

Biodiversity for mountain resilience: seeds in the landscape

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1. Introduction to Kew Science
2. Persistence and use of seeds in the landscape
3. Alpine and mountain seed germination



7 July 2019

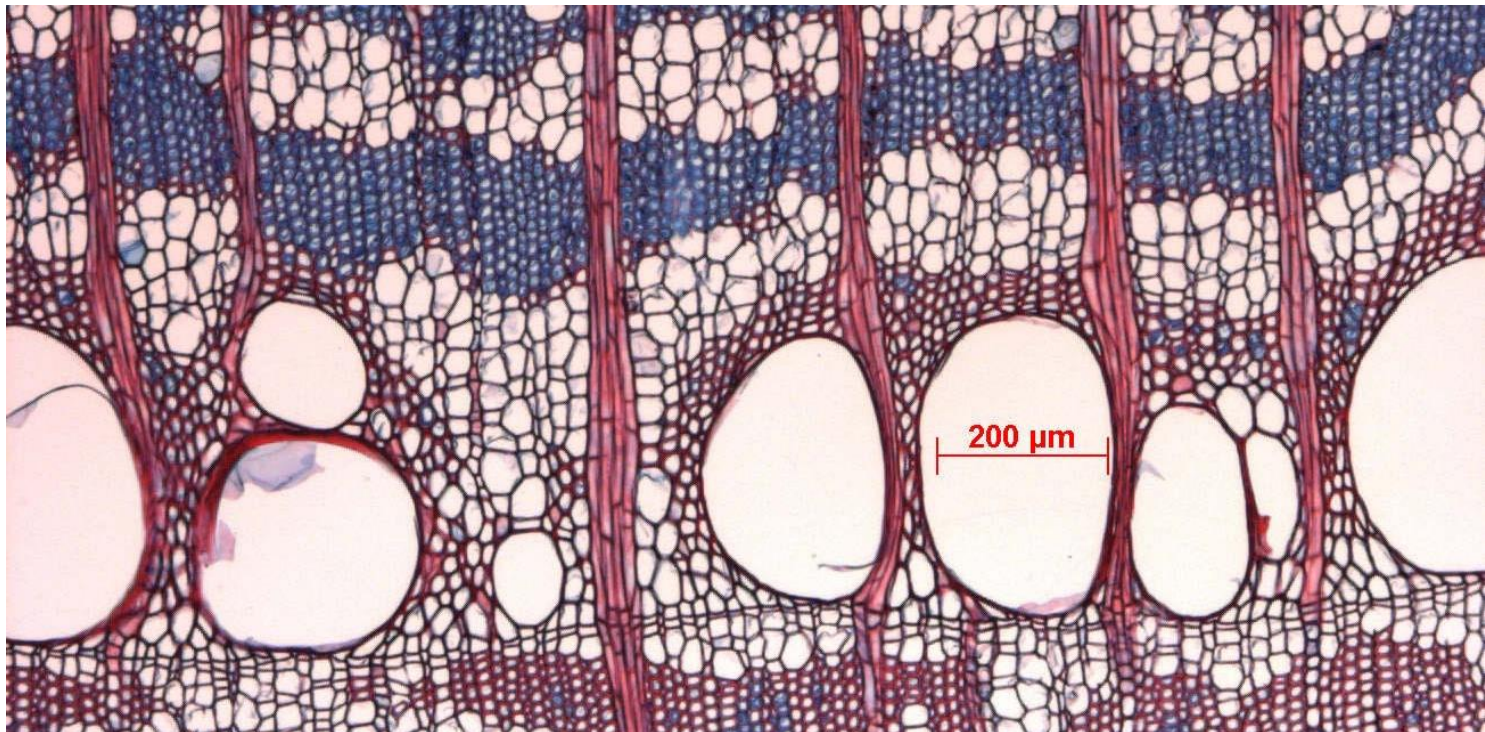
Introduction to Kew: a resource for biodiversity science



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Kew Science – priorities

1. Research into global plant and fungal diversity
2. Curating Kew's collections as a global asset for scientific research
3. Publishing, lecturing and outreach – to maximise impact in science, education and conservation

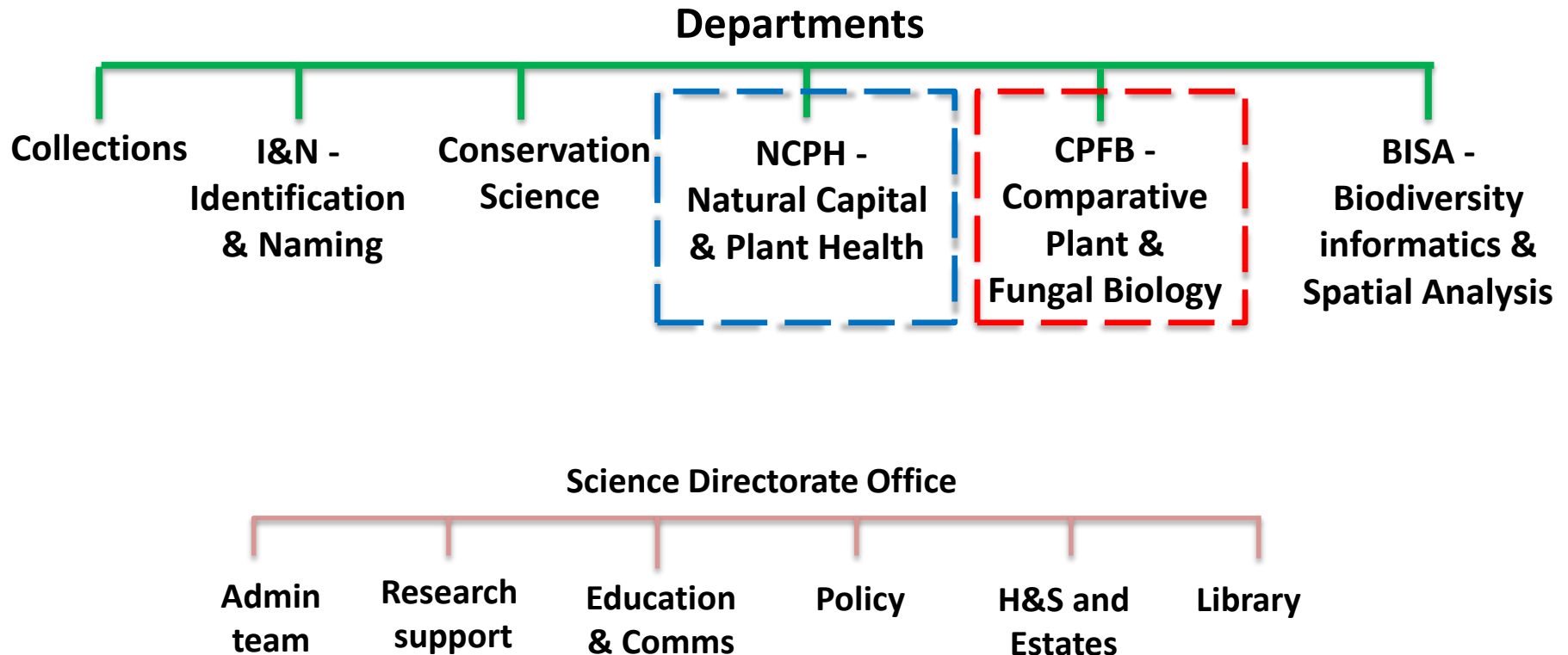


Kew Science – People

- *ca* 260 science staff
- *ca* 100 volunteers
- *ca* 90 Honorary Research Associates
- *ca* 50 students

Kew students in 2017:

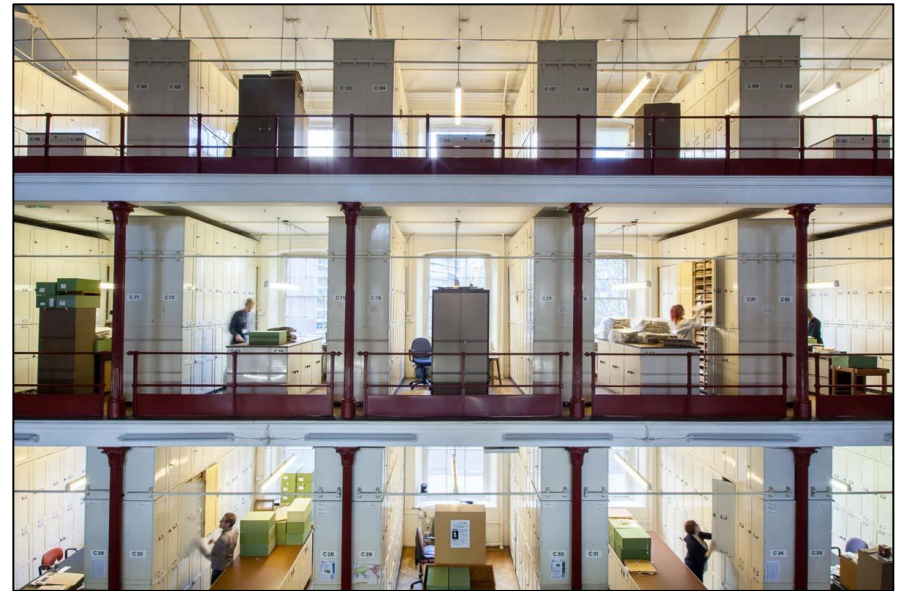
- 47 PhD students
- 19 students Kew MSc students (from 9 countries)
- 8 Intern students



Kew Science – Buildings

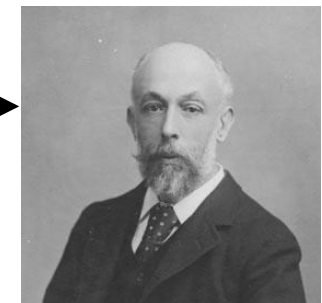
Kew Herbarium

- Founded on collections of George Bentham and William Hooker, *ca* 1853
- Hunter House (now grade II listed building), new wings/extensions added in 1877, 1902, 1968, 1988, 2007.
- First directors William Hooker (till 1865), Joseph Hooker (till 1885), William Turner Thiselton-Dyer.



Kew Science – early

Cryogen, temperature / time	Species	Reference
'froze mercury' (-39°C) / 15 min	wheat, barley, rye, broad bean	Edwards & Colin (1834)
-57 or -110°C / 30 or 20 min	9 species, including California poppy	Wartman (1860)
liquid air / 110 h	12 sorts from wide range of families	Brown & Escombe (1897)
liquid hydrogen (-250°C) / 1 – 6 h	several kinds	Thiselton-Dyer (1899)
liquid air / 176 days	sweet clover	Busse (1930)



Germination “unimpaired”, but some seeds can be brittle

Kew Science – Buildings

Jodrell Laboratory

- Founded in 1876 from donation of £1500 (by T. J. Phillips Jodrell, a Victorian philanthropist) for investigations into plant structure and function
- First Keeper: D.H. Scott, a pioneer in the study of fossil plants
- Rebuilt 1965, extended 2000, 2006 (Wolfson Wing)
- Now also houses the Kew Fungarium



Kew Science – Buildings


Wellcome Trust Millennium Building, home to the MSB

- Originally science based in 1590 mansion at Wakehurst Place in West Sussex
- WTMB opened in 2000; Millennium Seed Bank holds > 2 billion seeds from ca 41,000 plant species






Kew Science - building on 255-year history

- Collecting, identifying and naming plants and fungi (what)
- Determining their diversity and distribution (where)
- Documenting conservation needs (action in situ, ex situ)
- Understanding their relationships (drivers and processes)
- Identifying important properties (uses, sustainable development)

 **INDEPENDENT** News Voices Culture Lifestyle

Scientists reclassify all plants

Michael McCarthy, Environment Correspondent | @mjpmccarthy | Monday 23 November 1998 | 0 comments

   **0** shares

THE SCIENCE of botany has been turned upside down by a new classification of the world's flowering plants and trees based on their DNA rather than their appearance.

Worked out by a team led by scientists from the Royal Botanic Gardens at Kew, south-west London, it has caused a complete rethink of the relationships between many plant families. It shows, for example, that the closest relative of the lotus, the sacred flower of Buddhism, is not the water lily it so much resembles but the the smog-resistant plane tree of London's squares.

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 **SCI NEWS**

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Three New Mushroom Species Found in Shop-Bought Packet

Jul 11, 2014 by News Staff / Source « Previous | Next »

Published in
Biology

Tagged as
China
Mushroom
Porcini
United Kingdom

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Prognathodes basabei: New Species of Butterflyfish Discovered in Hawaiian Waters


Madagascanophis loto: New Species of Cat-Eyed Snake


Contents of a commercial packet of dried porcini containing three species new to science. Image credit: Bryn Dentinger.

Mycologists at [Royal Botanic Gardens, Kew](#), have identified three new species of mushrooms contained within a commercial packet of dried Chinese porcini purchased in London, UK.

Kew's collections

Herbarium collections	<ul style="list-style-type: none"> • <i>ca</i> 7 million dried pressed plants • 40,000 plants preserved in alcohol • 20,000 dried (non-viable) seeds and fruits
Mycology collections	<ul style="list-style-type: none"> • <i>ca</i> 1.25 million dried fungi • 1,100 living fungal cultures stored in liquid nitrogen • 500 isolates of mycorrhizal fungi
Economic Botany collection	<ul style="list-style-type: none"> • <i>ca</i> 110,000 artefacts & samples of known plant origin • <i>ca</i> 40,000 wood samples (xylarium)



Iridescent fruits preserved in alcohol



Dried herbarium material ready for mounting



Basket in Economic Botany collection

Kew's collections

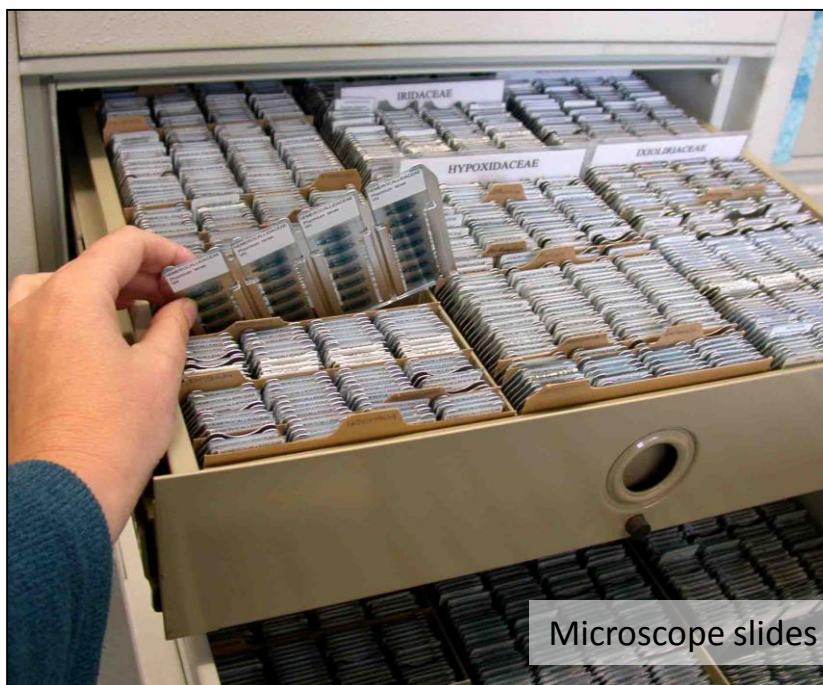
Microscope slide collections	<ul style="list-style-type: none"> • 10,500 mycology slides • 125,000 anatomy & cytology slides • 36,000 wood anatomy slides • 35,000 pollen slides
DNA bank	<ul style="list-style-type: none"> • 50,000 DNA samples stored at -80°C • 6,000 dried tissue samples
Millennium Seed Bank	<ul style="list-style-type: none"> • 2 billion living seed samples (dried to 15% RH, stored at -20°C)



DNA bank



Seed bank



Microscope slides

Microscope slides



Not all seeds tolerate banking



*Coffea
arabica*



*Azadirachta
indica*



*Elaeis
guineensis*

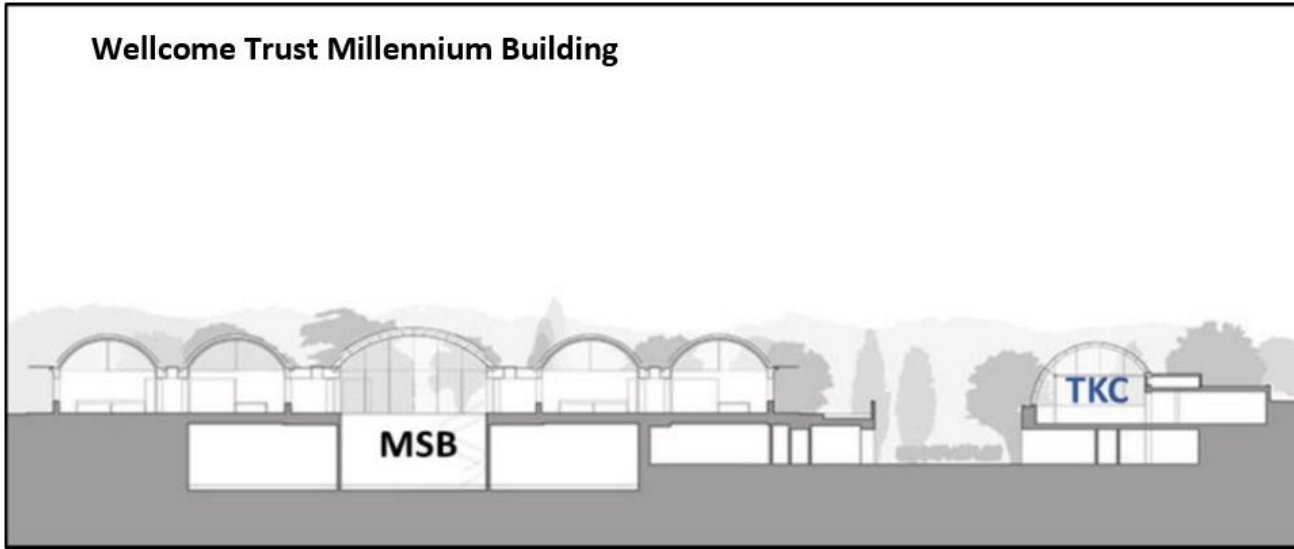


Carica papaya

Plus many large seeds of dominant tree species of temperate and tropical forests, e.g., oaks, dipterocarps

The Kew Cryosphere - concept

Wellcome Trust Millennium Building



Kew's collections

Living Collections

- 85,000 living plants in gardens and glasshouses
 - 25,000 living plants micropropagated *in vitro*
- Most of the living collections are curated by the Horticulture Directorate (except e.g. material micropropagated *in vitro*)
 - Important source of material for research



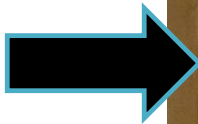
Kew's Library, Art & Archives

- 22 staff, 14 volunteers
- 300,000 books & pamphlets (including 11,000 Floras)
- 200,000 botanical illustrations (chiefly watercolours), portraits, photographs
- *ca* 25,000 maps
- **7,000,000 sheets of paper in archives (e.g. letters, notebooks, personal papers)**



Kew's Library, Art & Archives

6 hours in
liquid
hydrogen:
mustard
seed 88%
germination
after; all
others 100%



ROYAL GARDENS, KEW.

MEMORANDUM.

*Ch. to Dwyer
Aug. 4 '99*

Subject *Germination of seeds that had been
subjected to a low freezing temperature (Prof. Dwyer)
Sown 27-VII-99*

1	Pea	6 seeds	all germinated	healthy
2	"	4 "	all "	"
3	"	8 "	all "	7 healthy
4	Mustard	20 "	18 "	all "
5	"	153 "	136 "	{ Others had started but damped off.
6	Wheat	6 "	all "	healthy
7	"	13 "	all "	Slower than No. 6
8	"	11 "	all "	{ Only 4 above ground, others all good and sprouted.
9	Barley	18 "	all "	healthy
10	Musk	Germinated freely.		

*W. Watson
2-VIII-99*

*Seedlings of these dried Aug. 31 and sent to
Professor Dwyer, Dec.*

Thiselton-Dyer
(1899) *Proc.
Royal Soc., Lond.*

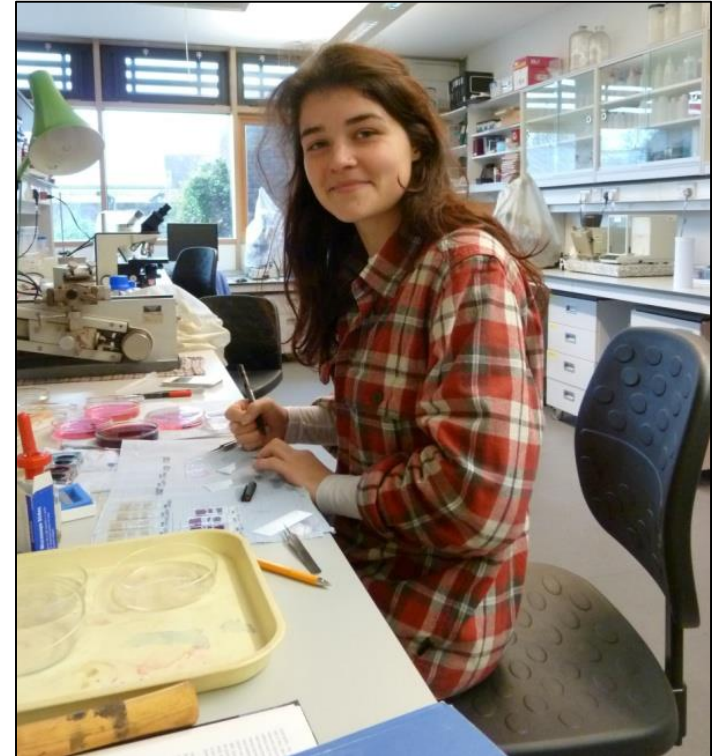
Kew Science – Lab facilities

Lab teams:

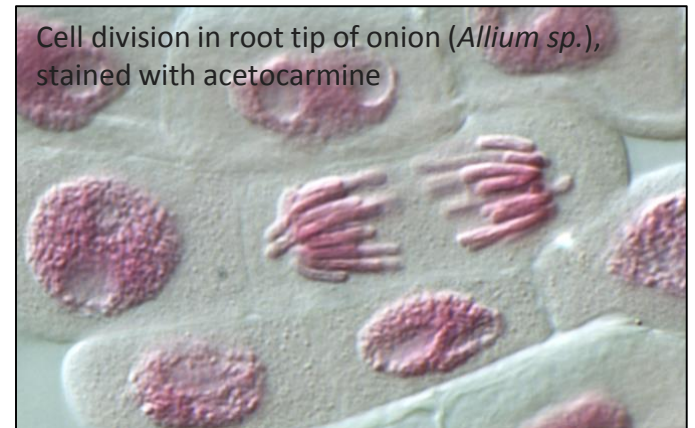
- Biochemistry
- Bioimaging
- Molecular
- Seed Biology
(WTMB, Sussex)

Range of techniques includes:

- Light and electron microscopy
- Flow cytometry
- DNA sequencing (Sanger, Microsat, AFLP, NGS)
- HPLC, GCMS, LC-MS, NMR
- *In vitro* micropropagation
- Seed germination, cryobiology
- Structural biology (DSC, DMA)



Cell division in root tip of onion (*Allium sp.*), stained with acetocarmine



Wellcome Trust Millennium Building, Wakehurst Place:

WTMB, home
to the MSB

14 study bedrooms on site

Diagnostics:

- GC-MS
- HPLC
- TD-NMR
- PCR

Ecophysiology:

- > 40 incubators
- 2 thermogradient plates
- 4 walk-in incubators
- Dark room (photobiology)

Structural biology:

- DSC
- DMA
- IgaSorp

Kew Science – Activities

- **Collections-based research** including Herbarium and laboratory (**plus model species**)
- **Fieldwork** (e.g. Brazil, Colombia, Madagascar, New Caledonia, Uganda, Sabah, UK)
- **Maintaining Kew databases** (e.g. GrassBase, Plant C-values database, Digifolia, IPNI, POWO)
- **Dissemination: presentations, organising conferences and workshops, publications (papers / books)**
- **Public Engagement and Outreach**



Madagascar, November 2015, collecting new species of canopy palms

Multiple interlinked projects

Genome size research at Kew has multiple uses and applications



Where am I? > Home > Kew Databases > Plant DNA C-values

Plant DNA C-values Database

(release 6.0, December 2012)
MD Bennett and IJ Leitch

News
Release of new data for over 1400 species not previously listed [More details](#)

Plant C-values

Angiosperm C-values

Gymnosperm C-values

Pteridophyte C-values

Bryophyte C-values

Algal C-values

<http://data.kew.org/cvalues>

- Genome size data for >8,500 plant species
- Largest genome size database on the internet
- Widely used by genome size community (c. 3 hits/hour over last year)

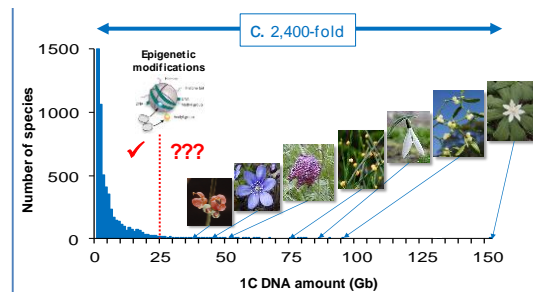
Practical applications

Whole-genome sequencing projects such as ash dieback



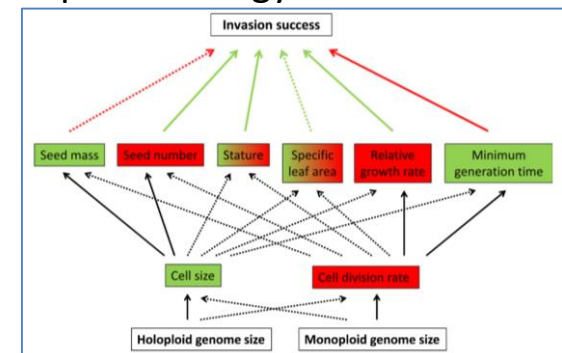
Fundamental research

Insights into genome dynamics and evolution



Applied

Impact of genome size on plant ecology



Kew Science – Strategic Outputs

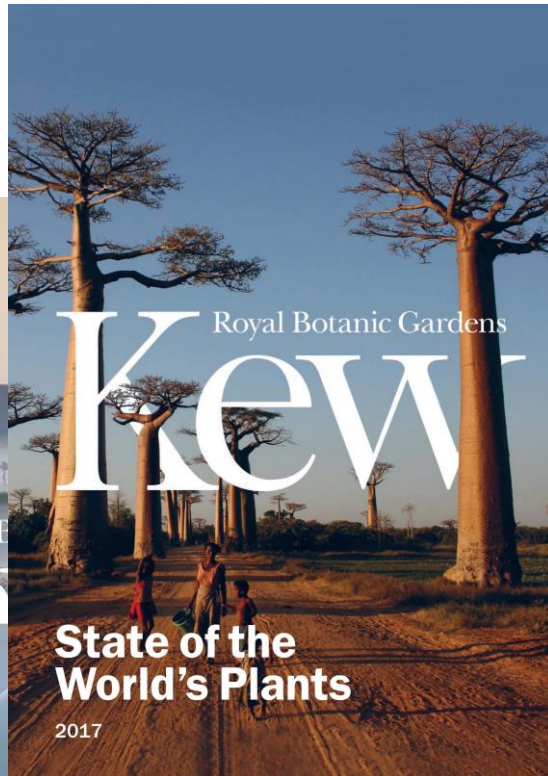
- Tropical Important Plant Areas (TIPAs)
- Plant and Fungal Trees of Life (PAFTOL)
- Plants of the World Online Portal (POWOP) (including Useful Plants and Fungi Portal)
- Banking the World's Seeds (25% of world species)
- Digitising the Collections
- Training the Next Generation (including Science in the Gardens)
- State of the World's Plants and Fungi (SOTWP/SOTWF)

State of the World's Plants (SOTWP)

- First SOTWP report and symposium, May 2016
- Second SOTWP report and symposium, May 2017
- State of the World's Fungi (SOTWF), September, 2018

Themes (e.g.):

- Current status of the world's plants and fungi
- Threats and their impacts to global plant species, populations and communities
- Effectiveness of international policies on conservation



**State of the
World's Plants**

2016

State of the World's Plants (SOTWP)



10 Describing the world's plants

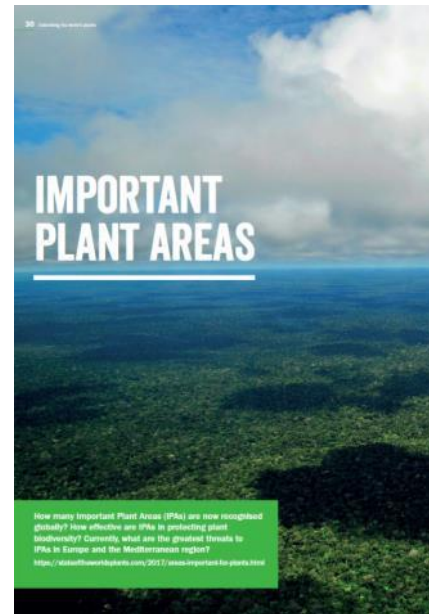
NEW PLANT SPECIES DISCOVERED IN 2016

1,730

VASCULAR PLANT SPECIES NEW
TO SCIENCE IN 2016 WERE LOGGED
IN THE INTERNATIONAL PLANT
NAMES INDEX BY MARCH 2017

What number of vascular plant species new to science were named in 2016? What are some of the most interesting new plants and where were they found?

<https://stateoftheworldsplants.com/2017/new-plant-discoveries.html>



16 Identifying the world's plants

IMPORTANT PLANT AREAS

How many Important Plant Areas (IPAs) are now recognised globally? How effective are IPAs in protecting plant biodiversity? Currently, what are the greatest threats to IPAs in Europe and the Mediterranean region?

<https://stateoftheworldsplants.com/2017/important-for-plants.html>

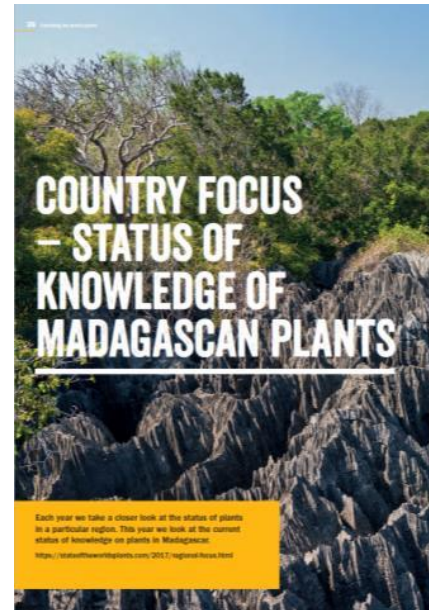


17 Assessing the world's plants

EXTINCTION RISK AND THREATS TO PLANTS

Are there particular biological attributes that make some plants more vulnerable to extinction through their effects?

<https://stateoftheworldsplants.com/2017/extinction-risk.html>

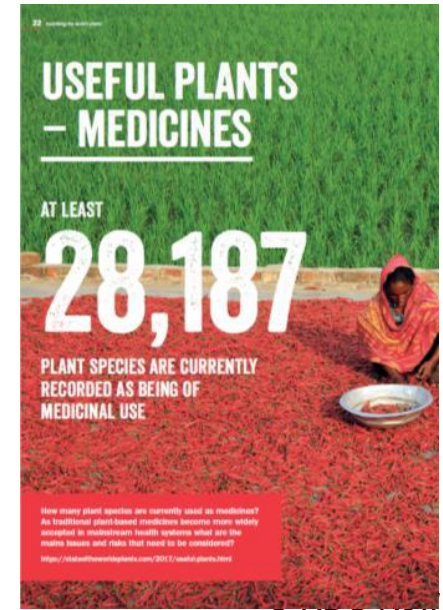


20 Identifying the world's plants

COUNTRY FOCUS — STATUS OF KNOWLEDGE OF MADAGASCAN PLANTS

Each year we take a closer look at the status of plants in a particular region. This year we look at the current status of knowledge on plants in Madagascar.

<https://stateoftheworldsplants.com/2017/region-focus.html>



22 Identifying the world's plants

USEFUL PLANTS — MEDICINES

AT LEAST

28,187

PLANT SPECIES ARE CURRENTLY
RECORDED AS BEING OF
MEDICINAL USE

How many plant species are currently used as medicines? As traditional plant-based medicines become more widely accepted in mainstream health systems what are the main issues and risks that need to be considered?

<https://stateoftheworldsplants.com/2017/used-plants.html>

State of the World's Fungi (SOTWF)

SOTWF Symposium

13–14 September 2018, RBG, Kew

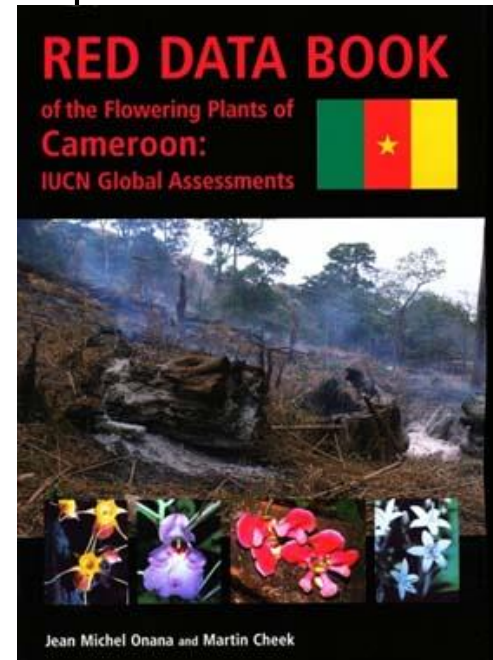
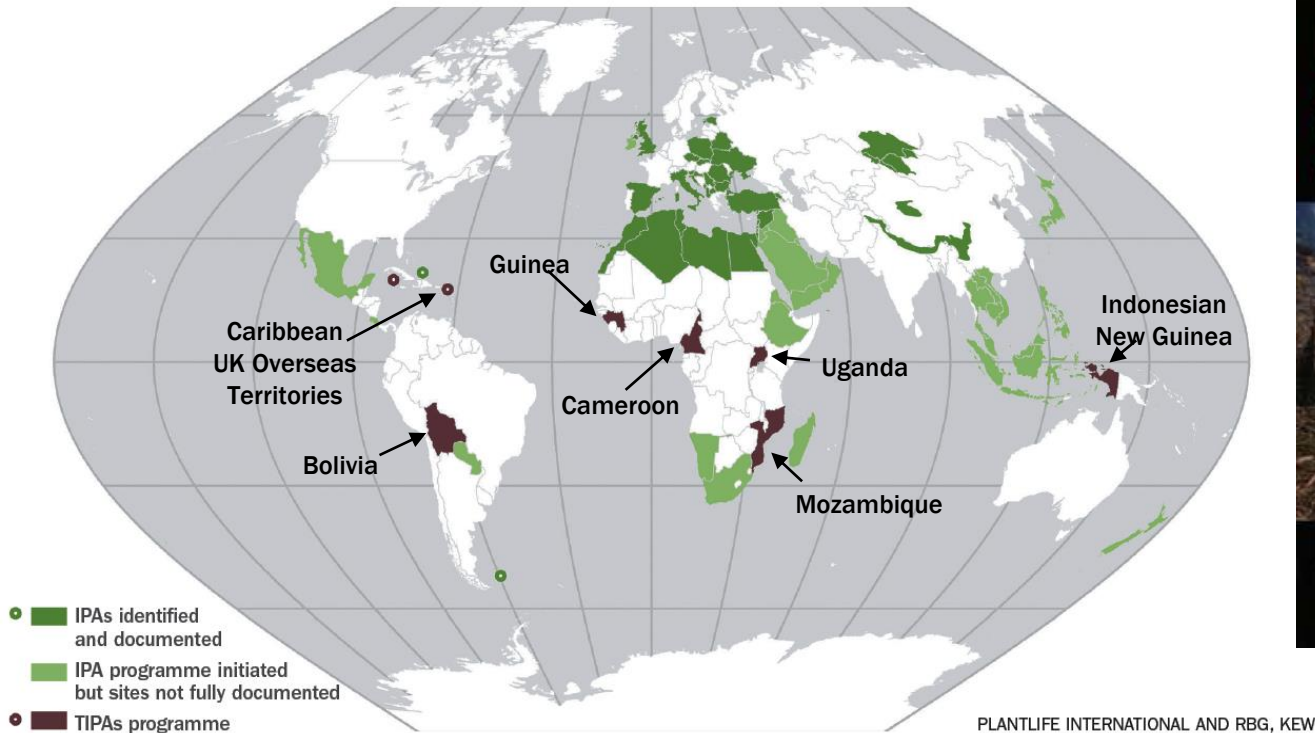
- Report highlighting current state of knowledge and major issues affecting fungal diversity and abundance.
- For scientists, the public and policy makers.
- Seven topical questions:
 1. Conservation of fungi: what, why, where and how?
 2. Does all plant life depend on fungi?
 3. Lichens
 4. Greater ecosystem service or disservice?
 5. Fungal networking – who benefits?
 6. Panning for gold in the mould: where do we find commercial value in fungi?
 7. Exploring the dark taxa: when does a molecular signature become a species?



Tropical Important Plant Areas (TIPAs)

TIPAs projects initiated in seven countries (dark brown on map below)

COUNTRIES THAT HAVE DESIGNATED IMPORTANT PLANT AREAS (IPAS) OR ACTIVE IPA PROGRAMMES



- Partner consultation, inception workshops, fieldwork and data compilation.
- Project Officers in place for UKOTs, Guinea, Mozambique, Bolivia
- First TIPA identified and documented in British Virgin Islands; TIPA assessments now being made in Guinea

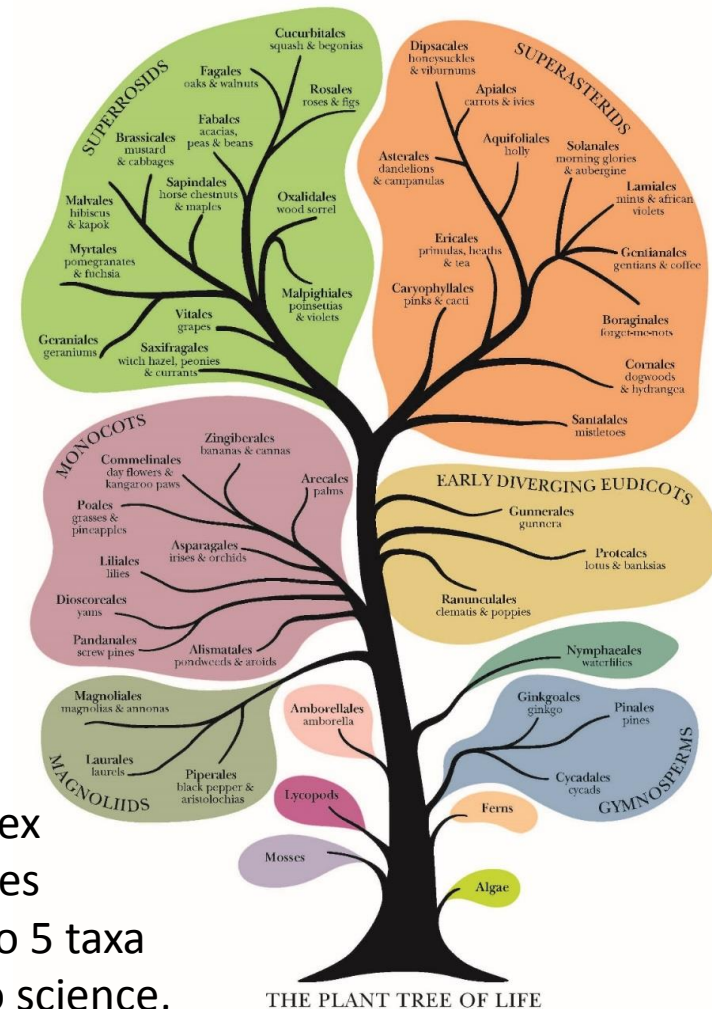
Plant and Fungal Trees of Life (PAFTOL)

- Genomic characterisation of Kew's collections
- Genome-scale data from each genus (>20,000 genera, including *ca* 14,000 plants, 8,200 fungi)
- Complete genus-level Trees Of Life for plants and fungi by 2020



Big blue pinkgill
fungus
(*Entoloma bloxamii*)

- European species complex
- British Fungarium samples sequenced and assigned to 5 taxa
- One of them was new to science, now named and described



Plant and Fungal Trees of Life (PAFTOL)

Application of new and emerging technologies to rapidly collect and analyse genomic data anywhere in the world

nature.com > scientific reports > articles > article > article metrics

a natureresearch journal

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Article metrics for:

Field-based species identification of closely-related plants using real-time nanopore sequencing

Last updated: Mon, 4 Dec 2017 08:26:07 GMT

Kew scientists sequence plant DNA on a mountain using handheld device

Online attention



Altmetric score (what's this?)

- Tweeted by 89
- Blogged by 5
- On 1 Facebook pages
- Picked up by 10 news outlets
- 18 readers on Mendeley



Plants of the World Online (POWO) portal

Launched in March 2017 – now c. 16,000 users per day

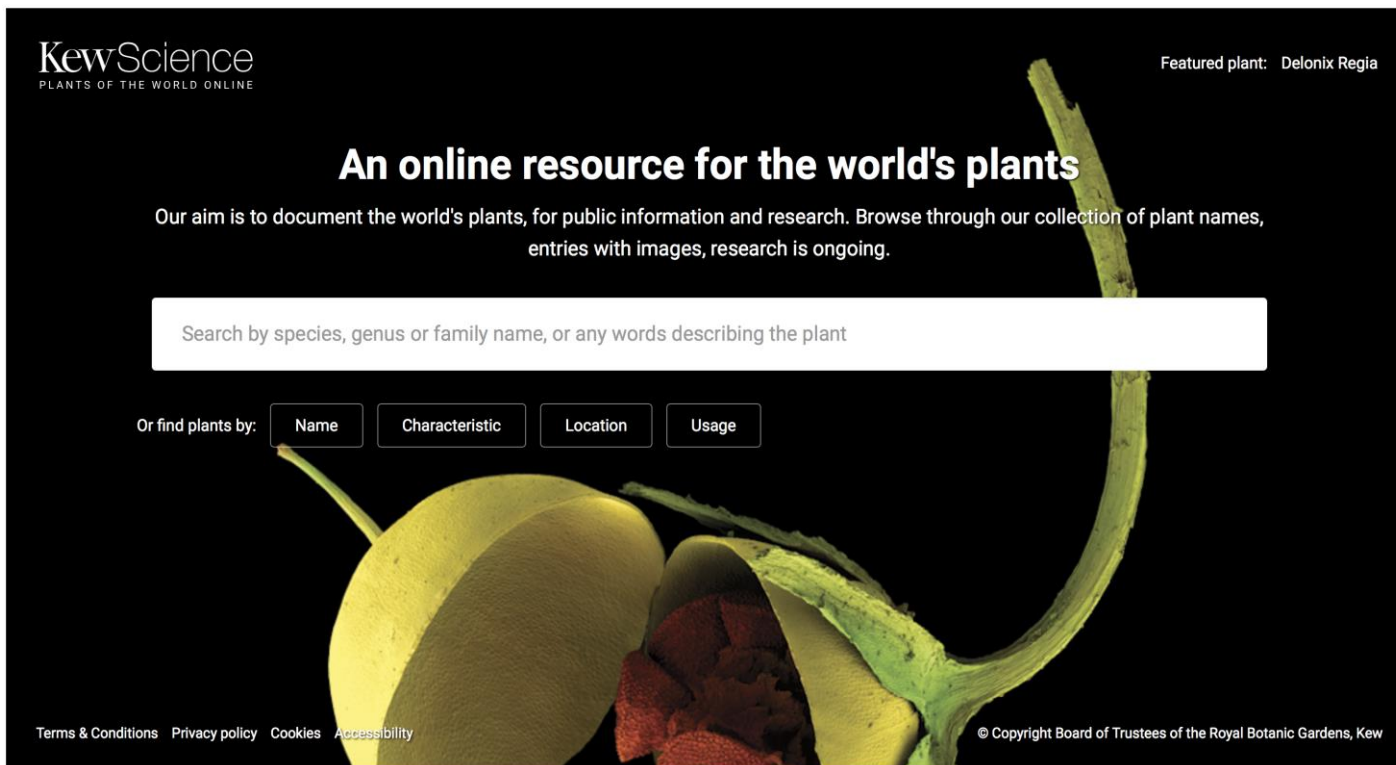
- In 2018: Working on Chinese Medicinal Plants Portal
- More content added to POWO & functional development

Open Access to:

- Core collections data
- Higher taxonomy
- Backbone taxonomy
- Descriptive data

Species Pages:

- Description(s)
- Distribution maps
- Taxonomy
- Common names
- Bibliography



<http://www.plantsoftheworldonline.org/>

Incorporating databases into POWO

Digifolia database: Nearly 11,000 images

Digifolia Feedback Help 61 Lynn Parker Start searching... Search

Create Import Actions Export

Assets - 4188 items
Projects - 20 items

DIGITAL COLLECTION NAME

Art & Illustrations	4188	<input checked="" type="checkbox"/>
Microscope Slides	3366	<input type="checkbox"/>
Press Office	602	<input type="checkbox"/>
Science Photographs	2811	<input type="checkbox"/>
Test Photographic Cata...	6	<input type="checkbox"/>

ADDED OR MODIFIED

Added by me	2686	<input type="checkbox"/>
Modified by me	361	<input type="checkbox"/>

ASSET USED

WORKFLOW STATUS

Pending Edit	443	<input type="checkbox"/>
Pending Approval	61	<input type="checkbox"/>
Approved	2841	<input type="checkbox"/>
Released	2841	<input type="checkbox"/>
No Status	843	<input type="checkbox"/>

ARCHIVE STATUS

Red	1130	<input type="checkbox"/>
Amber	668	<input type="checkbox"/>
Green	992	<input type="checkbox"/>
None	1398	<input type="checkbox"/>

ASSET QUALITY

Very Low	20	<input type="checkbox"/>
Medium	15	<input type="checkbox"/>
High	4153	<input type="checkbox"/>

Id: 251 "Miss Cotton", Victoria amazonica

Id: 249 Interior of the library at Hunter House.

Id: 244 Temperate House, Kew Gardens

Id: 237 Cambridge Cottage, Kew.

Id: 232 Totem pole from the village of Tanoo

Id: 225 Encephalartos hildebrandtii, Mombasa Cycad.

Id: 220 Exterior of the Palm House of the Royal Botanic Gardens...

Id: 186 Fico Brogiotto nero, Gallezio

Id: 181 Varieties of lettuces, Ernst Benary

Id: 179 Varieties of cabbages, Album Benary

Id: 162 Stapelia asterias, Francis Masson

Id: 150 Snapdragon, campanula, Scedel, Calendarium

Id: 148 Calendarium, Sebastian Schedel

Id: 143 Polyanthus and primroses by Maria Sibylla Merian

Id: 136 Rosa sp., by unknown artist

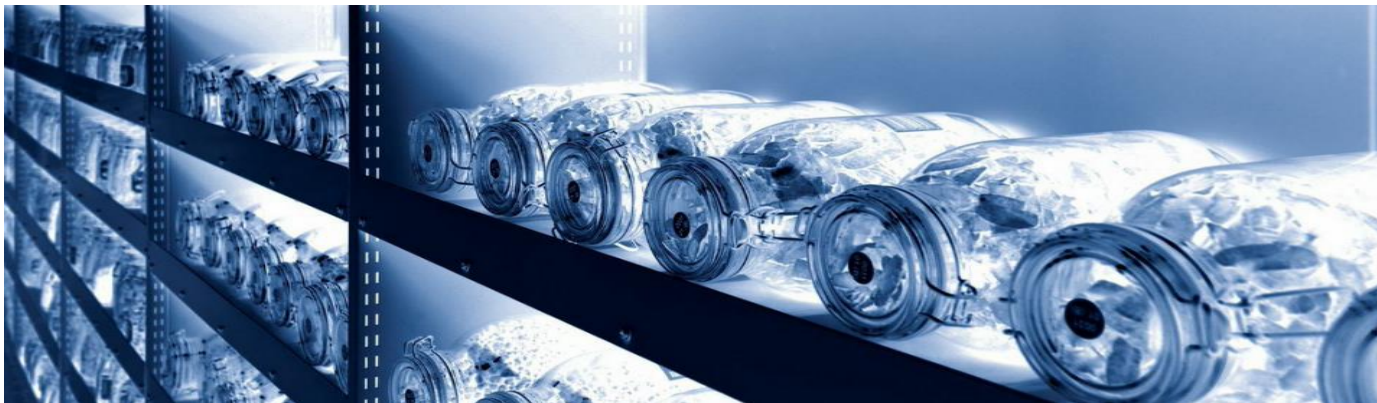
Id: 131 Tulips and Double Anemones

Id: 129 Common Chestnut Tree, Castanea sativa

Id: 124 Strelitzia angusta, Francis Bauer

Banking the Worlds Seeds

- Wellcome Trust Millennium Building currently houses over 2 billion seeds from > 41,000 plant species
- Seed of 25% of the world species to be banked
- Associated global network of seed banks maintained (Millennium Seed Bank Partnership: MSBP)
- Increased focus on:
 - Collection quality and genetic diversity
 - Crop Wild Relatives
 - UK flora (UK National Tree Seed project)
 - Cryopreservation of viable seeds



Training the Next Generation: *Kew MSc course*



The poster features a large image of the Palm House at Kew in the background. In the foreground, there are purple and yellow plants. The text is overlaid on the image.

MSc Plant and Fungal Taxonomy, Diversity and Conservation
Be one of the next generation of plant and fungal scientists

An exclusive opportunity to:

- Study at the Royal Botanic Gardens, Kew, with unrivalled access to Kew's scientific collections and archives
- Focus on global plant diversity, building your knowledge of taxonomy and skills in identification. Have access to Kew's Herbarium, which contains over seven million dried plant specimens
- Be taught by the UK's leading mycologists and study in Kew's unique Fungarium, which houses 1.25 million specimens
- Take part in a field trip to Kew's Madagascar Conservation Centre and develop skills in conducting botanical surveys and plant identification, and visit a number of active conservation projects
- Conduct a unique six-month research project and work alongside some of Kew's 300+ scientists in the lab and out in the field.

Bursaries are available from the Royal Botanic Gardens, Kew. For this MSc, Kew partners with Queen Mary University of London, ranked in the top 20* of UK universities.

*QS Graduate World University Rankings 2018

Interested?
For further information and how to apply visit kew.org/msc

Royal Botanic Gardens
Kew

In partnership with
 **Queen Mary**
University of London

MSc course launched in 2015
Year 2 in 2016/17 (21 students)
Year 3 in 2017/18 (20 students)
Year 4 in 2018/19 (25 students)



Training the Next Generation: *many short courses*

Applied Plant Taxonomy, Identification and Field Survey Skills Course 2018

Royal Botanic Gardens, Kew, supported by the NERC



The Royal Botanic Gardens, Kew is organizing an **Applied Plant Taxonomy, Identification and Field Survey Skills Course** from 18–29 June 2018. The course is designed for early career environmental scientists and PhD students of any discipline, with competitive bursaries supported through NERC funding.

Tropical Plant Identification Course



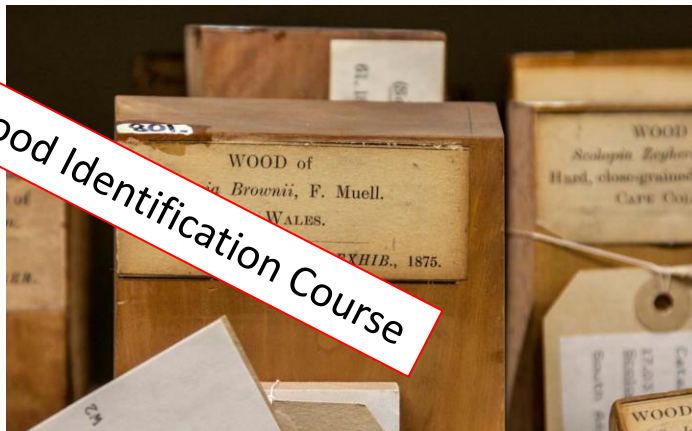
Tropical Plant Families Identification Handbook

Seed Conservation Techniques



The training programme of Kew's Millennium Seed Bank Partnership develops the specialised skills and knowledge needed to collect, conserve and manage *ex situ* seed collections. A combination of training activities are offered to partners, collaborators and other institutes, following a detailed 'training needs assessment' of existing experience.

Wood Identification Course



Training the Next Generation: *Science Festivals*

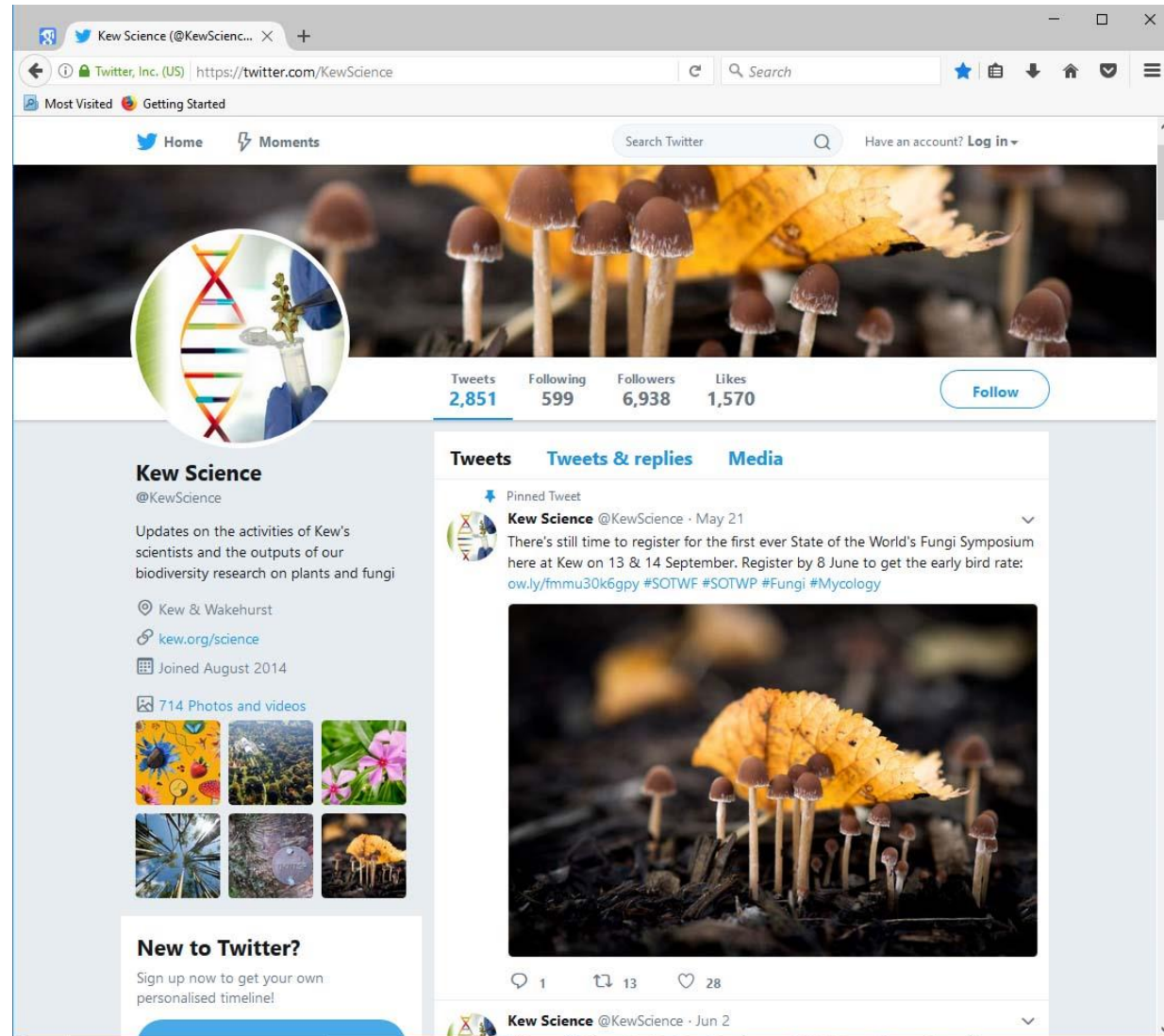
- Annual Kew Science Festival launched in August 2016
- Workshops, hands-on experiments, shows
- Two Science Festivals in 2017, at Kew and Wakehurst. One at Wakehurst in 2018 (5000 visitors). Two in 2019: Wakehurst (May; 3700 visitors).

<http://ow.ly/erpG30kfW9A> #WakehurstSciFest



Science Communications: Kew.org/Science

- Twitter
- Facebook
- Science blogs
- Weekly Newsletter
- Brown Bag talks



Comparative Seed Biology

Hugh W. Pritchard FRSB, FLS



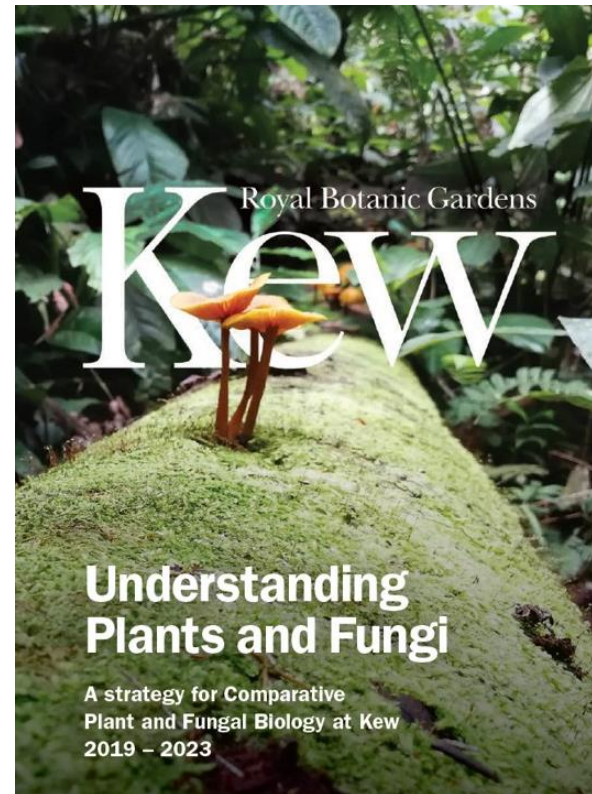
*The scientific vision of CPFBS is to **understand the principles that determine plant and fungal diversity**, applying this fundamental knowledge to the global challenges of today.*

- **Four teams**

1. **Comparative Seed Biology**
2. Comparative Fungal Biology
3. Integrated Monography
4. Character Evolution

- **Scientific priorities**

1. Building the tree of life
2. **Trait-based research**
3. **Lineage-focused research**



Personnel (+15 visiting scientists pa):

Dr Charlotte Seal



Dr Anne Visscher



Dr Louise Colville

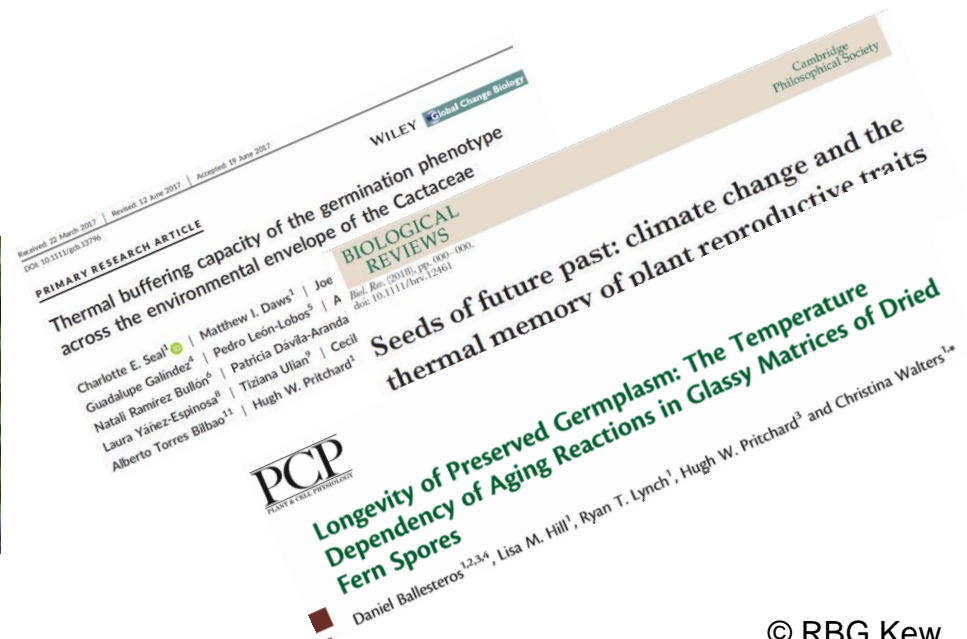


Dr Dani Ballesteros



Metrics 2012-18:

- £ 1 million income – grants (e.g. EU EcoSeed, NASSTEC), consultancies, fellowships (>£ 7 million value)
- 143 PR-journal papers
- Cumulative h-index = 23
- Co-authored with 30 nations



Current and future projects:

1. **TKC** -The Kew Cryosphere (RESILIENCE)
2. Over-wintering phenomena in seeds (TRAIT EVOLUTION & RESILIENCE)
3. **ESTO** - Evolution of seed traits in orchids (TRAIT EVOLUTION)
4. **BRACE** – Building biological Resilience in Asian Coastal Ecosystems (TRAIT EVOLUTION & RESILIENCE)
5. **GENESS** - Germination after Extreme Natural Exposure of Seeds on the International Space Station (RESILIENCE)

TKC: conceptual space

