GARNish

December 2010. Edition 14

GARNet

GARNet gets a new look

Updated website and new logo for GARNet
www.garnetcommunity.com

Also in this issue; UK Plant Science Portal and Spotlight on the University of Dundee and SCRI

Welcome to the December 2010 issue of GARNish!

It might keep you amused while camping on an airport or sipping from your thermos in a stranded car. Yes, the snow is a nuisance, but experiencing how quickly the country comes to a standstill when the weather takes a slightly unusual turn is probably a useful reminder of our responsibility as plant scientists to secure food production in an uncertain climate. Plant science in this country produces excellent results (see for example our report on the 2010 GARNet meeting in Durham), but in order to rise to new challenges it is vital that the research community is well connected, represented and funded. In this issue we report on a White Paper for a 'Federation of UK Plant Science Communities' that has been generated with the aim of providing a framework that would allow plant scientists to speak with a single and strong voice. We also present the new 'UK Plant Science' web portal, which has been created to support this development.

At last week's EPSRC 'Water for All' sandpit the desperate need to avoid a future food crisis was tangible. The event not only brought home the scale of the problem, but also made me realize that we have extraordinary opportunities for working towards sustainable solutions if we combine fundamental knowledge on biological systems with hands-on engineering solutions embedded in a realistic economic and socio-political context. It is essential that the information amassed on Arabidopsis and other plant species is readily available for such multidisciplinary projects, and clearly GARNet has an important role to play here. Several workshops and meetings were held over the last year to discuss the future of Arabidopsis informatics and you can read about their outcomes on pages 8-9.

To provide a window on the various facets of the current model-to-crop discussion GARNish would like to collect your stories on how Arabidopsis has assisted progress in your area of research and what role it could play in the future. Here we make a start with an article on 'What Arabidopsis has done for…'. GARNish has continued its 'tour' of the UK in their quest to find out what you are all working on. In this issue the University of Dundee and the Scottish Crop Research Institute open their doors and give you an overview of their current activities.

The Outreach & Education feature of this issue looks at plant and crop science related Master courses currently on offer in the UK (pages 22 – 27). We also publish e-interviews with recent graduates from Master courses in Warwick, Nottingham and Glasgow to give you a flavour of their expectations and experience. Clearly the benefit of a successful Master programme in the UK is not restricted to students. As many of them come from areas of the world currently facing the problems that we are addressing in the laboratory, regular contact with overseas students allows us to keep in touch with acute problems, forge new collaborations, understand stakeholder interests and spot new potential all over the world.

In the good democratic spirit of GARNet I am rotating off the advisory committee at the end of the year with Patrick Hussey and Claire Halpin. I would like to thank them for all the help and support they have provided GARNet over the past three years. Candidates standing for election are listed on page 3, please make use of your vote and give them your support.

Finally I would like to thank Ruth and Irene for designing a new layout for GARNish – it looks great!

Wishing everybody a Merry Christmas and a successful 2011,

Anna Amtmann

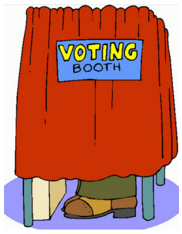
Contents

Many thanks to all who contributed to this issue, particularly Claire Halpin, Helen Carter, Ziyue Huang, Choon Kiat Lim and Fereshteh Malekpour.

GARNet Elections

Not only is December the time to panic about not having done the Christmas shopping, it is also the season for the GARNet Committee Elections. As part of the long-term development of GARNet, we hold annual elections to select new members of the committee. Advisory committee members generally serve a term of three years and a number of our committee members are reaching the end of their term and will be standing down at the end of 2010. We therefore need to elect new members to replace them. During November the community nominated the following people to stand for election

Malcolm Bennet – University of Nottingham
Anthony Dodd – University of York
Anthony Hall – University of Liverpool
Smita Kurup – Rothamsted Research
Alan Marchant University of Southampton
Joel Milner – University of Glasgow
Jim Murray – University of Cardiff
John Runions – Oxford Brookes
Colin Turnbull – Imperial College London



It is now up to you to decide who will join the committee. To cast your vote e-mail (ruth@garnetcommunity.org.uk) the names, in order of preference, of the three individuals who would wish to appoint to the committee. Voting will close on the 22nd December 2010.

A UK Plant Science Federation?

As many of you may of already noted from messages sent to the ArabUK Mailing list (www.lists.bbsrc.ac.uk/mailman/listinfo/arabuk), representatives of the Crop and Plant Science communities (MONOGRAM, UK-Brassica Research Community/OREGIN, UK-Solanaceae and GARNet) met during the summer to explore the possibilities of forming 'one voice for UK Plant and Crop Science' to help build a stronger UK plant research base.

The groupings listed above have been meeting informally over the last few years to help promote information exchange between the various networks. During

these interactions it had been highlighted that there could be mutual advantages from establishing a 'Federation of UK Plant Science Communities'. Such an endeavour would enable each community to benefit from retaining its identity, yet would provide considerable synergy from coming together to pool knowledge and expertise, identify new opportunities and assess where added value could be achieved by acting with one voice. It is of increasing importance to have a strong and clear voice amongst 'opinion-formers', within political and funding circles and the Federation could be one possible mechanism for achieving this. Informal feedback on the concept of a 'Federation' via community mailing lists was generally very positive and the first steps towards establishing a 'Federation' have therefore been initiated. A White Paper outlining the structure, goals and mission of the Federation has been drawn up and published online (www.plantsci.org.uk/news/list). Representatives of a number of stakeholders, including research communities, learned societies and industrial groupings will be invited to a meeting on the 31st January 2011 at NIAB, to discuss the White Paper and how to establish the Federation. If you would like further information regarding the 'Federation' please contact Ruth Bastow (ruth@garnetcommunity.org.uk) or Alex Webb (aarw2@cam.ac.uk).

A new look for GARNet

GARNet has recently updated its website (www.garnetcommunity.org.uk/) and redesigned its logo. Refreshing the GARNet website was one of the aims of the current grant so that it reflected the remit of GARNet, which has evolved in recent years. Today GARNet functions as network for Arabidopsis researchers and the wider plant science community rather than directly providing genomic resources for the Arabidopsis community, its original aim when GARNet was founded in 2000.

This renewal of the GARNet identity comes with a new logo, as featured on the cover of this issue, and with a more modern design of the GARNish Newsletter. In light of the feedback we received from the community the website has been updated so that it can be easily navigated, the design is consistent throughout the pages. The old lists of useful tools and links have been reorganised into a directory so that you'll need fewer mouse clicks to land on your favourite resource (www.garnetcommunity.org.uk/resources). Overall we hope that you will find the updated site a lot more intuitive to move between sections/pages. For example you can now easily see the content of old GARNish issues so you can find articles that you might have missed. http://www.garnetcommunity.org.uk/newsletters

A new addition to the site is the 'rogues gallery' of the committee members so you can easily identify your representatives on the committee, should you ever need to find them! Take a look at us all at www.garnetcommunity.org.uk/advisers We've also included a news section. So visit us regularly, and you won't miss any of the Arabidopsis news! http://www.garnetcommunity.org.uk/news We hope you like the updated site and we would love to hear from you if you have any feedback or news you would like to see featured. You can contact us at ruth@garnetcommunity.org.uk or irene@garnetcommunity.org.uk

UK Plant Science – A Unique Resource

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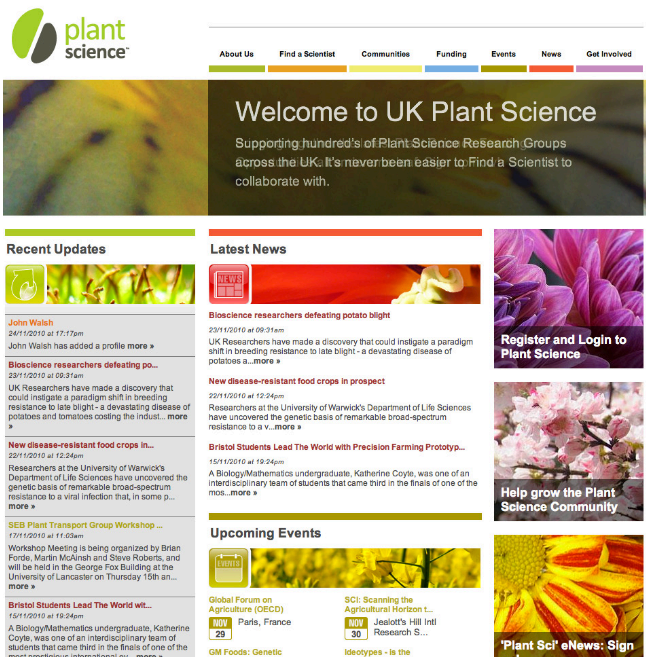
One of the aims of the current GARNet grant is to update the GARNet website, which as we reported in 'news and views' on page 3 of this issue has now been achieved, www.garnetcommunity.org.uk

During the process of renewing and modernising the GARNet website we realised that there was not an online mechanism to promote the communication of Plant and Crop Science research between communities or to others interested/working in the Plant Science arena. After discussions with the various UK Plant and Crop groupings, including UK-BRC (Brassica), UK-SOL (Solanaceae), MONOGRAM (Cereal and Grasses) and Gatsby Plants, we proposed it would be useful to set up a portal with links out to (and from) the UK plant science communities, that would also act as an information hub to facilitate communication and knowledge exchange across the whole community. Each community site would be maintained as it is now, providing an in depth set of information for its users, whilst the portal would function as an aggregator site, provide a window into UK Plant Science and hopefully promote cross community interactions.

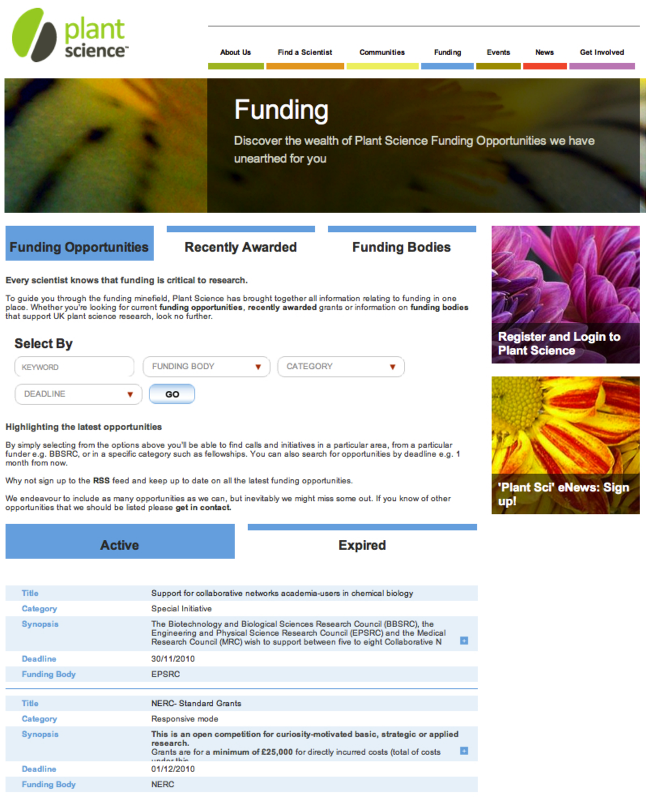
To make sure the portal was useful and not just another URL we carried out an online survey; we asked the community what it would like to see included in the new portal and used this as the basis of the brief to develop the new site – UK Plant Science www.plantsci.org.uk. We hope you like it.



A community site - www.plantsci.org.uk

UK Plant Science - 'PlantSci' was officially launched on the 10th December and aims to support Plant Scientists in their day to day research by providing the latest funding opportunities, news and information all under one leaf. PlantSci does all the hard work for you by trawling the web for all the relevant Plant Science related information, so you don't have to.

For example, we know that finding the right 'pot of money' for your research isn't easy, the competition is high and often you only hear about an initiative after if has closed. To ensure you make the best use of your time PlantSci has unearthed a wealth of information relating to funding, be it current opportunities, recently awarded grants or information on funding bodies that support UK Plant Science research. With all this at your fingertips you can respond to opportunities instead of searching for them. www.plantsci.org.uk/funding/opportunities/active

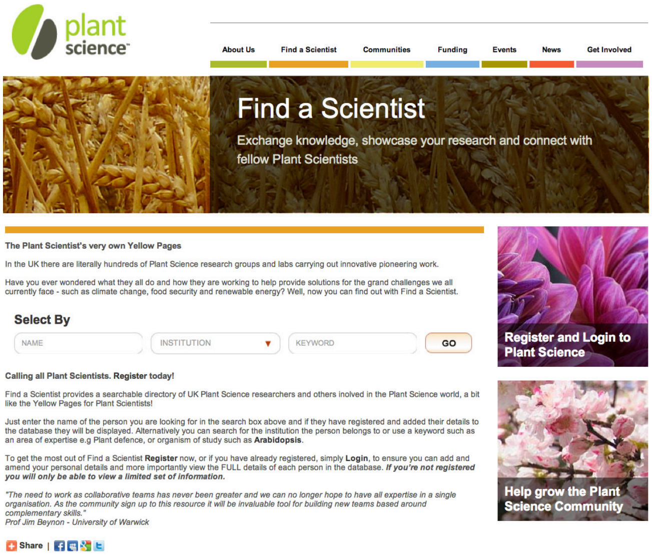


Find a Scientist

A large proportion of those that responded to our online survey said that they had difficulties in finding detailed information on the types and kinds of research that were being undertaken in the UK, to try and solve this problem the PlantSci site includes "Find a Scientist' www.plantsci.org.uk/scientists. This is a search

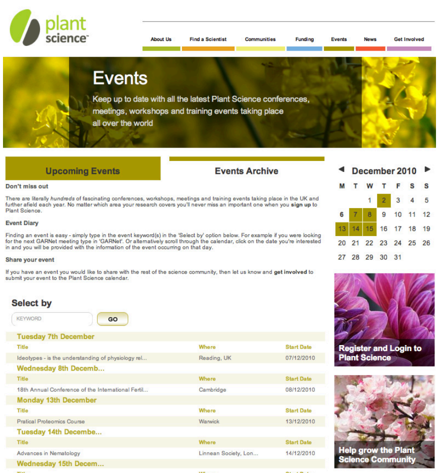
GARNish

A Portal for the Plant and Crop Science Communities



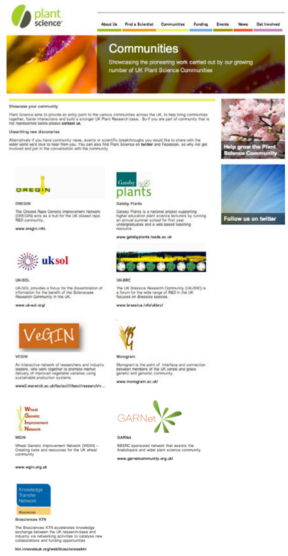
able directory; just enter the name of the person you are looking for, or the institution a person belongs to, or a keyword such as an area of expertise. We hope that this will become a 'Yellow Pages' for all those involved in Plant Science allowing users to find an expert in a specific field, track down a new collaborator or help students and post-docs learn more about a group they might like to join. However, to maximise the usefulness and impact to the user it requires input from everyone, including you. By signing up and placing your details in the directory you can to tell the world about your outstanding research or work in the field of plant science. So why not take this excellent opportunity to showcase your work to the wider community and register your details today. www.plantsci.org.uk/user/login

What's going on?



PlantSci also catalogues all the must attend conferences and meetings in Plant and Crop Science in the comprehensive PlantSci Events Diary. So now you can keep up to date and never miss an event. www.plantsci.org.uk/events/upcoming-events. Once you have registered as a user, you can also add your own events and submit news stories, the perfect way to help share information with the wider community.

Finger on the Plant Science pulse



To try and help promote interactions and information exchange between the variety of UK Plant and Crop bodies, PlantSci provides an entry point to these various groupings via the 'Communites' page www.plantsci.org.uk/communities. For example currently listed communities include VEGIN (A Defra funded network for improved vegetable varieties), OREGIN (Defra funded network for the Genetic Improvement of Oilseed rape and Biosciences KTN (network to promote the exchange of knowledge between the UK research base and industry). Do take a look; we are sure you will uncover something new and inspiring. If you represent a community that is not listed, we would like to hear from you. Please e-mail us ruth@plantsci.org.uk or irene@plantsci.org.uk.

Help us to 'grow' the Plant Sci community

We hope you'll find PlantSci an invaluable tool in supporting your day to day research. Please help us grow the Plant Science community by telling all your friends and colleagues about this unique and flourishing resource! We're always keen to hear what you think of the site so please do contact us with any feedback you have. You can even follow us on Twitter (twitter.com/plantscience)!

GARNet 2010

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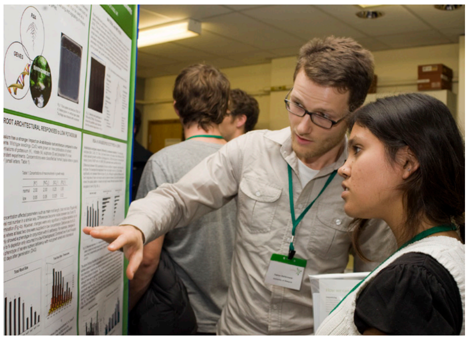
After one year of absence as a result of the ICAR Conference being held in the UK, in 2009, the GARNet annual meeting returned to the scientific calendar this year. Over 100 researchers came to Durham University to enjoy two intensive days of fascinating talks and workshops covering cutting edge biology and newly developed tools and resources.

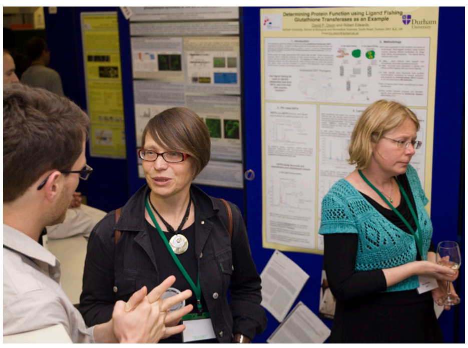
The first session of the meeting was Integrative Biology and this covered a wide range of topics. Jose Fejo (Gulbenkian Institute, Lisbon) developed and presented a 3-D theoretical modelling of ion fluxes and cytosolic diffusion in pollen tubes to elucidate the mechanisms that regulate intracellular patterns of ion fluxes. Jim Murray (University of Cardiff, UK) presented new data on cyclin D genes suggesting that this pathway plays an important role in the developmental coordination of the plant cell cycle. Liam Dolan (University of Oxford, UK) provided insight into the interactions of the transcription factors controlling root hair formation and growth in Arabidopsis and other land plants. Kim Kenobi (University of Nottingham, UK) presented data on inferring gene regulatory networks from the clustering of a group of genes known to be involved in lateral root emergence. Clare Hill (University of Warwick, UK) showed how gene modelling can help identifying the potential regulators of genes involved in the response pathway following *Botrytis cinerea* infection in Arabidopsis.

In the afternoon Cell Biology session, Karl Oparka (University of Edinburgh, UK) introduced super-resolution live imaging techniques such as Photoactivation Localization Microscopy (PALM) and Structured Illumination Microscopy (3D-SIM) that permit the visualisation of very small structures such as individual nuclear pore complexes and plasmodesmata components. Martin Huelskamp (University of Cologne, Germany) talked about the strategies used to develop meaningful mathematical modelling that describes the regulatory network involved in trichome patterning. Chris Hawes (Oxford Brookes University, UK) presented advances in imaging that elucidate the plant endomembrane system, including the development of a persistency map showing the skeleton of the moving endoplasmic reticulum and the anchor points through which it is most likely attached to the plasma membrane. Christine Faulkner (John Innes Centre, UK) showed that three pathogen-regulated receptor-like kinases localise to the plasmodesmata raising the question of the role of plasmodesmata regulation with respect to plant defence. Andrei Smertenko (Durham University, UK) provided insight into the remodelling of the actin filament network, which may occur via severing and end-joining of existing polymers. Celia Knight (Gatsby Plants, UK) advertised the wealth of educational resources including on-line lectures, images, and animations provided by the Gatsby Plants TREE (Tool for Research Engaged Education) http://www.gatsbyplants.leeds.ac.uk/tree/gatsby_tree.php for undergraduate plant science teaching.



A workshop on confocal laser scanning microscopy spinning disk and total internal reflection microscopy technologies and their applications in plants gave the opportunity to the GARNet delegates to explore them first hand, whilst a concurrent workshop on synthetic biology explored the meaning and potential of this emerging field in plant science.

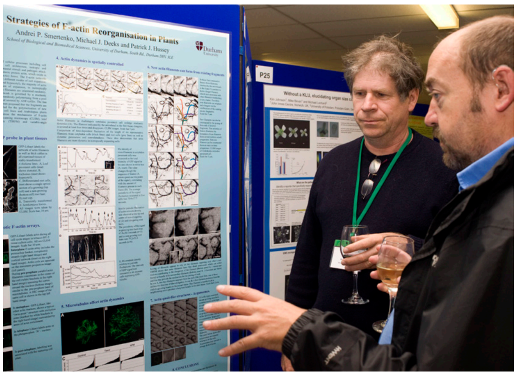
On the second day, Jim Beynon (University of Warwick, UK) opened the signalling networks session. He gave an overview of the BBSRC SABR systems biology PRESTA project, which aims to elucidate the high level networks that control the common components of biotic and abiotic plant stress responses. Nicholas Harberd (University of Oxford, UK) talked about genetic and genomic approaches to plant growth regulation and its adaptation in response to environmental variables, in particular the regulatory process of the



GARNet 2010 Cells and Systems Meeting

giberellin hormone and the DELLA proteins. Karen Halliday (University of Edinburgh, UK) illustrated the work carried out by BBSRC SABR ROBuST project that shows how the circadian system can help to buffer the effects of temperature. Karen presented data on how molecular light pathways maintain rhythmic gene expression, plant growth rate, leaf biomass and flowering time at warm ambient temperatures. Carlos S. Galvan-Ampudia (University of Amsterdam, The Netherlands) presented novel salt stress-induced signals that control the direction of plant growth. Iruke Meskiene (University of Vienna, Austria) concluded the session showing that three novel PP2C-type MAP kinases may act as negative regulators of MAP kinases, in particular AP2C3 stimulates cell proliferation and converts epidermal cells into stomata and provides a link between MAPK signalling and the cell cycle control.

In the Phenotyping session, Francois Tardieu (INRA Montpellier, France) introduced the need of modelling in high throughput phenotyping to dissect genetic variability. Ulrich Schurr (Forschungszentrum Juelich, Germany) illustrated the recent developments in the technologies and applications of phentyping platforms provided by the Forschungszentrum Juelich http://www.fz-juelich.de/icg/icg-3/jppc and illustrated how in a controlled environment with biotic and abiotic stress factors the phenotype of plants with defined genetic material will be monitored by sensors capable of delivering quantitative data at temporal and spatial resolution in the triangle formed by defined genotypes, sensors and relevant simulations of environments. Nathalie Wuyts (INRA Montpellier, France) illustrated how within the PHENOPSIS phenotyping platform, which is an automated platform for the conditioning of the plant environment including soil water content and the monitoring of growth, a technique for three-dimensional imaging of leaf thickness of Arabidopsis leaves and the quantitative analysis of their growth is used to determine the cell volume, length and width of individual cells, therefore allowing analysis in Arabidopsis mutants affected in stomatal conductance. Fabian Kellermeir (University of Glasgow, UK) showed that QTL analysis using the EZ Rhizo software http://www.psrg.org.uk/Software/Rhizo/index.htm to measure spatial and temporal root architecture led to the discovery of novel regulators of nutrient sensing and signalling. Mary Williams (American Society of Plant Biologists, USA), presented the Teaching tools in plant biology of The Plant Cell, http://www.plantcell.org/teachingtools/teaching.dtl which include customizable slides in current topics in plant biology.



The last session was dedicated to Genome Scales Approaches. Neil Hall (University of Liverpool, UK) presentation illustrated the Next Generation Sequencing facilities available at Liverpool and their applications for Arabidopsis and wheat. Jane Rogers and Mario Caccamo (TGAC, UK) introduced The Genome Analysis Centre (TGAC) http://www.tgac.bbsrc.ac.uk/and its capabilities in next generation sequencing and *de novo* assemblies. Silke Robatzek presented a high throughput imaging method that quantitatively detects membrane compartments at subcellular resolution. Analysis of these images suggests the existence of a control mechanism that regulates the number and size of endosomes in response to biotic or abiotic stress. Achuthanunni Chokkathukalam closed the meeting with a talk that illustrated how the subcellular localization of enzymes can be predicted based on their transcriptional profile combined with knowledge of structure of the metabolic network that the enzyme functions in.

The 2010 GARNet Meeting provided an excellent opportunity for plant scientists to discuss advances in tools and technologies along side current and future challenges in plant biology. The GARNet 2010 Cell and Systems showcased plant systems biology, plant cell biology and the emerging field of phenomics, illustrating how mathematical modelling, advanced microscopy and high throughput platforms are shaping plant science.

The Future of Arabidopsis Informatics

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The wealth of resources that have been generated in Arabidopsis over the past decade has allowed researchers to make outstanding discoveries in both plant and general biology. This progress has largely been driven by a combination of substantial investment and a collaborative international community that have generated a gold standard genome and a wealth of data and resources. These in turn have been mined and exploited by researchers to enhance our understanding of plant processes that will ultimately be translated to advances in the field. Without the curation and storage of all these data and information by groups such as TAIR and NASC, for researchers to continually access and analyse such success would not be possible.

> *"a single data management structure would be required and this would need to be organised/managed by an international consortium."*

In light of the announcement of reduced funding to TAIR (1), Autumn 2009, the Arabidopsis community began a timely analysis of the current and future informatics needs of the Arabidopsis community. This was initiated at two workshops (Nottingham, April 2010, Washington, May 2010) and then followed up at a discussion meeting at the ICAR in Yokohama in Japan, June 2010. The outcomes of these meetings have recently been published in Plant Cell (2) www.plantcell.org/cgi/content/abstract/tpc.110.078519v2, and this article provides a summary of this paper.

The Debate

The workshops considered the current data types that are generated by the community as well those that may be in generated in years to come. Those present at the workshops reflected on the challenges that these data sets and new technologies would impose on the informatics and infrastructure requirements of the community. It was concluded that to meet the needs of the community a single data management structure would be required and this would need to be organised/managed by an international consortium. Attendees at the workshops and meeting noted that any future infrastructure would have to accommodate the ever increasingly and complex data being generated by high throughput technologies so that it would be possible for all researchers to undertake systems biology approaches to understanding and modelling plant process. Equally all data and information needs to be easily accessible to researchers using other plant species, other organisms or researchers working in other fields. Those involved in the discussions agreed that to achieve such a vision would require the community to move beyond the current infrastructures and develop novel approaches to data management, integration, and access. The International Arabidopsis Informatics Consortium (IAIC) was therefore proposed to meet all these goals.

The International Arabidopsis Informatics Consortium (IAIC)

The IAIC model that has been proposed by the community to meet its future informatics needs will consist of a distributed system of data, tools, and resources that would be coordinated by a single international consortium and could be funded by a variety of sources.

At the centre of the IAIC would be an Arabidopsis Information Portal (AIP), that would interact with and link to resources around the world, including Arabidopsis data sets generated in individual laboratories, information from other species, and other biological data sets. It is envisaged that all data would be accessed via the AIP, which would act a single user friendly interface for all queries and data searchers to the IAIC. Such a structure would enable optimized use of data, tools, and resources and thus maximize the return on public research investment for the wider scientific community.

In addition to the AIP there would also be 3 further components, which would be essential for the basic function of the IAIC and form its core. These core components would carry out the following tasks:

1. Act as a single user friendly interface that links all data in the IAIC
2. Maintain the gold standard annotation of the Arabidopsis Genome
3. Support genome/sequence curation to ensure that up to date and relevant information on each gene, its product(s) and the associated regulatory landscape are available to the user in a genomic context
4. Provide the data and information required for stock and resources databases
5. Develop clear standards to allow data archiving, data exchange and interoperability between all components of the IAIC

Using the core as the basis for the IAIC, additional noncore modules can then be added to form the IAIC, as illustrated in Figure 1. Indeed, this structure with clearly defined sets of standards would allow any data, resource, or tools generated across the globe to become part of the IAIC. In addition to leveraging costs, sharing expertise and innovation, this model would provide the user with the impression of a seamless whole.

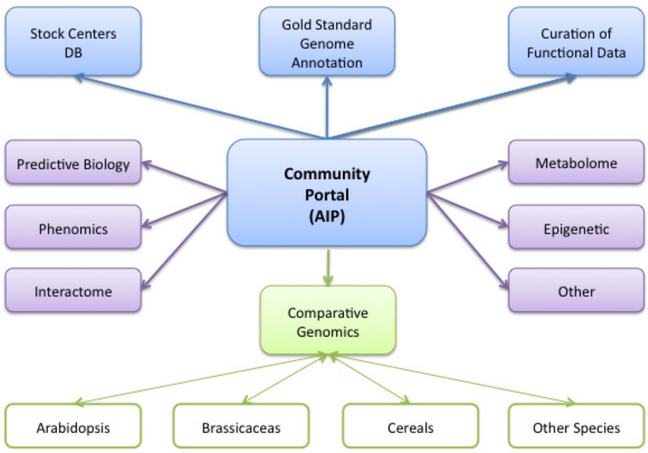

Figure 1: The structure of the IAIC
IAIC consists of core of four components in blue: (1) the AIP, which is the central hub of the consortium, provides a single user interface to access to all the constituent parts of the consortium, sets standards, and provides training; (2) gold standard genome annotation; (3) curation of functional data; and (4) stock center database(s) to enable rapid access to resources. Noncore modules are illustrated in purple; those listed in the figure are just examples and are not meant to be an exhaustive list. The comparative genomics module (in green) provides one example of how the IAIC will link out to other plant species.

To ensure that the IAIC functions effectively, it was proposed that an International Scientific Advisory Board (SAB), an IAIC Committee, and a Scientific Advisory Panel (SAP) should be established.

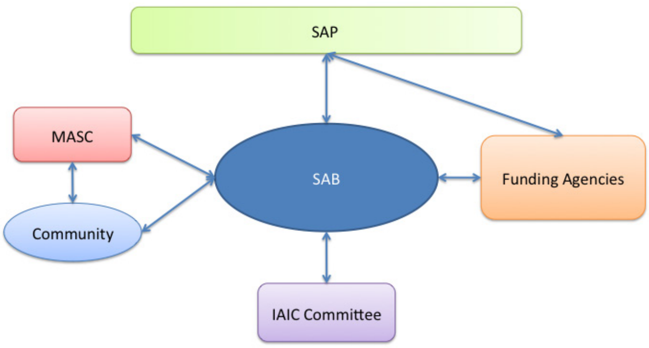

Figure 2: Management structure of the IAIC
The IAIC committee would represent the modules making up the IAIC. The SAB (Scientific Advisory Board) would oversee the development of the IAIC, interact with funding agencies, the user community and MASC. The SAP (Scientific Advisory Panel) would provide a review body for the IAIC.

The SAB would provide the main steering body for the IAIC to carry out such tasks as directing future activities of the IAIC, liaising with funding agencies, acting as a point of contact for those wishing to become involved in the IAIC and the general user community. The SAP would review and assess the progress of the IAIC. The IAIC committee would consist of all individuals leading the components of the IAIC itself. The interaction and management structure of the three groupings are outlined in Figure 2.

Next Steps

To try and translate the idea of the IAIC from paper into reality a grant application, a Research Coordinated Network (RCN), to bring together key individuals and groups to build a framework on which the IAIC can be built, has been submitted to the NSF. Whilst the outcomes of this grant are currently unknown, to continue the momentum that has been initiated at the workshops earlier in the year an open workshop is planned to take place at the Plant and Animal Genome (PAG) Meeting in January 2011, San Diego, US to continue the dialogue with the community. In addition, an IAIC webpage has been set up (arabidopsis.org/portals/masc/IAIC.jsp) to inform the community of developments.

"The IAIC model [...] will consist of a distributed system of data, tools, and resources that would be coordinated by a single international consortium and could be funded by a variety of sources."

The Arabidopsis community is at a critical junction, a range of new data types are becoming available in addition to the ever-growing mountain of data and information that researchers are faced with every day. International groups are also inventing new informatics approaches and tools that the community needs to be able to find, utilise and enhance. If the community is to try to address the problems currently facing the globe, it will need to be able to integrate, visualise and analyse this plethora of data, and access the wealth of tools and resources. To achieve this will require a new multinational informatics structure that can leverage expertise and funding on a global scale. The IAIC is one such solution to achieve this.

1. Abbott, A. (2009) Nature 462, 258-259
2. International Arabidopsis Information Consortium (2010) Plant Cell 22, 2530-2536

What Arabidopsis has done for our understanding of membrane transport and ion homeostasis

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Electricity everywhere: from giant algae to squid axons

Many of the scientific problems encountered during our efforts to generate better crops are related to ion transport and homeostasis. Almost all minerals, metabolites and hormones circulate within the plant in their ionic form. The fact that they are electrically charged means that many of the traits that we would like to improve in crops such as nutrient usage efficiency, salt and heavy metal tolerance, or specific allocation of metabolites and toxins, are dependent on membrane potential and conductance. Nowadays electrophysiology is rather unpopular with plant science students and researchers but this was not always the case. In fact, the seminal work by Osterhout, Blinks, and Cole and Curtis (1-3) on membrane potentials in giant algal cells preceded and inspired Hodgkin's work on action potentials in squid axons (4), and algae routinely served as substitutes in marine laboratories when squid was in short supply.

From crops to model

Figure1: *Chara australis*, an old favorite with electrophysiologists (courtesy of Mary Beilby, University of NSW, Australia)

Giant cells of Characeae (Figure 1) were also the favourite objects of plant electrophysiology labs setting up in the UK and Australia from the late 1950 onwards (5, 6) before higher plants entered the scene in the 1970s in the shape of major crops such as maize, carrot, barley, wheat, oat, bean and red beet (7). Electrophysiologists like to 'strip' leaves or roots of their epidermal layers, 'poke' cells with several electrodes (voltage clamp) and 'suck' on isolated protoplasts or vacuoles (patch clamp, Figure 2), and they therefore naturally chose big plants with large cells. *Arabidopsis thaliana* was clearly not on their list of preferred models. Only in the 1990s, acknowledging the immense possibilities offered by molecular biology and genetics (8), electrophysiologists turned to Arabidopsis to find that not only it was amenable to all essential biophysical methods but also it offered the opportunity to combine them with imaging techniques (9-12). Linking the measurement of electric potentials and ion fluxes to the imaging of intracellular signals (e.g. Ca) and the localisation of individual fluorescently tagged transport proteins allowed the scientists to carry out 'live' experiments, in which they could apply stimuli, and monitor cellular responses in real time.

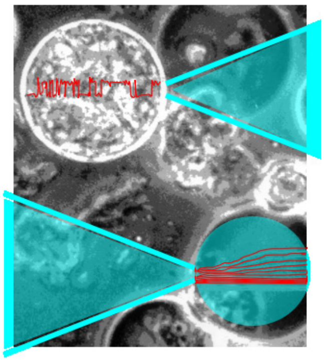

Figure2: Patch clamping detects single-channel and whole-cell currents in barley protoplasts

A small cell at the centre of big questions

Electrophysiology and confocal microscopy combined with the molecular and genetic tools of *Arabidopsis thaliana* created an explosive mixture that unleashed fist class science and led to the comprehensive description of a particular cell type - the stomatal guard cell - which is probably unparalleled in biology (13). The first quantitative model of a guard cell was presented at this year's International Workshop of Plant Membrane Biology in Adelaide (www.adelaide.edu.au). Mike Blatt and colleagues from Oxford and Cambridge have created a software package (On Guard) that incorporates all available information on ion transporters in both plasma membrane and tonoplast, as well as physical and chemical parameters of the cell and the environment, to generate functional stomata that open and close in response to external stimuli. The particular beauty of the guard cell system is that it links information at the level of individual atoms and molecular structures, genes and proteins, ion gradients and intracellular signals with water consumption, CO_2 exchange and photosynthetic activity of the whole plant (forest, ecosystem etc), and it thus takes a central position at the interface of land, oceans and atmosphere. Since stomata use ubiquitous molecular and biophysical entities (ion and water channels, voltage and pressure) to carry

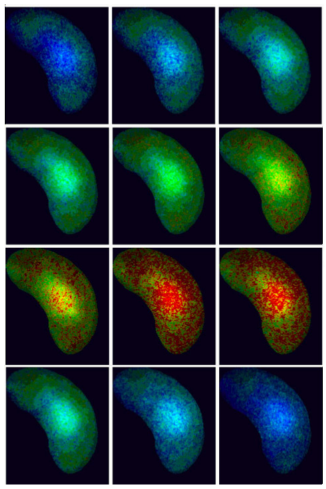

Figure3: A series of confocal images following a rise of cytoplasmic calcium in a guard cell (courtesy of Mike Blatt, Glasgow University)

out a very plant-specific function the usage of Arabidopsis as a model species was fully justified. Once we understand one guard cell we can now find out how this organ has evolved from a simple ancestor and further specialised in other species - 'variations of a theme', not a new tune, are to be expected from this research.

Yeast and Arabidopsis, the perfect couple

Another way for Arabidopsis to get a foot into the door of plant ion transport labs was paved by a different model organism – yeast. Yeast is a 'very hungry' cell that swallows nearly every compound it encounters and readily adjusts its metabolism to the available menu. Therefore a huge number of mutant lines display distinct nutritional problems, for example, they don't grow when a certain nutrient is in short supply. Complementation of these yeast mutants with cDNA libraries allowed plant scientists to clone the first plant ion channels from Arabidopsis (14, 15) and has since led to the identification of myriads of plant proteins mediating the transport of nutrients and metabolites, e.g. ammonium and amino acids (16, 17). Because yeast possesses a vacuole it could also be used to characterize plant vacuolar transporters, in particular those required for the sequestration of toxic ions, metals or herbicides (18-20). Yeast complementation assays can of course be carried out with cDNA from any plant species but subsequent cloning and functional characterization was mostly carried out in Arabidopsis. The importance of this wok for crop improvement is becoming apparent as functional chains of individual transporter are designed and expressed at specific locations within the plant to create and direct ion fluxes with the aim to enhance nutrient usage and allocation, as well as detoxification and phytoremediation. Progress through synthetic biology and crop biotechnology in this area is unthinkable without the building blocks previously identified using the molecular-genetic tools of *Arabidopsis thaliana*. While expression, regulation and physiological role of individual transporters may vary between species the molecular features determining kinetics, affinity, specificity and regulation of the transport proteins will have been subjected to similar structural constraints during evolution and therefore well conserved.

A lucky dip with big impact

The last and probably most striking example for how Arabidopsis research has shaped our understanding of ion transport and homeostasis comes from an experimental approach that was least likely to produce valuable results in Arabidopsis – a mutant screen for salt tolerance. The criticism is obvious: a) Arabidopsis is not a halophyte, so why would it teach us anything about salt tolerance? b) Sodium homeostasis will involve a complex signalling network with regulatory entities likely to be different in different species. Nevertheless when Jian-Kang Zhu as a post-doc in Arizona screened a large mutagenized population of Arabidopsis for salt-hypersensitivity using a clever root-bending growth assay he hit a gold mine. Several of the identified so-called SOS (salt-over-sensitive) mutants were defective in genes that belonged to the same, clearly delimited, signalling pathway involving a calcineurin-like calcium binding protein (CBL), a CBL-interacting protein kinase (CIPK) and a target transporter (in this case a plasma membrane sodium/proton antiporter) (21). Not only have the individual components of the SOS pathway since been characterised in detail, additional targets been identified and its existence has been verified in crops and halophytes, but over the last years it has also become apparent that the SOS-pathway is just one output of a generic regulatory system that underlies ion sensing and ion homeostasis in plants (22).

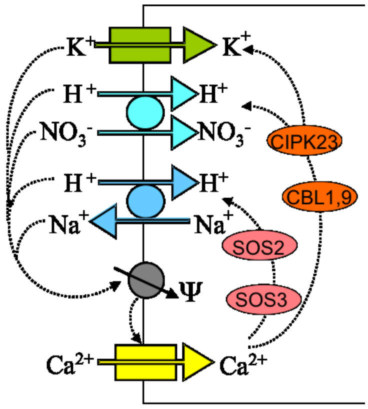

Figure4: The CBL/CIPK system adjusts transporter activity to external ion concentration via membrane potential and voltage-gated Ca-channels

Both the voltage-gated root K-uptake channel AKT1 and the root nitrate sensor/transporter CHL1 are regulated by CBL-CIPKs (23-25). These findings have put an end to years of misery for electrophysiologists trying to functionally express AKT1 in Xenopus oocytes (CBL1 and CIPK23 are vital ingredients!) and they have provided a molecular handle for studying co-regulation of different transporters (e.g. for pottasium and nitrate). Even more importantly, in the case of CHL1, CBL/CIPK action directly precedes the transcriptional responses that switch the cell from low to high nitrate status and vice versa, involving the adjustment of nitrate uptake, assimilation and root development (26). In its various combinations of Ca-binding protein, kinase and target transporter the CBL-CIPK system links a cytoplasmic Ca signal to the activity of an ion transporter thereby modulating ion fluxes across cellular membranes in response to an external stimulus. It therefore underscores not only nutritional and ionic stress responses but also the first processes that occur after an attack from path-

Figure5: Patch clamping Arabidopsis protoplasts requires patience and skill (but not, usually, a helmet)

ogens or pests (27). Reports on regulation of ion transport by CBL and CIPK in other plant species are turning up in the literature suggesting that the CBL-CIPK system has indeed ubiquitous importance for optimising ion uptake and homeostasis in a particular environmental condition. Many more combinations of functional CBL-CIPK-transporter triplets can be expected to be discovered in the future and at this stage we are only beginning to appreciate the impact that this knowledge will have on crop improvement.

Back to crops: yes please, but....

Probably more than any other field of research plant membrane transport has its scientific roots in non-Arabidopsis species. Electrophysiologists and cell biologists will be only too happy to work again with larger plants as long as they can carry out efficient genetic manipulation and diagnostics. The enormous amount of physiological knowledge that is already available for crops, e.g. on mineral nutrition (28), will be an invaluable asset for crop improvement when combined with the molecular information gained from Arabidopsis. However, it would be wrong to consider Arabidopsis a model of the past. Each of the above examples (and many studies not covered here) have not only generated fundamental knowledge that can be translated to crop species, but also new questions that are best tackled in Arabidopsis. To mention just a few: how is information on environmental change communicated to intracellular membranes; how are transport activities fine-tuned between different membranes; how is metabolite transport adjusted to metabolic activity; how are transporters and regulators assembled to functional superstructures? Answering any of these questions requires exquisite cell biological tools and rigorous hypothesis testing through molecular genetics. Clearly, the Plant Membrane Transport community is not yet ready to release Arabidopsis from its grip.

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Additional information:

The Plant Transport Group (PTG) within the Society of Experimental Biology (SEB) regularly contributes sessions on the topic to the annual SEB meeting, organizes the annual PTG meeting and occasional symposia. www.sebiology.org/plant/Groups.html

The International Workshop on Plant Membrane Biology (IWPMB), the main international meeting of the Plant Membrane Transport community, takes place every 3 years. The 2013 meeting will take place in Japan, China or the US. www.adelaide.edu.au/iwpmb2010/IWPMB2013/

The Gordon Research Conference (GRC) on 'Salt and Water Stress in Plants', which regularly includes a session on ion homeostasis, takes place every 2 years. The 2012 meeting will take place in Hong Kong or the US. www.grc.org/programs.aspx?year=2010&program=salt

SEB Society for Experimental Biology

Glasgow 2011

Annual Main Meeting July 1 - 4, 2011

CELL SESSIONS

Tip Growth in Plant Biology
Organized by: Kriss Vissenberg (University of Antwerp, Belgium) and Claire Grierson (Bristol University)
Confirmer Speakers: Prof. Dr. José Feijó (Instituto Gulbenkian Ciência and Univ. Lisboa, Fac. Ciências), Prof. Dr. Erik Nielsen (Univ. Michigan, USA), Dr. Vera Meyer (Leiden University)

Frontiers in Algal Biology
Organized by: John Love (University of Exeter)
Confirmed Speakers: Saul Purton (University College London)

Nuclear Envelope
Organized by: Martin Goldberg (Durham University)

Gas sensing and signalling in animal cells
Organized by: Martin Cann (Durham University)
Confirmed Speakers: Yosef Gruenbaum (Hebrew University of Jerusalem), Cormac Taylor (University College, Dublin) Nick Dale (University of Warwick) Mario de Bono (MRC Laboratory of Molecular Biology, Cambridge) Phillip Moore (Kings College, London)

PLANT SESSIONS

Regulation of resource allocation and growth
Organized by: Astrid Wingler (University College London) and Matthew Paul (Rothamsted Research)
Confirmed Speakers: Gerrit Beemster (Antwerp), David Jackson (Cold Spring Harbor), Hendrik Poorter (Utrecht/ Jülich), Paul Struik (Wageningen), Andy Fleming (University of Sheffield), Joost Keurentjes (Wageningen University), Céline Masclaux-Daubresse (INRA Versailles), Henriette Schluepmann (Utrecht University), Ronan Sulpice (MPI Golm), Cristobal Uauy (John Innes Centre), Carol Wagstaff (University of Reading), Achim Walter (ETH Zürich)

Pathways and fluxes: analysis of the plant metabolic network
Organized by: R. George Ratcliffe (University of Oxford) and Nicholas J Kruger (University of Oxford)
Confirmed Speakers: Stephanie Arrivault (MPI Golm), Andrew Hanson (University of Florida), Ron Milo (Weizmann Institute of Science), John Morgan (Purdue University), Jörg Schwender (Brookhaven National Laboratory), Yair Shachar-Hill (Michigan State University), Ralf Steuer (Humboldt University Berlin), Lee Sweetlove (University of Oxford), Guillaume Tcherkez (Université de Paris-Sud)

Plant Transcription: regulation and mechanism
Organized by: Heather Knight (Durham University) and Piers Hemsley (Durham University)
Confirmed Speakers: Professor Stefan Björklund (Umeå University), Ueli Grossniklaus (Institute of Plant Biology, Switzerland), Richard Meagher (Genetics Department, University of Georgia), John Brown (Plant Sciences Division, University of Dundee), Martin Huelskamp (Botanical Institute, University of Cologne), Nick Monk (School of Mathematical Sciences, Nottingham), Ari Sadanandom (Warwick HRI, University of Warwick), Jerzy Paszkowski (Department of Plant Biology, University of Geneva), Dao-Xiu Zhou (Institute of Plant Biology, CNRS Paris)

Integration of abiotic and biotic stress responses: from systems biology to field
Organized by: Katherine Denby (University of Warwick) , Christine Foyer (University of Leeds), Miriam Gifford (University of Warwick), Robert Hancock (SCRI)

EPA SESSIONS

Science Communication Training Day
Organised by: Jeremy Pritchard (Birmingham), Sarah Blackford (SEB),
David Evans (Oxford-Brookes), Iain Barber (Leicester), Tijana Blanusa (Reading)

Media Workshop
Organised by: Jenny Sneddon (Liverpool John Moores)

Careers Workshop
Organised by: Sarah Blackford (SEB), and Peter Lumsden (University of Central Lancashire)

www.sebiology.org

There are over 350 plant research groups in the UK, in 42 institutions scattered from Aberdeen to Exeter. Many of these groups are international leaders in their field. To promote the breath of plant science throughout the UK, and increase awareness of the different types of research being undertaken, GARNet is focusing on geographical areas and institutions across the UK. In this issue we continue our tour around the country highlighting the outstanding research being undertaken at the University of Dundee and at the Scottish Crop Research Institute.

Spotlight on the University of Dundee

The Division of Plant Sciences is part of the top-rated College of Life Sciences (CLS) and is based at the Scottish Crop Research Institute (SCRI), 10 minutes away from the University of Dundee main campus. The Division is a relatively new (established 2007) and vibrant centre for plant science and aims to grow through the recruitment of new PIs attracted by the combination of quality of science and quality of life that Dundee offers. The internationally recognised basic research of the division examines the mechanisms by which plants grow and develop in response to their environment. The Plant Sciences Division mission is to deliver international quality plant science and translate their research findings into areas of topical relevance such as biofuels and crop improvement. The unique partnership between CLS and SCRI provides access to state-of-the-art plant growth facilities, fosters collaboration with a wider community of plant scientists, and offers joint funding opportunities in plant and crop science. Together they have recently developed an MRes course 'Crops for the Future' (http://www.lifesci.dundee.ac.uk/courses/MRes/CES/) aimed at students with interests in careers in crop breeding, pathology and biotechnology.

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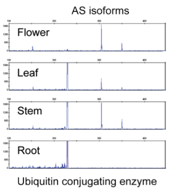
Plant disease and disease resistance

The Birch lab is trying to address the following questions: How do pathogens suppress or otherwise manipulate host processes to establish disease? And how are plants able to detect pathogens and respond with effective disease resistance? The main focus is on the late blight pathogen, *Phytophthora infestans*, which remains the most serious global constraint to potato and tomato production. Paul's group are using comparative and functional genomics, and a range of cell and molecular tools, to identify and characterize the virulence functions of *P. infestans* effector proteins which enter living host cells to manipulate disease resistance and metabolic processes. They are interested in the mechanisms by which they are delivered inside plant cells. They want to know when these proteins are required by the pathogen and where they are localized during infection. They also want to understand the mode of action of such virulence determinants: what are their host targets and what roles do those targets play in plant defence or metabolic processes?



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Post-transcriptional regulation of expression

Alternative splicing (AS) is a major level of post-transcriptional control of gene expression (see GARNish June 2010, pp. 4-5). AS generates more than one mRNA from a gene, which increases protein complexity and regulates mRNA transcript levels. AS modulates and fine-tunes transcript levels of genes in developmental, signaling and metabolic pathways and biotic and abiotic stress responses. In Arabidopsis, the extent of AS is still not fully defined but it is likely that at least 60% of genes undergo AS. AS is a dynamic process and the Brown lab has developed a high resolution RT-PCR system to measure changes in AS in 300 genes including important regulatory genes. They are using this system to address the function of a range of different splicing factors in regulating AS, to examine how AS is affected during development and by abiotic stress, and to identify common patterns of AS in terms of regulation of expression. The system is being further developed to investigate the influence of AS on regulation of specific pathways and processes by systematically identifying all AS events in genes involved in the same pathway. For example, they have shown that AS and nonsense-mediated decay (NMD), a mechanism for regulating transcript levels by the production of AS isoforms targeted for degradation, influences expression of many important regulatory genes. With support from EURASNET (http://www.eurasnet.info/) John's group have established collaborations with researchers interested in how AS affects their particular genes and processes. The importance of AS in regulating key processes will impact crop development and productivity and there is a need to capture AS information in crop systems. The Brown lab is also interested in the function of the nucleolus in mRNA biogenesis and NMD, and in the identification and function of small nucleolar RNAs.

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The genomics and genetics of crop plant diversity

Crop plants derive from wild ancestors and their improved performance for food and feed production derives mostly from reassorting gene alleles derived from the wild. Andy Flavell is interested in both the patterning of gene diversity in wild crop germplasm (barley and pea) and the identification of gene alleles that encode important yield-related traits in barley. The Flavell lab applies high throughput markers (Illumina SNP and retrotransposon RBIP), together with next generation sequencing (NGS) of 'captured' gene segments to address both of these issues. The diversity of wild barley is related to the evolutionary history and geographical distribution of the species, plus the genomic context of the genes that are affected by selective pressures. A major goal of the Flavell group is to understand how these forces have moulded the genomic diversity of wild barley and pea. A second objective is to identify gene alleles directly responsible for yield in barley, the Flavell lab is using a two-tier association genetics approach that first scans the whole genome for the approximate location of QTL affecting component traits such as Thousand Kernel Weight (TKW), grains per ear, ear length etc, in a collection of several hundred European barley cultivars. Once an association peak is identified, the genomic region containing it is scanned, gene by gene, by NGS.

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Cell walls/bioenergy/recombination

Claire's research focuses on two different areas: lignin biosynthesis and meiotic recombination. Lignin is an essential component of many plant cell walls, where it waterproofs and rigidifies the structure, protecting it from degradation. This complicates the release of cell wall sugars or cellulose during ruminant digestion and in biofuel and paper production, although lignin itself is a useful staring material for the production of valuable chemicals. The lignin biosynthesis pathway has been well-studied but important basic features are still poorly understood. The spatial organisation of the pathway, how it is regulated, and how it coordinates with other aspects of cell wall development and wider plant metabolism, are areas of intensive current research. The Halpin group are using association genetics (in barley) along with mutants and transgenic plants where lignin has been manipulated (barley, tobacco and Arabidopsis), to discover new genes related to lignin biosynthesis and to determine how the lignin properties influence plant biomass suitability for industrial and agricultural uses.

Recombination during meiosis is one of the principal events that create the genetic diversity driving evolution and is a fundamental process underlying crop breeding programmes. However, in some important crop species such as barley, large areas of chromosomes rarely, if ever, recombine. Greater understanding of how recombination is controlled in barley might allow the manipulation of the process to improve the available genetic diversity and the speed and accu racy of plant breeding. Claire's group are building on knowledge of recombination generated in Arabidopsis to evaluate the role of orthologous barley genes in recombination using both transgenic and mutant plants.

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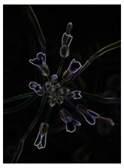
Virulence acquisition during Phytophthora-host interactions

The Huitema lab aims to understand the mechanisms by which *Phytophthora spp.* achieve virulence and ravage crops. Their research is guided by the observation that two classes of secreted molecules (RxLR and CRN effector proteins) from Phytophthora are delivered inside host cells where they play pivotal roles in disease establishment and epidemics. They therefore aim to study and perturb the pathways that control their delivery and activity *in vivo* with the overall goal to disable pathogenesis and control disease. To achieve these aims, Edgar's group exploit the broad host range pathogen *Phytophthora capsici*. *P. capsici* is genetically amenable to transformation and shares a host (tomato) with *P. infestans*, features that allows unparalleled opportunities for studying Phytophthora (effector) biology. With the identification of both host and pathogen genes with roles in disease susceptibility and subsequent functional studies, the group will explore and unveil new processes that underpin host-pathogen interactions.



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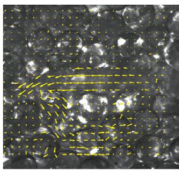
RNA and regulated gene expression controlling development

Precision in the control of flower development is underpinned by quantitative regulation of gene expression. By studying Arabidopsis mutants defective in this process, Gordon's lab has uncovered a form of regulated gene expression that may be of widespread significance. The Simpson group recently discovered that alternative processing of non-coding antisense RNAs can regulate transcription of the corresponding sense strand gene. His lab discovered that two RNA binding proteins that mediate this effect control the site of RNA 3' end formation. The lab is currently pursuing the mechanisms underlying sense-antisense gene pair regulation, facilitated by the development of a simple proteomics approach that identifies the protein assemblies involved. In collaboration with Geoff Barton's bioinformatics group at Dundee, the Simpson lab has used deep sequencing to detect and quantify shifts in 3' end formation of sense and antisense transcripts genome-wide. Therefore, by first studying how precision in flowering time control is delivered, the lab is now revealing fundamental features of plant gene expression of widespread relevance. Since some of the factors and gene regulation processes under study are widely conserved, work is also underway to translate out of the Arabidopsis model to understand their role in human cells and to dissect how cereals control the number of flowers that they make.

Spotlight on the Scottish Crop Research Institute

The Scottish Crop Research Institue (SCRI) research focuses on processes that regulate the growth of plants and their responses to pests, pathogens and the environment. It includes genetics to breed crops with improved quality and nutritional value. The main customer for the research undertaken at SCRI is the Scottish Government, although SCRI does carry out research for a wide range of government bodies and commercial organisations. Research is organised into four science programmes: Environment Plant Interactions, Genetics, Plant Pathology, and Plant Products and Food Quality. SCRI also hosts Biomathematics and Statistics Scotland (BioSS) and the Division of Plant Sciences of the University of Dundee. Research is conducted on a wide range of plants but particularly the crop plants barley, potato, blackcurrant and raspberry. SCRI's research activities make a clear contribution to the economic wellbeing, quality of life and implementation of policy objectives in Scotland as well as delivering excellence through research outcomes impacting on, and being recognised by, the global scientific community. In spring 2011, SCRI will merge with the Macaulay Land Use Research Institute to form a new 'super institute'. The New Institute will strengthen Scotland's rural-environmental research capacity and further enhance international competitiveness. It will be the first institute of its kind in Europe and will be a new powerhouse for research into food, land use and climate change. SCRI currently has over 40 research leaders, only a few of whom are profiled here.

Environment Plant Interactions



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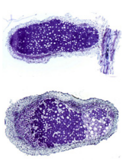
Plant-soil interactions

Paul's multidisciplinary group bridges plant and soil sciences with a specific focus on root traits and the rhizosphere. There are eight research leaders in the group, each with a different set of skills. They have an overall objective of identifying root traits to overcome biotic and abiotic stresses in soil. This includes investigating soil properties that limit plant productivity and need to be managed to ensure sustainable food production. Tracy Valentine uses both crop and model plants (including Arabidopsis) to examine changes in the meristem and overall structure of roots in response to physical stress. Her work with Glyn Bengough, in collaboration with colleagues in the Universities of Dundee and Cambridge tracked cell expansion in roots, and their interaction with the rhizosphere, and is illustrated in the accompanying photo. Glyn is a biophysicist who inves tigates mechanical constraints to root penetration and the mechanisms roots use to overcome these stresses. Soil properties that limit root proliferation and the preferential growth of roots through biopores are studied by Blair McKenzie, who also investigates soil management practices to improve crop productivity. Paul Hallett examines the physical development of the rhizosphere and how roots alter the physical behaviour of soil. Rhizosphere microbial ecology is the central focus of Tim Daniell's research, particularly in relation to the cycling of nitrogen and other nutrients. This is complemented by research by Roy Neilson on soil fauna, including key free-living nematodes that are excellent bioindicators of the health of soil. One research interest of David Hopkins is the interaction of genetically modified plants with soils, specifically the decomposition of residues from plants with modifications to lignin biosynthesis in soils. The newest member of the group, Alison Bennett, examines plant-arbuscular mycorrhizal fungal mutualism, including benefits to resource capture, parasite resistance and interactions with other soil microbes.



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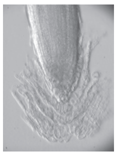
The biology of sustainable systems

The biological processes that determine the life cycles and survivorship of plants and invertebrates are examined at scales from cell to ecosystem. Questions are asked in two 'directions': how does change imposed at the scale of the organism affect ecological process, and which properties of the ecosystem determine the type and functioning of its component organisms? The ultimate aim is to quantify how much energy and matter may be diverted for food and other products, while leaving enough for the essential element cycles and trophic webs. Specific research topics include multitrophic interactions, nitrogen dynamics, geneflow, functional biodiversity, and individual-based modelling. The group comprises 20-25 people, typically five PIs (all developing their own specialist areas), 6-10 PhD students, technical expertise and post-docs. The principal model is the production system of the maritime north-east Atlantic, but the relevance of the work is global, particularly the issues of GM cropping and integrated pest management. Funding from Scottish Government is augmented by grants from the EU, Defra, LINK, TSB and the research councils. The group has a strong outreach ethic, driving several of the Institute's major initiatives such as its new long-term field platform, the Centre for Sustainable Cropping; integrated farm management through the LEAF (Linking Environment and Farming) Innovation Centre; and the education and public perception roles of the Living Field project http://livingfield.scri.ac.uk/welcome. Results inform GM policy and practice in Europe, the UK and further afield, for example through the European Food Safety Authority and the International Organisation for Biological Control.



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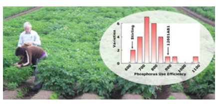
www.scri.ac.uk/research/epi/plantsoilinteractions

Plant-soil interactions

Root growth in soil is influenced both by physical and biological interactions. The ability of root system to draw nutrients and water resources from soil depends on the plasticity of the root system in respect to its overall size, the position of roots within the soil profile and their ability to respond to and overcome the physical constraints imposed by the soil. Drawing on the genetic diversity of cultivar, mutant and mapping populations of Arabidopsis and barley, the interactions between genotype and the physical environment on the growth of seedling roots is revealing large variations in responses to soil structure, soil strength and water availability. Novel screening methods are being developed with the aim of selecting root traits suitable for these potentially constraining soil environments. Further real-time RT-PCR methods are being used to link the molecular responses of the plant roots to quantified soil constraints. Cell biology methods are also being developed to understand root growth in high temporal detail and also to study the impact of soil conditions on root growth. One project funded by the BBSRC in collaboration with Glyn Bengough (SCRI), and the Universities of Dundee and Cambridge, has led to the development of new software (PlantVis) and protocols for the analysis of Arabidopsis root growth during time intervals of <3 minutes. The software is further being developed to support analysis of roots growing in soil (rather than agar).



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Plant Mineral Nutrition

Philip leads a Research Group that conducts excellent, innovative research enabling the production of safe, nutritious, agricultural produce with minimal impacts on the environment. His group has three broad objectives. The first objective is to develop methods to optimise the use of mineral fertilisers by crops and, thereby, to reduce fertiliser inputs and pollution. In recent years, this research has focused on the phosphorus nutrition of brassica, cereal and potato crops. The second objective is to reduce the entry of toxic elements into the food chain. Thus, they are devising strategies to reduce the concentrations of radioisotopes and toxic cations in edible portions of crop plants. The third objective is to improve the nutritional quality of crops through their biofortification with essential mineral elements including selenium, zinc, iron, calcium and magnesium. This collaborative work includes the development of commercial products and intervention studies.

Genetics

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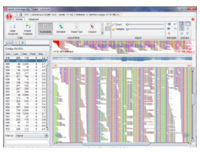
Using *Phytophthora infestans* effectors to identify more durable resistances in potato

Recently, a number of oomycete avirulence genes have been identified, all of which share a signal peptide for secretion, followed by the motif RXLR and an acidic region. The RXLR and the acidic region are both required for translocation inside the plant cell and is consistent with their recognition by host NB-LRR resistance proteins. In a "paradigm-shift" from conventional disease resistance breeding, Ingo's group exploits the knowledge of recent dramatic changes in the *Phytophthora infestans* pathogen population to unravel the underlying variation in pathogen effectors, using this to drive the search for durable resistance. They seek universally expressed, essential (i.e. functionally non-redundant) and sequence-conserved effectors that are targeted by resistances from wild potato and Solanaceous non-host species. A central component of the group's work is the use of next generation sequencing (NGS) and novel DNA capture technology to greatly accelerate discovery and isolation of resistance to *Phytophthora infestans* (Rpi) genes.



Iain Milne
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http://bioinf.scri.ac.uk/tablet

Next generation sequence assembly visualization

The increasingly complex data sets generated through new DNA sequencing technologies require a new generation of software tools to aid analysis and interrogation. The sheer volume of data imposes limitations on scientists' ability to inspect the results of analyses and look for patterns that reflect either quality control issues or biologically meaningful structure in the data. Therefore, to support and enable analyses of genetic and genomic data, the Bioinformatics Group at SCRI have developed Tablet, a lightweight, high-performance graphical viewer for next generation sequence assemblies and alignments that is capable of providing quick and efficient viewing and navigation of data sets from just a few megabytes in size to many hundreds of gigabytes in size. Aimed at users of all abilities, Tablet combines simple installation on a desktop machine with ease of use and a visually rich interface. Although primarily developed to meet the needs of SCRI scientists and their collaborators, it is also made freely available to all, and is currently used by researchers in over sixty countries around the world. Tablet has previously been described in GARNish (GARNish Ed 13, June 2010, p12, www.garnetcommunity.org.uk/sites/default/files/newsltr/garnish_jun10.pdf)

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Genetic diversity in natural and agricultural systems

Research has focussed on the use of molecular markers to explore and understand plant diversity in natural and agricultural systems. Extensive collections of barley germplasm including cultivars, globally distributed landraces and wild progenitors have been genetically characterised using over 3000 SNPs identified through international collaborations (Barley Oligo Pooled Arrays BOPA1 and BOPA2). Using association genetics approaches, genes controlling a range of phenotypes have been located. As well as agriculturally important species, a number of gene based markers have been developed in a range of agroforestry species including, *Calycophyllum spruceanum*, *Theobroma cacoa* and *Cocos nucifera*, as well as important fruit trees, *Prunus Africana* and Allanblackia species from sub- Saharan Africa, much of this work has been in collaboration with colleagues at World Agroforestry Centre (ICRAF). Gene based markers have been developed from transcriptome libraries in species of high conservation priority, offering novel insights into biodiversity, including sequence diversity and its relationship to biological function. Most of this work is focussed on Scottish biodiversity, including sub-arctic willow scrub which is essentially restricted to the Scottish mountains; the rare species *Anastrophyllum joergensenii*, a dioecious leafy liverwort restricted to cool montane high-rainfall areas; *Athyrium distentifolium*, a diploid out-crossing fern of montane areas and *Koe nigia islandica*, a diminutive annual and Scots pine and associated ground flora and are in collaboration with the Royal Botanic Gardens, Edinburgh; Macaulay Institute and Universities of Aberdeen and Edinburgh.

Spotlight on the Scottish Crop Research Institute

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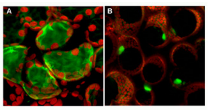
Crop genetics

Robbie leads the Genetics Programme within SCRI which focuses on three groups of crops: potatoes, soft fruits and barley. The programme supports five research themes that reflect the main areas of activity of each group: Biodiversity, Genetics and Breeding, Genes and Development, Genome Biology, and Bioinformatics and Platform Technologies (http://www.scri.ac.uk/research/genetics). The aim is to develop and exploit genomics and informatics technologies and resources, in conjunction with traditional skills in genetics and plant breeding, to identify genes underlying both simple and complex traits. The group is investigating the link between sequence variation, recombination and linkage disequilibrium and quantifying biological diversity of crops and native and endangered species. They are particularly interested in exploiting natural genetic variation via the development and application of appropriate technologies and applying them to appropriate genetic materials. In particular, they are exploring the potential of Association Genetics in barley using highly parallel SNP genotyping in an attempt to identify genes / loci in elite barley germplasm that control traits manipulated by UK breeders, and traits useful for biofuel production. They are conducting a program of research to genetically characterise the majority of the morphological and developmental variation that has been described in barley by mapping c. 1000 well characterised mutants. They are centrally involved in barley structural genomics through extensive BAC end sequencing and linking BAC contigs to the barley genetic map. Bioinformatics, sequencing, transformation and other aspects of functional genomics underpin research throughout the Genetics programme.

Plant Pathology



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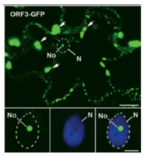
Genomics of plant parasitic nematodes, molecular basis of plant-nematode interactions

Many plant parasitic nematodes have complex, biotrophic interactions with their hosts. The potato cyst nematode, *Globodera pallida*, induces the formation of a single syncytium – a large multinucleate feeding structure – on which it depends for all the nutrients required for development to the adult stage. Work in the Plant Nematology group at SCRI is focused on identification and functional characterization of effectors from *G. pallida* that are responsible for induction of the syncytium and suppression of host defences in this structure. The group is part of a consortium (which includes Leeds University, Rothamsted Research and the Wellcome Trust Sanger Institute) sequencing the genome of *G. pallida* and have identified candidate effectors from this sequence. They have examined subcellular localization of effectors in the host and have identified many that target the plant nucleus. They are currently screening effectors in order to identify those that suppress host defence signaling pathways.



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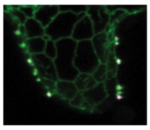
Plant molecular virology

The nucleolus and cajal bodies (CBs) are sub-nuclear domains involved in a number of crucial aspects of cell function. Certain viruses interact with these compartments but the functions of such interactions are largely uncharacterized. Michael's group has recently shown that the ability of the umbravirus ORF3 protein to move viral RNA through the phloem strictly depends on its interaction with CBs, the nucleolus and the nucleolar protein, fibrillarin. The ORF3 protein targets CBs and enters the nucleolus by causing fusion of these structures with the nucleolus. The group have proposed a model whereby the ORF3 protein utilises trafficking pathways between CBs and the nucleolus, and recruits fibrillarin for the formation of viral ribonucleoprotein particles capable of systemic movement. A role of the nucleolus in exogenous plant macromolecular trafficking in the phloem is currently being investigated. In addition, the group is involved in studies of programmed cell death (PCD). In collaboration with the Vartapetian's team, they discovered a plant protease with activity of classical animal caspases. The protein was identified as subtilisin-like protease and named phytaspase (plant aspartate specific protease). Phytaspase has been shown to be essential for responses to biotic (virus attack) and abiotic stresses. The group have proposed a model whereby after translation, phytaspase is activated and secreted into the apoplast in which it may be sequestered before PCD and/or fulfils a guarding function. In response to a variety of biotic or abiotic stresses, phytaspase is re-localised from the apoplast to inside the cell where it functions as executioner of PCD.



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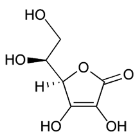
Plant-microbe interactions

Lesley's group aims are to identify the molecular and cellular interactions involved in virus replication, movement and transmission by vector. Increased knowledge of these processes will be used to develop sustainable methods of disease control. Currently, the main focus of research is soil-borne potato mop-top virus (PMTV) and aphid transmitted potato virus Y (PVY). Live cell imaging of virus reporter clones and interaction analysis (BiFC, yeast two hybrid) has been used to elucidate cellular interactions of the triple gene block movement proteins of PMTV and root transformation systems are being developed to study the virus-vector-plant interactions. A gene for extreme resistance to potyviruses has been found in clones of the edible diploid potato *Solanum phureja* and is currently being mapped. Virus resistance and other traits are being evaluated in applied research projects to improve seed potato production systems in Kenya and Malawi.

Plant Products and Food Quality



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Molecular physiology of quality traits in crops

Research in the Hancock laboratory focuses on the accumulation of antioxidant phytochemicals at the whole plant level, examining both metabolite fluxes within the edible parts of the crop (fruit, tubers) in addition to consideration of the role of long-distance transport processes. Part of this has focused on mechanisms of ascorbic acid accumulation in blackcurrant fruit and they have shown that this occurs by *in situ* biosynthesis via only one of the four pathways proposed to operate in plant cells. The group's observation that symplastic phloem loaders specifically tag ascorbate for transport by the addition of sugar moieties suggests that transport may be important across a broader range of species. The role of long distance transport in the control of potato tuber quality is currently under investigation with the impact of metabolism, genetics and growing environment on acrylamide forming potential within the potato tuber being elucidated. As part of this Rob's team are investigating the contribution of long-distance transport and within-tuber metabolite fluxes to the accumulation of key acrylamide precursors using stable isotope labelled metabolomics. Such techniques will be used to understand the impact of genetic variation and fertilisation regimes on tuber acrylamide forming potential. Work conducted by Rob's group on long-distance transport processes has broadened to questions regarding the impact of phloem phytochemistry on aphid performance. They have observed that plants manipulated to enhance phloem ascorbate content support more rapid development of aphid populations. As aphids feeding on high ascorbate plants simply excrete excess ascorbate, they hypothesise that enhanced aphid fecundity results from impairment of the plants reactive oxygen signalling and defence pathways. This hypothesis is currently being tested via collaboration between the Hancock laboratory and that of Prof. Christine Foyer (University of Leeds).

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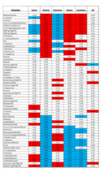
Phytochemical derived product quality

The research within Derek's group focuses on plant-based food quality, safety, functionality and bioactivity. The Stewart group has shown that there is clear evidence that many of the components of soft fruit, more specifically the polyphenolics, exert often potent, simplistic antioxidant and/or pharmacological activity and, via a collaborative with clinical and biomedical collaborators, they have now shown the efficacy of many classes of plant food phytochemicals with respect to degenerative diseases such as cardiovascular disease, cancers, Alzheimers over the range from *in vitro* to *in vivo* and fundamental to applied. For example at the fundamental level they have recently shown that fruit phytochemicals, specifically flavonols, impact in an anticancer manner on the mammalian cell's antioxidant and detoxification system by stabilising and reducing the degradation and cycling of the Nrf2 protein, a transcription factor that is recruited to cellular Antioxidant Response Elements in inducible genes. Such an approach has been expanded into other area of food functionality and bioefficacy including human digestion processes and diabetes. Underpinning much of these studies has been the development and application of metabolomics as a high-throughput platform technology. The approach, encompassing LC-MS, GC-MS and Volatiles GC-MS is now key to the groups' research and its ability to report on 100s of compounds simultaneously has seen it now applied to studies on plant development and crop quality, abiotic stress, novel food safety and bioactive trait inheritance. More recently this approach has been used to dissect the interplay between primary and secondary metabolism in soft fruit and the implications for end user (sensory) parameters. More recently Derek has been coordinating the EU funded project DEVELONUTRI, which is successfully assessing the validity of using metabolomics and other high throughput and detailed analytical technologies to optimise the nutritional value of crops and crop-based foods. This advances the successes of SAFEFOODS and UK FSA funding into determining the changes in the metabolome accompanying variation in a wide range of genotypes, geographical regions, growing regimes (e.g. organic, conventional) and seasons and also covered a comparison of the impacts of breeding systems such as GM and non-GM.



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Metabolite flux and transport processes

The main focus of Mark's group research is on understanding the molecular basis of quality traits in potato tubers. A wide range of contemporary approaches, including transcriptomics and phytochemical analysis, are employed to exploit variation in traits of interest in potato germplasm collections. One of these is isoprene metabolism. Isoprenoids are a large group of metabolites some of which have important nutritional value, such as the carotenoids, whereas others are involved in plant growth regulation and have important roles in the tuber life-cycle and possibly temperature sensing. Potato carotenoid work is being driven under the banners of FP6 (EU-SOL) and FP7 (MetaPro) projects. Dormancy in potato is also a research focus with a transcriptomic approach being used to dissect the control of tuber dormancy using a near-whole transcriptome array and transgenic lines in which dormancy characteristics have been altered. This is being translated through to the strategic/applied arena in collaboration with industry with the aim of developing ethylene as a sprout control agent in potato storage. The basis and genesis of potato organoleptic quality is also being addressed with varietal differences in texture and (non-) volatile metabolites linked to associated microarray analysis, target gene characterization and validation via transgenic approaches.

Masters in the UK

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The UK offers a wide range of excellent post-graduate courses in Plant Science and related subjects. Master courses are usually one-year programmes combining taught modules with practical research projects. The individual courses are flexible and tailored around the research strength of the resident scientists. While some courses have a more fundamental and molecular research portfolio and others focus on more applied topics all of them offer students the opportunity to get involved with cutting-edge research of the highest international standard. At the same time the courses are firmly integrated into standard programmes of the respective Graduate Schools providing training in transferable skills. Differences between the individual courses concern the relative ratio of taught and practical activities, and additional features such as field work, industrial links, site visits, etc. The list below gives an overview of courses currently on offer in the UK. The information was compiled from FindAMasters.com (extracted with http://www.findamasters.com/search/courses.aspx?filter=1&PID=4959) and links thereof to course web pages. In addition, many other courses not listed here include topics and projects that are related to plants (e.g. Masters in Biotechnology, Pest & Disease Management, Molecular Sciences etc.). These can be found by searching web pages for Postgraduate Courses at the University of your Choice.

University of Birmingham, School of Biosciences

MRes in Conservation and Utilisation of Plant Genetic Resources

www.findamasters.com/search/CourseDetails.aspx?CID=10489
www.biosciences.bham.ac.uk/study/graduate/research/masters/conservation.shtml

The MRes course is of 12 months duration commencing in late September, and comprises two taught modules, a conservation field course in the Mediterranean, and two extended research projects. The course is taught using a mix of lectures, seminars, field course, small group discussions, but primarily through hands-on research projects, one in the School and the second in an industrial placement.

University of Bath, Department of Biology and Biochemistry

MRes/MSc in Molecular Plant Sciences

www.findamasters.com/search/CourseDetails.aspx?CID=17309
www.bath.ac.uk/bio-sci/postgrad/mres/molplant.html

The MRes is based on a 45 week working year which, when vacation periods are included, will last approximately 47 calendar weeks. The student will undertake five taught courses, an extensive research training course lasting two semesters, two 20-week laboratory projects, a literature review, critical analyses and grant proposal writing. Attendance at departmental external seminars and internal research seminars is required. The MSc programme consists of five taught units including research training and support skills in semester two and a final one-semester research project.

University of Dundee, College of Life Sciences

MRes in Crops for the Future

www.findamasters.com/search/CourseDetails.aspx?CID=11713
www.dundee.ac.uk/postgraduate/courses/crops_for_the_future_mres.htm

The one year course is based on 11 taught course units, together with a series of case studies where particular course aspects are covered from a detailed practical viewpoint. In addition to units dealing with contemporary Crop Science, there is a strong emphasis on aspects of ecology and environmental biology relevant to sustainable agriculture in the 21st Century. Teaching will be delivered by our international leaders in this scientific area and our colleagues in industry and other institutions. A key component is the full-time research project for the last 4 months of the course in a research laboratory.

University of East Anglia, School of Biological Sciences

MSc in Plant Genetics and Crop Improvement

www.findamasters.com/search/CourseDetails.aspx?CID=1215
www.uea.ac.uk/bio/courses/msc-plant-genetics-and-crop-improvement

The taught modules of this one-year course cover subjects including plant molecular genetics and biotechnology, target traits for crop improvement, and plant breeding. Training in a number of key transferable skills is also included. Students will also undertake a six-month laboratory-based research project under the supervision of a member of BIO faculty or a senior scientist at the John Innes Centre. Students will be required to submit a dissertation and present a seminar on their research project.

Plant Science related Master courses in the UK

University of Edinburgh, School of Biological Sciences

MSc/Dip in Biodiversity and Taxonomy of Plants

www.findamasters.com/search/CourseDetails.aspx?CID=7622
www.rbge.org.uk/education/professional-courses/msc-in-biodiversity-and-taxonomy-of-plants

The one year programme includes lectures, practical work, a 14 day tropical field course in Belize, an individual research project and dissertation. There are also workshops on the practical aspects of plant identification, cytology, plant-parasite interactions, pollination ecology, molecular methods, herbarium techniques, and bibliographic methodology. Visits to other plant research institutions are arranged. Following the taught programme, students either embark on a four month research project to qualify for the MSc, or graduate with the Diploma.

University of Essex, Department of Biological Sciences

MSc in Plant Biotechnology

www.findamasters.com/search/CourseDetails.aspx?CID=17006
www.essex.ac.uk/bs/plant/MScPlantBiotech.html

This course offers graduates in the biological sciences the opportunity to study biotechnology as applied to the production of the essential new crops for food and fuel needed for our growing population. The course offers 6 taught course modules and a 12 week research project that runs from May until September. Projects will be in the area of Plant Biology and will reflect the research interests of the academic staff in the Plant Productivity and Sustainability Group.

University of Exeter, School of Biosciences

MSc Food Security and Sustainable Agriculture

www.findamasters.com/search/CourseDetails.aspx?CID=17345
biosciences.exeter.ac.uk/postgraduate/taught/foodsecurity/

The programme is arranged into 11 week teaching terms and a 5 month project. It consists of core modules in Crop Security, Sustainable Land-use in Grassland Agriculture, Political Economy of Food and Agriculture, Research and Knowledge Transfer for Food Security and Sustainable Agriculture, Professional Skills, and a Research Project or Dissertation, which can be a practical project conducted in the field or research laboratory, or it can be a dissertation undertaken in part during a placement in a policy-producing agency.

University of Glasgow, College of Medicine Veterinary and Life Sciences

MRes Plant Science

www.findamasters.com/search/CourseDetails.aspx?CID=13396
www.gla.ac.uk/postgraduate/taught/plantscience/

This 1 year programme consists of two 20 week research projects and two taught courses. There are also possibilities to do a 36 month part-time MRes or a 9 month PgDip. The course focuses on new ways to address questions of fundamental biological importance that will have a far-reaching impact on agriculture and food production in the decades to come. Projects are carried out in the research laboratories of the highly successful Plant Science Group, offering you have a wide range of choice for your research topics. From 2011 onwards University of Glasgow will also offer a MSc in Crop Biotechnology.

Imperial College London, Division of Biology

MRes in Molecular Plant Biology and Biotechnology

www.findamasters.com/search/CourseDetails.aspx?CID=8371
www3.imperial.ac.uk/pgprospectus/facultiesanddepartments/lifesciences/postgraduatecourses/molecularplantbiology

The backbone of the MRes in Molecular Plant Biotechnology is a 12 month period of research starting in the first week of October. The course, which is based at the South Kensington Campus, enables you to join active research groups focusing on plant genetic engineering, plant development, plant molecular biology, molecular markers, membrane biophysics, proteomics, plant biochemistry, plant-microbe interactions, transcriptomics and bioinformatics. Research topics will be interdisciplinary and will include two different, but sometimes related, areas of work.

Lancaster University, Lancaster Environment Centre

MSc-R Plant Science (by Research)

www.findamasters.com/search/CourseDetails.aspx?CID=11486
www.lec.lancs.ac.uk/postgraduate/masters.php?course=007636

The MSc by Research is designed to fit around your research interests, which are assessed on a piece of original research carried out with the Department, and subsequent submission of a dissertation. Typically, a student will be expected to undertake an induction course, followed by an eight-month research project, and then spend three further months writing up the dissertation.

Plant Science related Master courses in the UK

University of Leeds, Faculty of Biological Sciences

MSc Bioscience (Plant Science and Biotechnology)

www.findamasters.com/search/CourseDetails.aspx?CID=5325
www.fbs.leeds.ac.uk/gradschool/MSc_Bioscience/MSc_Bio_Plants.htm

Crop plants are critical for global food security and the delivery of new medicines while non-food plants have potential applications for molecular farming. This programme provides training in theory and methods necessary to understand and develop novel methods to exploit plants for these purposes. The 12 month programme consists of core research training modules, a research project in an area of Plant Science and a taught specialist Plant Science module.

University of Manchester, Faculty of Life Sciences

MSc Plant Sciences

www.findamasters.com/search/CourseDetails.aspx?CID=14357
www.ls.manchester.ac.uk/masterscourses/courses/plantsciences/

The MSc programme provides research training addressing key areas of plant science. Experimental approaches will range from studies of individual molecules through to the whole plant in its natural environment. Well-characterised model plants such as Arabidopsis, as well as crops and natural species are used to provide training in interdisciplinary approaches. During the 12 month course, students spend the majority of their time working on two original research projects, gaining the practical laboratory skills required for plant-related careers in industry or academia.

University of Nottingham, School of Biosciences

MSc Plant Genetic Manipulation/MSc/PGDip Crop Improvement

www.findamasters.com/search/CourseDetails.aspx?CID=553
www.findamasters.com/search/CourseDetails.aspx?CID=549
www.nottingham.ac.uk/biosciences/prospectivestudents/postgraduate/courseinformation.aspx

The MSc in Plant Genetic Manipulation is designed to provide students with specialist knowledge of the theory and practical skills of plant genetic manipulation relevant to plant biotechnology, plant breeding and genome research. The MSc in Crop Improvement examines crop improvement through advances in resource use efficiency, crop protection and modern crop improvement and breeding techniques, focusing upon the understanding of plant to crop systems with an emphasis on research training. The full-time MSc courses are 12 months and consist of a number of taught modules and a major research project.

University of Plymouth, Faculty of Science and Technology

MSc Botanical Conservation

www.findamasters.com/search/CourseDetails.aspx?CID=860
www.plymouth.ac.uk/courses/postgraduate/taught/2363/MSc%2FPgDip+Botanical+Conservation

The course provides a broad and deep understanding of the subject of plant conservation emphasising the importance of classification, evolutionary history, the ecological roles of plants in different ecosystems and the processes that underlie the structure and dynamics of plant communities. Core modules covering research skills and methods and ecological concepts provide a wide knowledge base. The course dissertation will focus on a particular problem in plant conservation and allow the students to contribute to this important field. There is a possibility to undertake a 9 months PgDip instead of the full 1 year course.

University of Reading, School of Biological Sciences

MSc Plant Diversity

www.findamasters.com/search/CourseDetails.aspx?CID=2988
www.reading.ac.uk/biologicalsciences/pg-taught/biosci-pgtcourses.aspx

This 12 month programme, with its specialist routes, will be of interest to those wishing to make a career in ecology, conservation, or plant identification. It is run in association with the Royal Botanic Gardens, Kew and the Natural History Museum, London. During the first term all students study diversity and identification of plants, conservation and biodiversity, basic plant ecology, plants and climate, evolution of plant diversity. During the second term the focus of the course moves into an area of specialisation i.e. taxonomy and evolution, biodiversity assessment and conservation or vegetation survey and assessment.

University of Sussex, School of Life Sciences

MSc Plant Conservation

www.findamasters.com/search/CourseDetails.aspx?CID=19302
www.sussex.ac.uk/study/pg/2011/taught/1604/23864#tabs-1

This MSc offers theoretical and practical training at postgraduate level in a broad range of aspects of plant conservation, including pure and applied ecology, biodiversity and habitat ecology, restoration ecology, seed banking, seed physiology, plant genetics and molecular biology, and plant tissue culture. These fields will be comprehensively reviewed to survey the strategies available for conserving plant species, their habitats and genetic resources, and for analysing plant diversity. The 12 month degree is taught by faculty at the University, members of the Seed Conservation Department, Royal Botanic Gardens/Kew, at Wakehurst Place, and by guest lecturers from Kew and other institutions.

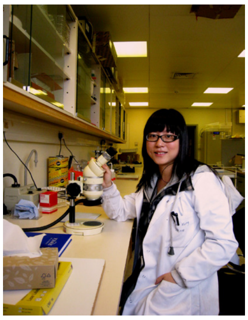
University of Warwick, Warwick HRI

MSc Plant Bioscience for Crop Production/Sustainable Crop Production Agronomy for the 21st Century
www.findamasters.com/search/CourseDetails.aspx?CID=5691
www.findamasters.com/search/CourseDetails.aspx?CID=16951
www2.warwick.ac.uk/study/postgraduate/courses/depts/lifesci/

Advanced crop production techniques, molecular science and genomics will be integrated with developments in physiology, pathology, pest and weed ecology along with the latest strategies for optimising soil, water and nutrient use efficiencies. Students will learn to exploit modern plant biosciences through familiarity with biometry and the application of essential statistics for evaluating technical data, and knowledge of supply-chain management. Bioscience, politics and social acceptability will be explored to understand the social and political forces influencing the acceptance of new technologies and products. The one-year course will be delivered as 10 taught modules followed by a research project or dissertation.

Master students tell us about their experience

GARNish has carried out e-interviews with four recently graduated Masters. Their responses provide a flavour of how the Master courses they attended have met their expectations and equipped them with the necessary skills and knowledge, curiosity and confidence that has allowed them to embark on a career in active Plant Science research.



Ziyue Huang

Where you are from and what did you study before?
I'm from China and I studied Chinese Herbal Medicine.

Which Master course did you do and when?
I did my Master in Plant Bioscience for Crop Production at Warwick HRI from October 2007 to September 2008.

Why did you choose this particular course?
I'm very interested in the natural botanical resources, e.g. what is the mechanism of plant growth, how to increase the crop yield, how to improve the crop quality, etc., and this Master course, as advertised, provided me with a broad knowledge and wide range of practical skills.

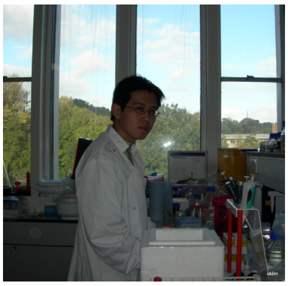
What did you expect from the course? Were your expectations fulfilled?
I expected to have a deeper understanding of the world of plants, and the course fulfilled my expectations in this aspect whilst broadening my horizon; I've gained insight into agricultural and bioscience management, policy making and some modern crop breeding techniques.

Which part of the course did you find most useful, which one did you enjoy most?
Small group interactive workshops, practicals and tutorials were really useful to be fully involved and inspired by others during the discussion. It was a good way to deepen the understanding of the principles that are taught in the lectures. The most amazing part of the course for me were the field and site visits. Each trip was impressive and enjoyable, I've gained insight into the latest advances in agriculture in the UK. It is indeed quite an experience to have a close contact with the real fields and industries.

Did you carry out a lab project?
Yes, I carried out a final project for my Master degree.

What was the topic, which plant did you work with and what techniques did you learn?
The title of my project was 'The germination response of *Meconopsis cambric* seeds to temperature, stratification, gibberellic acid and nitrate'. I used the plant *Meconopsis cambrica*, the same organism I had previously studied at my Chinese university. I've learnt how to do seed germination tests and different kinds of pre-treatments to the seeds for dormancy release, such as stratification, scarification, application of gibberellic acid (GA) and nitrate. I've also learnt how to use the software of SigmaPlot and GenStat to analyse my experimental data.

What you are doing now?
I'm in my 2nd year of PhD now, and I'm still at the University of Warwick. My decision to stay in the UK and do a PhD in plant science was mainly influenced by the one-year-experience of my Master course; although it was quite intense and stressful, it was a great fun!



Choon Kiat Lim

Where you are from and what did you study before?
I am from Malaysia, and I have gained a BSc (Hons) in Biotechnology.

Which Master course did you do and when?
I studied for a MRes Plant Science at Glasgow University (2008-2009).

Why did you choose this particular course?
In one year I had the opportunity to learn cutting edge techniques that are essential to my future career in science.

What did you expect from the course? Were your expectations fulfilled?
I expected close supervision from experts in plant science, the opportunity to use state of the art equipment to carry out research and all my expectations were fulfilled!

Which part of the course did you find most useful, which one did you enjoy most?
The two independent research projects were useful to develop all essential research skills. I enjoyed the viva sessions with internal and external examiners, during which I had the opportunity to share my research and learn from them.

Did you carry out a lab project?
Yes.

What was the topic, which plant did you work with and what techniques did you learn?
I worked with the model plant *Arabidopsis thaliana*. I assessed the effect of salt priming and its effects on the gene expression of *Arabidopsis thaliana*. In a second project I investigated the effect of okadaic acid on stomatal closure. Skills learnt included real time PCR, plant cultivation techniques, confocal scanning microscopy, and stomatal assay.

What you are doing now?
I am a PhD student in Biosciences at Exeter University (Plant Science).

Helen Carter

Where you are from and what did you study before?
I'm from the UK and did an undergraduate degree in Biological Sciences from Oxford University between 2005-2008

Which Master course did you do and when?
I did an MSc in Plant Science for Crop Production at Warwick HRI from October 2008.

Why did you choose this particular course?
I had read the description of the taught modules online and they seemed to cover a wide range of topics that I was interested in. I then visited the campus on an open day and liked what I saw. The course at Warwick also had opportunities which you could apply to for help with funding, which was also an important consideration for me.

What did you expect from the course? Were your expectations fulfilled?
My undergraduate degree was relatively broad, and hadn't included much agricultural science, so I was hoping to gain some more specialist knowledge from the taught side of the course. From the project, I wanted to get a feel for working in a research environment. I didn't have much experience of this and felt I wasn't quite ready to commit to a 3 or 4 year PhD programme until I had a bit more idea of what it entailed. I think that both of these main expectations were fulfilled, particularly the second one.

Which part of the course did you find most useful, which one did you enjoy most?
I found the project the most useful part of the course; I felt it gave me a lot more confidence when working in the lab which was really helpful in the first few months of my PhD. Some of the taught modules involved visits to companies such as Syngenta and British Sugar. I found this was an interesting insight into industry, which wasn't something I had come across much as an undergraduate and definitely enjoyed.

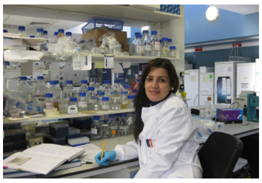
Did you carry out a lab project?
Yes, for the last 5 months of the course.

What was the topic, which plant did you work with and what techniques did you learn?
I chose to do a plant pathology project looking at the genetic diversity of *Sclerotinia sclerotiorum*, a fungal pathogen of numerous different crop plants. Most of the work involved working with the pathogen itself: obtaining isolates from infected plants and culturing them, before extracting DNA and carrying out microsatellite analysis. I was particularly interested in the interaction between

S. sclerotiorum and *Ranunculus acris* (Meadow Buttercup), which is known to be a wild host of the pathogen. This part of the project involved infecting buttercup plants with *S. sclerotiorum* and monitoring the development of disease symptoms in a glasshouse environment.

What you are doing now?

I've just started my second year of a PhD at Rothamsted Research, working in the plant pathology department.



Fereshteh Malekpour

Where you are from and what did you study before?

I am from Iran and my Bachelor degree was on Plant Breeding and Agronomy.

Which Master course did you do and when?

Plant Genetic Manipulation at Nottingham University (2008-2009).

Why did you choose this particular course?

I had been interested in studying plant genetics for a long time when I heard about this course and since the University of Nottingham is well known I decided to embark on this course.

What did you expect from the course? Were your expectations fulfilled?

Most of my expectations were fulfilled and as expected I learnt genetics, basic lab techniques, tissue culture, genomics and gained a great deal of other knowledge. In addition, I have improved other skills such as presentation and time management.

Which part of the course did you find most useful, which one did you enjoy most?

Actually the whole course was very useful for me and the best part was the project and lab work.

Did you carry out a lab project?

Yes, I did.

What was the topic, which plant did you work with and what techniques did you learn?

My project involved the cloning and expression in *Nicotiana tabaccum* of 7β-hydroxylase of the paclitaxel pathway. During my project I have learnt a number of lab techniques such as PCR, DNA extraction, RNA extraction and other plant molecular lab techniques including plant tissue culture techniques, protein expression and purification techniques, spectrophotometry, biochemistry and microbiology lab-centrifugation, western blot, pH buffering and sonication.

What you are doing now?

I am doing my PhD in the University of Nottingham.

Anything else you may want to comment on:

I just would like to thank my professors and supervisors for all their help.

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