collections of Henslow, Lindley, and Lemann (each discussed later in this paper). The situation seems to be similar for material collected by Richard Spruce (1817-1893), who travelled in the Amazon and the Andes between 1849 and 1864, sending back huge numbers of specimens and ethnographic material and information. There are large numbers of Spruce specimens at CGE, likely in the same three private collections mentioned above, now all housed in the same room.

In addition to preserved plant specimens, CGE also contains a substantial, virtually undocumented and unpublished collection of original botanical artwork, photographic slides, microscope slides, printed photographs, some portraits on various media, large format teaching illustrations, archive documents and collectors' notebooks, and an impressive botanical library, part of the Library of the University of Cambridge Department of Plant Sciences.

History of CGE and major collections to the end of the 19th century

18th century origins: Martyn's Hortus Siccus

The gift of John Martyn's *Hortus Siccus* and fine botanical library to the University of Cambridge, in the 1760s, is considered to be the foundation of the CGE collections. Martyn (1699-1768) was the second professor of botany at Cambridge, and combined his botanical career with being a London-based medic. In 1721, Martyn was one of a group who formed a botanical society, with Martyn as the secretary and Johan Jacob Dillenius (1684-1747) (later the first Sherardian professor of botany at Oxford University) as the president. Invited to give a series of lectures in Cambridge, teaching medical students basic plant morphology - as a precursor to learning to identify medicinal and poisonous taxa - ultimately led to his election to the chair of botany in 1733.

It is not currently clear how large Martyn's original collection was but it seems that over 3,000 specimens survive today (Figure 1). Martyn collected specimens around London and the west of England, and added specimens made by other British collectors including Patrick Blair (c.1666-1728), Samuel Brewer (1670-1743), John Clayton (1694-1773), Johan Jacob Dillenius (1684-1747), Robert Foulkes (c.1702-1729), William Houstoun (c.1695-1733), Joseph Miller (d. 1748), Richard Pultaney (1730-1801), Isaac Rand (d.1743), James Sherard (1666-1738), William Sole (1741-1802), and Daniel Carl Solander (1733-1782).

Thomas Martyn (1735-1825), succeeded his father in 1762 to become the third professor of botany in Cambridge, and although he is not thought to have added significantly to the number of specimens in the collection over his lifetime, he is known to have gone through his father's collection and added Linnean binomial names, genus and specific epithet, to each specimen. Meticulously, he often seems to have included the reference to the page in Carl Linnaeus' *Species Plantarum*, published in 1753 after many of the specimens were made, on these 18th century 'det. [*determinavit*] slips'. Holding the chair of botany in Cambridge for over 60 years, Thomas Martyn did not teach (or live) in Cambridge for the last 30 years of his tenure and the Herbarium was left in poor conditions, subject to attack by pests and damp, in spite of Thomas Martyn lobbying the university for better accommodation for the specimens.

Henslow's rescue and scientific development in 19th century

In 1825, John Stevens Henslow (1796-1861), became the fourth professor of botany in Cambridge. One of the tasks he set about early in his new position was the recovery and conservation of as many specimens as possible from Martyn's collection, which were by now in a terrible condition. Lobbying the University for funds to purchase suitable paper for the specimens, Henslow seems to have single-handedly remounted over 3,000 of the original 18th century specimens, stamping or labelling each as 'Mus. Martyn', but the rest of the material could not be salvaged and was destroyed.

Over the next 20 years, Henslow added over 3,500 of his own specimens to the collection, many from locations in Cambridgeshire, neatly labelled in his meticulous handwriting with the taxon, location, collection date, and collector name, and a label marking the sheet as part of 'Mus. Henslow'. The majority of Henslow's specimens show his quite unusual 'collated sheet' method (Figure 2), where he effectively records the variability seen in a plant population, from smallest to largest in size, and different growth forms, with multiple plants arranged on a single sheet. Many of these collated sheets have the plants arranged in an aesthetically pleasing manner, in ascending or descending order of height, or bell curves. Besides variability, Henslow's specimens also show his interest in recording and studying nature's 'monstrosities' (i.e. mutant forms), hybridisation, and his teaching practices, and include many hand drawn diagrams and illustrations cut out from journals (Figure 3).

Henslow was an innovative teacher and CGE is home to a wide selection of his materials, including hundreds of his illustrated teaching sheets which would be used in his lectures and practical classes, and a complete (and recently conserved) set of nine large format teaching diagrams produced by the Department of Art and Science in 1857 and distributed around the country. Few complete sets of these illustrations, precursors to the far better-known German botanical illustrations produced by Dodel-Port, Kny, and others, seem to exist today. Henslow's original hand-drawn, large-format illustrations - which were used in the Cambridge School of Botany up until the mid-20th century - are now in a large collection of botanical illustrations held in the University's Whipple Museum of the History and Philosophy of Science.

Figure 1. Anemone nemorosa specimen in Martyn herbarium (CGE08887) © Cambridge University Herbarium

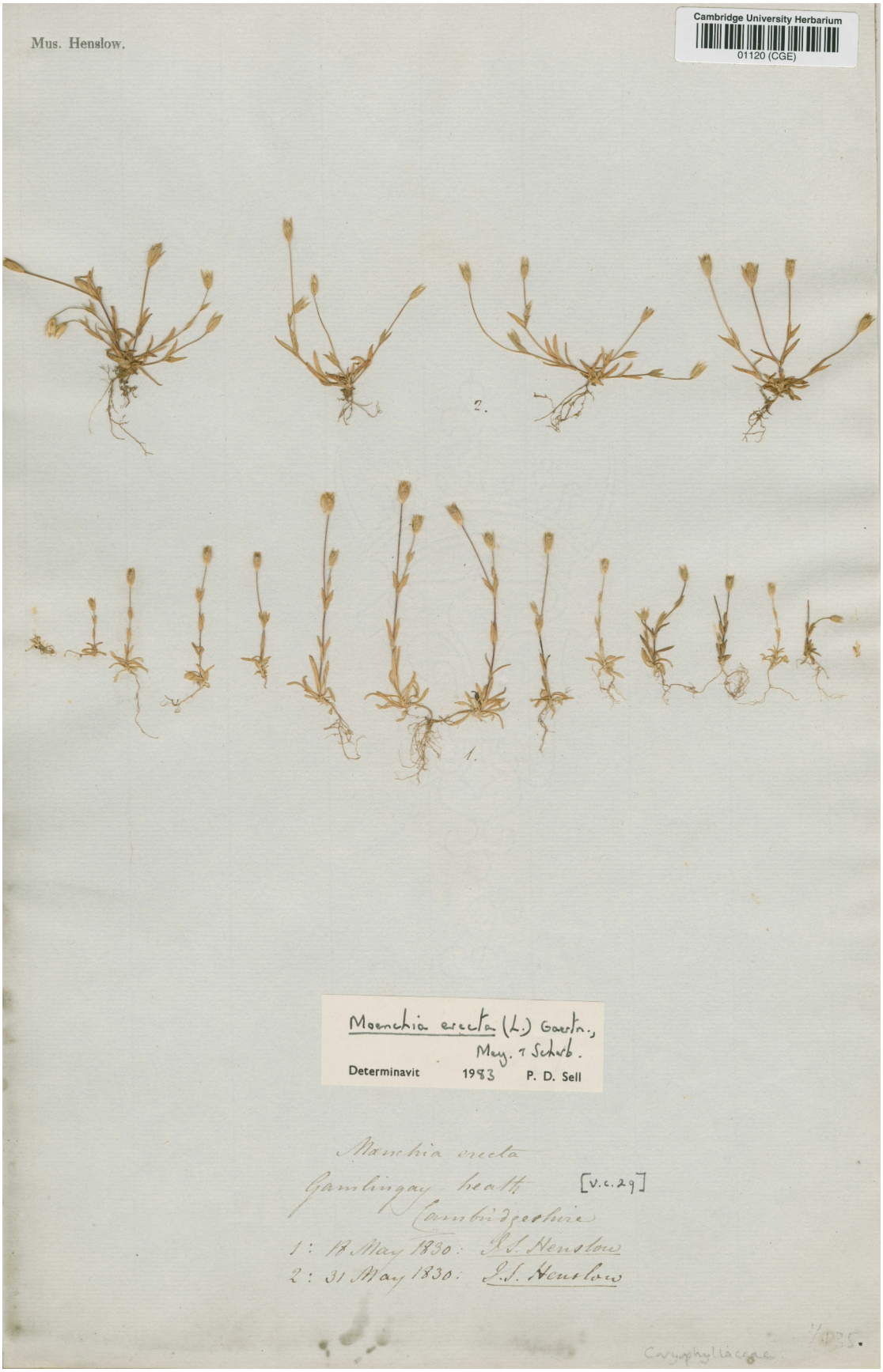

Figure 2. Moenchia erecta specimen showing Henslow's 'collated sheet' method (CGE01120) © Cambridge University Herbarium

Henslow was extremely well connected to other members of the British scientific community of the age, and with his friend Adam Sedgwick, professor of geology in Cambridge, had founded the Cambridge Philosophical Society back in 1819. The entomologist Leonard Jenyns (1800-1893) was a lifelong friend, collecting many specimens with Henslow, and became his brother-in-law, having introduced Henslow to his sister. Henslow corresponded with his student Charles Darwin throughout his life, and with other influential scientists including Kew's first Director, William Jackson Hooker (1785-1865) and his son Joseph, later to become Kew's second Director. Indeed, Joseph Hooker's first wife was Henslow's daughter, Frances Harriet (1825-1874). Many additions to CGE under Henslow would have been due to his network of friends and fellow botanists, and other notable acquisitions included specimens from Richard Thomas Lowe (1802-1874), William Swainson (1789-1855), and the herbaria of Charles Morgan Lemann and Charles Darwin.

Charles Morgan Lemann (1806-1852)

Lemann studied medicine at Trinity College, Cambridge, and in his short lifetime travelled and collected botanical specimens in Madeira, Gibraltar, Italy, Tenerife, and Spain. He built up a collection of over 50,000 specimens, incorporating others' collections from all over the world, especially from southern Europe, North America, Brazil, Guiana, the Cape of Good Hope, and Australia. Known to be rich in type specimens, the Lemann herbarium is even more interesting on the basis that a condition of Lemann's will was that the collection be bequeathed to Cambridge - but only after George Bentham (1800-1884), Secretary of the Royal Horticultural Society 1829-1840) and later based at the Royal Botanic Gardens, Kew, was allowed to name and arrange it first. Bentham spent much of the next seven years mounting, naming, arranging – and adding to – the collection. In 1860, the collection came to Cambridge

Figure 3. Eschscholzia californica specimen showing Henslow's illustration and interest in 'monstrous' forms (CGE01967) © Cambridge University Herbarium

and, under Charles Babbage, was incorporated into the main 'World' section of CGE.

Charles Robert Darwin (1809-1882)

Charles Darwin is one of Cambridge's most famous students, and the bulk of his botanical specimens reside within CGE, and form the most well-known part of the collections. Darwin was a student at Christ's College from 1828 to 1831, officially studying theology but able to attend other lecture series alongside his religious studies. Encouraged by his cousin, also at Christ's, Darwin became fascinated with natural history and attended Henslow's innovative lecture series on botany three years running. Henslow would take his students on field excursions in Cambridgeshire, during which many of the 'Mus. Henslow' specimens were made, and Darwin's attendance at these 'herborizing' trips and Saturday rambles was so consistent that the otherwise unknown student came to be referred to as 'the man who walks with Henslow'.

It was Henslow who recommended Darwin to Captain Fitzroy to act as the ship's naturalist and a companion for Fitzroy on the voyage of the H.M.S. Beagle, and to Henslow that Darwin sent all of his botanical, zoological, and geological specimens during the five-year voyage (1831-1835). Henslow and Darwin corresponded throughout the voyage, and much of this correspondence is held in the Cambridge University Library, and has been digitised as part of the Darwin Correspondence Project (Burkhardt et al., 1985–). Kohn et al. (2005) discussed the impact of Henslow's teaching on Darwin and his scientific thinking, focusing particularly on variation, 'monstrous' forms (i.e. mutants), and hybridisation, based on the evidence presented in Henslow and Darwin's herbarium specimens, all held at CGE.

Darwin collected approximately 1,400 plant specimens during his circumnavigation of the world (Figure 4). Henslow mounted and labelled these on their arrival in Cambridge, sending many to the Royal Botanic Gardens, Kew and others to identify (and in several cases name and publish new species), allowing them to retain duplicated specimens for their own herbaria. The Galapagos specimens received particular attention and were studied by Joseph Hooker at Kew, who published his findings in a series of papers (Hooker, 1847a; 1847b). The vast majority of the Beagle specimens were returned to CGE, and today comprise nearly 1,000 sheets, alongside a number of specimens Darwin made in the UK before and after the voyage, including the first known specimens attributable to Darwin, made at the end of a trip to north Wales with the Cambridge professor of geology, Adam Sedgwick, just months before H.M.S. Beagle departed with Darwin on board.

Babington's tenure: a period of acquisition

The fifth professor of botany, Charles Cardale Babington (1808-1895) had been a contemporary of Charles Darwin studying under Henslow, and later became a demonstrator for Henslow's lectures. When Henslow moved to a country parish in Hitcham, Suffolk, in 1839, only returning to deliver his annual lecture series, Babington became his deputy in the Botany School. Babington collected his own specimens across the British Isles and also in Iceland, and his personal herbarium of c. 55,000 sheets was incorporated into the main collection at CGE during his lifetime. During Babington's tenure, CGE gained its first Curator, William Hillhouse (1850-1910) in 1880, followed by Thomas Hughes Corry (1859-1883) in 1882, Michael Cresse Potter (1858-1948) in 1883, and Isaac Henry Burkill (1870-1965) in 1891. Burkill rearranged the entire herbarium in accordance with Bentham and Hooker's recently published three-volume *Genera Plantarum* (Bentham and Hooker 1862-1883), and the bulk of the 'World' collections remain in this sequence. Babington was responsible for the enormous growth of CGE with the acquisitions of many specimens, via purchase and bequests, including several herbaria of a similar size and scale to his own – most significantly with the collections of John Lindley, Charles Fox Bunbury, John Edward and Maria Emma Gray, and Leon Gaston Genevier. He also acquired an outstanding personal library which he left to the University.

John Lindley (1799-1865)

Lindley worked as an assistant librarian for Joseph Banks in 1819, before being employed to edit the *Collectanea Botanica* (1821) for William Cattley (1788-1835), the merchant and amateur orchid collector for whom the orchid genus *Cattleya* was named. He then created his own *Rosarum Monographia* in 1820 and monograph of *Digitalis* in 1821. In 1822, Lindley became assistant secretary of the Horticultural Society (which would later become the Royal Horticultural Society), under Joseph Sabine (1770-1837), then vice-secretary 1841-1858, before becoming secretary and a member of council. Working with George Bentham, he initiated the first of the society's flower and fruit exhibitions, established Gardeners' Chronicle in 1841, and became a prolific author of botanical publications

Figure 4. Sicyos villosa specimen collected by Charles Darwin in 1835 © Cambridge University Herbarium (CGE00353)

Figure 5. Echeveria acutifolia specimen collected by Carl Hartweg in 1842 © Cambridge University Herbarium (CGE05621)

and newly described species. The Horticultural Society, and Lindley himself, became a hub for the publication and promotion of the thousands of species new to western science being collected around the world. These new species came from the Society's own plant collectors, including Karl Theodor Hartweg (1812-1871) (Figure 5), and those of the great Victorian nurseries of James Veitch and Sons in Chelsea, and Loddiges in Hackney. Specimens from Richard Spruce (1817-1893), Thomas Lobb (1820-1894), William Lobb (1809-1864), David Douglas (1799-1834), James Drummond (c.1784-1863), Alfred Russel Wallace (1823-1913), and many other great collectors of the Victorian era are held in this collection.

After Lindley's death, the University of Cambridge purchased his herbarium of 58,000 sheets (excluding the orchids, which the Royal Botanic Gardens, Kew, bought) in 1866. The collection is extremely rich in type specimens, especially for species described by Lindley himself, often in the highly illustrated Botanical Register (which he edited between 1829-1847) the Gardeners' Chronicle, and his other publications (Lindley 1820; 1821a; 1821b). During his life, Lindley's friends and correspondents George Bentham, William and Joseph Hooker, Jacob George Agardh (1813-1901), and Christian Gottfried Daniel Nees von Esenbeck (1776-1858) contributed to and studied the collection. It has been suggested anecdotally by multiple colleagues and visitors that it is likely duplicates of important specimens (including types) destroyed in the Berlin Herbarium in Germany during the second world war may yet be identified from this collection. These specimens may be likely to reside in Lindley's collection and also Babington's own herbarium, Babington having long corresponded with German botanists including Heinrich Gottlieb Ludwig Reichenbach (1793-1879), Wilhelm Daniel Joseph Koch (1771-1849), and Jacob Sturm (1771-1848).

Charles Fox Bunbury (1809-1886)

Bunbury studied at Trinity College, Cambridge. He collected plants in the UK, especially in East Anglia, and also South America (1833-1834), South Africa (1838-1839), Madeira (1853), and Tenerife (1853). He also brought together specimens from correspondents and family members from around the world, including South American material from his uncle Henry Stephen Fox (1791-1846), the herbarium of the author Charles Kingsley (1819-1875) from Devonshire, Tenerife, and the West Indies, and collections made by Charles Darwin in the UK. Bunbury's herbarium, thought to be 6,000 sheets, came to CGE on his death in 1886, but has never been incorporated into the main collection. It appears to have been the subject of virtually no research to date.

Gray and Genevier

Other substantial collections added to CGE during Babington's professorship include the Gray algae collection added in 1877, and the Genevier herbarium in 1869. John Edward Gray (1800-1875) and Maria Emma Gray (1787-1876) left their collection of 3,000 algae specimens to Cambridge University. The Keeper of Zoology at the British Museum (now the Natural History Museum) between 1840-1875, John Gray was also an algologist and hepaticologist, and Maria Gray (nee Smith) was a conchologist and organised the cryptogam collections at the British Museum. The large herbarium of Leon Gaston Genevier (1830-1880) was purchased by Babington and incorporated into the main collection, with the exception of the 6,000 sheets of *Rubus* specimens, an important collection which remains separate.

The evolution of CGE through the 20th century and into the 21st

Marshall Ward and the new 'Cambridge Botany'

In 1895, after the death of Babington, the chair of the Botany School in Cambridge was awarded to a student of Thomas Huxley, Harry Marshall Ward (1854-1906), father of the botanist and explorer Frank Kingdon-Ward. Marshall Ward oversaw the building of a new Botany School building, on the Downing Site in central Cambridge (Figure 6), opened by King Edward VII and Queen Alexandra on 1 March 1904. The herbarium was moved to occupy a purpose-built space on the ground floor of the new state of the art steel-framed building.

Figure 6. Botany School, University of Cambridge, 1904 © Department of Plant Sciences, University of Cambridge

During Marshal Ward's tenure, however, there was a move away from more traditional taxonomic botany, towards other aspects of plant science, such as physiology, pathology, and ecology. This continued under the next professor of botany, Albert Charles Seward (1863-1941), appointed in 1906. Herbarium Curators during the Marshal Ward and Seward periods were Henry Harold Welch Pearson (1870-1916) in 1898, Richard Henry Yapp (1871-1929) in 1900, Robert Heath Lock (1879-1919) in 1905, and Charles Edward Moss (1870-1930) in 1907.

The inter-war period: British and European taxonomy start to flourish

The appointment in 1921 of Humphrey Gilbert Carter (1884-1969) as Curator of the Herbarium, and also Director of the Cambridge University Botanic Garden (CUBG), reinvigorated botanical taxonomy in Cambridge via Gilbert Carter's inspirational teaching. Many now well-known botanical names passed through Cambridge during this and the post-war period.

John Scott Lennox Gilmour (1906-1986) followed Gilbert Carter in the Curatorship of the Herbarium 1930-1931, and Gilbert Carter continued as Director of CUBG until his retirement in 1951. After periods at the Royal Botanic Gardens, Kew and the Royal Horticultural Society between 1931-1951, Gilmour became Director of CUBG, a post he held for the next two decades. Gilmour and Tutin (1908-1987) published a booklet in 1933 about the 'more important collections' at CGE (Gilmour and Tutin, 1933) with the help of a young William Thomas Stearn (1911-2001), who worked in CGE during his lunch breaks in the 1930s. Stearn went on to work at the Lindley Library, Royal Horticultural Society, and then the Natural History Museum, London. David Henriques Valentine (1912-1987) was Curator of CGE in 1936-1945, going on to become the Professor of Botany at the University of Durham, and later of the University of Manchester.

Major collections bequeathed to CGE in the inter-war years were the British herbarium of Edward Shearburn Marshall (1858-1919), comprising some 23,000 sheets; the mostly Indian plant collections of William Philip Hiern (1839-1925); approximately 4,000 sheets of North American plants from Kenneth Kent Mackenzie (1877-1934); 6,000 sheets of British plants from Joseph Edward Little (1861-1935); and 24,000 sheets of British plants from Spencer Henry Bickham (1841-1933).

Post-World War II: The years of immense toil

The end of the second World War and the arrival of (Stuart) Max Walters (1920-2005) in 1948 as Curator of CGE heralded the start of a highly productive era of taxonomy and systematic botany in Cambridge (Walters, 1981). Signs in 1944 had not been promising, however; as Peter Derek Sell (1929-2013) later recalled, the Cambridge University Herbarium was 'a dead and dreary place' (Sell and Murrell, 2018). Peter Sell worked in CGE from 1944 until (and well after) his retirement in 1997, becoming Assistant Curator in 1972. In spite of his initial impressions, he later referred to the subsequent and extremely productive decades in the Herbarium as 'the years of immense toil'.

During the second half of the 20th century, the Cambridge Botany School, as with those in most other British universities, continued to move into more developmental, physiological, ecological, and molecular research areas, becoming the Department of Plant Sciences. The Herbarium and discipline of taxonomy formed a distinct 'group' within the department, as with most botany departments in UK universities. CUBG experienced a sustained period of expansion in the 1950s, with the substantial injection of funding provided by the Cory bequest, from Reginald Radcliffe Cory (1871-1934), who also left generous bequests for the Royal Horticultural Society's Lindley Library. Strong links with CUBG were maintained and aided by the now common (but not continuous) practice of co-appointment of the Herbarium Curatorship and Directorship of the Botanic Garden – Max Walters became Director of CUBG in 1973, handing over the Curatorship of the Herbarium to David Briggs.

Botanists based in Cambridge and at CGE formed an important base for much of the *Flora Europaea* (1964–93) project, with the six volumes published by Cambridge University Press (Tutin et al., 1964-1993) and contributors from 30 countries attending the final conference held at King's College, Cambridge in 1977. The resulting collections at CGE for continental Europe are large and comprehensive, but have been relatively little studied since this period. Over his lifetime, Sell added some 50,000 of his own specimens to CGE from across Great Britain and Ireland, many collected with Gina Murrell, who was Assistant Curator from 2002-2012 and his co-author on the five-volume *Flora of Great Britain and Ireland*, published between 1996 and 2018 (Sell and Murrell, 2018).

The Department's appointment of researchers and Chairs in subjects such as forestry, ecology, and tropical ecology, including the eminent figures of Augustine Henry (1857-1930), Arthur George Tansley (1871-1955), Edred John Henry Corner (1906-1996), Oliver Rackham (1939-2015), and Peter Grubb (1935-), whose work involved using and depositing specimens in CGE (Grubb, Stow and Walters, 2004), continued to add to and enrich the collections. CGE was part of the undergraduate teaching syllabus into the 1990s. Many students of these individuals went on to have prominent roles in botanical research around the world, and their collections and annotations on specimens at CGE alongside those of their supervisors further developed the herbarium. Henry's working set of specimens for the seven-volume *The Trees of Great Britain and Ireland* (Elwes and Henry, 1906-1913) are at CGE, as are many of Corner's South East Asian fig (*Ficus*, Moraceae) and mycological specimens.

Later in the 20th century, focus shifted away from taxonomic teaching, but new interest in some of the historical specimens at CGE developed. A substantial body of botanical research was produced based on the Darwin Beagle specimens, mostly in works published by Duncan Porter (1980a; 1980b; 1983; 1984; 1985; 1986; Porter, Murrell and Parker, 2009), but also via an early digitisation project based at CGE and funded by Microsoft. This project involved imaging and databasing the Darwin Beagle specimens and making them available online (although for some years now this dataset has been unavailable and only low resolution images have been available via the Herbarium's own simple website). During his time in Cambridge, John Stewart Parker, Director of CUBG and Curator of CGE between 1996 and 2010, undertook an enormous amount of work studying the specimens and writings of John Stevens Henslow, the influence of his innovative teaching methods in Cambridge and in his parish of Hitcham and their wider reach. In response to declining funding for CGE from the Department of Plant Sciences, Parker set up an informal 'Friends of the Herbarium' group of volunteers, several of whom continue to contribute much appreciated time and energy at CGE today.

21st century changes and challenges

In 2011, CGE moved physical home again, after over 100 years in Marshall Ward's at-the-time cutting-edge building into the 21st century equivalent, the £82 million Sainsbury Laboratory Cambridge University (SLCU) (Figure 7). Funded by the Gatsby Charitable Foundation, the SLCU is an ultra-energy efficient Stirling Prize winning building, housing state-of-the-art laboratory facilities and plant growth facilities, as well as facilities for CUBG and space for CGE in the basement of the building. A separate research institution within the University of Cambridge, research groups in the SLCU specialise in fundamental plant growth and development.

Figure 7. The Sainsbury Laboratory Cambridge University © Stanton Williams Architects.

Recognising that the facilities in the Department of Plant Sciences building in central Cambridge were not ideal for CGE, and that pest problems were an increasing risk to the specimens, CGE was moved into the new building and into modern compactor storage (Figure 8), with -30°C freezers for specimen quarantining. In addition, for the first time in many years, the entire CGE collection was able to be brought together and housed in the same space; the bryophytes had long been stored in another part of the Department, and much of the historic material had been stored off-site in various non-ideal locations, or in inaccessible locations in the old herbarium.

The move of CGE into new facilities corresponded with a number of key retirements in the herbarium, including that of the Curator (who had also been the Director of CUBG) and the Assistant Curator two years later in 2012, leaving the collections with a part-time

Figure 8. Compactor units inside the new Cambridge University Herbarium © Fu Xiang Quah, https://fxquah.smugmug.com

Technician as the sole member of staff until they, too, retired in 2017. In recent decades, CGE has had relatively limited research use by members of the Department, other Cambridge University Departments, and external individuals and organisations, and little integration into undergraduate or postgraduate teaching. Most recent research use has understandably focused on the Great Britain and Ireland collections, and CGE is relatively well-known to British and Irish botanists through Sell and Murrell's flora, and organisations such as the Botanical Society of the British Isles (BSBI). The other main research use of CGE is the many external enquiries received each week from botanists looking for Darwin or historical type specimens, especially those relating to names published by Lindley.

Current priorities for CGE

The potential of the CGE collections is significant, and the specimens a rich and a virtually untapped mine of scientific and historical research data but current knowledge or use of the Herbarium is very limited. With the appointment of a new Curator in late 2017, the role of the Herbarium (within the Department of Plant Sciences, University of Cambridge more widely, and internationally within the botanical and collections community and beyond), is being reassessed and new initiatives and collaborations planned.

A priority is to make the collections more accessible and usable for researchers, updating and creating policies for research use, loans, destructive sampling, and accessions, as well as upgrading collections care procedures and facilities, looking particularly at environmental and pest monitoring and control. The high-resolution digitisation of specimens, especially nomenclatural type specimens and particularly important collections such as the Martyn specimens, is now possible with the funding and acquisition of a new high-resolution imaging set-up and database, using international standards. It is planned that herbarium specimen images will be made accessible online via commonly used portals such as JSTOR Plants, the Global Biodiversity Information Facility (GBIF), and also on the Cambridge Digital Library (part of the Cambridge University Library, and home to digital versions of a huge array of internationally important documents including Isaac Newton's *Principia*, Stephen Hawking's PhD thesis, a copy of the Gutenberg Bible, and a Shakespeare First Folio edition).

Embedding CGE into the present-day research and teaching of the Department of Plant Sciences will be an important way of securing the collection's long-term future, and a productive way through which to explore the collections and stimulate their investigation. Raising awareness of the collections within the Department and other parts of the University via small group tours, open to all researchers, students, technical and administrative staff has been a remarkably successful approach. These tours have initiated many conversations about collaborative projects, teaching integration, and exhibitions, and work has started on a number of these activities already.

The investment of the University in housing the CGE within the Sainsbury Laboratory is significant, and the conditions in which the collections are now housed are far superior to those ever possible previously. Unfortunately, there are currently no financial resources to employ staff in Curatorial Assistant, Collections Manager, or Digitisation Assistant posts. Volunteer and student assistance is proving invaluable in order to maintain the basic functioning of the Herbarium, but also to initiate small 'proof of concept' projects via which to scope and properly cost funding applications for more significant and impactful activities. Further development of the number and range of volunteer and student opportunities is planned, but relying on unpaid assistance to fulfil the core tasks and functions of a herbarium is unsustainable and unethical. It will be essential to secure funding for even a modest level of staffing in the future, in addition to underwriting the position of Curator, who is currently appointed on a fixed-term basis only.

The first step of most research projects will simply involve documenting the relevant specimens in the collections and digitising them, and in doing so, build a database of CGE specimens. The nature of the arrangement of many of CGE's specimens, in quite atomised sections either relating to specific collectors or collections, taxonomic groups, or geographic areas, lends itself to a series of discrete small (50-1,000), medium (1,000-99,000), or large (100,000s of specimens) digitisation projects which could be undertaken at different funding levels. It is envisaged that these independent but linked projects would open up new avenues for further impactful research, and myriad 'stories' which could be used in teaching, engagement, and outreach. A priority will be to image Darwin's non-Beagle material and more recently discovered specimens which were previously elsewhere in the collection; the 12,000 type specimens already separated into red folders; and the 18th century Martyn collection.

The Herbarium is now part of the University of Cambridge Museums network, providing a pool of experienced colleagues across disciplines and areas of expertise – including conservation care, volunteer coordination, research impact, and public engagement. Staff, students, and volunteers are starting to investigate links between herbarium specimens at CGE and existing research going on in the Department and connections with the other University of Cambridge collections. Such links include those between the plant voucher specimens collected on the 1898 Haddon expedition to the Torres Strait Islands and the anthropological objects, notebooks and manuscripts housed at the Museum of Archaeology and Anthropology, and the re-discovery of the links between the teaching illustrations in CGE and the Fitzwilliam Museum and the Whipple Museum of the History and Philosophy of Science. The 'Bunbury' collection, only recently unwrapped from the paper bundles in which it had been stored for decades (if not longer), is currently being curated and this collection will be digitised and made available for study as a discrete project.

As CGE is explored and documented further, new type specimens, undescribed species, and previously unrecognised but important specimens will be discovered. In 2011, the largest known surviving set of plant specimens collected by Alfred Russel Wallace (41 fern sheets from Borneo), were discovered in the Lindley collection (Cicuzza, 2014; Figure 9); in 2012 several previously undocumented Darwin specimens, still in the original newspapers they were collected into, were found (Figure 10); and in 2018, part of Darwin's type collection of the fungus *Cyttaria darwinii*, collected in Tierra del Fuego. The Cambridge University Herbarium still has many secrets to be revealed.

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Figure 9. Cyathea wallacei specimen collected by Alfred Russel Wallace in Borneo (CGE12731) © Cambridge University Herbarium

Figure 10. Fungi specimens collected by Charles Darwin on the Voyage of the H.M.S. Beagle in their original newspapers (CGE12472-124727) © Cambridge University Herbarium

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