



Cambridge University
Botanic Garden

Annual Report 2017–2018



UNIVERSITY OF
CAMBRIDGE

Cambridge University Botanic Garden (CUBG) supports University teaching and research while also being a place of enjoyment and inspiration to visitors of all ages. The Botanic Garden is one of the largest University-owned botanic gardens in the world. Opened to the public in 1846, the 40-acre Garden has an unparalleled living collection of over 8,000 species, including nine National Collections, with glasshouses, experimental plots, lake, herbarium and botanical library.

The Garden offers year-round inspiration for gardeners as well as an exciting introduction to the natural world through a programme of family, school and adults' activities and events. CUBG collaborates with national and international researchers from a wide range of partner organisations, including universities, conservation bodies and botanic gardens worldwide, to promote the conservation and scientific understanding of global plant biodiversity.

Director's Report



The core goals of Cambridge University Botanic Garden stay constant from year to year – to support a globally excellent network of research and teaching around plants while providing stimulating opportunities for educational groups and visitors to engage with the collections. But in some years our focus is on particular aspects of those goals, and in some years life has other plans for us! This year our focus has been on the fruition of our “Understanding Plant Diversity” project, to reinvigorate the scientific value, horticultural quality, interpretation and engagement value of our wonderful Systematic Beds. But at the same time, the hottest and driest summer for several decades pulled our attention firmly back to our horticultural standards and our responsibility to lead by example when it comes to sustainable horticulture.

The Understanding Plant Diversity project began in 2015, supported by a generous grant from The Monument Trust. Our Systematic Beds occupy nearly 3 acres in the south west corner of the Garden, and were laid out in 1846 by the Garden's first Curator, Andrew Murray, to showcase contemporary understanding of the relationships between plant families as proposed by Augustin de Candolle. Over the decades small changes here and there had eroded the fidelity with which the beds represented Murray's original design, but with no strategic decision to adopt a more contemporary classification system. Our project started with a consultation on the scientific and heritage value of the beds, leading to a decision to compromise – we have kept the overall de Candollean structure with its major divisions separated by hawthorn hedges, but within those divisions we have repositioned families to lie close to their currently determined relatives. At the same time we have taken the opportunity to reinvigorate the area by lifting the plants, turfing over and then cutting out the beds afresh, and producing new labels in line with current naming conventions. To allow this work to be appreciated properly we commissioned local architects Chadwick Dryer Clarke to produce our new Rising Path – a graceful curving extension of the gardenesque path network that leads the viewer upwards through the evolutionary history of plants on land to a viewing platform across the Systematic Beds themselves. On the platform, and below it, interpretation seeks to explain how and why we sort plants into different groups, and uses the conflict between de Candolle's version of how plants are related and current hypotheses to explain the work we have done on the ground. We're incredibly proud of the project. It has taken enormous effort and commitment from all staff in the Garden, not just those working with the plants and the path structure but also administration, learning, finance, visitor services, marketing and curation staff have worked hard to bring the project together. It is a wonderful example of Cambridge University Botanic Garden at its best – combining scientific utility with heritage, horticultural excellence with visitor accessibility, and the opportunity to learn and engage at whatever level suits.

But while we began this academic year fully focused on the Systematic Beds, the weather had other plans for us. Little rain in May was followed by none at all in June and none again until the 27th of July. We are very committed to sustainable principles in horticulture. Our glasshouses are watered using rainwater captured in tanks, and any outdoor watering (which we keep to a minimum) is done using our borehole. However, a two month drought exhausted the rainwater tanks, and the borehole pressure was very low. Our Head of Horticulture developed a strategy of watering only those plants which met key criteria – essential for research, recently planted and not yet established, essential for another aspect of the Garden's function. In practice this meant that the majority of the grass in the Garden was left to dry out, and time and energy was devoted to

explaining to visitors why this was happening. We took the opportunity to produce articles and take part in radio/TV interviews advising gardeners on how to nurse their gardens through the drought sustainably. As the drought dragged on concern for our trees became a major problem. Summer branch drop occurs without warning, when the lack of water dries branches out and trees let them fall. Our trees are monitored carefully all year round, and we are aware of any weaknesses, but summer branch drop is notoriously unpredictable. As trees across the city started to drop branches we took the decision to rope off some of our biggest specimens, in the interests of public safety. Again, this required a good deal of careful work communicating decisions to our visitors, and sharing our knowledge and advice more widely. Thankfully, in August, the rain came back, and the Garden recovered. Although we were sad to lose a few of our accessions, good management paid off and the majority of the collection was unharmed.

While 2017/18 will be remembered by us as the year of the Rising Path and the drought, many other activities were ongoing during the year. Work continues on our Collections Strategy, which we intend to launch in 2018/19. Our Science on Sundays series of drop-in talks, Festival of Plants, Apple Day, February's Orchid Display, Sounds Green summer music series and our drop-in guided tours were more popular than ever this year, and it's wonderful to see the appetite that people have to connect with plants when given the opportunity. To encourage more self-led engagement we produced new trails for the Garden and developed new interpretation for our Bee Borders and our Understanding Plants area.

Support from visitors was tremendous this year, with a record 304,313 visitors passing through our gates in addition to the many other course, tour and community groups that we welcome separately. Our Friends Scheme continues to thrive, with over 7,400 current members enjoying newsletters, e-updates and the opportunity to take part in a dedicated programme of events throughout the year. This year we also refreshed our Corporate Friends Scheme, and launched a new Patrons Scheme, the Henslow Circle, for those interested in connecting more deeply with the Garden. We are grateful for the support and enthusiasm of all our visitors, whether regular Friends or one-off tourists. This support and interest provides the incentive to continue to develop the best horticultural displays, interpretation, engagement opportunities and events that we can. Just as crucially, income raised from visitors also provides us with the resource needed to continue to develop our collection and its role as an internationally focused research and teaching resource. We are very grateful.

Professor Beverley Glover – Director

The year in pictures...



October: Lights, camera, action! Glasshouse transformation for UCM's 'India Unboxed'



November: The International Garden Photographer of the Year (IGPOTY) 10-year anniversary exhibition on display in the Autumn Garden



February: Twilight at the Museums



February: Titan arum fruits



March: More snow turns the Garden into a winter wonderland

Howard Rice



May: A glorious blue sky day for Festival of Plants attracts record visitors



May: We bid a fond farewell to Alan 'Al' Langley who retired after 46 years here at CUBG



December: We're still standing! Early snow and the horticultural team get creative and competitive



January: Truffle hunting with Prof Ulf Büntgen, Dept of Geography, & Lucy the truffle-hunting hound



February/March: Our exhibition 'How to build an orchid' reveals, from the root up, what makes an orchid an orchid



April: The Alpine team replant the North American area of the Rock Garden



April: Microphones at the ready! CUBG hosts BBC Radio 4's Gardeners' Question Time



July: The most successful Sounds Green series to date



August: Record temperatures & drought take their toll on the Garden but attract media coverage & advice on which plants thrive and survive in hot, dry weather



September: The Rising Path opens

Research

The diversity of roles the Garden plays in Research, both across the University and more widely, always amazes our visitors and Friends. Pages 15-19 of this Annual Report provide a summary of research conducted in 2017-2018. Our primary research role is to provide access to our living plant collection, and requests for living plant material, seed or DNA come from all over the world. We also offer horticultural support for any project which needs to grow plants, and our landscape and underpinning facilities support research in a wide range of disciplines. Within Cambridge alone we are proud to be involved with projects in the departments of Archaeology, Architecture, Biochemistry, Chemical Engineering, Chemistry, Geography, Physics and Zoology, as well as our close associations with the Sainsbury Laboratory and the Department of Plant Sciences. We welcome requests for material and resources from colleagues from all academic and research organisations, and are delighted to be able to support such a diversity of projects.

Ways of looking

Each year in this Annual Report we select a subset of our supported research to discuss in more detail. This year's focus is on a set of projects that emphasise the importance of looking at nature in different ways. The inspiration for the theme comes from our Understanding Plant Diversity project, on the Systematic Beds. One of our interpretation themes there has been "Ways of looking", as we encourage visitors to look closely at the plants around them and to consider how scientific ways of looking at plants have evolved over the last 170 years.

Seeing like a bee

One of the more popular areas of the Botanic Garden for our visitors is the Bee Borders, in front of the Glasshouse Range. Here visitors can enjoy a selection of plants brought together to provide the best and most attractive resources for a range of bee species. Beverley Glover's research group has been focused for some time on understanding how the surfaces of petals reflect light in ways that are attractive to bees, and this work culminated at the start of this academic year with a paper describing a novel optical property of many bee-pollinated flowers, the blue halo.

The study, published in the journal *Nature*¹, began from an analysis of the petal surfaces of plants growing in the Systematic Beds. Various species from across the range of angiosperm diversity were shown to produce nanoscale ridges on their petal surface, organised in regular arrays that ran the length of the petal. Not surprisingly, these varied between species, with some very tall and narrow, looking like

eyelashes or a comb, while others were much shallower and more widely spaced. What was surprising, though, was that all of these flowers produced the same optical signature. Analysing the light reflected from their petals revealed that they all produced a peak of reflection in the blue and ultraviolet part of the light spectrum, and that this reflected light was visible over a wide range of angles. It was this reflection profile that we called the blue halo.

The blue halo arises because the ridges on the petals are not spaced regularly. Their irregularity introduces disorder into the way the light interacts with the flower, and the particular types and degrees of irregularity that the different petals produce all introduce a blue or ultraviolet bias to the reflected light. This is surprising, since they are all so different, and suggests that there might be an adaptive reason for flowers to reflect blue light. And that's where seeing like a bee becomes important. Bees, and many other insects, see much further into the blue and ultraviolet part of the spectrum than we do. So flowers that look yellow to you might look quite different to a bee, if they're also reflecting ultraviolet light from a blue halo. To test these ideas we used the diversity of petal surfaces we'd found in the Systematic Beds to work out what the rules were that enabled a disordered ridged surface to produce the halo. Then we made artificial surfaces, using electron beam lithography, that produced the same halo effect. On some pigmented backgrounds, including yellow, we could not see the blue halo at all – just as we couldn't in some of the yellow flowers we'd measured it from. But when we used these same surfaces as artificial flowers in our flight arenas we found that foraging bumblebees could not only see the blue halo very clearly and use it to identify a food source, it also helped them to find flowers more quickly and improved their foraging efficiency.



Ursinia calendulifolia

Howard Rice



Curly Whirly plant

Exploring South African floral diversity

Many of the blue halo flowers in our study originate from South Africa, one of the great biodiversity hotspots for plants. As part of our commitment to maintain a living collection that is as widely useful as possible for research purposes, we have started to build on our South African accessions. Sam Brockington's research group has initiated a research project looking at the evolution of the Namaqualand Curly Whirlies. These Curly Whirly plants have developed an astonishing leaf morphology that on first sight seems completely mystifying. But a closer look reveals that the spiralling leaves trap moisture droplets from the air along their edges, and then funnel them down towards the roots, with the spiral acting as a gutter. It is believed that these unusual morphologies are connected to the ability of these plants to harvest non-precipitating fog moisture, an important adaptation in the semi-arid environments in which these plants survive. Loubab Zedane, a post-doctoral research associate in the Brockington Lab, is currently sequencing the DNA from two genera that exhibit these morphologies, *Gethyllis* and *Eriospermum*, in order to understand the evolution of these fascinating plants. To support his work Sam visited the Western Cape in August to collect *Eriospermum* species, and the Garden now houses a collection of some 45 species from this rarely cultivated genus, which will facilitate future work. In the same season Alex Summers, Glasshouse Supervisor, and Angela Cano, Assistant Curator, visited the Northern Cape as part of a collecting trip arranged jointly with the Royal Botanic Gardens, Kew. Their targets were twofold – succulent plants to enhance the parts of our collection that allow researchers to explore adaptations to arid environments, and plants from the family Neuradaceae, to see how common the blue halo effect was in this particular family. All of these collection trips are designed to serve our research function, but it is exciting to be able to showcase the plants, and the research projects that they underpin, in our horticultural displays.

Magical microscopy

One of the most exciting collaborations for the Garden in the last few years has been with Raymond Wightman, of the Sainsbury Laboratory. Ray is charged with running the Sainsbury Laboratory's microscopy facilities, and is always keen to explore the ways that plants look using different microscopes that investigate different elements of plant structure. Ray's interest in plant secretory surfaces led him to work

closely with our Alpine and Woodland team, Paul Aston and Simon Wallis, focusing on our extensive collection of *Saxifraga* species. Using cryo scanning electron microscopy they were able to follow the development of the leaves of *Saxifraga cochlearis*, revealing deeper insight into the morphogenesis of secretory pits on the leaves than ever seen before². They followed this up by assessing the secretory products of *Saxifraga scardica* leaves, using Raman microscopy to identify the rare mineral vaterite in the silvery crust³. So successful and exciting has this collaboration become that it has also fuelled new plant collecting work. Ray and Simon set out for the Pyrenees in September 2018 to search for *Saxifraga oppositifolia*. This species offers the possibility to gain enormous insight into how plants pattern their organs because, although it usually places its leaves directly opposite one another, in pairs, it sometimes places them in a spiral instead. Ray and Simon were thrilled to find both forms in the field, and to bring them back for cultivation in the Garden and analysis under the microscope of how the growing tips differ between the two morphologies. This particular way of seeing – the ability to watch something very closely as it develops – promises to change the way we think about patterning and morphogenesis of plants, and is something that the Garden is very excited to be part of.

Looking to the future

In the year ahead we will be launching our Collections Strategy document for the Garden. This strategy will reflect our local climatic constraints, while anticipating the diverse uses of our Garden by a wide range of visitors and stakeholders. But its primary focus will be on our commitment to supporting plant science research. Our determination to do so in a strategic way is strengthened by the intellectually exciting research collaborations that are now arising out of our collections. We look forward to discussing the strategy more fully in the next Annual Report.

¹Moyroud, E. et al. (2017) Disorder in convergent floral nanostructures enhances signalling to bees. *Nature* 550, 469-474.

²Wightman, R. et al. (2017) Hydathode pit development in the alpine plant *Saxifraga cochlearis*. *Flora* 233, 99-108.

³Wightman, R. et al. (2018) Leaf margin organisation and the existence of vaterite-producing hydathodes in the alpine plant *Saxifraga scardica*. *Flora* 241, 27-34.

Professor Beverley Glover, Director and Dr Sam Brockington, Curator



A potted specimen of *Saxifraga scardica* from the CUBG collection



Saxifraga scardica showing vaterite

Horticulture



Tomato cultivation in nursery polytunnel, Schools' Garden

The year was another exciting one for the horticultural team, with each section carrying out new projects as well as maintenance tasks. Several developments stand out as highlights.

Schools' Garden and Horticultural Learning Co-ordinator

The Garden has, for many years, had a Schools' Garden which has acted as a demonstration garden for schools wishing to expand their horticultural offering, but which has also hosted a Schools' Gardening Club. In the past this area has been tended by volunteers from the horticultural staff, who have been able to provide only limited input. This year the Garden was awarded funds for three posts by the Higher Education Funding Council for England (HEFCE), including a Horticultural Learning Co-ordinator, which sits within the horticultural team. The aim of this role is to maintain and develop the Schools' Garden; to deliver assisted visits to further education and higher education colleges; to develop and deliver the public horticultural learning programmes; and to provide horticultural support to the learning team, and learning support to the horticultural team. We were delighted to have Sandie Cain join us in early 2018 in this exciting new role, having previously worked in horticultural and outreach positions.

Since joining us, Sandie has transformed the Schools' Garden into a well-maintained demonstration garden which serves to inspire not only teachers and pupils, but also general Garden visitors. Sandie has developed a planting and maintenance schedule for the vegetable plots, and has already produced a plentiful harvest of salads and vegetables throughout the summer. The polytunnel has also been transformed into a covered growing environment for tomatoes, and also as a nursery facility. A collection of espaliered fruit trees has been planted to provide further horticultural interest and training opportunities for the future. Improvements have also been made to the infrastructure and facilities

within the Garden, including the installation of water butts, replacement compost bins and the laying of slabs on the herb bed to improve access for gathering. In addition, Sandie has supported the Schools Learning Officer in developing a programme for the Gardening Club, and also in the provision of material for these sessions. Pupils involved with the Gardening Club have, during the year, planted out all of the vegetables, and have reaped the rewards of their labours by harvesting their own produce, including tomatoes, basil, squash and courgettes, and celebrating this with a harvest meal. The role has also provided horticultural assistance to the Garden's Learning Officer with responsibility for community engagement at Hanover and Princess Court, where a programme of regular horticultural activities is provided for residents. In this new post, Sandie has also drawn on the horticultural elements of the Garden's public education programme and courses for 2019, while assisting horticultural staff with preparation of material and course delivery. In addition, Sandie has extended our offering to horticultural students, and has been developing links with the College of West Anglia, delivering sessions to horticultural apprentices in plant names and pests and diseases, supplementing their apprenticeship schemes with tailored tutoring using our collections and resources.

The American Section of the Limestone Rock Garden

The Alpine and Woodland team have been further improving the plantings on the Limestone Rock Garden as part of an ongoing programme of works. The Rock Garden is a key feature of the western landscape, having been installed in the 1950s to display high altitude

plants from around the world. In recent times one geographical planting of this feature has been the focus of attention for redevelopment each year. This year work was focused on the American section beside the rock garden stream. Work began with the propagation of material from the previous display in 2016-2017, and in autumn 2017 all existing plantings were removed. Once clear of plants the impoverished soil, which had been *in situ* for many years, was dug out. This allowed access to the rock structure, which was reinforced in places where it had subsided over the years, and improvements were also made to the stream to repair leaks and to improve the flow of water. With structural repairs complete, a new bespoke compost mix of equal parts sterilised loam, shredded wood fibre, sharp sand and grit was shovelled into the planting pockets. Once this had settled, planting of a range of North American alpines began. Proven favourites, including *Eriogonum umbellatum* and *Penstemon glaber* var. *alpinus*, were replanted, while new additions, such as *Lewisia cotyledon* var. *howellii* and *Penstemon confertus*, were also added. Along with the re-development carried out in preceding years in the American and European section of the Rock Garden, this has improved not only the aesthetic of the area, but has also allowed us to enhance the alpine collections. An added bonus has been reduced maintenance, following the removal of an existing seed bank with the old soil. In future years this programme of improvements to the Rock Garden will be rolled out across the remaining plantings, continuing through the European, Asian and southern hemisphere sections.

The Systematic Beds and Understanding Plant Diversity

On the Systematic Beds horticultural endeavours for the Understanding Plant Diversity project continued throughout the year, work having begun on this in autumn 2016. Here the horticultural work was phased in order for the horticultural staff, and particularly John Kapor and the Systematics team, to manage work effectively while continuing to maintain normal activities of cutting down, digging, propagating, planting, and weeding in areas unaffected at this stage by the Project. Prior to September 2017 we had already decanted existing plantings, lifted existing turf, buried stones and levelled the site, before re-turfing the Monochlamydeae (southern), and the Thalamiflorae (western) sections of the Systematic Beds. In addition, we had also cut out the new beds and begun replanting the Monochlamydeae section. In autumn 2017, with turf fully established, we cut out the new beds in the Thalamiflorae section. Simultaneously, plant material for retention was lifted from the third section, Corolliflorae, or eastern section, and housed temporarily in a Systematics decant area. Most plants were cleared from this section, though mature specimens of *Vitex negundo* and *Periploca graeca* were retained. With the majority of plants removed the existing turf was stripped, and the site levelled, cleared of stones and re-turfed



New beds on the Thalamiflorae section

during winter and spring 2017-2018, ready for the cutting out and shaping of new beds in autumn-winter 2018. In each area of the Systematic Beds, the bed design and content took into account the current Angiosperm Phylogeny Group classification, horticultural requirements, research, economic, native, aesthetic and heritage value, and Andrew Murray's original design for the Systematic Beds. The new design will provide increased interest and diversity, allowing us to include species not previously grown on the Beds, alongside accessions which have been with us for many years. Tender perennials including *Citrus limon* (lemon) and *Bougainvillea glabra* will be plunged annually and overwintered in the glasshouses. Further horticultural interest will be added by new perennial climbers such as *Campsis radicans*, *Clematis armandii* and *Jasminum officinale*, which will be supported on bespoke Accoya obelisks. Native species, including *Pulsatilla vulgaris* and *Spergularia rupicola*, will also be included, while the interests of current research projects will also be reflected by, for example, extended representation of the Caryophyllales. This has also provided opportunity for us to review which families should be represented here, and we now have Magnoliaceae included on the Beds.

This year's phase of work was hindered by exceptional weather during the year. A wet, cold spring limited the introduction of new plantings on the Thalamiflorae section of the Beds, while the hot, dry spell which immediately followed dictated that we irrigated new plantings and turf to ensure successful establishment. Much of the work for this project has fallen to John and his team, with considerable input from Adrian Holmes and his Landscape and Machinery team who have assisted with clearing areas, site preparation and turfing. One of the added benefits of the project has been to bring staff from all horticultural sections together to assist with the laying of new turf – 8000m² of it in total. The horticultural team were also involved in site preparation for the Rising Path in the New Pinetum, and here work involved clearance, and reinstatement of the site after the structure was installed. The focus of this work was in the planting of a large specimen of *Magnolia grandiflora*, which we planted *in situ* before construction began, but subsequent to planting new beds were also installed beside the structure, which included representatives of early land plants such as *Equisetum hyemale* and *Ephedra*.

As we progress, we will continue to source and propagate new accessions for inclusion in the Monochlamydeae, Thalamiflorae and Corolliflorae sections. Once work is completed in these we will focus our attention on the remaining Calyciflorae (northern) and Monocotyledon (central) sections. These fall outside the original concept of the Understanding Plant Diversity project, but require curatorial and horticultural revisions. There will be plenty more to do on Systematics in the coming years.

Sally Petitt, Head of Horticulture



Retained *Periploca graeca* and new Accoya obelisk

Learning

Educational visits

We welcomed 10,248 students via 357 educational visits to the Garden in the reporting period. The bulk, 6,919 students, were from Primary schools, with 2,288 from Secondary schools and over 1,000 from Tertiary establishments.

Natural forms resources boxes, containing plant material and resources from the Garden and the University Herbarium, were developed to support GCSE and A Level Art. They were piloted at four schools across the region, and we have already had great feedback from the Art Department at Hills Road Sixth Form College. We have also begun supporting student enrichment projects at this college.

A four-part Masterclass series Feeding our Planet was run in March, in collaboration with the Gatsby Plant Science Education Programme (GPSEP) and the Sainsbury Laboratory (SLCU), with talks and tutoring from scientists and post graduate students from the University.

Our sixth-form passes scheme expanded, with 543 issued in autumn 2017. Work is now beginning on piloting this scheme with a group of undergraduate students in the Biology Department at Anglia Ruskin University and we are trialling ways to evaluate the scheme's impact on those taking part.

Looking ahead we have begun work using the HEAT (Higher Education Access Tracker) system to evaluate our impact on work with students, alongside more interaction with, and assistance for, visits from external Further Education and Higher Education students.

Families at the Garden

We created two new family trails this year – Sense Safari and Plant Patrol. The latter, run in the summer holidays, was so popular that we had to reprint half way through the summer. Numbers attending our regular monthly Family Saturday events also continue to grow, with 980 participating during the year. Events ranged from Magic Beans and Rainforest Riches to Superworm Science and Petal Power. Our summer family activities introduced yoga, drama, dance and storytelling with plants as their themes, as well as a family bat walk.

With the majority of the planting now in place in the newly developed area behind the Scented Garden, we will begin running events to introduce this area of the Garden to our family visitors in the next year. We have decided to name it The Dell.

Lifelong learning

Our adult programme delivered 58 courses to 553 participants across topics including the chemistry of plants, Regency gardens, winter tree identification, plant based inks and illustrating vegetables. Well over half (324 participants) were new to our course programme - demonstrating that the diverse range of courses we offer continues to support new engagement with the Garden and its collections. This year we were delighted that the Gatsby Plant Science Education Programme offered two bursaries for students to attend our five-day Flowering Plant Systematics and Taxonomy Course.

The Science on Sunday talks series also continued to attract a keen audience, with 265 participants attending the six talks from March to August. A new series will launch in 2019.

Looking ahead, a series of new adult focused trails are due to launch in early 2019, including Garden Sketchbooks, and another on chemicals in plants to coincide with the International Year of the Periodic Table.

Community outreach projects

Now in its fourth year, our community gardening project at Hanover and Princess Court is a well-established link with our local community. Weekly sessions during the growing year have produced both beautiful and tasty results, with a range of flowers and vegetables being grown by the group with help from our staff and volunteers. With the Garden's new Horticultural Learning Co-ordinator in place we hope to see our community gardening programme flourish even further.

Alongside seasonal visits to a local care home, and monthly walks for the Thursday group at St Paul's Centre, we continue to support City and County council projects including leading exercise referral walks, activity sessions for local families and facilitating an away day for members of the Youth Offending Team.

We have also continued to work with the local charity, Rowan Humberstone, who designed and built a new weather interpretation board, and a miniature house for the Schools' Garden. A series of new mini world installations, made by the woodworking team at Rowan, will soon feature in The Dell, behind the Scented Garden.



Petal Power 2018

Working with University of Cambridge Museums (UCM)

As part of the UCM, funded by Arts Council England, we undertook a number of collaborative projects this year. These included the annual Twilight at the Museums event in February, which runs across all the University Museums. For this night-time family adventure we used Top-Trumps-style Orchid Adventure cards to help children navigate the Orchid Display in the Glasshouse Range.

We joined our learning colleagues from across the UCM for a Zoology Live event to celebrate the re-opening of the Zoology Museum. Our stand focused on pollination – with staff and volunteers making paper flowers and bee finger puppets with visitors.

In August we ran a new collaborative event for children called Science Detectives. This UCM Science Day involved educators and volunteers from the Sedgwick, Whipple, Zoology and Polar Museums. The morning was spent learning techniques based on science from each of the collaborating collections and was held at the Zoology Museum. The children then spent the afternoon solving a crime, using these newly gained skills, by examining five 'crime scenes' set up at the Garden.

The highlight of our UCM collaboration this year was A Nursery in Residence – a joint research project developed with the Learning Team at the Fitzwilliam Museum. It was inspired by My Primary School is at the Museum – a research project led by King's College London (see inset box).

A Nursery in Residence

In October 2017 we invited nine children from a local nursery school to spend five consecutive mornings in residence at the Garden and the Fitzwilliam Museum. Working in partnership with educators from the Museum, and alongside Early Years practitioners from the nursery, we used photography, video, audio and field observation techniques to gather data on the experience of this group of three year olds during the week. Links were made between plant collections at the Garden, and art and objects at the Museum. A report on the research project gives insight into the ways that storytelling, play, natural exploration, drawing and facilitating curiosity allowed us to see our collections through the eyes of the children. We aim to continue to use evidence from this initial study to develop a better understanding of what our settings can offer to young learners, and to share and develop good practice in both organisations.

A full report on the project can be found at:
https://www.museums.cam.ac.uk/system/files/ucm_nursery_in_residence_report.pdf



Supporting University outreach

During the University's Festival of Ideas, in October 2017, we hosted two popular talks. One, with garden historian, Twigs Way, covered mythical and misguided garden tips through history. A second, with author, Jackie Bennett, delighted in Jane Austen's gardens.

For the Science Festival we launched our family trail Sense Safari, and the Science on Sunday talk series. We also offered a talk from ecologist and author, Ken Thompson, on Making Sense of the Science in your Garden and a mindful walk led by mindfulness practitioner and researcher, Chantek Mary McNeilage.

A highlight in this area of our work was the running of a Crest Award project with the University Admissions team. We worked with PhD student, Hamish Symington, from Beverley Glover's Lab to deliver a week of sessions for a small group of children, from within the local authority care system, to examine the science of pollination.

Staff and Conferences

In October 2017 we said goodbye to Hannah Elkington, as temporary Family and Community Officer, and welcomed back Sally Lee. Chantal Helm joined the team as Higher Education and Research Impact Co-ordinator, and we also gained support from within the Garden's horticulture team, from a Horticultural Learning Co-ordinator, Sandie Cain.

During the year the Learning team contributed to three conferences. Bronwen Richards delivered a session on our Masterclass programme at BGCI's Congress in Geneva and also joined Flis Plent in delivering sessions on the Nursery in Residence project at the NatSCa conference in Leeds and BGCI's Education Congress in Warsaw.

The Learning team relies on the support of dedicated volunteers to deliver events and activities across the programme. This year we welcomed a number of new volunteers to the team and we thank all our Learning volunteers for 200 hours of time, given generously to our programmes throughout the year.

Flis Plent, Head of Learning



UCM Science Day 2018

Curation



Sam Brockington

View of the surrounding landscape while collecting in the Cedarberg



Sam Brockington

A dusting of snow in the Kamiesberg mountains – a semi-arid biodiversity hotspot

With the addition of our new Assistant Curator, Ángela Cano, to the Curation team, the main areas of focus over the past year have been on enhancing our acquisition of plant material, on international collecting expeditions, and on improving the taxonomic provision that we offer to staff and our stakeholders.

Over the past year we have conducted four collecting expeditions. Our Curator, Sam Brockington, spent nine days in Kyrgyzstan, searching for wild tulip species. This expedition was undertaken in association with Flora and Fauna International, in conjunction with the Bishkek Botanic Garden, and the Kyrgyzstan National Academy of Sciences, supported by a Darwin Project award from DEFRA. The Garden holds the National Collection of species tulips, and the overarching goal of this project is to leverage the strength of our collections to foster research on tulip diversity, and to inform conservation activities in Kyrgyzstan. Central Asia is the centre of tulip diversity, and Kyrgyzstan holds about 40% of all wild tulip species, however many are threatened with extinction through overgrazing and through bulb harvesting. On this expedition we travelled through several mountain ranges to survey and collect over fifteen of these threatened tulip species. We performed population surveys and collected bulb and seed in order to build *ex situ* tulip collections in both Bishkek Botanic Garden and our Botanic Garden. We also conducted over one hundred interviews with pastoralists and nomads to better understand the cultural appreciation and use of tulips within Kyrgyz communities. The expedition culminated in a weekend workshop attended by several major stakeholders including charities, NGOs, and Kyrgyz government agencies, to outline a roadmap for tulip conservation in Kyrgyzstan.

We also held two concurrent expeditions to the Northern and Western Capes of South Africa and a week-long trip to the Spanish Pyrenees. The first expedition was led by the Curator, in conjunction with a post-doctoral Research Associate and local geophyte expert, with the goal of collecting fog harvesting geophytes of the Namaqualand region, focused especially on the genus *Eriospermum*. The trip covered over 2,400 miles of road in just six days, with bulbs and herbarium material of forty-five species collected. The material will be an interesting addition to our living collections as well as supporting on-going research in the Brockington Lab, into the evolution of fog-harvesting life strategies. South Africa was also the focus of a much larger expedition lasting for five weeks and led by our Assistant Curator, Ángela Cano, and Glasshouse Supervisor, Alex Summers, in collaboration with the Royal Botanic Gardens, Kew. This trip collected more broadly across the families of Crassulaceae, Aizoaceae, and Neuradaceae, and travelled

through notable hotspots of diversity including the Knersvlakte and the Transfrontier National Park, the Richtersveld. The trip was a huge success, and over three hundred collections were made, including multiple species of the genus *Grielum*, which will be used to support on-going research by the Garden's Director, Beverley Glover. Finally, Ángela Cano was involved in the planning for an expedition to the Spanish Pyrenees led by one of the Alpine and Woodland team, Simon Wallis, in conjunction with the Sainsbury Laboratory. This expedition collected over forty alpine species for our collections, included species of *Saxifraga*.

In terms of collection management, we have been focusing on harnessing the taxonomic skills of Ángela Cano, who has been busy verifying species of uncertain taxonomy, particularly in the Glasshouse and Alpine and Woodland sections. Ángela has been playing a key role in improving and enhancing curation processes across the Garden and is instrumental in liaising with various other teams to deliver on our various initiatives. Pete Atkinson, our Plant Records Officer, has also been trialling the use of two handheld smartphone devices which will allow the bulk of the horticultural databasing work to be done while outdoors, helping to ensure that the horticulture teams stay on top of the computational side of their work. We will look to roll out these devices to all staff over the coming year. Our Curation Technician, Mar Milan, has been maintaining high standards in our provision of material to our various research stakeholders and has been leading the charge in converting the Garden's labels to the latest DNA-based classification system, APGIII. We hope to complete the transition to APG by the close of 2018, with the help of our valued volunteers. We have finished the scoping phase of a project which will see us launch an online portal for our living and Herbarium collections in the coming year. Finally, we are delighted to report that, with the help of our intern, Laura Housden, we have finished databasing the entire Garden Herbarium for the first time since its inception. Overall the collections are in increasingly good condition, and we look forward to setting out our vision for how they will be shaped with the launch of the Living Collections Strategy in 2019.

Dr Sam Brockington, Curator

Friends



Friends' trip to Galicia

Another busy year for the Friends scheme saw membership exceeding 7,000 for the first time at the end of 2017, and 2018 has so far seen the highest number of new memberships to date.

The Friends' events calendar was diverse and full as usual. Highlights included the Annual Lecture – this year given by Sandra Knapp, Head of Algae, Fungi and Plants Division at the Natural History Museum.

A specialist on the taxonomy of the nightshade family, *Solanaceae*, she talked about their many uses. Other events included the hugely popular Early Bird Tours with Julia Mackenzie; Pete Kerley hosted a fascinating behind-the-scenes tour of the Demonstration and Display areas of the Garden; Sally Pettitt gave a tour showing what happens in the Garden in winter; the Christmas Wreath-making workshop sold out (again); the Sainsbury Lab hosted two more sold-out tours of the building; and Ian Loe gave a talk about the incredible world of butterflies and moths. We had the best weather in years for our Friends' Evening Highlights Tour on 28 June, enjoying an early evening glass of prosecco on the Main Lawn in the first weeks of the summer heatwave.

Trips away from the Garden included visits to Nymans and Wakehurst, and a rather soggy group enjoyed Galicia in Spain in March. The Friends were also taken for a storm-threatened tour of Trinity College gardens by Head Gardener, Tom Hooijenga.

45% of the Friends have signed up to receive the monthly e-news of plant picks, where we also update the Friends with Garden news and upcoming events. Electronic copies of the newsletter are now sent to 29% of our Friends, reducing the number of printed copies we have to produce.

2018 saw the launch of a new Corporate Friends Scheme in June where we introduced new levels and pricing structure. We have now created a two-tier scheme, with a higher tier of Corporate Friends membership at £1,000 and a lower level at £350. Both tiers allow staff to come in any day of the week, and also allow non-staff to use the cards – making the scheme easier to administer internally within their

organisations, and to monitor at the Garden gates. The lower tier, Cambridge Oak Friends, is limited to 12 free entry cards and is aimed at smaller, neighbouring businesses. The higher tier, Redwood Friends, gives the member organisation new benefits – including tickets to an annual Corporate Members' Late Night Opening, which will be exclusive to Corporate Members. Other benefits include a free group tour and 20 free entry cards for staff, with the option of purchasing more.

So far, 98% of existing Corporate Friends have renewed since the launch and new Corporate members continue to join the scheme. We would like to thank AstraZeneca, Cantab Asset Management and Prowler.io for being our first Redwood Friends.

Anna Patterson Lee, Head of Development and Communications



Tours of Sainsbury Laboratory Cambridge University

A new perspective

The Rising Path opened in September 2018, offering exciting new ways to explore the science and heritage of the Garden's unique Systematic Beds.



Smith & Walker

In autumn 2017, just as the horticultural staff began ground preparation on Corolliflorae (the third section of the Systematic Beds to undergo extensive renovation) and on the back of resoundingly positive feedback gathered at a public exhibition of our plans, the University's Estate Management team submitted our planning application for the Rising Path, a key element of the Understanding Plant Diversity project.

The Understanding Plant Diversity project seeks to revitalise the contemporary relevance and public understanding of the Systematic Beds for researchers, teachers and all our visitors. The Systematic Beds occupy nearly three acres and are of global heritage significance: they were designed in 1845 by our first Curator, Andrew Murray, and their design uniquely translates the leading botanic text book of the time by Augustin de Candolle into a display for teaching plant taxonomy - the science of identifying and classifying plant species. The whole of the design has taxonomic significance and is, today, of unique heritage importance. The Understanding Plant Diversity project has two major strands.

The first is a programme of horticultural and curatorial improvement to ensure the Systematic Beds remain a useful teaching tool in the modern world: incorporating contemporary understanding of the plant family tree is key. In reworking the Systematic Beds in the light of taxonomic understanding today, we have sought to stay true to the vision of the Garden's founder, Professor John Stevens Henslow, of a relevant teaching garden for all; to restore the first Curator's original design for larger beds that result in an immersive, sensory

experience; to update the plantings to ensure our historic, unique rule of only ever putting one plant family in a bed remains true today; and, to reposition some family beds within their historic sections so that the most closely related families on the modern plant family tree are grown close together. When work is complete in 2020, the Systematic Beds will represent about 1,600 plant species belonging to about 78 families dispersed across 119 beds.

The second strand has been the delivery of an interpretation hub, the keystone of the public engagement aspect of the project. Cambridge architects, Chadwick Dryer Clarke Studio, conceived a gently sloping path 100 metres in length that leads off from the established 'gardenesque' path network. The journey up the Rising Path spirals through the maturing conifer collection of the New Pinetum to arrive at a stunning vantage point at three metres' elevation over our unique Systematic Beds, with a ground-level exhibition area beneath. The brief called for a 'modest, light-touch, inviting, intriguing, accessible and sustainable' structure, from which, having discovered and absorbed the viewpoint and display materials, visitors could 'walk back wisely' to explore and enjoy the Systematic Beds further.

While the Cambridge City Planning Department considered our application, we continued with procurement and site preparation. University Information Services successfully diverted the principal Granta information network to leave just a tributary running through the site, and carried out enabling works for installation of public WiFi to augment the interpretation offering. The University's Estate Management team worked with Chadwick Dryer Clarke to

appoint the principal contractor, undertook the necessary site investigations and steered the project through the relevant committees. When planning consent was granted in December 2017, we were consequently able swiftly to appoint the successful contractor, Millcam Construction. Millcam began work in spring 2018 amid a hive of horticultural activity: new beds being cut on Corolliflorae, planting up of Thalamiflorae, and the installation of a semi-mature *Magnolia grandiflora* into the central oval space circumscribed by the Rising Path, part of the planting strategy to help bed the new structure into the landscape. While keeping the new *Magnolia* irrigated through the drought was a challenge, thankfully summer rain came the week after Millcam handed the Rising Path over to us which helped the Landscape and Maintenance team quickly re-establish the central grass oval, where the carpentry teams had set up their workshop and cut all the Accoya timbers for the balustrade.

We have striven throughout to use the landscape and plant collections actively in the interpretation narratives: the gymnosperm collection, through which the Rising Path winds, inspired us to develop the rest decks as interpretation nodes to highlight the innovations that allowed plants to leave the water for life on land. A strong graphic design routed into the decking boards delivers key messages in a completely novel way and indicates, as the journey continues, how the plant universe begins with very little species diversity 400 million years ago but becomes crammed with the advent of the flowering plants a mere 130 million years ago. Accompanying interpretation, inset into the balustrade for a flush finish, expands on the theme and references the living collections in view. Once the elegant and spacious viewing platform over the Systematic Beds is reached, the visitor has all the context for the angiosperm explosion in plant diversity that they represent. At ground level, free-standing exhibition units composed in a modular way inspired by plant cell structures host discrete but thematically linked stories, curated around the twin educational purpose of the Systematic Beds: how to look at plants, and how to sort those plants to provide a robust framework for effective research and communication.

Plants are full of shapes, patterns, numbers, colours, textures, scents and tastes: the 'ways of looking' theme starts by encouraging close observation of the different parts of a plant and seeing how the roots, stems, leaves and flowers all fit together – the beginning of how plants are described, defined and named. The theme is brought up-to-date by the inclusion of research case studies illustrating contemporary ways of looking: the discovery that some flowers have 'blue halos' highlights the role of the latest DNA techniques whilst a simple interactive explores how powerful, new microscopy technology has helped uncover the nanostructures of plants.

The 'ways of sorting' theme gets to the nub of what the Systematic Beds are for, introduced through a hybrid game between *Happy Families* and *Animal Vegetable Mineral* which invites visitors to sort pictures into groups by identifying a common characteristic. Seeing the family resemblance segues into understanding the family tree, focusing on how scientists today study the genetic composition of plants to determine evolutionary relationships. A relief model of the Systematic Beds helps to illustrate the points of convergence and divergence between the two approaches, and provides a discussion table around which visiting groups can gather.

Henslow provided the lodestar that guided the 'feel' and philosophy of all the interpretive elements: *'I had given the children in our village school instruction in Botany as a useful and not unimportant method of awakening curiosity'*¹. We have therefore tried to encourage an active, multi-sensory approach that would appeal to the multi-generational family and friends visits that characterise the Botanic Garden audience. There are magnifying lenses, plant stem cross sections to feel, flower shapes to explore, a nature table on which to share finds and draw treasures, and a bean seed abacus. We have even included songs! For illustrations, we have drawn extensively not only on the archives of the Garden, but the collections of the University Herbarium, the Whipple Museum and the University Library to add detail, diversion and visual richness to the displays.

The Rising Path opened in September 2018 accompanied by enthusiastic press coverage and Sorted! a festival of public talks which brought together artists and art historians, garden experts, scientists, collection curators, researchers and writers to share their perspectives on how we bring nature to order. Fully booked and enthusiastically welcomed, feedback from attendees was superlative: 'Remarkable three days, off the scale extraordinary'; and, via Twitter, came 'Have had an absolutely wonderful time @CUBotanicGarden at the #SortedFestival learning about petal iridescence, Virginia Woolf's sense of colour, hyperspectral sensing, Henslow's stunning wall charts and much more! Massive congratulations to @cubsystematics'.

As the world faces key challenges, such as food security and biodiversity loss, which have plants at the heart of their solutions, we are very excited to be able to enhance our visitors' understanding and enjoyment of our iconic Systematic Beds through this unique project. The Botanic Garden is at its very best when it combines cutting-edge science, world-class horticulture and thought-provoking interpretation. We are forever grateful to The Monument Trust for sharing our vision.

¹ From Henslow's essay prepared to advertise the publication of Prof. Henslow's *Botanical Diagrams*, 1858, collected into Babbington's *Botanical Tracts*

Juliet Day, Project Manager, Rising Path



Construction underway

Juliet Day

Communications

As ever, it was a busy year for the Comms team and we would like to thank our brilliant volunteers for all their help.

With so much going on in the Garden and behind the scenes, we have had a lot to talk about! Highlights this year included working with the BBC Countryfile team and University Central Comms team on a feature for Countryfile about the research being done on truffles in the Garden with the Department of Geography; hosting the BBC 1 Breakfast weather forecast during the Festival of Light, and BBC Radio 4's Gardeners' Question Time; talking about the research on Saxifraga in articles on BBC World and BBC Look East; plus a host of great features in the local press, radio and TV. Head of Horticulture, Sally Petitt, had a regular spot on the BBC Radio Cambridgeshire Drivetime show focusing on individual plants within the Collection and several different members of staff featured on local radio throughout the year.

We hosted our first Press Day in the Garden to introduce the Rising Path, which resulted in good coverage in a variety of media, including a live feature on BBC Cambridgeshire Evening News.

The Garden's social media profile has increased and continues to be a great way to communicate with supporters, peers and sister institutions. CUBG's Facebook followers grew by 43% and our Twitter followers rose from 9,430 to 10,459. We also continue to develop our Instagram following which jumped from 1,312 to 2,696. Our average reach (the number of people seeing posts but not necessarily following us) on Facebook was 46,500. In March 2018, the reach hit 260,000 for a post covering the flowering of the Jade Vine. On Twitter, our monthly impressions (interactions of any sort with a tweet) averaged 121,000 with a peak of 284,000 in December when the snowy scenes of the Garden proved very popular.

We have also hosted Facebook Live sessions from the Garden this year, and worked with our sister museums and the UCM umbrella to promote each other's activities.

Anna Patterson Lee, Head of Development & Communications

Summary of News Coverage 1 October 2017 – 30 September 2018

Type of news cover	Number of appearances
National Television	8
National Radio	1
National Magazines	13
National Press	11
Local Magazines	12
Local Press	22
Local Radio	20
Local TV	1
Worldwide online press/journals	60



BBC Countryfile filming Ulf Buntgen in the Garden about the life cycles of truffles. Feb 2018



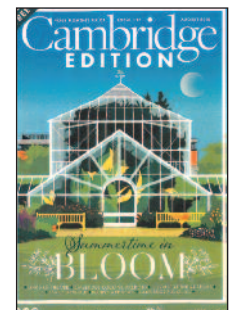
Cam Twilight filming with Louise Hubball for BBC Look East



Floral Firsts by Robin Lane Fox about the Winter Garden in the FTWeekend. March 2018



Sally Petitt, Head of Horticulture, is interviewed by Look East about which plants thrive in the heat. Aug 2018



Cambridge Edition front cover. August 2018



The Rising Path on BBC Look East live. Sept 2018



Flowers use 'blue halo' optical trick to attract bees. The Guardian Oct 2017

Research supported and facilitated

The Botanic Garden maintains and makes accessible the living plant collection of the University of Cambridge. Research and teaching is supported through the plant collections of over 8,000 species, the Experimental Section which facilitates the use of glasshouse and open ground research plots, and through the 40-acre landscape. In addition to home-grown research the Garden supports a wide range of projects throughout the University of Cambridge and collaborates with a great many external partners.

Professor Beverley Glover, Director:

Research programme focused on the evolution and development of flowers, plant/pollinator interactions, and plant surface properties, funded by the BBSRC, NERC, HFSP, EU Marie Curie Actions, Leverhulme Trust, Isaac Newton Trust, and the Cambridge University Botanic Garden Research Fund. Material maintained at CUBG, analysed in the Experimental Plots, or accessed from the Living Collection, for projects including:

- Stamen evolution in *Solanum*, with Dr Sandy Knapp (The Natural History Museum) and Gwen Davis (PhD student).
- The relationship of floral morphology to pollination success in *Vicia faba*, with Dr Jane Thomas (National Institute of Agricultural Botany).
- Molecular evolution of key developmental pathways in plants, with Dr Sam Brockington (Curator, CUBG) and Dr Chiara Airoidi (post-doc).
- Development and evolution of insect-mimicking petal spots in *Gorteria diffusa*, with Dr Paula Rudall (RBG Kew), Dr Allan Ellis (Stellenbosch University), Boris Delahaie and Roman Kellenberger (post-docs) and Roisin Fattorini (PhD student).
- Development, function and evolution of iridescence in plants, with Dr Paula Rudall (RBG Kew), Professor Richard Bateman (RBG Kew), Professor Ulli Steiner (Adolphe Merkle Institute, Switzerland), Professor Jeremy Baumberg (Department of Physics, University of Cambridge), Dr Silvia Vignolini (Department of Chemistry, University of Cambridge), Dr Edwige Moyroud (Sainsbury Laboratory Cambridge University), Dr Chiara Airoidi and Dr Carlos Lugo-Velaz (post-docs) and Jordan Ferria (PhD student).
- The effect of plant viral infection on pollinator attraction, with Dr John Carr (Department of Plant Sciences, University of Cambridge), Dr Alex Murphy (post-doc) and Netsai Mhlanga (PhD student).
- Evolution and development of nectar spurs in *Linaria*, with Erin Cullen (PhD student).
- Conservation of *Potentilla porphyrantha* in Armenia with Lydian International, Dr Peter Carey, Dr Jo Trewweek and Chris Davis (PhD student).
- Interactions between petal surface and pollinator claw morphology, with Dr Walter Federle (Department of Zoology, University of Cambridge) and Jonathan Patrick (PhD student).
- Petal epidermal cell morphology and the association with insect pollinators in *Nicotiana*, with Gabriela Doria (PhD student).
- The relationship of floral morphology to pollination success in strawberry, with Hamish Symington (PhD student).
- The role of pollination in ethylene production and fruit development in tomato, with Dr Saumya Sand (post-doc).
- Provision of liverworts, mosses, ferns, lycophytes and cycads for undergraduate teaching.

Dr Sam Brockington, Curator:

Research programme focused on the evolutionary genomics of the order Caryophyllales, funded by NERC, the NSF and the Isaac Newton Trust, and using material grown in the Experimental Glasshouses, and across the Living Collection:

- Sequencing transcriptomes in Caryophyllales in collaboration with Stephen Smith (University of Michigan) and Michael Moore (Oberlin College, Ohio).
- Reconstituting the betalain pathway in heterologous host systems with Alfonso Timoneda (PhD student) and Hester Sheehan (post-doc).
- Understanding the relationship between betalain pigments and anthocyanins with Rui Guo (Visiting Scientist, Wuhan Botanic Gardens).
- Exploring the evolution and regulation of arogenate dehydrogenase (TyrA), the key enzyme for the production of the essential aromatic amino acid tyrosine (Tyr), in Caryophyllales, with Dr Samuel Lopez Nieves (post-doc).
- Sampling the diversity of liverwort specimens in the Garden to extract high quality DNA for genome sequencing by BGI (Beijing, China), as part of the 10KP genome sequencing project.
- Genomic evolution in Caryophyllales with Nathaniel Walker-Hale (PhD student).
- Evolution of fog-harvesting plants in Namaqualand with Loubab Zedane (Visiting CARA Fellow).
- Phylogenetics and conservation of Tulips in Central Asia with Vicky Wilkins (FFI).

Department of Plant Sciences, Cambridge

Professor Sir David Baulcombe, FRS (RNA Silencing and Disease Resistance Group)

Use of the Experimental Glasshouses to propagate the progeny of *Solanum lycopersicum* x *S. pennellii* hybrids through to the F4 generation, to investigate segregation in hybrid plant populations. Transgressive segregation results in plants that have heritable properties that are outside the range of the parents, and this work aims to understand the molecular biology of this important trait so that it can be harnessed more efficiently for crop improvement. Also growing *Zea mays* for analysis of inheritance of key traits.

Dr John Carr (Plant Virology Group)

We have been using a bay of the Glasshouse Range, and part of the outdoor Experimental Plots, to investigate the effects of virus infection on the interactions of tomato and bean (*Phaseolus vulgaris*) with bumblebees (*Bombus terrestris*). The work suggests that virus-infected plants are more attractive to pollinators than healthy or resistant plants and findings may be useful for improving pollinator service in gardens and for understanding how plants, pathogens and pollinators coevolve in the wild.

Professor David Coomes**(Forest Ecology and Conservation Group)**

Measuring silica content of rice leaves taken from the Tropical Wetlands House and comparing them with spectral readings from a field spectrometer to develop a simple non-destructive method for testing responses of plants to herbivory and other stressors.

Professor Howard Griffiths (Plant Physiological Ecology Group)

Maintaining collections of succulent plants for analysis of those with Crassulacean acid metabolism. The diversity and evolution of epiphytic bromeliads from the neotropics are being investigated. The compromise between water use and carbon gain is also being used to infer evolutionary origins and biomass production potential in succulents and grasses. In grasses, many savanna species have evolved the C4 pathway to enhance productivity, and the selection pressures leading to changes in leaf vein anatomy and metabolic partitioning are being investigated. These processes led to the development of highly productive crops such as sugar cane, sorghum and maize. *Agave tequilensis*, *Aechmea*, *Guzmania* (Bromeliaceae); *Jatropha*, *Kalanchoe*, *Mesembryanthemum* and rice plants all are maintained at the Botanic Garden. Various moss species are also used from the collection in the Garden and cultured in shade for analysis of moss metabolism.

Dr Ian Henderson**(Genetic and Epigenetic Inheritance in Plants Group)**

Growing wheat plants for a range of projects exploring plant sexual reproduction and the processes that generate variation between generations. Specifically, projects focus on the meiotic cell division where gametes are generated with half the number of chromosomes of parent cells.

Professor Julian Hibberd (Molecular Physiology Group)

Rice, millet and wheat are grown for anatomical analysis, RNA isolation and deep sequencing as part of a project to understand the genetic differences between the more common C3 photosynthesis and the more efficient C4 photosynthesis.

Dr Uta Paszkowski (Cereal Symbiosis Group)

The mutually beneficial arbuscular mycorrhizal (AM) symbiosis is the most widespread plant-fungal association between roots of terrestrial plants and fungi of the Glomeromycota, in which the fungus receives photosynthates from the plant and enhances its mineral, particularly phosphate, nutrition. This research focuses on the identification and characterisation of molecular mechanisms underlying the development and functioning of AM symbioses in the crop plants, maize and rice. Maize and rice lines are grown in the Botanic Garden's Research Glasshouses and Experimental Plots for genetic characterisation and seed amplification. Also exploring the presence of mycorrhizal associations in diverse grass species from the Garden's collection.

**Professor Alison Smith and Dr Matt Davey
(Plant Metabolism Group)**

The Botanic Garden has provided space for the Algal Innovation Centre glasshouse facility, to allow different algal species to be grown to establish what role algae can play in the development of a low carbon economy.

Dr Edmund Tanner (Tropical Ecology Group)

Exploring root herbivory in different soil types.

University of Cambridge

Dr Edwige Moyroud (Sainsbury Laboratory)

The bullseye patterns in the centre of many flowers attract pollinating insects, but we do not know how plants control their formation. We are working with *Hibiscus trionum*, which creates a central bullseye of pigmented tissue in the middle of the flower, to understand the development of these patterns. In the Experimental Glasshouses we are screening a large population of mutagenised *H. trionum* plants to identify mutants with altered floral patterns.

Dr Sebastian Schornack (Sainsbury Laboratory)

Plants engage with fungi to improve access to nutrients such as phosphate. We sample liverwort species from the Botanic Garden and stain them to detect fungal structures. Comparing early land plant symbiosis with the root symbiosis of higher plants will allow us to highlight evolutionary aspects of symbiosis establishment in different parts of plants.

Dr Raymond Wightman (Sainsbury Laboratory)

Working with CUBG Alpine and Woodland Section to study hydathode development in *Saxifraga* using cryoSEM microscopy and to analyse their secretion products with Raman microscopy. Additional work focuses on the control of phyllotactic patterning in *Saxifraga* species.

Mathawi Chomthong (Sainsbury Laboratory)

The study of stomatal mechanics using AFM techniques.

Professor Paul Dupree (Department of Biochemistry)

Use of the Experimental Glasshouses to grow thermotolerant plants for biochemical analysis. Provision of species with polysaccharide gums. Pilot investigation of the presence of polysaccharides of interest. Eventually, the polymer could be used to study enzyme activity from microbes involved in digestion.

Maria Stroyakovski (Department of Biochemistry)

Isolating bacteriophage from environmental water samples against *Burkholderia gladioli* – a known plant pathogen.

Professor Peter Leggo (Department of Earth Sciences)

Experiments using digested food waste pelletised with finely ground zeolitic tuff and diatomite as soil improvers using *Nicotiana*. This work aims to find the mixture giving maximum plant nutrients.

**Dr Kristian Franze and Maximilian Jakobs
(Department of Physiology, Development and Neuroscience)**

Boquila trifoliata, a climber from the temperate rainforests of southern Chile, exhibits extraordinary leaf mimicry. It can adopt the leaf colouring, shape, and size of other plants in close proximity, seemingly without requiring physical contact. We propose building a Biosensor that will monitor *B. trifoliata* growth under laboratory conditions to establish a mimicry model for biological experiments.

Professor Nick Davies (Department of Zoology)

Feeding behaviour of blue tits and great tits in the Botanic Garden, studied over many years..

**Professor Chris Jiggins and Dr Erika de Castro
(Department of Zoology)**

Heliconius is a Neotropical genus of colourful and toxic butterflies, which feed as larvae exclusively on *Passiflora* plants. Both *Passiflora* and *Heliconius* are toxic because they have cyanide-containing compounds called cyanogenic glucosides (CNGlcs). Although *Heliconius* produce their own aliphatic CNGlcs, they can also uptake cyclopentenyl CNGlcs from their larval host. This project aims to unravel the genetic basis of the balance between sequestration and biosynthesis of CNGlcs in *Heliconius* and how this has shaped their co-evolution with *Passiflora*.

Walter Federle (Department of Zoology)

Biomechanical measurements of *Nepenthes alata* to explore pitcher plant evolution and function.

Nathan Wright**(McDonald Institute for Archaeological Research)**

The FRAGSUS project based in the Queen's University Belfast, the University of Cambridge and Malta has been formed to study environmental sustainability and subsequent radical change during the Maltese Temple Building phase of prehistoric Malta in the 4th and 3rd millennia BC. Leaf and Branch material from CUBG informs our understanding of archaeological finds.

Professor Ulf Büntgen (Department of Geography)

Analysis of the presence and types of truffle found living in association with diverse tree species in the Garden's collection. Use of camera traps to record interactions of local animals with truffles. Analysis of the truffle lifecycle.

External collaborations

Dr Julia Mackenzie**(Department of Life Sciences, Anglia Ruskin University)**

Blue tits and great tits breeding in the Cambridge University Botanic Garden have been studied for over 15 years. The project involves monitoring breeding birds and colour ringing of adults to identify breeding pairs. This year's work focused on the effect of urban noise on birdsong and bird behaviour.

Dr Thomas Ings and Stephanie Maher (Anglia Ruskin University)

Studies of bee populations, foraging behaviour and ecology in CUBG. This year's work focused on bee parasite loads, the influence of bumblebees on honeybee foraging, and the prevalence of bee nest sites in different soils.

Dr Tim Pankhurst (Plantlife)

The Fen Orchid, *Liparis loeselii*, is the principal focus of a collaboration between Plantlife and CUBG, also involving RBG Kew, Norfolk Wildlife Trust, Suffolk Wildlife Trust, Butterfly Conservation and Natural England. We have been trying to better understand the reproductive strategy of this European protected species. This has involved a programme of seed-baiting to a) locate and identify the symbiotic fungus that it relies upon for germination, b) assess the suitability of potential reintroduction sites, and c) develop an *ex situ* population, both for study and as stock for reintroduction.

Dr Peter Stroh (Botanical Society of the British Isles)

I am a Scientific Officer for the BSBI, based at Cory Lodge. In 2017 I co-authored *Threatened Plants in Britain and Ireland* (Walker et al., 2017), interpreting data collected for the BSBI's Threatened Plants Project. This was the most extensive sample-based survey of threatened plants ever undertaken in the British Isles, and focused on 50 of our least studied threatened plant species. The main aims of the project were to quantify the extent of recent losses, why they had taken place and gather information on their local abundance, habitats and ecological and management requirements.

Jonathan Shanklin (Cambridge Natural History Society)

The Cambridge Natural History Society continued its annual series of visits to the Garden to record the fungal population. The 2017 visit took place following a long dry summer. A description of the conclusions from visits made since 2000 was published in *Nature in Cambridgeshire* (Shanklin & Tribe, 2017) and a one-page checklist of the more common species prepared for the use of visitors. Shanklin, J. & Tribe H. (2017) Fungi in the Cambridge University Botanic Garden. *Nature in Cambridgeshire* 59, 3-5.

Eliot Jan-Smith (John Innes Centre)

Exploration of the biosynthesis of plant triterpenoid saponins, with a goal towards production of industrially relevant molecules through synthetic biology techniques.

James Cohen (Kettering University, USA)

The project is an examination of the phylogenomic relationship of species of Boraginaceae to extend our understanding of the evolutionary relationships in the family beyond phylogenies based on a small number of genes. Samples of *Lithodora zahnii*, *Moltkia suffruticosa*, *Pentaglottis sempervirens*, and *Trachystemon orientalis* were supplied.

Kaitlin Barrios (University of Georgia, USA)

We are interested in comparing the genomic identity of several species and cultivars within the *Liquidambar* genus to evaluate their relationships. We will use whole genome sequencing analyses to compare the specimens provided.

Konstantinos Roumpos (University of Freiburg, Germany)

I am developing hierarchical surface patterns in polymer films. Plant surfaces are characterised by a large variety of topographical patterns, which result from the patterning of the plant cuticle. Such pattern formation can be mimicked in polymer thin films and I aim to explore plant surfaces at a variety of scales and relate them to polymer films.

Kevin Debray (University of Angers, France)

This project aims to study the relationships within the genus *Rosa*, a complex genus where hybridisation and polyploidy occur. Broad sampling of this genus is important to improve node resolutions and obtain a well-resolved phylogeny at deep levels. Samples are analysed using genomic sequencing techniques.

Matthias Fladung (Thünen-Institut of Forest Genetics, Germany)

Reconstruction of phylogeny in birch species including *Betula nana* by chloroplast DNA and nuclear DNA sequences.

Professor Michael Donoghue and Miranda Sinnott-Armstrong (Yale University, USA)

Structural colour is common in birds, insects, leaves and flowers but poorly known in fruits. *Viburnum tinus*, a plant with metallic blue fruits, may have structural components to its blue colouration. In this project we are comparing the structural colour in *V. tinus* to other *Viburnum* fruits in order to assess how common structural colour is, and how widespread the traits underlying it are in *Viburnum*.

Itzi Fragoso Martinez**(Universidad Nacional Autonoma de Mexico)**

My aim is to generate a reliable phylogeny for *Salvia* subgenus Calosphaea based on multiple low-copy nuclear genes. The resulting strongly supported phylogenetic framework will serve as the basis to conduct analyses of diversification rates, divergence times, morphological trait evolution and biogeography.

Daniel Prat (Université Claude Bernard Lyon, France)

Analysis of variation among lavender species and of trait transmission. Morphological traits will be measured and their inheritance will be analysed by controlled crosses and progeny tests. The same approach will be applied to secondary metabolites.

Ioana Crişan (Agrobotanical Garden Cluj-Napoca, Romania)

This study analyses the effects of mycorrhizal associations on the growth of *Iris* species, with the aim of providing detailed information of mycorrhizal requirements to growers and breeders of ornamental *Iris* cultivars.

Guangda Tang (South China Agricultural University and Missouri Botanical Garden, USA)

The Rutaceae is a large family of aromatic trees, shrubs, and herbs that is divided into six subfamilies. The phylogenetic relationships of this family are not well solved. We will use transcriptome data to explore phylogenetic relationships in more detail.

Leonor Morais Cecilio (Seccao Genetica Instituto Superior Agronomia, Portugal)

Quercus suber and *Q. cerris*, although very close at the phylogenetic level, have contrasting phenotypes. *Q. suber* is the only oak that produces a thick cork bark, which can be periodically harvested for industrial purposes. We will perform a genetic association study based on well-characterised phenotypes of known genealogy in an attempt to find functional alleles involved in cork development.

Jelena Mlinarec Novosel (University of Zagreb, Croatia)

We will determine the chromosomal position of telomeric repeats in species of the genus *Tanacetum* using fluorescent *in situ* hybridisation.

Real Jardín Botánico (Madrid, Spain)

Cytogenetic work in *Anacyclus*, specifically looking at interstitial telomeric sites in related species.

Nick Barton (BGCI)

Information for BGCI-US, in partnership with the United States Botanic Garden, to assess living collections of Crop Wild Relatives in North America.

Dr M. Welch (Natural History Museum, London)

A comparative study of Diptera foraging preferences with regard to native and non-native flowers at CUBG.

Rosie Earwaker (Cambridgeshire County Recorder, bees, wasps and ants)

Analysing hymenoptera and hoverfly populations and working on a small book on the bees of the Botanic Garden.

Kevin Hand (National Bat Monitoring Project)

The Garden was included in surveys as part of the National Bat Monitoring Project. I found good numbers of the two target species, pipistrelle and noctule, as in past years. Very few are found in the surrounding streets, so the Garden is important for feeding bats.

Rachel Fosberry (Oxford Archaeology East)

Seedheads supplied to create a botanic reference collection for archaeological research.

Chris Preston (Biological Records Centre)

Recording the presence of various naturally occurring species in the Garden.

Lynn Hempton and Peter Hadfield (Ecology Solutions)

Surveying roosting habitat for various animal species in the Garden.

Pam Newman (U3A Botany)

Seeds and fruits for use in botanical teaching sessions.

Dr Tim Upson (RHS Wisley)

Ongoing research into the systematics of the genus *Lavandula*.

Plant material supplied to other Gardens

CUBG supplied 261 accessions of plant material to 34 sources.

Treborth Botanic Garden

Material for general horticulture use (72 accessions supplied)

Royal Botanic Gardens, Kew

Expansion of *Fritillaria* collection (16 accessions supplied)

Eden Project

One accession supplied

Orto Botanico Università di Pisa

Cuttings of two accessions supplied

Chatsworth House

For display purpose (two accessions supplied)

Department of Plant & Soil Science, Aberdeen University

Seed of five accessions supplied

Nantes Botanic Garden

Seed of two accessions supplied

Jardin expérimental Jean Massart, l'Université Libre de Bruxelles

Seed of 25 accessions supplied

National Botanic Garden of Wales

Seed of two accessions supplied

Der Zoologisch-Botanischer Garten, Wilhelma

Seed of two accessions supplied

Hochschule für nachhaltige Entwicklung, Eberswalde

Forstbotanischer Garten

Seed of three accessions supplied

Botanic Garden, Tartu University

Seed of 11 accessions supplied

Jardin des plantes de Montpellier

Seed of 11 accessions supplied

Institute of Tropical and Subtropical Agriculture, Agricultural University, Czech Republic

Seed of six accessions supplied

Botanischer Garten, Hamburg

Seed of five accessions supplied

Botanischer Garten der Universität Leipzig

Seed of six accessions supplied

Hortus Botanicus Universitatis, Cracow

Seed of 10 accessions supplied

Botanischer Garten der Justus-Liebig-Universität

Seed of six accessions supplied

Jardin botanique de l'université de Franche-Comté et de la Ville de Besançon

Seed of one accession supplied

Hortus Botanicus, Botanicka Zahrada

Seed of 10 accessions supplied

Giardino Botanico 'Caplez'

Seed of eight accessions supplied

Institutum Botanicum Academia, Průhonice

Seed of 11 accessions supplied

Botanischer Garten der Universität Ulm

Seed of one accession supplied

Research Institute for Botany and Ecology, Vácrátót

Seed of eight accessions supplied

Lamorran Gardens

Plants of 16 accessions supplied

Les Jardins Suspendus – Le Havre

Seed of 13 accessions supplied

Cambridge City Council

One plant supplied

Stephen P. Tomkins

Plants supplied for an introduction into Kingfisher Bridge nature reserve

Mona Abboud, National Collection Holder for Corokia

One plant supplied

Royal Botanic Garden, Edinburgh

Seed from one accession supplied

Paignton Zoo

Seed from one accession supplied

Plant material supplied for teaching

The Garden supplied 65 plant accessions for teaching to 13 sources.

Plant material accessioned

During the period 1st October 2017 to 30th September 2018, the Garden accessioned 690 plants, of which 329 were of wild origin. In addition we accessioned 94 seed lots and databased 3,832 herbarium specimens.

Publications by Botanic Garden staff

- Carr, J., Donnelly, R., Tungadi, T., Murphy, A., Jiang, S., Bravo-Cazar, A., Yoon, J., Cunniffe, N., Glover, B.J. & Gilligan, C. (2018) Viral Manipulation of Plant Stress Responses and Host Interactions With Insects. *Advances in Virus Research* 102, 177-197.
- Glover, B.J. (2018) Beverley Glover. *Current Biology* 28, R248-R249.
- Fattorini, R. & Glover, B.J. (2018) Joining the dots. *Nature Plants* 4, 10-11.
- Wilts, B., Rudall, P., Moyroud, E., Gregory, T., Ogawa, Y., Vignolini, S., Steiner, U. & Glover, B.J. (2018) Ultrastructure and optics of the prism-like epidermal cells of *Eschscholzia californica* (California poppy). *New Phytologist* 219, 1124-1133.
- Bailes, E. & Glover, B.J. (2018) Intraspecific variation in the petal epidermal cell morphology of *Vicia faba* L. (Fabaceae). *Flora* 244, 29-36. <https://doi.org/10.1016/j.flora.2018.06.005>
- Bailes, E., Patrick, J. & Glover, B.J. (2018) An analysis of the energetic reward offered by field bean (*Vicia faba*) flowers: nectar, pollen and operative force. *Ecology and Evolution* 8, 3161-3171.
- Cullen, E., Fernandez-Mazuecos, M. & Glover, B.J. (2018) Evolution of nectar spur length in a clade of *Linaria* reflects changes in cell division rather than in cell expansion. *Annals of Botany* mcx213, <https://doi.org/10.1093/aob/mcx213>
- Fernandez-Mazuecos, M., Ferrer-Gallego, P., Miguel, M., Glover, B.J. & Saez, L. (2018) A synopsis of the Iberian clade of *Linaria* subsect. *Versicolores* (Antirrhineae, Plantaginaceae) based on integrative taxonomy. *Plant Systematics and Evolution* <https://doi.org/10.1007/s00606-018-1517-0>
- Moyroud, E., Wenzel, T., Middleton, R., Rudall, P., Banks, H., Reed, A., Mellers, G., Killoran, P., Westwood, M.M., Steiner, U., Vignolini, S. & Glover, B.J. (2017) Disorder in convergent floral nanostructures enhances signalling to bees. *Nature* 550, 469-474.
- Moyroud, E. & Glover, B.J. (2017). The evolution of diverse floral morphologies. *Current Biology* 27, R941-R951.
- Fernandez-Mazuecos, M., Mellers, G., Vigalondo, B., Saez, L., Vargas, P. & Glover, B.J. (2017) Resolving recent plant radiations: power and robustness of genotyping by sequencing. *Systematic Biology* 10.1093/sysbio/syx062
- Fernandez-Mazuecos, M. & Glover, B.J. (2017) The evo-devo of plant speciation. *Nature Ecology and Evolution* 1, 0110.
- Patrick, J., Block, W. & Glover, B.J. (2017) The effect of the bee gym grooming device on *Varroa destructor* mite fall from honeybee (*Apis mellifera*) colonies. *Journal of Apicultural Research* 56, 63-70.
- Moyroud, E. & Glover, B.J. (2017) The physics of pollinator attraction. *New Phytologist* DOI: 10.1111/nph.14312.
- De Jager, M., Willis-Jones, E., Critchley, S. & Glover, B.J. (2017) The impact of floral spot and ring markings on pollinator foraging dynamics. *Evolutionary Ecology* doi:10.1007/s10682-016-9852-5.
- Lopez-Nieves S, Yang Y, Timoneda A, Wang M, Feng T, Smith SA, Brockington, SF and Maeda, HA. (2018), Relaxation of tyrosine pathway regulation underlies the evolution of betalain pigmentation in Caryophyllales. *New Phytologist*, 217: 896-908
- Smith SA, Brown JW, Yang Y, Bruenn R, Drummond CP, Brockington SF, Walker, JF, Last, N, Douglas, NA, Moore, MJ (2018), Disparity, diversity, and duplications in the Caryophyllales. *New Phytologist*, 217: 836-854.
- Mounce R, Rivers M, Sharrock, S, Smith P, Brockington SF (2018) Comparing and Contrasting Evidence-Based Threat Assessments of Plant Species At The Global And Sub-Global Level. *Biodiversity and Conservation*, 27 (4), 907-930
- Yang Y, Moore MJ, Brockington SF, Mikenas J, Olivieri J, Walker JF and Smith SA (2018), Improved transcriptome sampling pinpoints 26 ancient and more recent polyploidy events in Caryophyllales, including two allopolyploidy events. *New Phytologist*, 217: 855-870.
- Walker, JF, Yang Y, Feng T, Timoneda A, Mikenas J, Hutchison V, Edwards C, Brockington SF, Moore MJ, Smith SA (2018) From cacti to carnivores: Improved phylotranscriptomic sampling and hierarchical homology inference provide further insight into the evolution of Caryophyllales. *American Journal of Botany* 105(3): 446-462
- Cheng S, Melkonian M, Smith SA, Brockington SF et al. (2018) 10KP: A phylodiverse genome sequencing plan. *GigaScience* 7 (3).
- Brockington SF and Glover BJ (2017) Botanic Gardens and Solutions to Global Challenges in Plant Conservation Science and Practice: *The Role of Botanic Gardens* (eds Oldfield S and Blackmore S) Cambridge University Press, 7:166-191.
- Walker, J., Yang, Y., Moore, M., Mikenas, J., Timoneda, A., Brockington, S. & Smith, S. (2017) Widespread paleopolyploidy, gene tree conflict, and recalcitrant relationships among the carnivorous Caryophyllales. *American Journal of Botany* 104:6
- Smith, S., Brown, J., Yang, Y., Bruenn, R., Drummond, C., Brockington, S., Walker, J., Last, N., Douglas, N. & Moore, M. (2017) Disparity, diversity, and duplications in the Caryophyllales. *New Phytologist* DOI: 10.1111/nph.14772.
- Mounce, R., Smith, P. & Brockington, S. (2017) Ex situ conservation of plant diversity in the world's botanic gardens. *Nature Plants* 3: 795.
- Pettitt, S. (May 2018). Geraniums: the experts' shortlists. *RHS The Garden*.
- Wightman, R., Wallis, S. & Aston, P. (2018) Leaf margin organisation and the existence of vaterite-producing hydathodes in the alpine plant *Saxifraga scardica*. *Flora* 241: 27-34.
- Wightman, R., Wallis, S. & Aston, P. (2017) Hydathode development in the alpine plant *Saxifraga cochlearis*. *Flora* 233: 99-108.

Funding

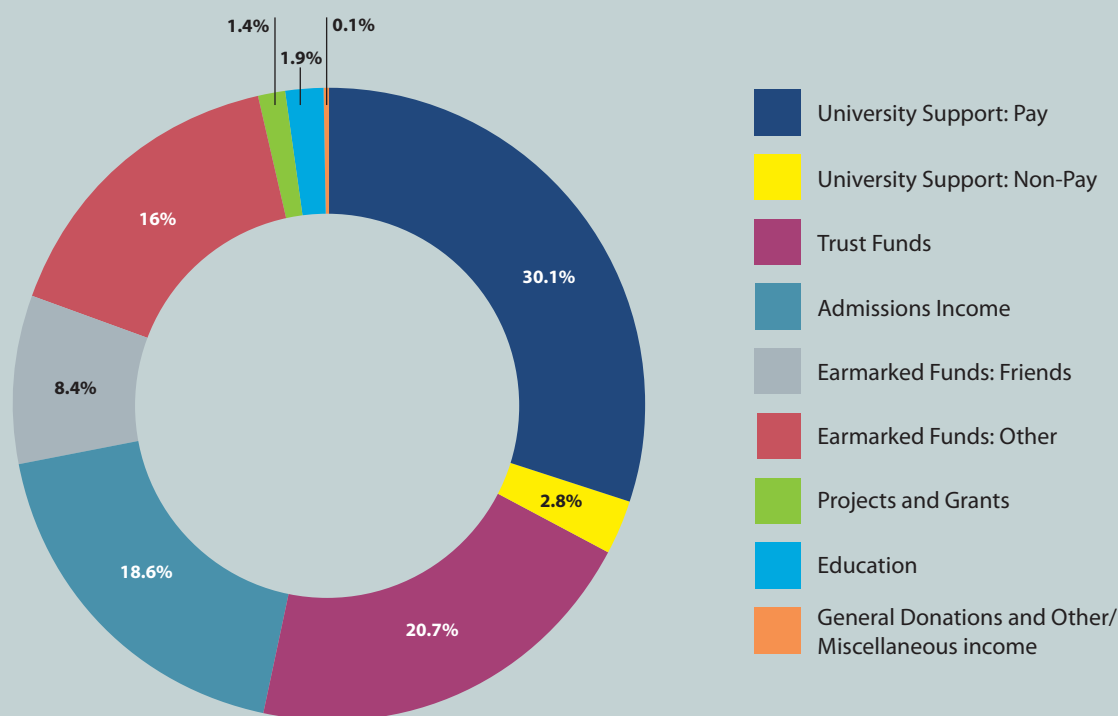
This was a positive year for the Garden in attracting ever increasing numbers of visitors and Friends to share in a host of events and activities. It was a year also for planning and strategy with focus remaining on our primary roles of research and education, but with emphasis also required on the estate and visitor experience.

Although income reduced overall (2016-17 saw the final Monument Trust grant payment), Admission and Trust Fund income increased encouragingly. Expenditure increased, as work on the Rising Path intensified (funded by the Monument Trust) and investments were made on equipment and on the Botanic Garden estate. Equipment purchases of note include a new triple mower, a forklift and an anemometer to accurately measure wind speed.

Projects include further development of the new website (to be launched autumn 2018), development of The Dell (an outdoor space for exploration) and a pilot project to create a Collections Portal (a searchable collections database for all). Funding was also committed towards planned upcoming capital projects.

2017-18 was the first year of funding from Research England (formerly HEFCE) University Museums, Galleries and Collections Fund (included within University Support). Funding was awarded to contribute towards the additional costs of providing a service to the wider research community. Three new staff appointments have been made and planning undertaken to achieve set objectives over the next few years. CUBG was the first Garden to be awarded this type of funding.

Income 2017-18



Income/Budgets

Funding Source	Details	£k	£k
		2017-18	2016-17
University Support	Pay	882.3	744.3
	Non Pay	81.6	60.8
Trust Funds	The Cory Fund	589.1	545.8
	Other Trust Funds	17.9	16.4
Admissions Income	Gate takings (to include tours, guidebooks etc)	545.3	521.4
Earmarked Funds	Friends (to include income for events and activities)	245.5	249.9
	Other Specific Donations and Trade (to include trading Events)	469.7	586.4
	Project Grants/ Funding	42.2	326.8
Education Courses, Donations and Events		56.0	56.0
Donations – General		4.8	4.9
Other/ Miscellaneous income		0.0	0.3
Total Income		2,934.4	3,113.1 *

Breakdown of Income (Friends: Earmarked Funds)

	£k 2017-18	£k 2016-17
Friends of the Botanic Garden – Subscriptions	238.5	241.1
Friends of the Botanic Garden – Outreach programme	3.6	6.5
Friends General Donations and 25 Fund	2.1	1.2
Other	1.2	1.1
Total	245.5 *	249.9

Breakdown of Income (Project Grants/Funding)

The Monument Trust (Rising Path)	1.0	301.0
Perennial – Funding towards Trainee Programme	21.6	20.8
Audience and Learning / Strategic Audience Engagement Grant (University of Cambridge Museums)	15.0	5.0
Finnis Scott Foundation	4.5	0.0
Interpretation (HEIF5 Funded)	0.1	0.1
Total	42.2	326.8 *

Expenditure

		£k	£k
Expenditure Type	Funding Source	2017-18	2016-17
Pay	University Support	778.8	705.8
	Trust Funds	504.0	473.5
	Admission and Tours	387.9	364.3
	Earmarked Funds: Friends	80.8	80.5
	Earmarked Funds: Other	61.9	92.8
	Specific Project Grants/ Funding	54.4 See breakdown below	60.7
	Education Courses, Donations and Events	17.0	17.5
		1,884.6 *	1,795.1
Non Pay	University Support	101.2	99.4
	Trust Funds	35.2	88.2
	Admission and Tours	43.0	26.8
	Earmarked Funds: Friends	139.0	132.2
	Earmarked Funds: Other	183.7	135.6
	Specific Project Grants/ Funding	367.7 See breakdown below	288.9
	Education Courses, Donations and Events	31.4	50.4
Donations – General	2.5	1.2	
		903.6 *	822.8 *
Total Expenditure		2,788.3 *	2,617.8 *

Breakdown of Expenditure (Specific Project Grants/Funding)

	2017-18	2016-17
The Monument Trust (Rising Path)	377.4	330.4
Perennial – Funding towards Trainee Programme	19.8	21.9
Audience and Learning / Strategic Audience Engagement Grant (University of Cambridge Museums)	12.0	3.2
Finnis Scott Foundation	4.5	0.0
Interpretation (HEIF5 Funded)	8.3	23.7
The Geoffrey and Eileen Adams Garden Room	0.0	-29.7
Total	422.0	349.6 *
Total Income less Total Expenditure:	146.1	495.2 *
Less: Earmarked funds held for future planned expenditure	-143.8	-489.9
Funds reinvested by Cory and Trust Fund Managers	-0.1	-0.5
Committed reserve funds temporarily invested in the 'Research Fund'	0.0 See Note 1	-191.8
Funds remaining for discretionary use	2.2	-187.1 *

Notes:

1 Legacies and other reserves not required within a 3-5 year period, were temporarily invested in the University Endowment Fund for the 'Research Fund', the annual distribution of which is used to further science and research at the Botanic Garden in the short term.

* Calculations include minor rounding differences.

Syndicate and Cory Managers

Four meetings of the Botanic Garden Syndicate were held during the year under the Chairmanship of Dame Fiona Reynolds. Syndicate members were Professor Paul Brakefield, Professor David Coomes, Professor Nick Davies, Dr Laurie Friday, Dr Ian Furner, Mr Donald Hearn, Professor Nick Jardine, Professor Ottoline Leyser, Dr Mike Rands and Professor Alison Smith. The Secretary was the Garden's Director, Professor Beverley Glover. Professor David Coomes stood in as Acting Director and Secretary to the Syndicate during Professor Glover's sabbatical in the Easter term. The Syndicate were pleased to meet the Botanic Garden staff following their July meeting.

The Cory Managers met four times during the year under the Chairmanship of Professor Alison Smith (Head of the Department of Plant Sciences). Managers for the year were Mr Michael Allen, Professor Howard Griffiths and Dr Alan Munro with Mr Jonathan Appleton as the representative of the Director of Finance.

Botanic Garden Staff – October 2017 to September 2018

Director

- Professor Beverley Glover

Administration

- Administrator: Wendy Godfrey
- Finance Officer: Rachel Agnew
- Deputy Finance Officer: Anouska Arthur
- Finance Administrator: Elaine Dalton
- Assistant Administrators: Richenda Whitehead and Katy Cooke
- Learning Administrator: Emma Daintrey
- Friends Administrator: Sacha Watson
- PA to Director: Jane Adams

Curation

- Curator: Sam Brockington
- Assistant Curator: Angela Cano (from April 2018)
- Plant Records Officer: Pete Atkinson
- Plant Records Assistant: Mar Millan
- Cory Library Manager: Jenny Kirkham

Development

- Head of Development and Comms: Anna Patterson Lee
- Marketing and Communications Co-ordinator: Helen Needham
- Monument Trust Project Manager: Juliet Day

Estates

- Head of Estates and Operations Manager: Carl Tatterton
- Estates Manager: Phil Starling
- Estates Assistant: Kris Leitans (from November 2017)

Horticulture

- Head of Horticulture: Sally Petitt
- Horticultural Learning Co-ordinator: Sandie Cain (from February 2018)
- Alpine & Woodland Section: Supervisor - Paul Aston; Assistant – Simon Wallis
- Demonstration & Display: Supervisor - Pete Kerley; Assistant - David Austrin
- Experimental Area: Supervisor - Pete Michna; Assistant – Katie Martyr
- Glasshouse Section: Supervisor - Alex Summers; Assistant - Alan Langley (to May 2018), Barbara Griffith (from August 2018)
- Landscape & Machinery: Supervisor - Adrian Holmes; Assistant - Alistair Cochrane
- Systematics Section: Supervisor – John Kapor; Assistants - Julie Clos, Pete Wrapson, Penny Brice (Maternity cover from February 2018)
- Trees & Shrubs Section: Supervisor - Mark Crouch; Assistant – Robert Bradshaw (from October 2017)

- Trainee Horticultural Technicians: From September 2017 to September 2018: Rosalyn Anderson, Penny Brice (to February 2018), Rut Gallmeier, Luigi Leoni, Andrew Clarke, Jenny Allwood-Booker, Russell Beeton. From September 2018: Amy Spencer, Ciaran Bradshaw, Elizabeth Mansfield, Jessica Tyler, Louise Spencer, Matthew Payne, Wendy Watson.

Learning

- Head of Learning: Flis Plent
- Learning Officer: Sally Lee
- Learning Officer: Hannah Elkington (Adoption leave cover to November 2017)
- Schools Learning Officer: Bronwen Richards
- HE and Research Impact Co-ordinator: Chantal Helm (from June 2018)

Visitor Services

- Head of Visitor Services: Nicci Steele-Williams
- Deputy Head of Visitor Services & Team Leader (Tuesday-Thursday): Laura Welford
- Team Leader (Friday-Monday): David Evans
- Visitor Services Assistants: Andy Bryant, Amanda Wilkins, Lucinda Fudge, Sue Baker, James Oliver, Kathryn Villanueva, Anca Cojocar, John Neville, Vikas Shinde.
- Visitor Services Receptionist: Heloise Toop

Botanic Garden staff activities

The following members of staff have contributed to external organisations and groups in connection with their posts:

- Professor Beverley Glover: fellow of Queens' College; trustee of the Royal Botanic Garden Edinburgh; member of the Science Advisory Committee of the Royal Botanic Garden Edinburgh; member of the Council of the European Society for Evolutionary Developmental Biology; member of the Council of Scientists of the Human Frontier Science Programme; member of the Botanical Society of America; member of the British Society for Developmental Biology; fellow of the Linnean Society; member of the Linnean Society's Education Committee; external Examiner for Botany at Trinity College Dublin; patron of the Cambridgeshire Gardens Trust; vice-president of the Cambridgeshire Beekeepers' Association; member of the Advisory Board of New Phytologist; Strategic Advisor, Plants, People, Planet; member of the Editorial Board of Current Opinion in Plant Biology; member of the Natural Environment Research Committee's Peer Review College; serves on the Royal Society's Small Grants Panel and the Royal Society's 150K grants panel; gave invited lectures at the University of Warwick, the John

Innes Centre, and a Bioinspiration Winter School in St Moritz, and to the Friends of Oxford University Botanic Garden, to the Cambridge Alumni of Dorset and to the Cambridge Alumni Festival; gave invited talks at the Living Light meeting in Cambridge and the Biennial meeting of the European Society for Evolutionary Developmental Biology in Galway.

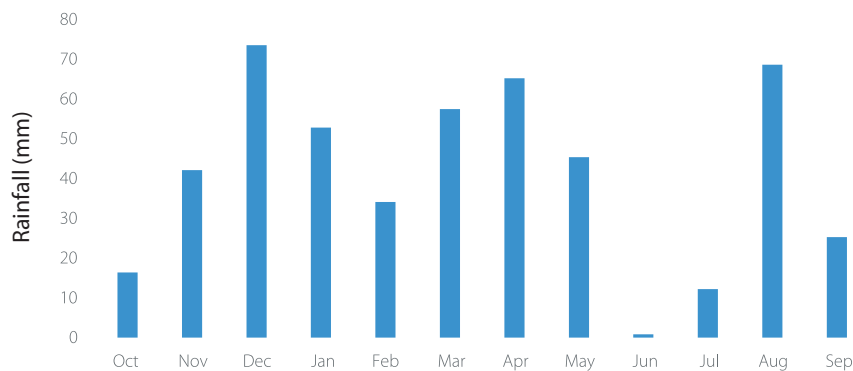
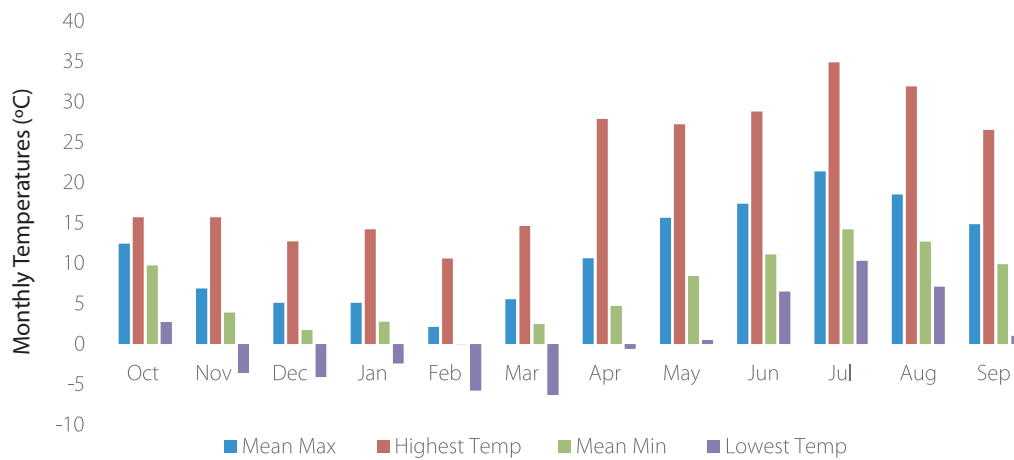
- Dr Sam Brockington: member of the High Value Chemicals from Plant Network, member of the Botanical Society of America; fellow of the Linnean Society; trustee of the Bedfordshire, Cambridgeshire, & Northamptonshire Wildlife Trust; gave lecture at the BCN Wildlife Trust Annual Meeting, a lecture as part of the three day Sorted! conference, a lecture at the Open Plants Forum at John Innes, and a lecture at the Higher Value Chemicals from Plants AGM, convened a workshop on Central Asian Tulip conservation in Bishkek, Kyrgyzstan, led a 10-day expedition to South Africa, and participated in a week-long expedition to Kyrgyzstan.
- Dan Jenkins: member of the UK Plant Sciences Federation committee; serves on the Experimental Science Working Group of the Royal Society;

continued as a member of the UK Biology Education Research Group and the Royal Society of Biology's Education Policy Advisory Group.

- Dr Charlotte Carroll: member of the Careers Committee of the Royal Society of Biology.
- Flis Plent continued as director on the board of The Botanic Gardens Education Network (BGEN).
- Juliet Day continued as a member of the Executive Board of PlantNetwork.
- Carl Tatterton continued as a trustee of the Hobson's Conduit Trust.
- Helen Needham continued as a member of the Great Days Out In & Around Cambridge committee.
- Sally Petitt continued as chair of the Merlin Trust (which provides travel awards to young horticulturalists) and as a member of the Borde Hill Garden Council.
- Alex Summers continued as a member of the RHS Tender Ornamental Plant Committee.
- Simon Wallis continued as chair of the Saxifrage Society and as a member of the RHS Joint Rock Garden Plant Committee.

Weather

This academic year gave us a wet spring and a consistently warm and dry summer, especially during June, July and August 2018.



October was a dry month. It was still mild for the time of year, however on the 30th we saw -1°C on the ground. November was a month of fluctuating temperatures, as frosts frequently crossed the UK. Although the frosts were not sufficiently sharp to bring the leaves down they gave exceptional leaf colour. During the evening of November 30th we had heavy snow showers, which did not settle for long as the ground was not frozen.

December was an unsettled month as fronts continued across the country. The night of the 25th was particularly wet with 21.9mm, and the rain turned to snow. Temperatures constantly fluctuated with cold spells interspersed by mild weather, and it was a wet month. January started on an unsettled theme. The winds were sufficient on the 3rd for the Garden to be closed and re-opened at 12:30pm. In the early hours of the 18th a vigorous low swept across the country, the southern flank of which hit East Anglia hard. The Garden sustained two tree losses, the *Crataegus laevigata* 'Plena' on the Systematic Beds, and the *Quercus agrifolia* on the Main Lawn, and throughout the Garden there was a lot of debris.

Between February 26th and 2nd March, it was very cold and the Garden, unusually, had a snow covering all week, around 2.5 inches. Day time temperatures remained close to freezing. In March the cold lingered during the beginning of the month. We saw spring trying to make an appearance with 14.6°C , however winter refused to recede, and on the evening of Saturday 17th there was another snowfall.

April was quite inconsistent with unseasonably cold periods and then unusually very warm, reaching a maximum of 27.9°C on the 19th. May saw alternating temperatures - on the 8th of May we had 27.2°C , in contrast on the 18th we had -1.5°C on the ground. At the end of the month thunder occurred in the early hours of the 27th and in the afternoon of the 29th thunder was heard, but little rain fell. The last relatively high rainfall was on May 25th at 12.7mm and then the 2018 drought began.

June was dry, hot and bright for long periods throughout, the total rainfall was a mere 0.8mm. In July the weather continued to be unseasonably hot for England. The hottest day was 34.9°C on the 26th. With consistent heat and low rainfall the Garden began to have a scorched appearance.

August continued with hot dry weather, with a maximum of 31.9°C on 7th. Finally the weather returned to normal with 15.2mm rain on the 9th, followed by lower temperatures, ensuring the Garden greened up again. September was a cooler month with four ground frosts towards the end, -2.8°C being the lowest on the 30th. Despite this there were some pleasant temperatures at times, including 26.5°C on the 17th. September was a dry month with strong winds, closing the Glasshouse Range on the 21st. The wind also damaged two of our mature Cedars.

With thanks to John Kapor for helping to provide historical data and information for the year.

Katie Martyr, Experimental Assistant

Thank You

Gifts, donations and support received in Annual Report period 1 October 2017 – 30 September 2018

We would like to extend our sincere thanks to all who have chosen to support the Garden either financially or through the gift of time by volunteering. Your contributions are hugely appreciated and greatly valued.

Legacy Giving

- Peter Andrews Bilton payment of £48,348
- Sylvia Norton additional legacy payment £350

In Memory Gifts

- Donation from Enza Cancelli, In Memory of Winifred Glen, £240

Individual Gifts and Donations

- We would like to thank the generous support of our Friends, who continue to make significant gifts over and above the annual subscription.
- We are also delighted to receive visitors' donations, however small, and thank all visitors

who choose to make valued donations to support the work of the Garden.

- Special thanks goes to those who have chosen to Gift Aid admissions, subscriptions, and donations – it really does make an enormous difference and allows us to do so much more.

Grants, Trust and Societies

- Perennial, the Gardeners' Royal Benevolent Society, for the employment of an additional horticultural trainee – £21,597
- Finnis Scott Foundation – £4,500

Corporate and other support

- Bircham Dyson Bell for the Sounds Green Music Festival – £5,000
- Department of Plant Sciences for the Festival of Plants – £1,000
- Sainsbury Laboratory Cambridge University for the Festival of Plants – £1,000

- University of Cambridge Museums, Strategic Audience Engagement Grant – £5,000
- University of Cambridge Museums – The Botanic Garden Audience & Learning Strategic Partnership Grant (Year 1 of funding – 1 April 2018 – 31 March 2019) – £10,000
- University of Cambridge Museums support for the CamLates Botanic Nights – £800
- University of Cambridge Museums Training Grant, Workforce Development Fund – £500

Donors to the Cory Library, 1 October 2017–1st May 2018

- David Balfour
- Lucy Evans
- Claire Kendon
- Eileen Pembroke

Corporate Friends

Amazon EVI
Apple Europe Ltd
Arcadis
Arcus Foundation
ARM Ltd
Arts Council England
AstraZeneca (Redwood Friend)
Bellerbys College
Bircham Dyson Bell LLP
Birketts LLP
Blackdot Solutions Ltd
Bloomhall Ltd
Bromium UK Ltd
Brookgate Development Management Ltd
Cambridge Assessment
Cambridge Centre for Sixth Form Studies
Cambridge Crystallographic Data Centre
Cambridge Education Group
Cambridge Institute for Sustainability Leadership (CISL)
Cambridge Intelligence Ltd
Cambridge Judge Business School
Cambridge University Department of Chemistry
Cambridge University Department of Pathology
Cambridge University Department of Pharmacology
Cambridge University Investment Office
Cambridge University Press
Cambustion Ltd
Cantab Asset Management (Redwood Friend)
Cantab Capital Partners
Carter Jonas
Centrica Connected Home
Churchill College

Clare Hall University of Cambridge
Costello Medical Consulting Ltd
Deloitte LLP
Department of Chemistry
Department of Geography
Docker UK Ltd
Dow Agrosiences Ltd
Electric IMP Limited
eLife Sciences Publications Ltd
Eversheds-Sutherland LLP
Excelcare
Faculty of Education University of Cambridge
Geant
Granta Design
Hills Road Sixth Form College
Historic England + English Heritage
Intrasonics Limited
Irwin Mitchell LLP
John Lewis Cambridge
KPMG
Lynfields Management Ltd
Marks and Clerk LLP
Marshall Sports and Social Club
Microsoft Research Ltd
Mills and Reeve LLP
Mott MacDonald Ltd
Mander Portman Woodward (MPW)
MRC Cognition and Brain Sciences Unit
Nash Matthews LLP
Natural England
Netronome Systems Ltd
NIAB
PEM

Pembroke College University of Cambridge
Penningtons Manches LLP
Peters Elsworth and Moore
Prowler.io (Redwood Friend)
Qualcomm Technologies International Ltd
Ramboll UK Ltd
Raspberry Pi Foundation
Repositiv Ltd
Samsung Cambridge
Saunders Boston Ltd
Savills (UK) Ltd
School of Clinical Medicine University of Cambridge
Siemens Industry Software Ltd
Slater & Gordon (UK) LLP
St Faith's School
St Mary's School
Stephen Perse Foundation
Stone King LLP
Strutt & Parker
Taylor Wessing LLP
Thales E-Security Ltd
The Biodiversity Consultancy Ltd
The Burdon Institute
The Cambridge Centre for Paediatric Neuropsychological Rehabilitation (CCPNR)
The Leys School
Thomson Webb & Corfield
Transversal
Trustonic
Undo Ltd
VNC Automotive Limited
Woodfines Solicitors
WSP

... and thank you to everyone who visited the Garden

Visitor numbers through ticket offices (including Friends, groups and paying visitors) 304,313. Adult Education course participants 1,053. Educational visit participants 10,248.



Front cover image by Richard Chivers
Back cover image by Martin Bond

The paper used in this publication is 100% recycled

www.botanic.cam.ac.uk