GARNish

June 2014 Edition 21

Software Carpentry

GARNish
Editorial & Contents

Welcome to the June 2014 Issue of GARNish

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At GARNet, we're excited about the GARNet 2014 conference that will be held 9–10 September at the University of Bristol. This promises an opportunity for the UK Arabidopsis community to see bleeding edge science, learn from fabulous international speakers, build new collaborations and develop careers.

As I write this in my 100-year old office in Bristol, I'm reminded that I am fortunate to be moving to the state-of-the-art, eco-friendly and architect-designed Bristol Life Sciences Building. Since this new building is the venue for the GARNet 2014 poster reception, GARNet 2014 delegates will have the opportunity to see this exciting new facility for plant sciences research.

We were delighted by the popularity of the sell-out Software Carpentry Bootcamp held at the University of Warwick during April. This pointed complete beginners, with no or little experience of programming, towards UNIX shell basics, programming in Python, and import/processing of data. We're grateful to Christina Koch, who travelled from Vancouver to run the bootcamp, alongside Aleksandra Pawlik from the Software Sustainability Institute.

Given the success of the bootcamp and desire within our community to learn the basics of coding, GARNet is planning another bootcamp in November this year at the University of Liverpool – keep an eye on our mailing list and Twitter feeds for more news as it breaks!

Contents

Thanks to: Antony Dodd, Katie Tomlinson, Anne Osbourn, Jim Haseloff, Fuquan Liu, Mahmut Tör, Claire Stoker, Leonor García Gutiérrez and Graeme Sneddon.

In this issue of GARNish, we have an article by Anne Osbourn (John Innes Centre) and Jim Haseloff (University of Cambridge) about the exciting OpenPlant initiative for the development and sharing of technologies for plant synthetic biology.

There's also an article concerning the archiving of data within the Gene Expression Omnibus (GEO) repository for community sharing. Whilst our article focuses on microarray data, GEO stores other data types including NGS and proteomics. We have also provided a round-up of the new facilities funded by the BBSRC ALERT13 awards that could be of value to the plant sciences community.

Also in this issue is a feature by Katie Tomlinson from the British Society of Plant Pathology about the BSPP's "Plant Doctor" show at a variety of science fairs around the UK. It's great to read about the BSPP's approaches to inspire a wider interest in the importance of the plant sciences, both to help the public understand why what we do is so important, and also recruit new young people into the field!

This issue has a focus upon plant sciences at the University of Worcester, which is a centre of expertise in pollen and spore biology within the National Pollen and Aerobiology Research Institute, but other interests also extend to the cell cycle, pathology, membrane transport, and plant ecology. We also pay a virtual visit across the Irish sea to the plant scientists at Queen's University Belfast.

I hope you enjoy the June 2014 issue of GARNish and we look forward to welcoming you to the GARNet 2014 Conference in the autumn.

Twitter: Follow Lisa @GARNetweets and Charis @weedinggems.

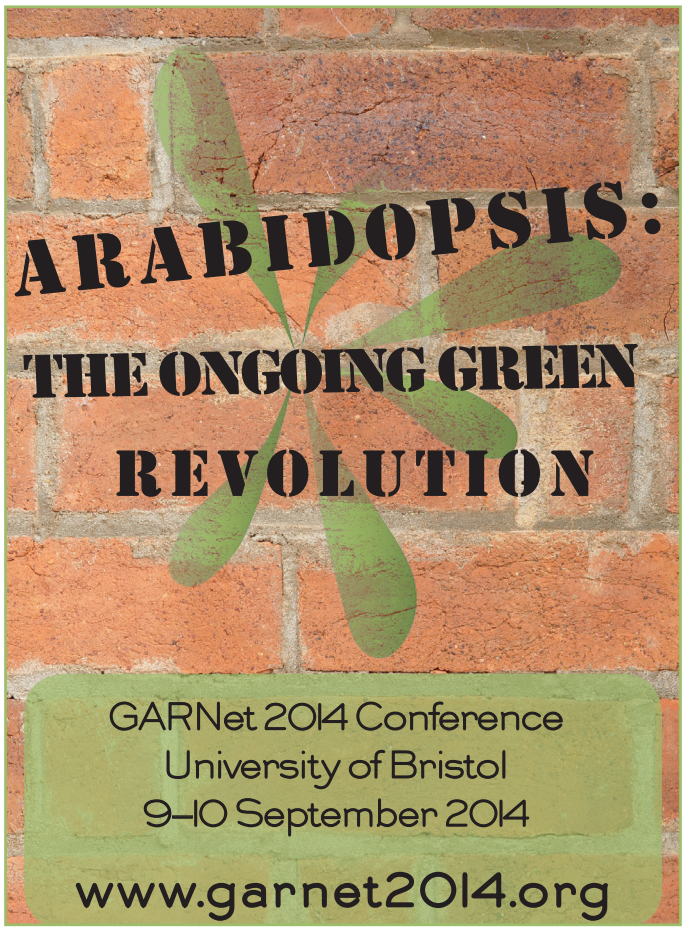
Also don't forget the **Weeding the Gems blog** at *http://blog.garnetcommunity.org.uk*. Please contact Charis at charis@garnetcommunity.org.uk if you would like to write a guest post!

GARNet 2014

Unless you've somehow managed to miss our tweets, posters and email alerts on the ARABUK mailing list, you'll already know that we are hosting our conference at the University of Bristol on the 9–10 September!

The title of GARNet 2014 is "Arabidopsis: The Ongoing Green Revolution" and provides an opportunity to be updated on the fantastic range of fundamental plant science research happening across the UK and beyond. In fact, it's the biggest Arabidopsis conference in Europe this year!

The conference will feature a great line-up of speakers across five themed sessions: Genome Biology, Physiology & Productivity, Natural Variation, Systems & Synthetic Biology, and Plant Interactions with their Environment. Delegates will have the opportunity to hear plenary talks from some very well-known and engaging speakers: Maarten Kournneef and Paul Schulze-Lefert from the Max Plank Institute for Plant Breeding Research, Rob Martienssen from Cold Spring Harbor Laboratory, Andrew Millar from Edinburgh and Alistair Hetherington from Bristol. GARNet 2014 will also celebrate the "rising stars" of our community, including oral presentations from selected PhD students and early career researchers.



Join the Ongoing Green Revolution! GARNet's 2014 conference is on 9-10 September at Bristol University.

The registration fee includes two days of speakers and panel sessions, a poster session, refreshments and a networking drinks reception. There will also be a conference dinner on the evening of the 9 September, which you are warmly welcomed to attend.

If you haven't already registered for GARNet 2014, what are you waiting for? Please visit *http://garnet2014.org* for more information.

Global Plant Council Update

In January, the Global Plant Council (GPC) and the Global Crop Diversity Trust (GCDT) held a joint workshop in San Diego to discuss the Digital Seed Bank (*http://tinyurl.com/digiseedbank*) and Seed Seq (*http://tinyurl.com/seedseq*) initiatives, which aim to capture and exploit crop bioversity to find new genes, alleles and genetic networks to improve crops.

The workshop was intense and successful, generating lots of enthusiasm and new ideas, and identifying barriers to overcome. As an output of the workshop the Diversity Seek (DivSeek) initiative has been established. This aims to bring together world expertise to harness the power of crop diversity in order to accelerate

The report UK *Plant Science: Current status & future challenges* was launched in January

the rate of crop improvement and furnish food and agricultural products to the growing human population. DivSeek will shortly release a white paper outlining the initiatives and its goal.

The GPC is also currently organising a forum on Biofortification. This will be held after the 3rd International Conference on Plant Metabolism in Xiamen, China. For more information on this and other global plant science events, sign up to the GPC's email mailing list by contacting ruth@globalplantcouncil.org, or visit the website *http://www.globalplantcouncil.org*. The GPC also has a Twitter account: @GlobalPlantGPC.

Finally, for news, views and articles from the global plant science community, the GPC also has a new blog! You can read it online at: *http://blog.globalplantcouncil.org*.

UK Plant Sciences Federation Update

January 2014 saw the launch of the UKPSF's report entitled "*UK Plant Science: Current status and future challenges*."

Based on the findings of a series of surveys and interviews with members of the plant science community, this report aimed to highlight the status of plant science in the UK, assess barriers to future success and make recommendations to ensure the UK's continued position as a world leader in plant science.

Recommendations made in the report included calling for a doubling of funding for UK plant science, creating a better balance of funding across the portfolio of fundamental and applied plant science research, greater support for translational research, inspiring the next generation of plant scientists, increasing opportunities for education and training to meet the skills needs of employers, and the establishment of more evidence- and risk-based regulatory frameworks.

In March, UKPSF representatives presented the status report in Westminster, at a meeting of the All-Party Parliamentary Group on Science and Technology in Agriculture (APPGSTA). They also met with BBSRC in March and the BIS Agri-Tech team in May to discuss how they can work together to support plant science and see the recommendations of the report implemented.

The UKPSF has established working groups to draw up a set of action plans relevant to the specific priorities identified in the report.

You can download a copy of the report from a link on the Society of Biology website: *http://tinyurl.com/UKPSFreport*.

The UKPSF's conference, *UK PlantSci 2014*, held at the University of York on the 30 March and 1 April, was a great success. Tim Benton, the UK's Champion for Global Food Security, gave a fascinating and thought-provoking keynote lecture, while in the Future Generations session we were treated to short talks from some of the UK's rising stars of plant science.

Congratulations to PhD student Presidor Kendabie (University of Nottingham) and early career post-doctoral researcher Sarah Harvey (University of Warwick) for their prize-winning talks.

Don't forget that you can keep up to date with news from the UKPSF by following the official Twitter account (@UKPSF), or by signing up to the mailing list at *http://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=PLANTSCIUK*.

GARNet launches Synthetic Biology Report

During GARNet Chair Jim Murray's talk at UK PlantSci 2014, we launched our very own report.

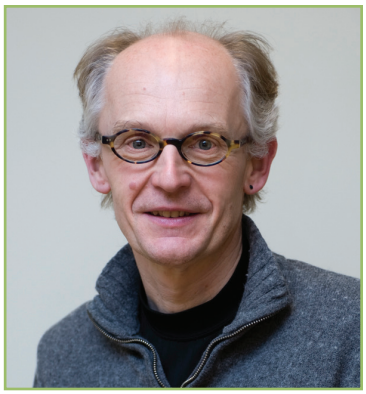
"*Developing Plant Synthetic Biology in the UK: Opportunities and Recommendations*" summarises discussions held at the "*Introduction to Opportunities in Plant Synthetic Biology*" workshop we held at the University of Nottingham last year, and makes a number of recommendations to help the UK develop a world-leading plant synthetic biology research base.

Download the report, and a related *Journal of Experimental Botany* paper, from the Reports section of the GARNet website: *http://www.garnetcommunity.org.uk/reports*.

High-Flying GARNet Committee Members

Congratulations are in order to two of GARNet's current Committee Members. First of all, back in March, it was announced that David Salt had been honoured with a Fellowship of the Royal Society of Edinburgh.

Professor Salt, from the University of Aberdeen, is a pioneer in the field of ionomics and is interested in understanding the functions of genes and gene networks that regulate the elemental composition of plant organisms, tissues or cells. He also seeks to understand the evolutionary forces that shape this regulation, and has developed the ionomicsHUB; an online resource for scientists studying the ionomes of a variety of organisms, including Arabidopsis.



Professor David Salt, FRSE

Then, in May, Malcolm Bennett, Director of the University of Nottingham's Centre for Plant Integrative Biology, was elected as a Member of the European Molecular Biology Organization (EMBO). This is in recognition of Malcolm's long-standing research interests in the mechanisms that control root growth and development in *Arabidopsis thaliana*.

Professor Malcolm Bennett, EMBO member

OpenPlant ERASynBio Summer School

Introduction to Synthetic Biology in plant systems

14th - 20th September 2014, John Innes Centre, Norwich, UK

The OpenPlant consortia (John Innes Centre and University of Cambridge) and Synthetic Biology ERA-NET (ERASynBio) are looking for PhD students and early career postdoctoral researchers to attend an advanced summer school on synthetic biology in complex systems.

Training will be provided in: DNA assembly, genome editing, metabolic engineering, transformation, new plant systems, genomic resources, software modelling, instrumentation, biotechnology and social impact.

Training, travel and subsistence costs will be paid for by ERASynBio.

Details of speaker, mentors and the application process will to be announced soon shortly on the websites of ERASynBio (www.erasynbio.eu) and OpenPlant (www.openplant.org).

John Innes Centre

UNIVERSITY OF CAMBRIDGE

ERA SynBio

GARNish

GARNet Workshop Report

Software Carpentry for Plant Scientists: 9–10 April 2013, University of Warwick

Lisa Martin
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Though many plant scientists rely on computer software, command line programming remains a mystery to many researchers.

Knowledge of coding, even at a basic level, can help improve research efficiency, for example by automating repetitive tasks, speeding up data analysis and facilitating collaborations with bioinformaticians.

To help address this skills gap, GARNet welcomed over 30 attendees from all over the country to the University of Warwick in April in order to take part in an intensive two-day Software Carpentry workshop.

Part of the Mozilla Science Lab initiative, Software Carpentry is a not-for-profit organisation that seeks to equip scientists and engineers with basic computer programming skills. Software Carpentry "bootcamps" are run by a global network of volunteer programmers who teach scientists how to code efficiently in order to get more done, in less time, with less pain.

For the GARNet bootcamp, our trainers were Aleksandra Pawlik and Christina Koch. Aleksandra holds a PhD in Computing from the

Delegates getting to grips with GitHub. *Photo: Charis Cook*

"I found the Software Carpentry bootcamp to be a unique and useful course for plant scientists wishing to use software tools in their research.

I already had a basic understanding of programming in Perl, however the Software Carpentry course widened my understanding of programming languages to include Python. I found the section on version control particularly useful; using GitHub to track changes and revert to previous versions of code helps to log vital changes to my code and helps in the management of computational aspects of my research.

The skills developed in this course will be useful not only for my research on NPH3/RPT2*-like proteins in Arabidopsis, but will be valuable in the job market."*

Graeme Sneddon
University of Glasgow

Open University and leads the training activities of the Software Sustainability Institute at the University of Edinburgh.

Christina came all the way from Vancouver in Canada, though a misunderstanding at border control meant that she was almost refused entry to the country! She has a Masters in Mathematics from the University of British Columbia, co-manages a math learning wiki, and works as a tutor.

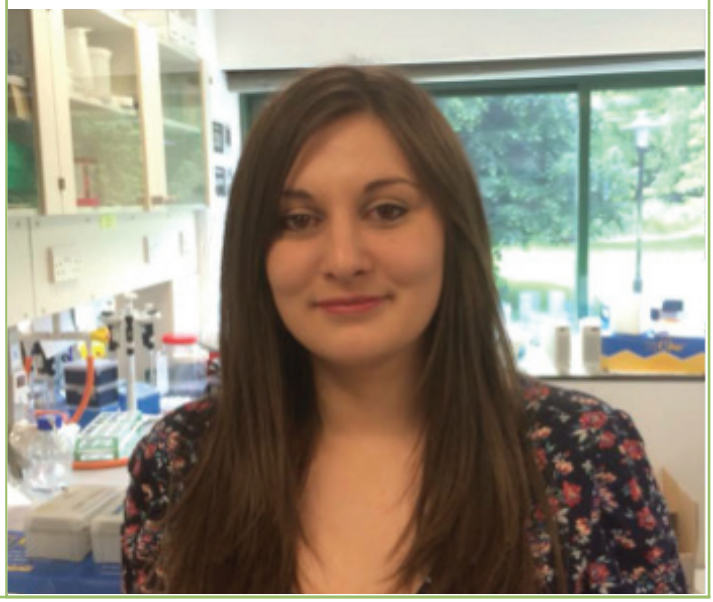
Many of our attendees were complete novices with little or no prior knowledge of coding, so after a welcome tea and coffee and setting up laptops on the morning of the first day, plenty of time was spent introducing the participants to the UNIX shell and the basics of command line programming. By starting very simply and gradually building up the code complexity, everyone had managed to write and run a simple shell script by the end of the session (even Charis and I managed it!).

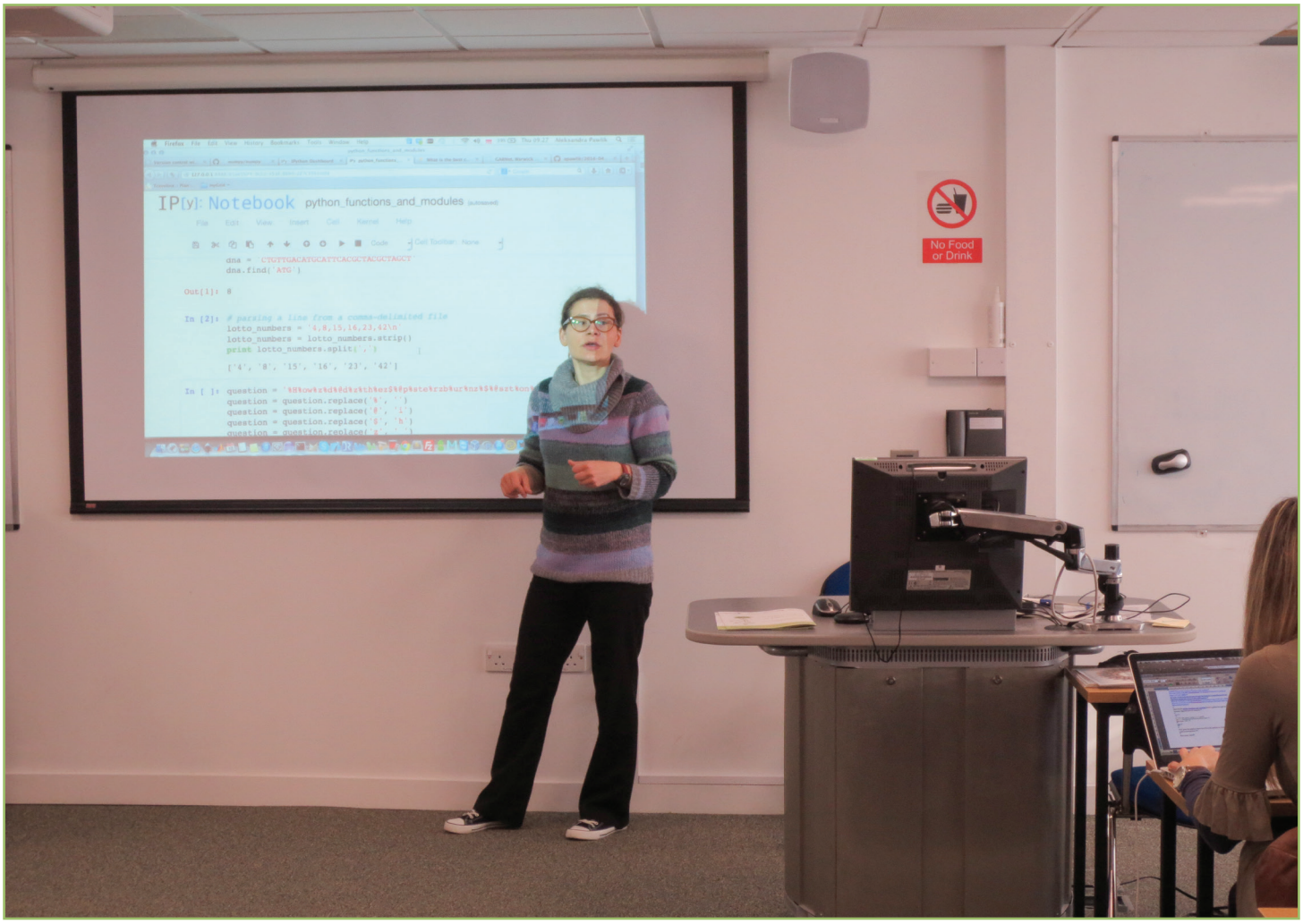
The next sessions were devoted to using GitHub and underlined the importance of version control as good practice in computer programming.

"I found the Software Carpentry for plant scientists very helpful; it has made me feel much more comfortable with the command line and using programming to help analyse my biological data.

The session on using data manipulation using Python was especially useful for me; Christina and Aleksandra were both very friendly and communicated the basic principles of Python extremely well."

Claire Stoker
University of Warwick





Aleksandra explains the iPython Notebook. *Photo: Charis Cook*

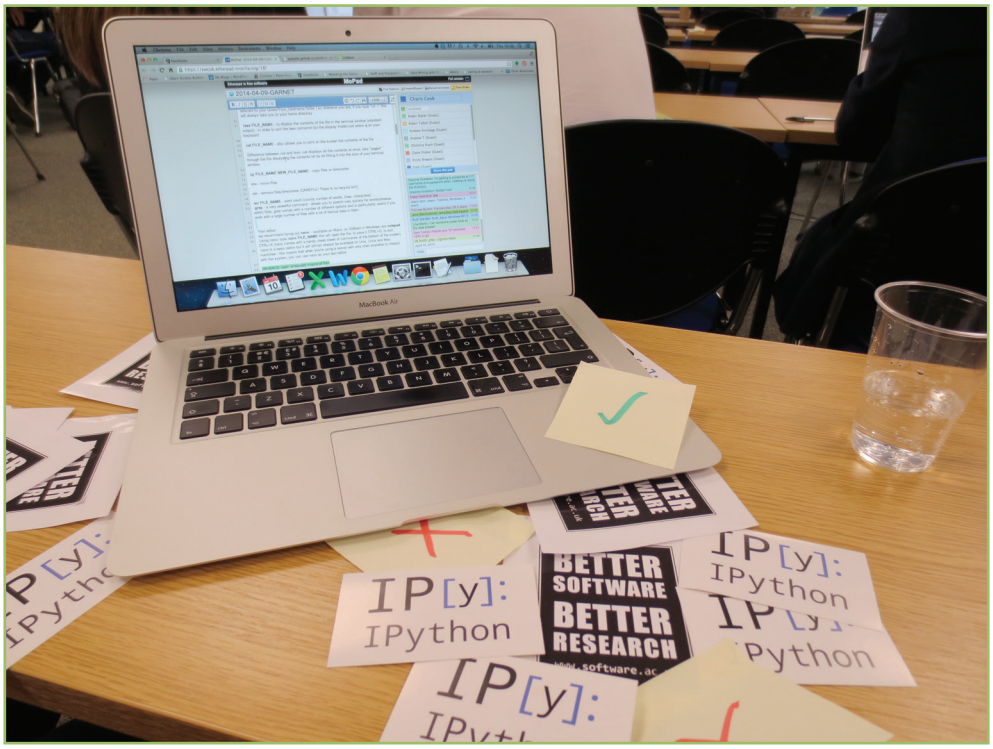
Version control ensures that if code contains errors or doesn't behave as expected, it can always be rolled back to a previous version to work out what went wrong. It also helps to reduce errors and compatibility issues when working collaboratively on software development. The underlying message was that version control may be simple, but overlooking it can cause lots of headaches!

Coding in Python was a key part of our Software Carpentry workshop, since this is something that many plant scientists will use, or will have at least heard of in the course of their research. Attendees were also introduced to the Pandas library through a practical tutorial that involved learning how to manipulate a large .csv file.

The bootcamp closed with some practical help in testing and debugging. Participants were asked to fork a repository with a faulty piece of Python code, and then work out what had gone wrong. It was a testament to our trainers, and the diligence of their students, that many attendees successfully completed this task despite having little or no knowledge of programming before the bootcamp.

Thanks must go not only to Christina and Aleksandra, but also to the three helpers we enlisted from the University of Warwick: Jason Piper and Krzysztof Polanski from Warwick Systems Biology, and Leonor García Gutiérrez from the Mathematics Institute.

The helpers are an invaluable part of any Software Carpentry bootcamp, since they can provide support to the delegates who need it while the trainers are delivering the tutorials.



Green ticks mean everything is OK! *Photo: Charis Cook*

Given the popularity of this Software Carpentry workshop (registration sold out within days, and we had a long waiting list!), we're pleased to announce that we are planning to hold another one soon. The next workshop will be held at the University of Liverpool, in conjunction with NERC, on the 17–18 November. We'll be opening applications very soon, so if you or your colleagues would like to take part, please keep an eye on our Twitter accounts and the ARABUK mailing list for more details.

Finally, all Software Carpentry tutorials are available online for free, so if you fancy learning some new skills, or refreshing your existing knowledge, simply visit *http://www.software-carpentry.org* and have a go.

"Being a helper was hard work and great fun! I learned about the importance of good software development in science, and shared my programming experience with the attendees when they got stuck.

The organisation was brilliant, and there was enough time during the breaks for informal chats. Although I know nothing about plant science, it was thrilling to listen to the attendees' research and help them figure out how to apply Python and the command line to their work.

The bootcamp was very intense (Git in particular!), but it showed how powerful these tools are and gave a good foundation. And that is incredibly empowering."

Leonor García Gutiérrez
University of Warwick

Depositing and searching for Arabidopsis microarray data in GEO

Charis Cook
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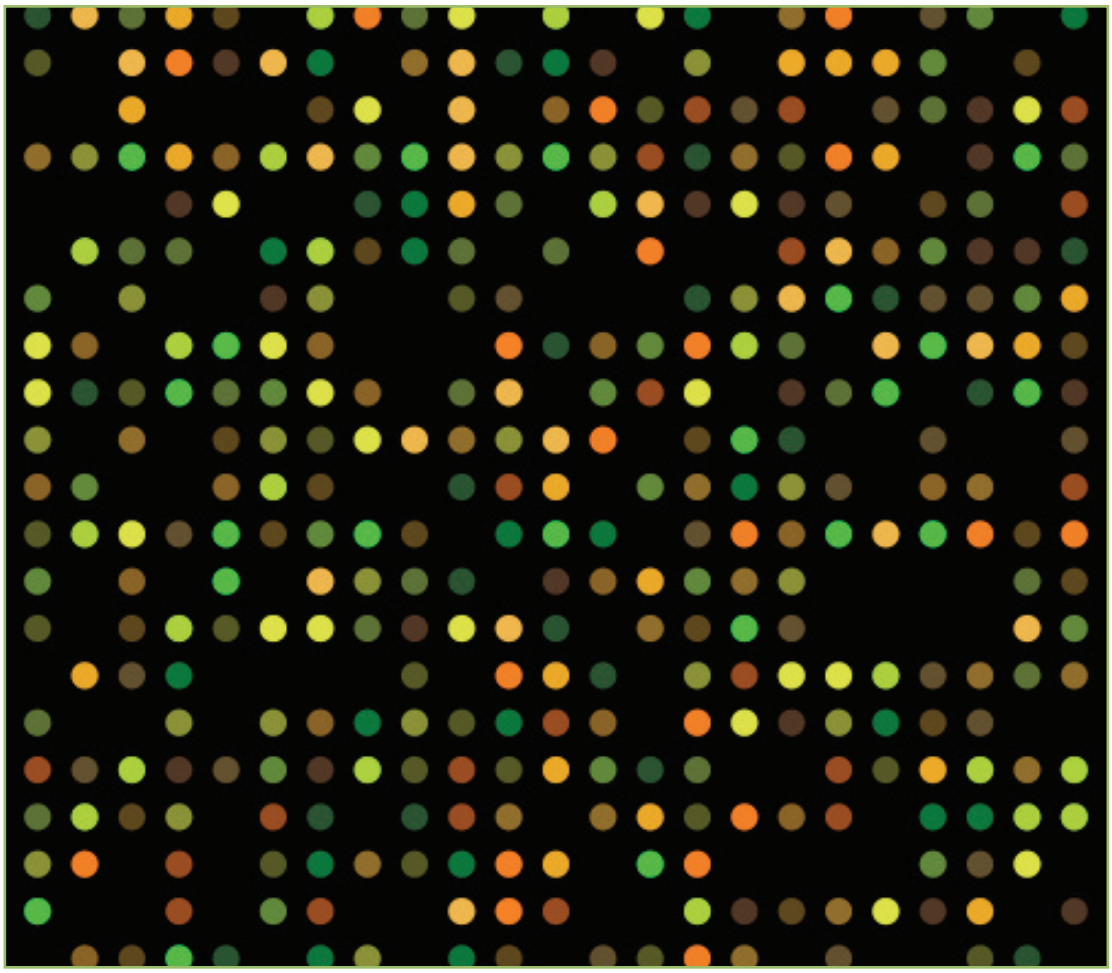
There are a number of university-based microarray services in the UK, including that at uNASC (see table opposite), which now operates as a collaborative facility; in exchange for authorship users purchase materials directly from Affymetrix. For more information on this and other UK microarray facilities please see the GARNet Microarray Facilities Resources page (*http://www.tinyurl.com/microarrayfacs*).

Previously, data generated by uNASC was automatically uploaded to NASCarrays; this is now no longer the case so you will need to arrange your own data sharing. Submission of gene expression data to the Gene Expression Omnibus (GEO) is a requirement of publication in most journals, so it important to know how to deposit your datasets.

Microarray experiments have well-established minimum information requirements and the four main microarray chip providers have customised information pages in GEO. An email address is provided for users to email enquiries and ask for help from GEO's curators.

The Affymetrix page (*http://www.ncbi.nlm.nih.gov/geo/info/geo_affy.html*) is probably the most useful for UK plant sciences.

Spreadsheet-based submission is recommended for Affymetrix deposits, so users should submit an Excel metadata worksheet, CEL files and processed data. The webpage gives advice on how to find required information, and there are template and example spreadsheets.



Once submitted, your dataset becomes a GEO accession and can be identified with a unique accession number. The accession number should be used when you or anyone else references or links to your dataset – an easy means of tracking its usage within the community.

If everyone shares their microarray results on GEO, it makes sense to

know how to unearth the data that interests you from the thousands of other datasets.

To find *Arabidopsis thaliana* microarray data, search: **(Arabidopsis thaliana[organism]) AND "expression profiling by array"**.

If want to narrow your microarray search to only Affymetrix data, just add another search term by using 'AND': **(Arabidopsis thaliana[organism]) AND "expression profiling by array" AND Affymetrix**.

To find other Arabidopsis datasets, search: **(Arabidopsis thaliana[organism])**.

On the left hand side of the window, there is a 'Study type' section. If you click on 'More…' a list of study types pops up from which you can select the data type you are looking for. Once you know your search options, you can add any search term you like to the search bar. For example, you could specify author, publication time, and a certain type of stress. Just keep adding AND in between each term.

GEO provides an informative guide (*http://www.ncbi.nlm.nih.gov/geo/info/download.html*) on how to download original records and curated datasets individually or in bulk. It is possible to download data directly from Accession Viewer pages in SOFT, MINiML or TXT formats. Raw data is also available in TAIR, and you can do bulk downloads via GEO's FTP site. All files are compressed using gzip.

It's also possible to access GEO programmatically in order to, for example, quickly retrieve CEL files from Arabidopsis stress experiments. Again, GEO provides a guide to this (*http://www.ncbi.nlm.nih.gov/geo/info/geo_paccess.html*), although this is better tackled with some pre-existing knowledge of programming.

UK Microarray Facilities

Note that prices are subject to change and do not include VAT. Prices quoted are discounted rates for larger experiments. The UK Affymetrix representative is Michael Evans (Michael.Evans@affymetrix.com).

Facility	Service provided	Cost per sample	Contact	Note
University of Bristol	Affymetrix ATH1 cartridge GeneST cartridge 24/96 arrayplate	 £500-£575 £400-475 £375/£275	genomics-facility@bristol.ac.uk	Price dependent on project numbers. Please contact the facility for an accurate quote.
University of Edinburgh	Affymetrix ATH1 GeneST	 £373 £280	richard.talbot@roslin.ed.ac.uk	For a 24-sample experiment
Glasgow Polyomics	Affymetrix GeneST	Contact via website	*http://www.polyomics.gla.ac.uk/ngs_omics.html*	
uNASC	Affymetrix ATH1 HTP	User buys materials	sean@arabidopsis.org.uk	Collaborative work only. No minimum number.
University of York	Agilent	£400	peter.ashton@york.ac.uk	For 8 samples per slide

ALERT 13

In December 2013, BBSRC announced the Advanced Life Sciences Research Technology Initiative 2013 (ALERT13) funding awards. Many of them may provide valuable services for Arabidopsis researchers, and those listed below were keen to be publicised among the GARNet community.

These are listed on the GARNet Resources webpages (*http://www.garnetcommunity.org.uk/resources*), and the complete list of awards can be found on the BBSRC website: *http://tinyurl.com/alert13equip*.

Please note that some of these facilities may not yet be up and running.

ALERT13 Equipment	Facility	Contact
Liverpool 3View: a national hub for 3D-EM bioscience research	Biomedial Electron Microscopy Unit, University of Liverpool	http://www.liv.ac.uk/emunit
A sharper light from gSTED microscopy on biological structure and molecular interactions	Octopus Facility, STFC Central Laser Facility	http://www.stfc.ac.uk/CLF/Facilities/Octopus+capabilities/14219.aspx
Affymetrix GeneTitan for use in high throughput genotyping	Bristol Genomics Facility, University of Bristol	http://www.bristol.ac.uk/biology/research/transcriptomics/
Photo-oxidation and cryofluorescence for Correlative Light Electron Microscopy	Wolfson Bioimaging Facility, University of Bristol	http://www.bristol.ac.uk/biochemistry/wbif/
Establishing Single Molecule Real Time Sequencing for the North of the UK	Liverpool Centre for Genomic Research, University of Liverpool	http://www.liv.ac.uk/genomic-research/
A superresolution microscope for biological research in the multi-user Microscopy Facility	Facility for Imaging by Light Microscopy, Imperial College London	http://www3.imperial.ac.uk/imagingfacility/equipment
Fluorescence Light Sheet Microscopy for live 3D and 4D imaging	Centre for Cell Imaging, University of Liverpool	http://www.liv.ac.uk/integrative-biology/facilities-and-services/centre-for-cell-imaging/
Multidisciplinary Super Resolution Microscopy Facility at Nottingham	Super Resolution Microscopy Facility, University of Nottingham	http://www.nottingham.ac.uk/Life-Sciences/Facilities/Super-Resolution-Microscopy/
Mass spectrometry imaging for biology and biotechnology	University of Liverpool	http://www.liv.ac.uk/pfg/

GARNet 2014 Conference
University of Bristol
9–10 September 2014

Speakers include:

Alistair Hetherington, Bristol
Andrew Millar, Edinburgh
Paul Schulze-Lefert, MPIZ
Rob Martienssen, CSHL
Maarten Koornneef, MPIZ

www.garnet2014.org

The OpenPlant Synthetic Biology Research Centre

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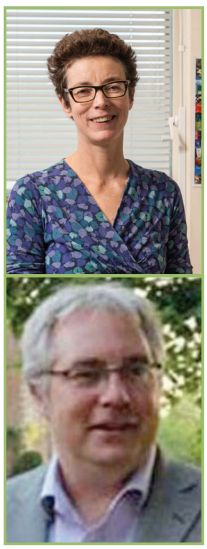

Scientists led by David Baulcombe and Jim Haseloff at the University of Cambridge, and Dale Sanders and Anne Osbourn at the John Innes Centre, will collaborate in a £12 million effort to develop open technologies for plant synthetic biology (*http://www.openplant.org*).

Plants are already cultivated globally at low cost, harvested on the giga-tonne scale, and routinely used to produce a very wide range of biostuffs, from fibres, wood, oils, sugar, fine chemicals, drugs and food.

Synthetic Biology offers new tools for the design and reprogramming of metabolism and architecture in plants. These new approaches offer considerable opportunities for agriculture, health and sustainability.

OpenPlant has three main aims:
1) To create a hub for interdisciplinary exchange between Cambridge and Norwich, between the fundamental and applied sciences, which will underpin advances in UK agriculture and bioproduction.
2) To establish systems for the open exchange of new plant tools and DNA components that will promote commercial innovation and international scientific exchange.
3) To explore the wider implications of the technology at local and global scales. This will bring together a wide range of engineers, scientists and policy developers to explore new technologies and possible models for sustainable agriculture, bioproduction and land use.

The OpenPlant initiative will establish internationally linked DNA registries for sharing information about plant specific parts and simple testbeds. The liverwort *Marchantia polymorpha* (Fig. 1) will be developed as a major new plant chassis for Synthetic Biology, with simple properties for high-throughput screening and analysis at the micron scale (*http://www.*

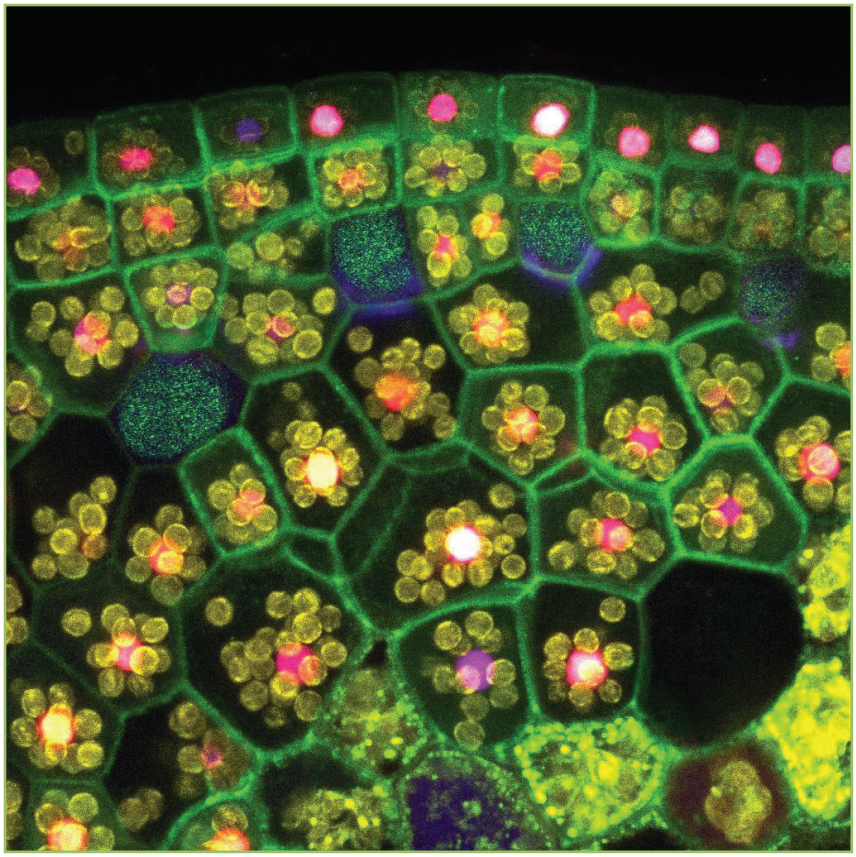

Fig. 1. Multispectral confocal microscopy imaging of a *Marchantia polymorpha* gemma, showing cell membranes (green), plastids (yellow), nuclei (red) and oil bodies (blue). *Plant transformation and imaging by Fernan Federici, Nuri Purswani and Li Hua Robertson, University of Cambridge.*

Fig. 2. The green vaccine machine. Representation of the expression of virus-like particles in Nicotiana benthamiana leaves via transient expression. *Image: Eva Theunemann.*

marchantia.org). This will complement our activities in *Arabidopsis thaliana*, *Medicago truncatula*, *Nicotiana benthamiana* and crop plants.

We will develop new DNA parts for the control and quantitative imaging of genetic circuits, techniques for routine genome-scale engineering in plants, and software tools with improved performance for automated DNA assembly, modeling of synthetic gene circuits and cellular morphogenesis. The development of new tools and parts will directly contribute to the engineering of new traits in plants, such as altered photosynthesis and leaf structure, changes in plant carbohydrate content, methods for high level production of biomolecules by transient expression (Fig. 2), engineered pathways for the production of natural products, and new forms of symbiosis and nitrogen fixation for crop plants.

Current agricultural practices and cultivation of trees, crops and pastures are responsible for major pressures on natural environments and land use globally. The OpenPlant initiative will bring together an exceptional collection of scientists, whose skillsets range from biophysics, chemistry and DNA assembly, to crop physiology and agronomy.

In addition, we have participants from the Science Technology and Innovation Studies Unit at the University of Edinburgh, OECD, the Woodrow Wilson Centre, BioBricks Foundation, and academics involved in conservation, entrepreneurship, policy development and the social sciences in Cambridge and elsewhere in the UK, who have demonstrated an interest in tackling the technical aspects of surveying future technologies.

An overarching aim of the project is to provide a map of feasible technical approaches to improving bioproduction and agriculture, including studies of possible economic models, opportunities and social implications for different scenarios and current practices.

OpenPlant is one of three new multidisciplinary research centres in synthetic biology that have been funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and the Engineering and Physical Sciences Research Council (EPSRC).

Photo of Anne Osbourn by Andrew Davis (John Innes Centre).

The Plant Doctors are Coming...

Katie Tomlinson, BSPP Outreach Officer
outreach@bspp.org.uk

"We have to get rid of sick plants because otherwise the fungus will spread to other plants and they can all die," a secondary school student poignantly asserted after taking part in the Plant Doctor stand at the Big Bang Fair.

The Big Bang Fair is the UK's largest celebration of science, technology, engineering and maths for young people. This year 75,000 people passed through the doors and most of these were between the ages of 7 and 19. Over 200 exhibits ranging from a safari bus to a giant tractor helped create a fantastic atmosphere of excitement and energy.

In amongst this frenzy was the Plant Doctor stand, where people can look at plant diseases up close, discover how pathogens infect host plants and cause disease, and what plant pathologists are doing about it.

I have created the Plant Doctor activities whilst working for the British Society for Plant Pathology's (BSPP) new outreach project. It is one of a series of activities I have developed to promote plant pathology to a wide audience, to show that the hidden world where pathogens and plants interact is massively exciting and important to understand.

BSPP Outreach was set up in October 2012, following a BSPP audit showing a decline in plant pathology teaching in higher education institutions. It also happened to coincide with the UK outbreak of ash dieback, which certainly helped to explain my new job to members of the public (and, helpfully, my Dad).

Budding young plant pathologists diagnosing sick plants in the Plant Doctor Hospital at the Big Bang fair.

So far we've run a range of outreach activities at a number of events, including the Leafy Murder Mystery days, where school students and members of the public went on a hunt for clues of plant pathogens in their local woodland. For me, this event really confirmed that members of the public and school students can find plant pathology interesting when it relates to the area they live in.

We've now refined the activities into the Plant Doctor stand for science events. Younger visitors make models of plant pathogens using pipe cleaners to represent bacterial flagella and fluffy balls to represent viral capsid proteins. We invite people to don white lab coats, grab a clipboard and enter the Plant Doctor Hospital, which has some seriously sick plant 'patients' to diagnose. Their job is to work out whether the plant has been attacked by a fungus, bacteria or virus. We then guide people towards our new 'Save our Plants' activity where people debate how we should treat plant disease, using pesticides, biocontrol and GM options.

Most of these activities are now available as resources on the new BSPP website (*http://www.bspp.org.uk*). Over the summer, we'll be contacting teachers we've met at events to follow up their students' experiences with more resources. We'll also be sharing resources on Twitter, and teacher resources sites, such as STEMNET.

To help put all these activities and resources together so quickly, I've had help from three brilliant internship students: Claire Stoker (University of Warwick), Odette Wills (University of Exeter) and Minghui Yin (University of Edinburgh). They have researched and written content for resources, delivered activities at events and without them, I'm not sure I would have survived!

This year we've been running the Plant Doctor roadshow at science fairs in Birmingham, Edinburgh, Norwich, York and Cardiff and hope to make it to Ireland soon. These events are great fun and only possible with the aid of volunteers to run the stands and deliver the activities. The volunteers report that outreach is a fantastic way to create a more personal link with the BSPP and also to communicate their own research area.

Look out for the Plant Doctors at a science fair near you!

One Big Bang Fair volunteer Becky Spanner (PhD student, John Innes Centre) said: "I will be considering the societal/economic impact more – outreach always feels like taking a step back and looking at the wider implications. I'm now excited at the prospect of explaining my research to the public."

BSPP Outreach is just getting started. In the future, we're hoping to build on our experiences by being involved in bigger, further reaching collaborative projects. The outcomes of outreach are often difficult to predict but after every event there are always those funny moments and insightful questions that really make it all worthwhile.

GARNish

Spotlight on the University of Worcester

Spotlight on the University of Worcester

The University of Worcester is home to the National Pollen and Aerobiology Research Unit (NPARU), a world-class centre for research and commercial activities in areas such as atmospheric science, allergy, forensic botany and palynology (the study of particles applied to scenes of crime), crop protection and fundamental plant science.

Thanks to Mahmut Tör, a senior plant science lecturer within the Unit, for compiling these fascinating summaries of his colleagues' research.

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Palynology & Pollen Forecasting

The National Pollen and Aerobiology Research Unit (NPARU) has a major background in the prediction of pollen and fungal spore levels for hay fever and asthma sufferers. The Unit's pollen forecasters operate in association with the Met Office to provide pollen forecasts to the public, media and pharmaceutical companies between March and September.

The Unit also offers detailed information on its website about the pollen and spore types that trigger allergy, along with advice on pollen avoidance, answers to frequently asked questions, and a weekly synopsis and forecast of the pollen and spore types that are current and upcoming.

Pollen forecasters often appear in media articles to discuss the current pollen season and provide advice on the forthcoming pollen types.

Beverley Adams Groom leads a team investigating and predicting pollen levels by looking at a range of factors including pollen data, preceding climate, in-season weather, plant phenological (timing) observations, and United Kingdom and Ireland regional variations in climate, latitude, topography and land-use.

Birch pollen release. Beverley Adams Groom leads research into pollen prediction.

Pollen data is generated by a network of pollen monitoring stations, which are studied for trends. Plant pollen production levels depend on the climate in the months leading up to the pollen season. For example, a long, cold winter usually leads to later pollen seasons and vice versa.

Researchers at NPARU are also studying ways to predict allergen levels in the air using molecular diagnostic methods. Research on pollen is funded by the Met Office, GlaxoSmithKline, Merck Sharp and Dohme, Asthma Society Ireland, Allergy UK, Met Eireann (Ireland) and MBC Netweather.

Carsten Ambelas Skjøth

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Bioaerosols and Air Quality

Carsten is an expert on atmospheric science and bioaerosols. In 2013, he moved from Denmark to lead the atmospheric group at the University of Worcester and to introduce new technologies.

The atmospheric group mainly works on bioaerosols such as pollen, fungal spores and pathogens; their sources and fate in the

environment. Traditional methods rely on detection with volumetric spore traps, while new methods include advanced atmospheric modelling and new detection technologies such as remote sensing using satellites or drones.

The research is mainly carried out within the pollen forecasting programme and the SUPREME (Simple Unified Pollen and Spore Release Model) project. SUPREME currently receives support from the Danish research council (2013–15) and the European Union (2014–18).

A main objective of SUPREME is to understand the governing mechanisms in relation to the release of bioaerosols. This can improve understanding and forecasting methods of harmful bioaerosols.

Additionally, the Biotechnology and Biological Sciences Research Council (BBSRC) has funded a new research project for 2014–17, which will have a focus on the detection and description of atmospheric transport of invasive pathogens (including ash dieback).

The group is connected to the SMARTER COST Action (2013–17), of which Carsten is vice chair. SMARTER (*http://www.ragweed.eu*) is one of the largest COST Actions ever supported and concerns the common ragweed (*Ambrosia artemisiifolia*).

Ragweed is a prominent invasive species, which has an impact on ecosystems and human health by producing billions of noxious allergenic pollen particles that can be transported hundreds of kilometres from the source region. As such SMARTER covers weed science, atmospheric science and human health.

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Plant Cell & Molecular Biology (specifically the Plant Cell Cycle)

In collaboration with Cardiff University, Rob has studied two genes important in the division of plant cells, *WEE1* and *CDC25*.

The eukaryotic cell cycle is regulated by cyclin dependent kinases (CDKs) at two checkpoints; at G1/S and G2/M. In yeast (*Schizosaccahromyces pombe*), the CDK CDC2, is phosphoregulated in G2; negatively by *Sp*WEE1 kinase and positively

Head of the atmospheric group, Carsten Ambelas Skjøth studies bioaerosols, and is Vice-Chair of the SMARTER COST Action group studying noxious common ragweed pollen.

by *Sp*CDC25 phosphatase. CDC25 has been discovered in plants (e.g. in *Arabidposis thaliana*) however, *At*CDC25 is not fully functional and its role is uncertain.

The team has shown that T-DNA insertion lines for *At*CDC25 are hypersensitive to hydroxyurea (HU). This suggests that CDC25 is a component, but not an absolute requirement, for recovery from a DNA replication checkpoint pathway. Over-expressing (OE) lines however, demonstrated enhanced growth and developmental responses compared with wild type (WT) when challenged with HU.

Other experiments on *WEE1* included work on gene dosage using OE and T-DNA insertion lines. There was significant increase in morphogenetic capacity in T-DNA insertion lines compared with WT. *WEE1* OE seedlings exhibited a slower cell-doubling time in roots and decreased morphogenetic capacity. There were significantly fewer adventitious roots for *WEE1* OE and significantly more for the insertion mutant. Thus, there is a gene dosage effect of *WEE1* on morphogenesis.

Expression of *WEE1* throughout the cell cycle was also examined, showing a fine-tuned regulation of WEE1 protein, which essentially disappeared from chromosomes at metaphase in both BY-2 cells and Arabidopsis roots. Data also demonstrated for the first time that WEE1 protein is degraded via the 26S proteasome in plants.

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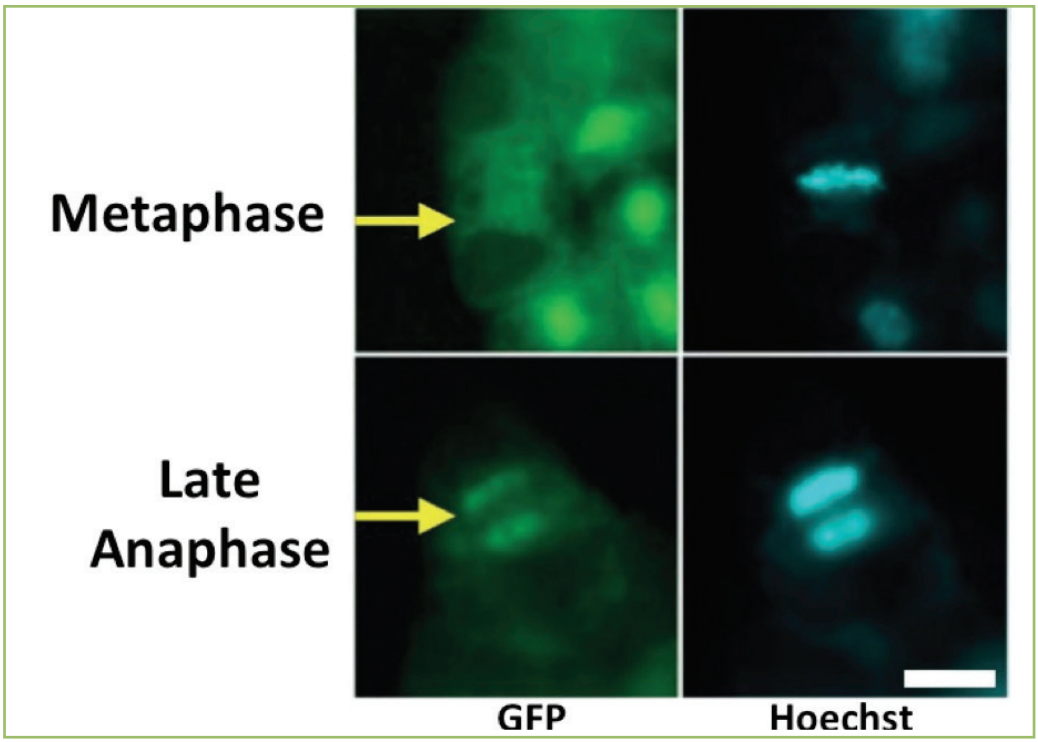
Crop Protection

Onion downy mildew (*Peronospora destructor*) is a geographically widespread and serious disease in bulb and salad onions and in onion seed production.

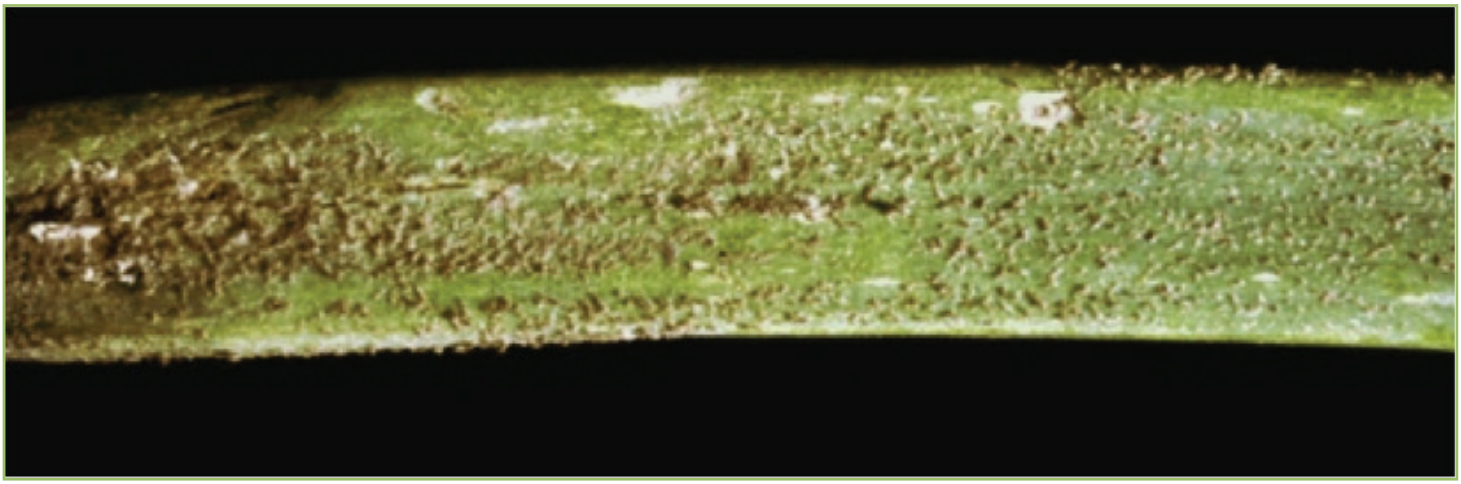
Actual losses in bulb onions of 60–75% have been recorded, whilst in salad onions yield losses can be as high as 100% with whole crops being discarded as downy mildew symptoms on the plant make them unmarketable.

Detection and quantification of airborne spore numbers can be used to predict disease accurately



Robert Herbert: In the AtWEE1–GFP line, GFP signal is greatly reduced in metaphase compared with other phases of the cell cycle e.g. late anaphase.

35S::AtWEE1–GFP GFP λ=530 nm Hoechst λ=420 nm. Scale bar=50 μm (From Cook GS, Lentz-Grønlund A, Sicilliano I, Spadafora N, Amini M, Herbert RJ, Bitonti MB, Graumann K, Francis D and Rogers HJ (2013). Plant WEE1 kinase is cell cycle regulated and removed at mitosis via the 26S proteasome machinery. *J. Exp. Bot.* 64:2093–2106).



Onion downy mildew. Gary Keane's work focuses on the detection this significant disease of bulb and salad onions.

before it is visible in the crop. Peaks of airborne spores are always detected prior to crops becoming infected.

Gary Keane is working on a HDC-funded project to develop in-field tests that can identify critical transmissible onion downy mildew spore concentrations in collected field aerosols.

This information is used in conjunction with an integrated forecast model (MILIONCAST) to predict the potential for onion downy mildew disease development in the field. This in turn can provide information to the farmers on the times when fungicide treatments may be required.

Gary has developed a quantitative lateral flow device, incorporating a monoclonal antibody, which is specific for onion downy mildew spores. The levels of onion downy mildew spores detected in the fields, obtained using lateral flow devices and used in conjunction with the integrated forecast model, are being compared to the disease subsequently found in the field.

Accuracy of the data obtained by the lateral flow devices is also being confirmed using other methods such as ELISA and visual counting of trapped spores in the field.

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Human Allergic Responses to Fungal Spores & Pollen

As part of the Health research group within NPARU, Roy Kennedy carries out research projects on fungal spores and pollen that cause allergic and other responses in animals and humans. Many of these species of fungi are also pathogenic on plants and important agricultural and horticultural crops.

As Head of Research at NPARU, the main unit conducting conducting laboratory research at the University of Worcester, Roy is also a member of the West Midlands NHS Clinical Research Network, and leads on human health and clinical trials involving allergens and infectious agents.

Roy was UK lead on the HIALINE European Union (EU) project investigating birch, grass and olive pollen potency. The HIALINE Network in Europe demonstrated seasonal variation in the potency of pollen for these three plant species.

Roy's PhD student is investigating and predicting atmospheric concentrations of allergenic fungal spores.

Roy is a PI on the THAPBI (Tree Health and Plant Biosecurity Initiative) project "New approaches for the early detection of tree health pests and pathogens." Funded by BBSRC, the Department for Environment, Food and Rural Affairs (Defra), the Economic and Social Research Council (ESRC), Forestry Commission, Natural Environment Research Council (NERC) and the Scottish Government, THABI aims to provide better methods for detecting tree pests and pathogens through the development of new technologies.

He is also part of the SMARTER COST Action (2013–17), which investigates control of common ragweed (*Ambrosia artemisiifolia*). Ragweed is an invasive species which produces highly allergenic pollen.

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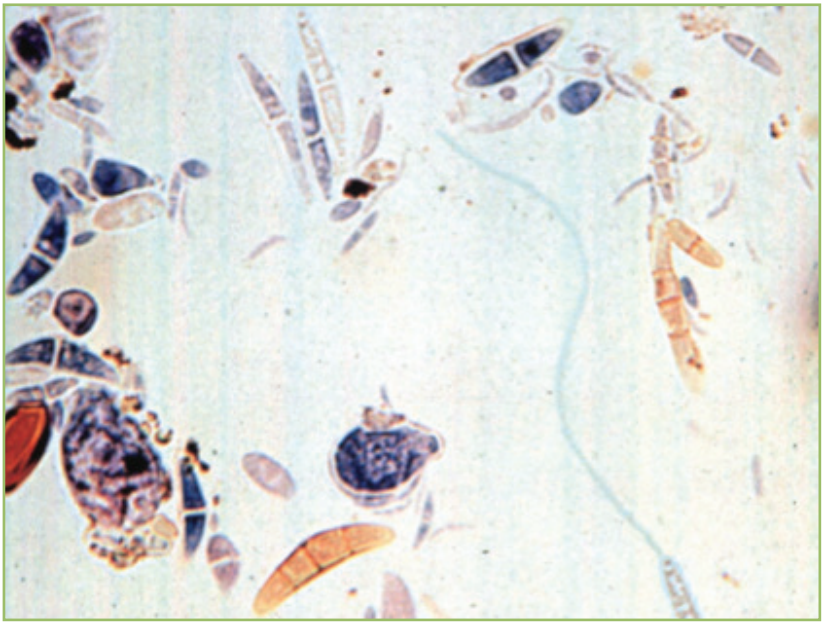
Detection of Clubroot in Oilseed Rape

Clubroot is a soil-borne disease that can result in crop damage and reduced yield in Brassica species, including oilseed rape (OSR) crops. This disease is caused by *Plasmodiophora brassicae*, which forms resting spores in the soil that germinate in the presence of Brassica species and infect plants, resulting in potentially severe crop damage.



Roy Kennedy studies air samples for fungal spores that cause allergic reactions in humans and diseases of crops.

Mary Lewis is carrying out research on the validation of clubroot detection tests and investigating the molecular quantification of clubroot resting spores by quantiative PCR (qPCR) across a range of clubroot contaminated arable soils.

The HGCA funded project will produce information on initial clubroot contamination in relation to OSR crop infection for a range of soil types. This research is also investigating the levels of initial clubroot contamination and the responses of resistant varieties in the presence or absence of other control treatments.

Mary has carried out soil sampling work at OSR sites in Scotland and England and *P. brassicae* contamination levels have been determined. Findings suggest OSR infection exhibits the same relationship between visible root infection and spore numbers found in vegetable crops. The fields surveyed are primarily growing resistant varieties (cv. Cracker), and would be predicted to contain relatively low levels of *P. brassicae* spores.

Evidence suggests spores are persisting within soils at high levels under different rotations, however the reasons for this are unclear. The project hopes to explain the mechanisms associated with the build up of clubroot in arable soils growing OSR crops.

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Plant Molecular Biology

John has worked in several areas of plant molecular biology, including the

development of plant transformation systems for Brassicas; the use of molecular markers to exploit genetic diversity in crop germplasm collections; and the study of transporters in plant membranes.

These pieces of work have been funded by BBSRC, NERC, the Department for International Development (DfID) and the EU.

Recent work on the genetic and physiological analysis of membrane transporter functions has included the elucidation of the functions of monovalent cation tranporters in *Arabidopsis thaliana*. Studies have also been carried out on zinc hyper-accumulation trait in *Arabidopsis halleri* using its inheritance following crossing with a closely related non-accumulating species.

The comparison of gene expression in segregating families helped directly identify genes implicated in the hyper-accumulation phenotype; inherited gene expression levels were also used as genetic markers in quantitative trait locus analysis.

Work on amino acid transporters in *A. thaliana* has involved transporters that act to control the concentrations of amino acids within phloem sieve tubes. This has been studied using an aphid stylectomy technique to access pure sieve tube samples, and by developing a novel micellar electrokinetic chromatography method to allow the analysis of nanolitre-volume biological samples.

Plant lines with altered sieve tube amino acid concentrations have been used to determine the effect of altered diet (with respect to nitrogen source) on phloem-feeding aphids. The methods developed have also revealed variation (including a diurnal variation) in amino acid concentrations in different sieve tubes in wheat and in investigations of gene expression within enucleate mature sieve tubes.

Clubroot on Oilseed Rape roots. Mary Lewis seeks to validate tests to detect clubroot in arable soils.

Mahmut Tör

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Molecular Plant-Microbe Interactions

Mahmut has long-term research interests in molecular plant-microbe interactions. While his group focuses on fundamental research, he translates the technology and advancements in the field for the benefit of food security. Through a Leverhulme Trust funded project, his group has been investigating the occurrence of new effectors. Using pathogen genetics and next generation sequencing technology, his team has uncovered the link between heterozygosity and virulence at the molecular level.

In a collaborative research project, he was part of an investigation into the soil borne fungal

pathogen *Fusarium oxysporum*, which causes serious losses in protected agricultural production areas all over the world. They used the beneficial microorganism Bacillus to control Fusarium, and showed that this bacteria releases lytic enzymes – cellulases, proteases, 1,4-β-glucanase and hydrolases – all of which contribute to degradation of the fungal cell wall.

Mahmut's interest in bacterial microorganisms also extends to *Erwinia amylovora*, a fire blight pathogen of rosaceous plants including apples, pears and rose. His team members are interested in a) identifying a resistance gene against this pathogen, b) deploying into the field to control the disease and c) determining the variation that exists within the pathogen's effectors.

To transfer knowledge to the area of food security, Mahmut uses next generation sequencing to rapidly generate molecular markers that are tightly linked to disease resistance genes.

Current PhD projects include the study of pathogen originated immune activators, apoplastic effectors, and the role of circadian rhythm in pathogenicity. The group collaborates in the field with colleagues from the Sainsbury Laboratory, Exeter University, Warwick University, Gothenburg University, Muğla University and Selçuk University.

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Development & Application of Diagnostic Detection Systems within the Environment

Disease development on immature pear fruit infected with *Erwinia amylovora*; one of Mahmut Tor's research interests.

Early diagnosis of plant, animal and human pathogens is central to the ability to control their potential impact. Protecting agricultural and horticultural crops, and natural plant communities, from the potentially devastating effects of invasive fungal pathogens has taken on a greater significance due to climate change predictions.

Alison Wakeham leads a team at the University of Worcester investigating the development and use of 'in crop' systems to monitor plant pathogens in bioaerosols, soil and water.

The development of new diagnostic approaches that can be easily translated into the field is a key driver of her research. This information needs to be translated in a timely and accessible way to end users for targeted and cost effective control measures to be taken to enable disease containment or eradication.

Alison's team has developed sampling processes and a suite of molecular and immunological tests that are used by growers and consultants to

Alison Wakeham develops lateral flow tests for plant pathogens.

assess disease development within the cropping systems.

The integration of diagnostics with mathematical approaches is an important component in her work (see *http://www.syngenta-crop.co.uk/brassica-alert/*). Research projects funded by the Australian Department of Primary Industries have resulted in the development and use of an in-field test for measurement of *Albugo candida* spores in vegetable Brassica growing areas of Victoria, Australia.

Alison is funded by the Agriculture and Horticulture Development Board (AHDB) within a range of horticultural crop sectors. She also works closely on the use of diagnostic approaches for fungi with a range of major manufacturers (Vax, Dyson, Samsung and Hitachi) and supervises allergen diagnostic tests developed for Allergy UK under their Seal of Approval programme.

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Utilising Biodiversity for the Delivery of Ecosystem Services

Duncan has a strong background in applying ecological principles to habitat restoration, creation and management, with extensive research experience on the management of agro-ecosystems to support biodiversity within the farmed landscape.

Whilst he has published extensively on the benefits of habitat manipulation for invertebrates and farmland birds, current research focuses on how biodiversity can be utilised to support the delivery of ecosystem services within the farmed landscape.

Duncan currently co-supervises PhD student Megan McKerchar who is investigating the benefits of supplementing floral resources in commercial apple orchards to promote pollination and pest regulation services. Commercial apple orchards are typically devoid of floral resources outside of the blossom period so growers are heavily reliant on the surrounding landscape to nurture populations of our wild native pollinators.

By introducing wildflower strips into commercial orchards we have the potential to reduce the risk to fruit production from a lack of pollinators. The project is funded by Waitrose Plc, Fruition PO, and the University of Worcester.

In collaboration with the University of Reading, Duncan has also investigated the inclusion of wildflower forages in the diet of growing dairy heifers to study the impacts on animal productivity and methane emissions.

Duncan Westbury: Red mason bee (*Osmia bicornis*) is an important wild pollinator in apple crops that is highly dependent on the availability of wildflowers outside of the apple blossom period.

Duncan Westbury: Floristically enhanced species-poor grassland to investigate the effects of wildflower forage on methane production in dairy cows

Under the Environmental Stewardship agri-environment scheme, options exist for farmers to enhance the botanical interest of species-poor grassland, but whilst this is likely to benefit biodiversity, we still do not fully understand the implications of incorporating such forages in the diets of modern livestock breeds. In the study, compared to conventional ryegrass forage, whilst wildflower forages were shown to reduce methane emissions, they reduced the extent of digestion and animal growth (unpublished data).

This study was funded by Defra, the Scottish Government, the Department of Agriculture and Rural Development (DARD), and the Welsh Government as part of the UK's Agricultural Greenhouse Gas Research Platform project (*http://www.ghgplatform.org.uk*).

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Investigating the Function of a Novel Family of Plant-Specific Secreted Proteins

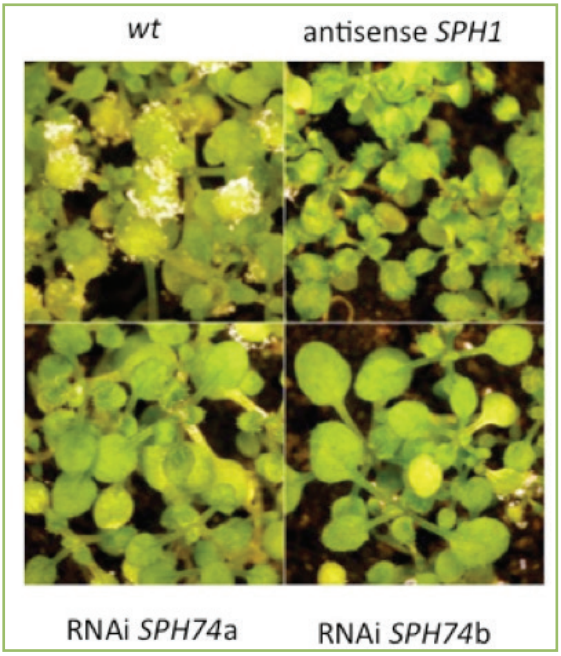
Mike has a background in researching cell–cell interactions in plant biology. His PhD and early postdoctoral work sought to find the pollen component of the poppy self-incompatibility system at the University of Birmingham. Since then Mike has become interested in the function of homologues of the secreted ligand (S-protein) of poppy self-incompatibility in other dicot plants. A large number of Arabidopsis genes appear to encode small secreted proteins and, as yet, most of these have no ascribed function.

Mike is currently analysing the function of the SPH (S-protein homologue) family of protein-ligand encoding genes. The genes are not involved in self incompatibility (*Arabidopsis thaliana* is self-compatible) and thus their function was initially a mystery.

All 84 members of this family have an N-terminal signal peptide and conserved secondary structure consisting of β-strand interspersed with hydrophilic loops although the primary sequence is diverse. Mike found that two members of the family (SPH1 and SPH74) act as negative regulators of pathogen responses. As such they are the first endogenous ligands found to be involved in plant defence regulation. However, most of the family are specifically secreted in floral tissue and thus potentially have roles in pollination and fertilisation.

Mike is currently supervising a PhD student (Mark Cook) who is examining the role of a subgroup of pollen-specific SPH proteins using over-expression and gene knockout studies, together with studies searching for potential cell-surface receptors for these secreted proteins.

In addition to the work on Arabidopsis Mike has initiated a project in collaboration with Dr Juliet Coates (University of Birmingham) to look at the role of SPH proteins in the model moss, *Physcomitrella patens*.



Resistance to strains of the oomycete pathogen *Hyaloperonospora arabidopsis* that normally grows on Arabidopsis.

SAVE THE DATE

SEB Prague 2015

30 June – 3 July 2015

ANIMAL BIOLOGY SESSIONS

Conservation Physiology: How environmental influences on parents and early developmental stages determine "winners" and "losers"

Integrative Physiology: From Genes to Environments

Thermal Biology: Oxygen capacity limitation of thermal tolerance

Endocrinology: Ecotox Genomic session

Osmoregulation: From Magnesium to Mosquitoes: a tribute to Klaus W. Beyenbach

Neurobiology: Understanding intraspecific variation in animal phenotypes from genes to behaviour

Ecophysiology: Movement Ecology

Biomechanics: Mechanics and biological functions of the Arthropod exoskeleton

Emerging models for studying the cardiovascular system

General Animal Biology

General Biomechanics

CELL BIOLOGY SESSIONS

Past Presidents Medallist session

Synthetic Bio update

Integrative Omics

Cell Biology of Mechanical Signalling

Immunity Systems

Modelling Cells

Hot Topics Session

PLANT BIOLOGY SESSIONS

Retrograde signalling from chloroplasts in development and stress responses

Plants roots: new challenges in a changing world

Plant Biotechnology

Linking N-terminal modifications to protein function in plants

Visualising Metabolism

Effector biology of beneficial and pathogenic microbes: a source to improve crop productivity

SEB
Society for Experimental Biology

WWW.SEBIOLOGY.ORG

Spotlight on Queen's University Belfast

Plant science research at Queen's University Belfast (QUB) falls under the remit of the University's School of Life Sciences. The School is further sub-divided into two main research groups: Molecular Sciences, and Ecology, Evolution, Behaviour and Environmental Economics, which also includes Quercus, a group focusing on the promotion and dissemination of research in biodiversity and conservation science in Northern Ireland.

QUB is also home to the Institute for Global Food Security, which carries out cutting-edge research into topics ranging from soil and plant health, to food security.

Many thanks to Fuquan Liu, a plant molecular biologist at QUB, who coordinated these research summaries from his colleagues.

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Plant Toxins

Katrina's research focuses on the mapping of plant toxins from origin to contamination in animal feed and food through the development of immunological bioanalytical tools and analytical methodologies.

Many toxicants are alkaloids that represent structurally diverse groups of plant secondary metabolites. Pyrrolizidine alkaloids (PA), found in many plant genera, are an emerging issue in feed, food and herb contamination. It has been estimated that about 3% of all flowering plants contain one or more of the more than 350 toxic PAs. There are four main PA types: senecionine, lycopsamine, heliotrine and monocrotaline types derived from *Boraginaceae*, *Compositae* (*Asteraceae*) and *Leguminosae* (*Fabaceae*) families including *Senecioneae*, *Heliotropium*, *Eupatorieae* and *Crotalaria* species. These toxins also display N-oxide forms.

Human exposure originates from PA containing herbs, teas and dietary supplements with increasing focus on honey. Tropane alkaloids (TA) are mainly found in feed as contaminants from *Datura* species, whereby the representative toxins of concern are atropine, scopolamine and hyoscyamine. Tropane alkaloid biosynthesis in *Datura* mainly takes place in the roots. From the site of synthesis, the compounds are translocated to upper parts of the plant. Changes in alkaloid content of leaves follow the fluctuation of roots, with a delay of approximately one month.

Plants producing TA have expanded dramatically in parts of Europe and contamination-related problems are emerging. With such diverse groups of toxic compounds and variability in occurrence the development of rapid diagnostics is extremely difficult. Through the EU project "Conffidence" generic antibodies were produced for incorporation into rapid multiplexing diagnostics. The monitoring of the occurrence of these toxins is impertinent for future food security.

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Soil biodiversity, Community Dynamics, & Plant–Soil Interactions

Tancredi has been a Lecturer in Soil Ecology at Queen's University Belfast since September 2013. During his doctoral studies (PhD 2006), he focused on soil organism community ecology, and more recently has been working on the community and functional ecology of soil microarthropods, fungi and the interaction between fungi, plants and animals, and the consequences of this interaction on belowground (e.g. soil structure formation) and aboveground (plant community dynamics) processes.

Tancredi's work spans a wide range of topics in terms of systems, scales, and methodologies. He has addressed systems as different as temperate forests and polar deserts, and groups of organisms from arthropods to AM fungi under the unifying conceptual umbrella of community dynamics and plant-soil interactions. He uses spatially explicit statistical models, and population and community models, to apply general ecological theories to soil organisms and plants, as attested by his work on the neutral theory of biodiversity, allometry and metabolic scaling theories, food web and network theories, and experiments addressing aboveground–belowground interactions.

Tancredi Caruso's research takes him to diverse locations.

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Controlling Plant Parasitic Nematodes

Jonny is a Leverhulme early career fellow, working on aspects of the plant–nematode interaction both *in planta* and *ex planta*. The development of RNA interference platforms for both plant and nematode has facilitated the analysis of gene function with respect to nematode activation, attraction and parasitism.

Understanding the molecular mechanisms of these behaviours and interactions has facilitated the development of novel control methods in conjunction with the Bill and Melinda Gates Foundation, the Royal Society, and the EUPHRESCO project. Jonny is also developing novel methods of triggering abiotic stress resistance in crop seeds in conjunction with Fuquan Liu, and Caroline Meharg.

Leverhulme early career fellow Jonny Dalzell studies the interactions of plants with parasitic nematodes.

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Stress Mechanisms & Responses within Cells, Organisms & Ecosystems

John graduated in Plant Biotechnology from Wye College, University of London (1990). His

research cuts across microbes (including fungi, yeasts, and algae as well as prokaryotes) and relates to various aspects of plant science.

Two novel stress mechanisms, and corresponding cellular stress responses, have been elucidated, which are induced by chaotropic and hydrophobic substances (including volatile organic compounds and other metabolites produced by plants and microbes).

The role of such substances in the emergence of microbial species as dominant members of communities was recently characterised in the context of weed biology by comparing the molecular and phenotypic traits of plant weeds with their microbial counterparts.

Part of the Quercus research group, Ruth Kelly investigates factors affecting the recovery of plant life after wildfires.

Other projects focus on:

- Novel methods to optimise the stress biology of biocontrol agents to enhance protection of crop plants against pests and pathogens
- Utilisation of chaotropic/hydrophobic plant metabolites within nanotechnology and development of nature-identical pesticides
- Characterisation of the microbial ecology of plant-associated habitats (high-sugar habitats, rhizosphere, phyllosphere, etc)
- Stress biology of algae in Arctic sea ice
- Investigation of the microbiology of arid environments in the context of soil- and plant-health, and food security.

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http://www.qub.ac.uk/sites/Quercus/AboutUs/CurrentstaffDrRuthKelly/

Recovery of Upland Habitats following Wildfires

Ruth's work examines the recovery of upland habitats in Northern Ireland following a spate of wildfires, which occurred in early 2011. The impact of wildfires on upland habitats is of increasing concern both from a scientific and conservation perspective. Global warming may increase the risk of wildfires in temperate regions and alter the capacity of natural habitats to cope with these events.

Ruth's primary focus is on assessing the recovery of vegetation, including both higher plants and bryophytes over a three year period. She is also examining the knock-on effects on food webs using invertebrates and birds as indicator species. Preliminary results indicate changes in community structure of both plant and invertebrate species following burning, and a decline in the abundance of common bird species.

Ruth is also interested in invasion ecology, climate change and macro-ecology. She completed her PhD on invasive aquatic plants in 2012. In this work she examined the distribution, spread and impacts of invasive aquatic plants using a combination of field work, laboratory experiments and statistical modelling. Ruth's work is being

conducted through the research group Quercus (*http://www.qub.ac.uk/sites/Quercus/*) in conjunction with experts at the National Museum of Northern Ireland and the Northern Ireland Environment Agency.

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Abiotic Adaptation in Plants

Fuquan has been working on the molecular mechanism of flowering control in Arabidopsis for almost 10 years. He is now refocusing on studying how plants respond and adapt to abiotic environmental stresses such as drought, extreme temperatures and heavy metal contamination in the soil. Genome wide association (GWAS) analysis of osmotic stress in 250 Swedish Arabidopsis accessions has identified one single significant QTL peak associated with tolerance to osmotic stress. There is no known osmotic tolerance gene found in the QTL region, suggesting that a new component of the osmotic adaptation pathway will be identified.

Following his previous work, Fuquan is also looking the function of the nuclear Dicer protein, DCL4, in transcription termination regulation in plants. Preliminary data showed that DCL4 is involved in cleaving nascent RNA on chromatin in a small-RNA independent manner.

Working with Andrew and Caroline Merharg, Fuquan is also searching for genes involved in the adaptation of *Holcus lanatus* in arsenate-contaminated and acidic soils.

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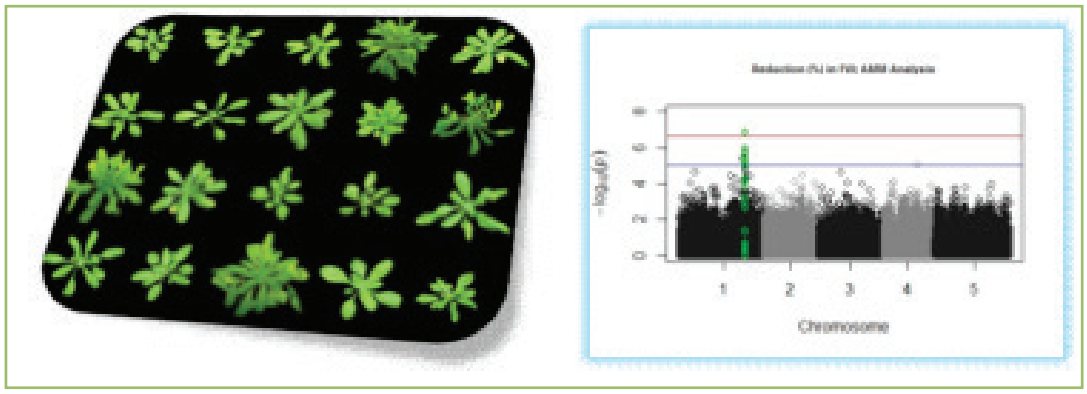
Phosphorus Cycling

Phosphorus (P) is an essential element for living organisms and is found in the environment in both inorganic form (as orthophosphate) and in a variety of organic compounds. In many terrestrial and aquatic environments, P is the growth-limiting nutrient; in others, human activity has led to an excess of P and consequent problems of eutrophication and environmental damage. Freshwater eutrophication represents one of the biggest water management issues and the most important single threat to clean water internationally.

Paradoxically, global P reserves are limited and, while timelines for 'peak phosphorus' are contentious, the P rock that remains is of undoubtedly lower grade and more difficult to access, thereby increasing processing costs. The price of ammonium phosphate fertiliser has increased by over 200% in the last decade. Security of phosphorus supply to the EU is also a key issue given the lack of appreciable P rock reserves in Europe.

John's research focuses on how microorganisms scavenge, store and recycle this nutrient and has two major strands: a) dissolved organic P metabolism; and b) inorganic P cycling. To this end he has



Fuquan Liu works with *Arabidopsis thaliana* to investigate osmotic stress tolerance.

carried out extensive studies on the biochemistry, genetics and ecology of microbial C-P bond and C-O-P bond metabolism in the terrestrial and marine environments using both biogenic and xenobiotic compounds, such as the herbicide glyphosate. Using a wide range of biochemical and molecular approaches he has also focused on identifying microorganisms that capture and store high levels of phosphate intracellularly as polyphosphate. Polyphosphate is a linear polymer composed of phosphate residues linked by high-energy phosphoanhydride bonds that is found as intracellular granules across a wide spectrum of microorganisms; its metabolism has been extensively investigated only in relatively recent years and its functions remain poorly understood.

John has studied the enzymes and genes of microbial polyphosphate biosynthesis and degradation, their distribution, and their regulation in wastewater treatment microorganisms. From this, he is developing a novel technology for P capture and recovery from waste streams. Using metagenomics and metatranscriptomics he has extended these investigations to the marine, soil and freshwater sediment environments. Coupled to this John is applying similar techniques to investigate the cycling of chemically-immobilised P and the reduced P compounds phosphite and hypophosphite in these environments.

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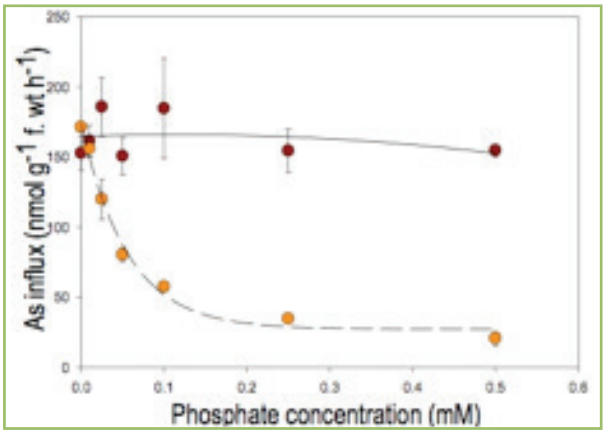
Plant–Soil Interactions

Andy Meharg is interested in how plants interact with soil with respect to plant acquisition and the subsequent metabolism, transport and localisation within plants of mineral nutrients (primarily copper, phosphorus, selenium and zinc) and toxicants (arsenic, cadmium, mercury and lead).

Since discovering that the rice grain was the dominant source of carcinogenic inorganic arsenic into the human diet, Andy's research has



Arsenate uptake is inhibited by its analogue phosphate, but not arsenite. Andy Meharg is trying to solve the problem of toxins in rice.

focused on why this should be the case. He integrates soil biogeochemistry, rice genetics and state-of-the-art analytical procedures (ion chromatography - ICP-MS and synchrotron based techniques) to both speciate and localise arsenic in rice tissues.

These studies also have a mitigating focus, looking at how breeding, soil management and grain processing may be used to lower inorganic arsenic in grain.

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Adaptation of Plants, Microbes & Plant/Microbial Interactions

Caroline Meharg's expertise is in comparative and functional genomics and transcriptomics, using next generation sequencing approaches and molecular methods.

With respect to plant science her interest is in investigating adaptation of plants, microbes and plant/microbial interactions to various environmental conditions such as variations in nutrients status, pH, salinity, metal-toxicity via investigation of stress-specific transcriptome responses, associated genome variations and corresponding genetics.

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Spotlight on Queen's University Belfast

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Effects of Past, Present & Future Climate Change on Genetic Diversity in Natural Populations

Jim Provan is an evolutionary geneticist who carried out the research for his PhD on genetic diversity in cultivated potato. He then worked on population genetics of the Scots pine and, since taking up an academic position at QUB 15 years ago, has been primarily interested in the effects of global change on natural plant populations.

Current research ranges from using phylogeographic approaches to elucidate the responses of species to previous climatic changes through the Ice Ages, through population genetic analyses of the impacts of present-day climate change on populations, to using next generation sequencing approaches to determine the potential for populations to respond to future climate change. He leads the Climate Change Research Theme within the recently launched Institute for Global Food Security at QUB.

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Role of Cellular Architecture in Plant Productivity

The morphology of plants impacts their efficiency to use energy and nutrients for production of agriculturally and industrially important products. While the total yield of biomass depends on cell proliferation and subsequent cell expansion, the quality of biomass is defined by biosynthetic activities of individual cells in specialised tissues that formed during differentiation. In some instances differentiation becomes terminal leading to programmed cell death.

Caroline Meharg seeks to understand aspects of plant adaptation to environmental conditions.

Terminal differentiation is essential for many developmental processes including embryogenesis, wood formation and seed development. Furthermore, components of the programmed cell death machinery facilitate defence against pathogens.

Several lines of evidence demonstrate that cytoplasm architecture orchestrated by the cytoskeleton plays a pivotal role in the smooth transition from proliferation to terminal differentiation. Our research addresses the role of cytoarchitecture in translating developmental and environmental cues into life/death processes with a focus on:

- Structural proteins of the cytoskeleton;
- Regulation of cytoskeletal organization and dynamics;
- Cytoskeleton in cell proliferation;
- Terminal differentiation and programmed cell death;
- Alteration of cellular architecture in response to stresses.

We address these questions using a combination of complementary investigative techniques including genetics, biochemistry, cell biology and microscopy.Andrei also holds an Assistant Professor position at the Institute of Biological Chemistry at Washington State University.

35th New Phytologist Symposium

The genomes of forest trees: new frontiers of forest biology

Arnold Arboretum of Harvard University, Boston, MA, USA

16–17 June 2015

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Peter Crane Yale University, New Haven, USA
Taku Demura Nara Institute of Science and Technology, Nara, Japan
Steve DiFazio West Virginia University, Morgantown, USA
Carl Douglas University of British Columbia, Vancouver, Canada
William Friedman Arnold Arboretum of Harvard University, Boston, USA
Andrew Groover USDA Forest Service and University of California, Davis, USA
Ykä Helariutta University of Helsinki, Helsinki, Finland
Catherine Kidner University of Edinburgh, Edinburgh, UK
Francis Martin INRA, Nancy, France
David Neale University of California, Davis, USA
Steve Strauss Oregon State University, Corvalis, USA
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