GARNish

December 2013 Edition 20

Data Mining with iPlant

Welcome to the December 2013 issue of GARNish

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It has been a busy few months for GARNet with a variety of activities to promote Arabidopsis research and aid researchers.

In case you haven't seen them, there is now a regular feature celebrating basic plant research on the GARNet blog (www.blog.garnetcommunity.org.uk/category/celebrating-basic-plant-science-2/), and a weekly Arabidopsis Research Round-Up on the GARNet website (www.garnetcommunity.org.uk).

Spreading the message further afield, GARNet's Liaison Officer Charis Cook gave a talk at the ASPB Plant Biology 2013 meeting in July – you can read about this on the GARNet blog (http://blog.garnetcommunity.org.uk/tag/plant-biology-2013/). Here, Charis met representatives from PULSE (see page 17), a US group addressing how to sustain undergraduate engagement with biology and to foster enduring relationships with the life sciences that continue into their careers and beyond.

Effectively communicating science to young people is also the subject of Anne Osterrieder's fascinating article (see page 16) on using social media to connect American high school students with 'real scientists.' The students' enthusiasm is very encouraging and suggests this form of outreach could be worth considering on our side of the Atlantic.

Back home, GARNet welcomed Lisa Martin to the team as our new Research & Engagement Officer in July.

Contents

Thanks to: Nitya Jacobs and the PULSE team, Pankaj Jaiswal, Heather Knight, Rebecca Nesbit, Anne Osterrieder, David Pink and the plant scientists at Harper Adams University, Elinor Thompson and the plant science team at the University of Greenwich, Christine Sambles and Daniel Tomé.

How to get the most out of increasingly large datasets is something that we all face. In this issue, Daniel Tomé and Christine Sambles, who attended GARNet's iPlant workshop in September (page 7), report on the advantages of iPlant's tools and resources platforms to both bioinformaticians and wet lab scientists. Moves to make data sharing among plant researchers easier are certainly welcome to improve access to large datasets for all.

The issue of curating and sharing large datasets is also addressed in the feature on page 11 about WikiPathways for Plants, a new online portal that follows the Wiki principle in bringing together expert researchers to build and share developmental, regulatory and signalling pathway information.

The GARNet Committee

As always, we bring you news from the various institutions in which UK plant scientists work. We focus on Harper Adams University's research on crop production and protection, as well as the breadth of pure and applied plant research carried out at the University of Greenwich.

GARNet's vision is to build on current successes, particularly the provision of workshops and training for plant biologists to tackle the big issues of scaling up research, working with large datasets and making the transition between Arabidopsis and other model and crop species.

To this end, we're looking forward to running a Software Carpentry workshop at the University of Warwick in April 2014 (see page 4) and preparations are also underway for the GARNet 2014 conference in September – Arabidopsis: the Ongoing Green Revolution (www.garnet2014.org). Registration for both of these event opens in January 2014 so we hope to see you there!

Seasons greetings to all our readers and let's hope 2014 heralds a Happy New Year for GARNet!

Twitter: Follow Lisa @GARNetweets and Charis @weedinggems.

Software Carpentry for Plant Scientists

GARNet will host a Software Carpentry bootcamp at the University of Warwick on 9–10 April 2014.

Software Carpentry teaches principles of good programming that can be applied to any coding language or application, whether sequencing data, phenotypic trait analysis or biochemical assays. The bootcamp will equip plant scientists with the skills to write a simple program that will make large datasets easy to handle, or save hours spent repeating the same steps.

The bootcamp will cover Python programming, managing data in Excel and Python, and scientific plotting using BioPython and R. Teaching will be via trainer-guided live coding and independent practical exercises.

Although the content will be suitable for beginners, researchers who know what a command line is will also benefit from being taught good practice like version control and test-driven development. These practices will make your programs more sustainable, thus vastly reducing replication in your code over time, and making them easier to share with team members, collaborators and even in publications.

For more information please visit: http://www2.warwick.ac.uk/fac/sci/lifesci/news/software/.

Global Plant Council Update

The Global Plant Council (GPC) met for its Annual General Meeting in October 2013, with now part-time GARNet Coordinator Ruth Bastow in post as the new Executive Director.

The GPC provides a voice for plant and crop science at the global level. Utilising the scientific knowledge and expertise of the 40,000 people involved in its 25 member organisations from around the world, the GPC can generate greater leverage than one organisation could achieve on its own.

The GPC's strategic priorities, and 'Initiatives for Global Challenges' to address these priorities, were agreed at the AGM as follows:

1. **Agricultural productivity and sustainability**
   A Digital Seedbank Initiative will capture and exploit crop bioversity to find new genes, alleles and genetic networks to improve crops.
2. **Food and human health**
   GPC's Biofortification Initiative aims to generate plant-based solutions to malnutrition.
3. **Adaptation to climate change**
   The Stress Resilience Initiative will seek to understand how plants grow, develop and interact with their environments to develop more stable crops in the face of climate change.
4. **Data, knowledge and resources**
   The sharing of data, knowledge and resources will be a common foundation of all GPC Initiatives.

For more information about the GPC, please visit http://globalplantcouncil.org.

CPIB wins gold at Chelsea Flower Show

Researchers from the University of Nottingham's Centre for Integrated Plant Biology (CPIB) won the Best RHS Environment Exhibit Award at the 2013 RHS Chelsea Flower Show.

The exhibit, Food for the Future, showcased the latest plant and crop research. It gave visitors the opportunity to talk to world-leading Nottingham researchers and find out what they are doing to secure food for the future.

David Bellamy enjoying CPIB's award-winning Royal Flower Show display.
Photo: University of Nottingham, via Flickr

Professor Neil Crout, Head of the School of Biosciences, said: "Achieving global food security is the one of the most pressing issues facing the world today. Our work is focused on developing crops to feed our growing world population, using fewer of the Earth's precious resources.

Celebrity gardener Alan Titchmarsh presented the University team with their Gold Medal and said: "Gardening isn't just about watering, mowing and getting wet in the winter; it's about research, making sure we have food to eat, and continuing to understand and control pests and disease."

UK Plant Sciences Federation Update

Following a consultation with over 300 members of the plant science community, the UKPSF will be launching a report titled *UK Plant Science: Current Status and Future Challenges* on 28 January 2014.

The report outlines priority areas for UK plant science research, and provides recommendations on how strategy and policy developments can build on existing strengths, fill critical gaps and guarantee success in meeting the challenges ahead.

Also, save the date for the UK PlantSci 2014 conference, which will be held on 31 March–1 April 2014 at the University of York.

Wolfson Research Merit Award for Malcolm Bennett

Congratulations to GARNet committee member Malcolm Bennett, who was recently presented with the prestigious Wolfson Research Merit Award.

The award will help Malcolm to continue his research into the regulation of root growth and development, which will be important for engineering new crop varieties in the quest for food security.

Biology Week, 12–18 October 2013

Biology Week began with a hands-on Big Biology Day in Cambridge where, among the many activities available, visitors could study bugs and plants under the microscope, and explore how the photosynthetic activity of algae and moss can be used to generate electricity.

Other events throughout the week included:

- UK Fungus Day on 13 October, with a competition to find the largest fairy ring, and an ongoing Fungi Festival at Kew Gardens.
- Professor Adam Hart's 'lecture-thon,' in which he talked about honeybees and leaf cutter ants for a whole 24 hours!
- Dr Mike Leahy's rainforest bus school tour to introduce children to his exotic animals.
- The Royal Institution's public debate on how modern knowledge of genetics and behaviour might influence decisions about criminal responsibility.
- A parliamentary reception where Professor Tim Benton spoke about food resources, consumers' responsibilities and global food security.
- Society of Biology Awards were presented for photography, science communication, books, student essays and to top students from accredited degrees.
- School assemblies on food waste were given, featuring a video of a talking sandwich.

To get involved in Biology Week 2014 please visit http://www.societyofbiology.org/biologyweek.

Gabija Vyšniauskaité's photo shortlisted for the Society of Biology's Under-18s science photography prize.

Plant Science Panel

GARNet advisory committee member Smita Kurup is one of a team of plant scientists who make up the Plant Science Panel.

There are regular, live, online Q&A sessions where members of the public can send questions to the panel about plant science or biotechnology, either via email or by using the Twitter hashtag *#plantsci*. The first few of these sessions, which took place during summer 2012, tackled genetically modified foods. The topics, questions and answers can be found on the Plant Science Panel webpage at http://www.senseaboutscience.org/pages/plant-science-expert-panel.html.

The Plant Science Panel now covers many more issues than the GMO debate. Recent Q&As have been about ash dieback, bee colony collapse and organic farming, while questions submitted and answered outside of the allocated Q&A times have been broader still, including the subtle differences between lemon and orange thyme, nutrient uptake by roots, and why nutrient burn causes leaf tips to brown and curl.

Postcards advertising the Plant Science Panel are available from Sense About Science. To request some, please email plantsci@senseaboutscience.org.

Plant Science Panel postcards.

software carpentry for plant scientists

A Practical Introduction to Programming for Biologists

9-10 April 2014 — University of Warwick

Introducing biologists to:

- Git and GitHub
- Python programming
- Version control
- Good practice and test-driven development

... and applying them them to applications including data management and scientific programming.

Registration opens in January

For more information, contact charis@garnetcommunity.org.uk or
http://www2.warwick.ac.uk/fac/sci/lifesci/news/software

GARNet — Software Sustainability Institute — elixir Data for Life

Data Mining with iPlant: 16–20 September 2013, University of Warwick

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Analysing 'Big Data', which seems to be getting bigger by the day, can be complex and overwhelming. To help address this issue within the plant science community, GARNet organised a 'Data Mining with iPlant' workshop in September.

The iPlant Collaborative is a US-based, National Science Federation-funded organisation that develops and provides cyberinfrastructure for big data storage, and open source analysis software.

The four-day, over-subscribed workshop was held at the University of Warwick's School of Life Sciences Interactive Computational Learning Suite. Nicknamed 'the Orchard', this suite of 120 high-spec Apple Mac computers and state-of-the-art audiovisual teaching and learning tools was the perfect location.

The first day gave a free introduction to iPlant's tools and services, while those staying for an extra three days received in-depth, hands-on training.

Over the four days, 78 plant scientists, including PhD students, post-docs and PIs, were equipped with the skills to use and manipulate iPlant's core services; Atmosphere and the Discovery Environment.

Our delegates came from all over the country, and we even had visitors from as far afield as Saudi Arabia, the Philippines and Canada!

The workshop was led and facilitated by four members of the iPlant team: Naim Matasci, Dan Stanzione, Jason Williams and Matt Vaughn. Mike Gleaves from The Hartree Centre and Rob Davey from The Genome Analysis Centre also gave talks.

We asked two iPlant delegates to describe their experiences of the workshop and update us on how they are using their new knowledge of iPlant.

For more information about iPlant, please visit www.iplantcollaborative.org.

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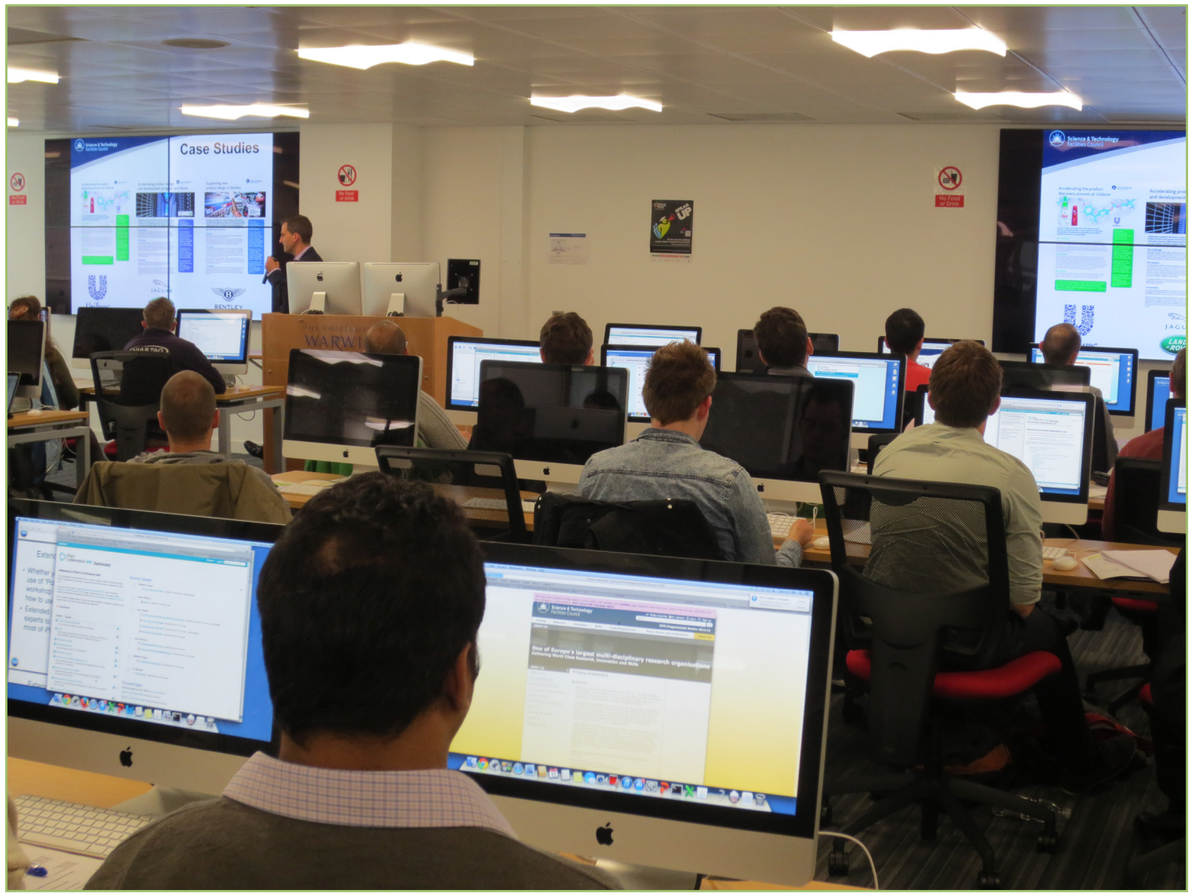
I was fortunate to attend the four-day Data Mining with iPlant workshop, organised by GARNet in association with the iPlant Collaborative. Its purpose was to introduce the features and capabilities of iPlant to newcomers.

I was surprised to learn how many free resources are available. For example, it is possible to access the Stampede super-computer, located at the University of Texas. It is the sixth fastest computer in the world and has a vast amount of online storage space.

iPlant allows you to upload data to the Discovery Environment. From there the user can access many applications that will help to analyse the data.

Non-bioinformaticians often find it hard master common applications used to handle big data. The great thing about iPlant however, is that it provides user-friendly 'wrappers' for these applications. This is useful because big data is becoming difficult to avoid in biology; as sequencing costs come down and new technologies deliver terabyte-sized datasets from single experiments, it is something that many more researchers will have to get used to.

The Data Mining with iPlant delegates who survived to the end of day four. *Photo: Charis Cook*



During the iPlant workshop, Mike Gleaves gave a presentation about the high-performance computing resources available at the Hartree Centre in Daresbury, Warrington. *Photo: Charis Cook*

Moreover, unlike many proprietary software applications, iPlant is open source. This means you can access the code behind each application and make modifications that you think might improve them. You can also attempt to make brand new applications and make these publically available to the community. This was something I was very keen on and it has got me refreshing the Perl coding skills I learned from my undergraduate days.

One thing that impressed me about the friendly iPlant staff was the use of the term "search on Google". When they did not remember how to do something they would look for it online and get an answer quickly. I found that this was a very efficient way to understand why a job that was submitted came back with a "fail". This happened all the time! But the sense of accomplishment that I felt when I got a "complete" was great.

Since the workshop, I have used iPlant to generate publication-quality images and I am very happy with it. I intend to use it in the future to analyse RNA-seq datasets and improve my bioinformatics skills along the way.

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As a bioinformatician working in the field of plant–microbial interactions, I am all too familiar with the issues of data storage and computer processing requirements. This bottleneck in our research is only exacerbated by the constant improvements and cost-effectiveness of Next Generation Sequencing (NGS).

At the University of Exeter, my work within the Plant Science group has included a range of bioinformatics projects, from wax production in *Arabidopsis thaliana* to investigating the biology of hydrocarbon production in algae. My current research is with the BBSRC-funded Nornex project; a response to ash dieback disease which is caused by the fungus *Chalara fraxinea*.

Led by Professor Allan Downie at the John Innes Centre (JIC), the consortium includes: The Sainsbury Laboratory, East Malling Research, the Universities of Exeter and York and The Genepool at the University of Edinburgh, the Norwegian Forest and Landscape Institute, The Genome Analysis Centre, Forest Research and the University of Copenhagen.

We plan to understand how ash dieback spreads and how some ash trees can partially resist attack, to enable the development of effective disease control strategies. It is essential that we uncover this information as quickly as possible in order to respond quickly to the threat.

We are already utilising the power of crowd-sourcing. This allows the findings of all the project partners to be instantly shared and analysed. iPlant will improve the effectiveness of this crowd-sourcing effort by opening up data analysis to a wider audience who would be able to analyse the data from a laptop without having any computational resources.

This can be done readily through iPlant's Discovery Environment (DE), where users can swiftly upload files, effortlessly share data, set up workflows, queue jobs, and rapidly have their data analysed for interpretation.

Using the Discovery Environment, the GARNet workshop led us through the steps involved in analysing data using this intuitive platform, without the need for command line programming. This enables non-bioinformaticians to have greater access to their data without such a steep learning curve.

From my point of view, it highlighted a resource I could recommend to non-bioinformaticians, freeing up my research time and enabling me to concentrate on more specialised analyses. I can even integrate my own tools and workflows and share them with my colleagues, along with any raw data and analyses, without worrying about storage space and transfer time.

We were also introduced to a new approach to teaching bioinformatics through the DNA Subway. Our current approach is to run workshops for NGS analysis (for staff, PhD students and PDRAs) on the Amazon Cloud. By using iPlant's free alternative, Atmosphere, it would mean we could afford to teach a much wider audience, including undergraduates, in an accessible and comprehensible environment.

The iPlant Collaborative is an exciting way forward in improving the efficiency and productivity of research without the need to acquire expensive access to high performance computing.

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Resources for Plant Scientists

WikiPathways for Plants: An Online Pathway Editing & Visualisation Portal for Plant Biologists.

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Many studies have focused on identifying genetic and molecular interaction networks involving developmental, regulatory and signalling pathways.

Plant databases such as Gramene (http://www.gramene.org), the Kyoto Encyclopedia for Genes and Genomes (http://www.genome.jp/kegg/), Arabidopsis Reactome (http://www.reactome.org), MapMan (http://mapman.gabipd.org/), MetaCyc (http://www.metacyc.org), Plant Metabolic Network (http://plantcyc.org) and BioCyc (http://www.biocyc.org) are good integrated resources for studying plant metabolic pathways.

Similarly, many of the regulatory gene-gene interaction networks are stored in databases of molecular interactions such as BAR, ARANet, RiceNet, IntAct and BIND, to name a few.

All of these resources try their best to integrate the most current information, with multiple curation efforts involving continuous monitoring of new publications, and providing updates on additional interactors.

With the growing trend for limited funding for dedicated human curators, the onus is now shifting to towards developing machine learning techniques. Journal publication authors are also recruited as expert freelancers to curate and update the information generated in their publications.

By involving members of the research community, current curation practices need a resource similar to Wikipedia, which is conveniently available to users for editing and reintegration through community curation projects. One such resource for curating and analysing pathways is WikiPathways (http://www.wikipathways.org).

For plant biologists, WikiPathways is an ideal resource for community pathway data curation and analysis. It provides users with tools for drawing/creating networks and pathways from their own or published works, allows the visualisation of pathways, overlaying gene expression, and statistical analysis.

WikiPathways is a freely available online portal that that allows anonymous users to browse and analyse data. It also provides tools for registered members of the research community who are interested in data quality administration and the curation of new and existing pathways, to make regular updates, edits and contributions to data management.

WikiPathways was developed as a community curation portal. It currently hosts more than 1,700 pathways and 21 species. These include several pathways on its Plants Portal (http://wikipathways.org/index.php/Portal:Plants) for Arabidopsis, rice and maize, making it a useful resource for the plant biology research community (Figure 1).

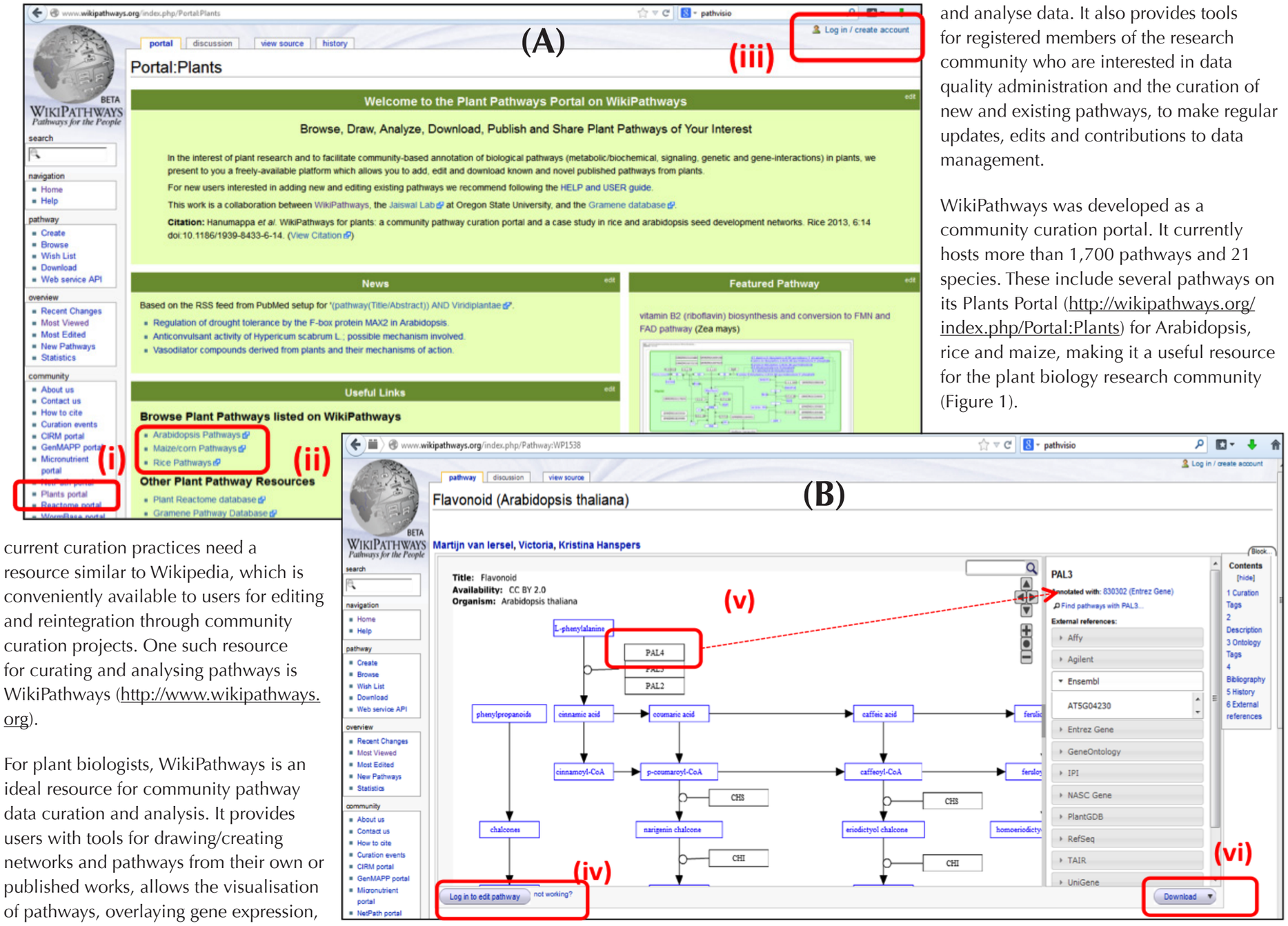

Figure 1: (A) Screenshot of the WikiPathways Plants Portal. Users can go to the website www.wikipathways.org and (i) visit the Plants Portal link, (ii) browse species-specific pathways and (iii) register/login to start editing content. (B) Screenshot of the curated Arabidopsis thaliana flavonoid pathway with (iv) links that enable registered users to edit, (v) references to similar information from other sources and (vi) download options.

For users interested in pathway curation, networks are drawn using the online version of the Wikipathways pathway editor and a standalone Java application, PathVisio (Figure 2). These editors use simple network data standards for drawing nodes (gene products, catalysts, metabolites, etc.) and edges (interaction types). Connecting nodes can be extracted in standardised network exchange formats such as BioPax, SBML and Simple Interaction Format (SIF).

PathVisio, the standalone pathway editor, can be downloaded from the website: http://www.pathvisio.org and installed locally on the desktop.

Following the instructions provided in the help documents and a set of tutorials (http://www.pathvisio.org/wiki/PathVisioTutorials), data nodes (genes and metabolites) and interactions (edges/connectors) between two nodes can be drawn. The interaction arrows represent activation/up-regulation and T-bars represent inhibition/down-regulation.

Groups of genes with the same functions and functional complexes can be created where necessary. Each gene node is labelled with a gene symbol and the name of the metabolite. Depending on its type (gene/metabolite), each node must, wherever possible, have reference database IDs, for example gene IDs referring the user to the relevant area of Gramene. Ensembl Gene IDs and metabolites may be referred to either with CAS numbers and/or ChEBI IDs, depending on their availability.

Additional references to PubMed literature IDs and other useful comments can be added in free text format in the comments field.

Despite the use of community standards in the curation of these networks, community curators and authors are not restricted from using their own styles. For example, nodes and edges/interactions can be colour-coded to reflect functional classifications such as external stimuli, subcellular localisations, self-interactions, etc.

Considering that some of the pathways drawn by individuals may not be public, users are allowed to create and save their own pathway drawings and use these for gene expression analysis using the desktop version of PathVisio.

As and when time permits, registered users can upload GPML format pathway diagram data from PathVisio to the online portal. Here, they may choose to keep it private, share it with other registered users, and/or make it public.

In addition to drawing the pathways the information provided in the diagrams can also be used for pathway enrichment and gene expression analysis.

For gene expression analysis, users need to map the expression of genes to the subset chosen in the pathways. This is done by downloading the species-specific gene database from http://www.pathvisio.org, which is provided through the BridgeDb framework (http://www.bridgedb.org).

To visualise and analyse prior to import by PathVisio for analysis, expression data stored in a CSV file is appended with a species-specific code, e.g. 'A' for Arabidopsis. More details on this are provided in the WikiPathways help documents.

We look forward to contributions from the plant research community that will develop a rich resource of curated plant pathways on the WikiPathways Plants Portal.

For more information about WikiPathways, please visit http://www.wikipathways.org.

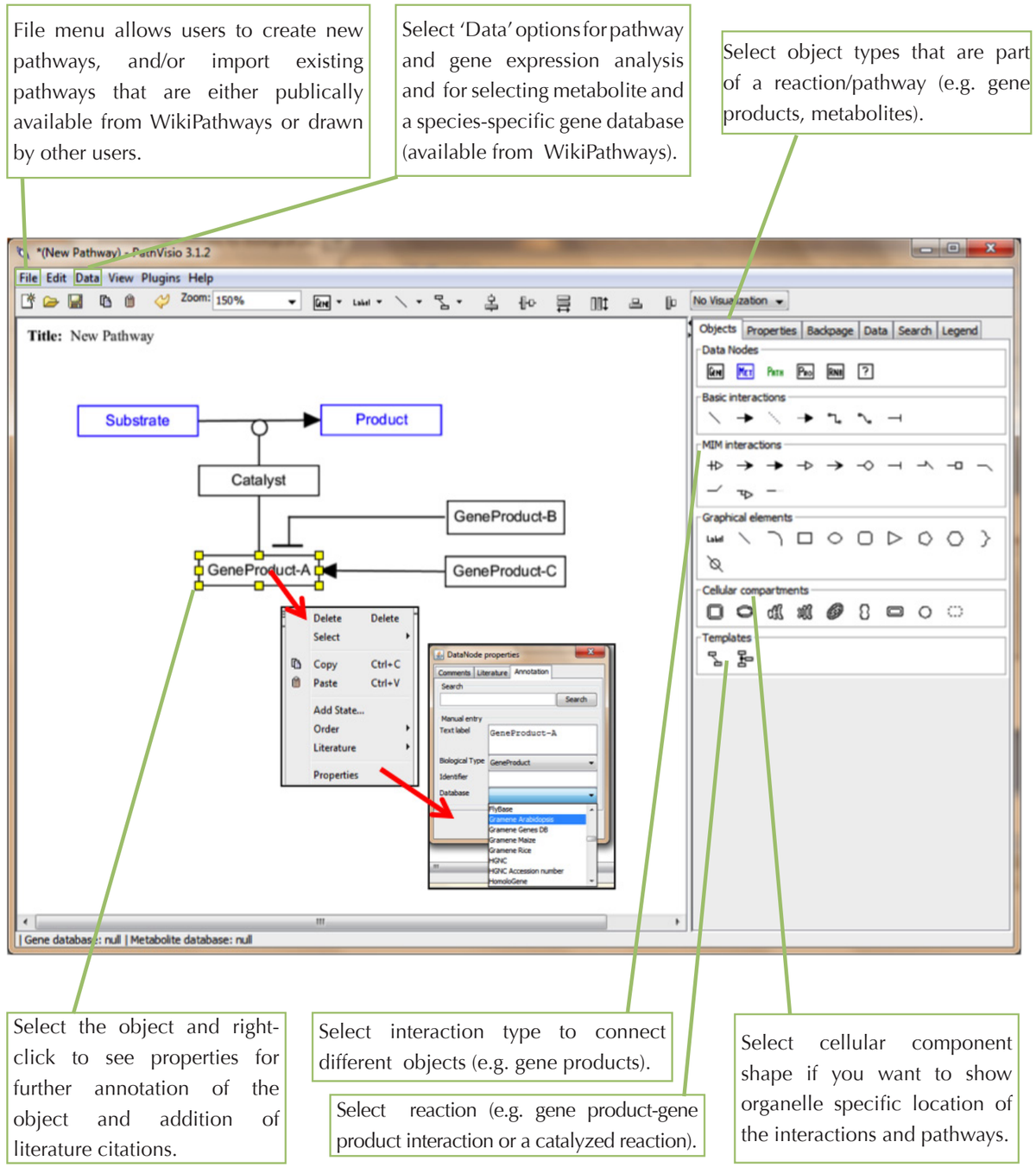

Figure 2: A screen shot of PathVisio, the desktop pathway editor and analysis tool. A similar editor is also provided by the WikiPathways portal for online editing.

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Inspiring Across Generations

If an Organelle Tweets, what Sound does it Make?

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"In your opinion, which of your publications had the biggest impact on your field?" After a pause to recover from my initial shock, I outlined the implications of my work. "Can your research be observed with a microscope or do you have to make conclusions indirectly?" "Since you live in England, what is your favourite tea?" Finally an easy question!

Who was my conversation partner? Not an interview panel, but high school students from Ohio, USA. My colleague Alessandra Rocchetti and I used Skype to connect directly into their classroom. Students prepared questions and took turns to quiz us via the webcam. We felt like part of a 'science speed-networking' session. Only afterwards we realised that our faces were projected onto a screen in front of 30 students!

How did two plant cell biologists in Oxford end up chatting to students in Ohio? The class had embarked on an interactive project to learn about cells. The brief: Design a presidential campaign for an organelle assigned to your group. The twist: Open a mock Twitter account to spread the word about the greatness of your organelle and slam your opponents.

As students were using the hashtag *#organellewars* to collate their tweets, I was able to find them. Interacting with a 'real' scientist made their excitement about the project rocket sky-high, so their teacher contacted me to ask about a Skype session.

The first '#Organellewars' project was initiated by US science teacher Brad Graba in 2012.[1] It turned into a spontaneous and hugely successful public engagement event when I and other scientists started to interact with the students. The #organellewars concept is still alive and kicking, and is now increasingly being adapted as teaching tool by other teachers.

The feedback from the Ohio students was wonderful. One commented, "I felt they were very laid back and easy to talk to, unlike what I was expecting. This sort of tells me that they might have the same problems as us, which makes it really exciting. It's fun to experience people who actually work on things we're learning in school". Another said: "I found it very pleasant to observe how passionate you are with your work. It inspires me to find a field of study that I will enjoy and want to continue on a daily basis."

Twitter is just one of numerous tools in my social media toolkit. My weblog sees a steady stream of readers who want to know more about plant cell biology. Students from all over the world watch our cell music videos on YouTube.

Social media helps me to reach new audiences by uncoupling content from location or fixed schedules, as people do not necessarily need to be online at the same time to interact in a meaningful way. Not all platforms prove to be effective or sustainable, so I abandon the ones that do not work and focus on the ones that are. I also constantly remind myself that numbers of views indicate reach, but not necessarily engagement.

Effective public engagement aims to establish a dialogue between scientists and non-scientists in which both sides can benefit and learn from each other. For me, 'Organellewars' is a perfect example for the potential of social media to facilitate such a dialogue.

[1] National Science Teachers Association Reports (2013). Social Media as a Teaching Tool. 25(2) 27. Available at: http://www.nsta.org/docs/2013SeptemberReports.pdf (accessed 6 November 2013).

Catalysing Educational Transformation: The PULSE Project

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Thomas Jack, Dartmouth College, NH

In 2006 the National Science Foundation (NSF), together with the American Association for the Advancement of Science (AAAS), initiated a conversation with the undergraduate life sciences community in the United States. The aim was to address how best teaching practices could be used to attract and retain students in the life sciences, and to prepare students for careers in an increasingly technology and science-driven world.

Recognising that a 21st century education requires changes in how biology is taught, how academic departments support and reward faculty, and how curricular decisions are made, led to the 2011 report *Vision and Change in Undergraduate Biology Education: A Call to Action* (V&C).

This report recommended broad strategies to enhance and deepen all students' learning, to reduce the achievement gap of students from disadvantaged backgrounds, and to overcome disengagement and student loss.

Appreciating the challenges associated with systemic implementation of V&C recommendations, the NSF, the National Institutes of Health (NIH/NIGMS), and the Howard Hughes Medical Institute (HHMI) founded the Partnership for Undergraduate Life Sciences Education (PULSE) in 2012.

An early step in the venture was the establishment of an online community to bring life science educators together (www.pulsecommunity.org). At present this online community consists of 1175 members.

Another key step was the selection and training of 40 PULSE Leadership Fellows (Figure 1) to develop strategies for implementing systemic change focused at the departmental level, at all types of postsecondary educational institutions in the US. The PULSE Fellows, drawn from a variety

Figure 1: The PULSE Leadership Fellows

of institution types, are academic leaders and have led successful change in biology education at their own institutions.

The work of the PULSE Fellows converged on several initiatives united by an overall vision referred to as the 'Roadmap for Change.' These initiatives, currently in progress, have been funded through a competitive NSF support scheme called 'Early-concept Grants for Exploratory Research.'

Roadmap for Change

The PULSE 'Roadmap for Change' (Figure 2, overleaf) outlines four phases of transformation through which a department will progress on the road to incorporating the V&C recommendations:

- **Phase 1: Raising Awareness and Building Capacity for Change.** The department in this phase is largely unaware of the V&C recommendations and the need for educational change.
- **Phase 2: Taking Action.** The department is aware of the V&C recommendations and potentially needs assistance in planning or laying the groundwork for implementation
- **Phase 3: Supporting Implementation.** The department is implementing locally appropriate V&C reforms.
- **Phase 4: Assessing and Improving.** The department is assessing and modifying reforms based on outcomes, as well as disseminating assessment results.

Helping departments to identify appropriate tools for prompting transformation is the Framework for Change (http://www.pulsecommunity.org/page/pulse-framework), that correlates phases in the Roadmap-specific activities, tools and outcomes to assist departments' progression to the next phase.

PULSE Outreach

To raise awareness of PULSE and V&C, the Fellows have developed a Public Awareness Campaign, which is being carried out in collaboration with the American Institute of Biological Sciences (AIBS). The campaign includes a three-part video documentary publicising the need for transformation in life science departments, and the current efforts successfully drawing on effective strategies for improving student engagement and retention.

Through this outreach, members of the life sciences community will deepen understanding of how they can implement educational change regardless of institution type.

Another form of outreach partners PULSE with Dr Shilad Sen and the Macademia project to produce a novel network visualisation/analysis tool that will connect members of the PULSE community who have shared pedagogical interests, research expertise or educational background.

Additionally, Microsoft Local Impact Maps will geographically catalogue and archive artifacts from V&C-related efforts and presentations across the nation. Finally, national organisation leaders are forming an advisory group to help align PULSE's outreach efforts with other national endeavors to disseminate and broaden the impact of V&C initiatives.

Regional Education Networks

We realise the systemic transformation urged in V&C is fraught with challenges, due in part to the distinctive features of higher education institutions such as faculty autonomy and "organised anarchical decision-making."[1] To overcome these challenges, PULSE is establishing five regional networks covering the US. Motivating

and supporting like-minded reformers, networks create collaborative interactions through which new 'mental models' of effective practices emerge; a process reminiscent of constructivists' views on learning.[2,3]

Using and refining PULSE initiative products, such the Rubrics and the Ambassadors Programme described next, the networks are promoting use of evidence-based strategies to improve retention and learning of students from all backgrounds in undergraduate biology programs.

For example, the New England Network engages with faculty seeking training in student-centred teaching practices through in-person and online workshops. These combine instruction in such practices with 'bottom-up' leadership cultivation through reflection on strategies for promoting systemic departmental change. Conferences of the Great Plains and Midwest Network and the Pacific Northwest Network are bringing together leadership teams comprising departmental chairs, deans and faculty change agents.

Beyond facilitating systemic change, network activities provide the means for gathering quantitative and qualitative data for evaluating ingredients of successful change strategies. These build on Graham's comprehensive study of transformation in undergraduate engineering in the UK and elsewhere, which highlighted the complexity of educational transformation.[4] Insights from the networks' evaluations can inform other efforts, in the US and elsewhere, to effect systemic change in higher education.

PULSE V&C Rubrics

The Rubrics, available at www.pulsecommunity.org, describe specific criteria in five broad areas for evaluating the level and degree of departmental implementation of V&C recommendations: 1) Curriculum Alignment with V&C, 2) Assessment, 3) Faculty Practice/Faculty Support, 4) Infrastructure, and 5) Climate for Change.

Each of these five contains multiple criteria and benchmarks usable by departments at a broad range of institutional types, from two-year colleges to research universities. Thus, highlighting achievements and shortcomings, the Rubrics can guide departments in assembling a strategic plan for changing practices.

The Rubrics, in the longer term, will form the basis for a certification programme for undergraduate life science departments that have adopted the principles described in V&C. Departmental certification, as envisaged by PULSE Fellows, will serve as a 'carrot' to reward departments making substantial progress in implementing curricular and pedagogical change, as well as as a 'stick' to incentivise departments that have not yet implemented the recommendations of V&C.

PULSE Ambassadors

Adoption of V&C recommendations by an entire biology department, needed for large-scale impact on students, requires multiple layers of change founded on a shared vision within a department. Building such vision and prompting organisational change is challenging, and external consultants can help. PULSE is launching an Ambassador Training Program designed to nurture faculty members as agents of change by equipping them with effective strategies and tools to guide a department in envisioning its future, identifying strengths and barriers, and removing barriers. All of this is necessary for synergistic, collaborative work towards change.

Trained Ambassadors will conduct visits to departments and will facilitate exercises to engage, support, and guide members of a department to develop an action plan for change. After the visit, the Ambassador team will continue to interact with the department to support and track progress towards change.

As with the other PULSE efforts, assessment will be undertaken to measure the impact of the programme on faculty and institutions.

In summary, the PULSE project envisions being a successful model for implementing change in life sciences education that would be transferrable to other education reform projects.

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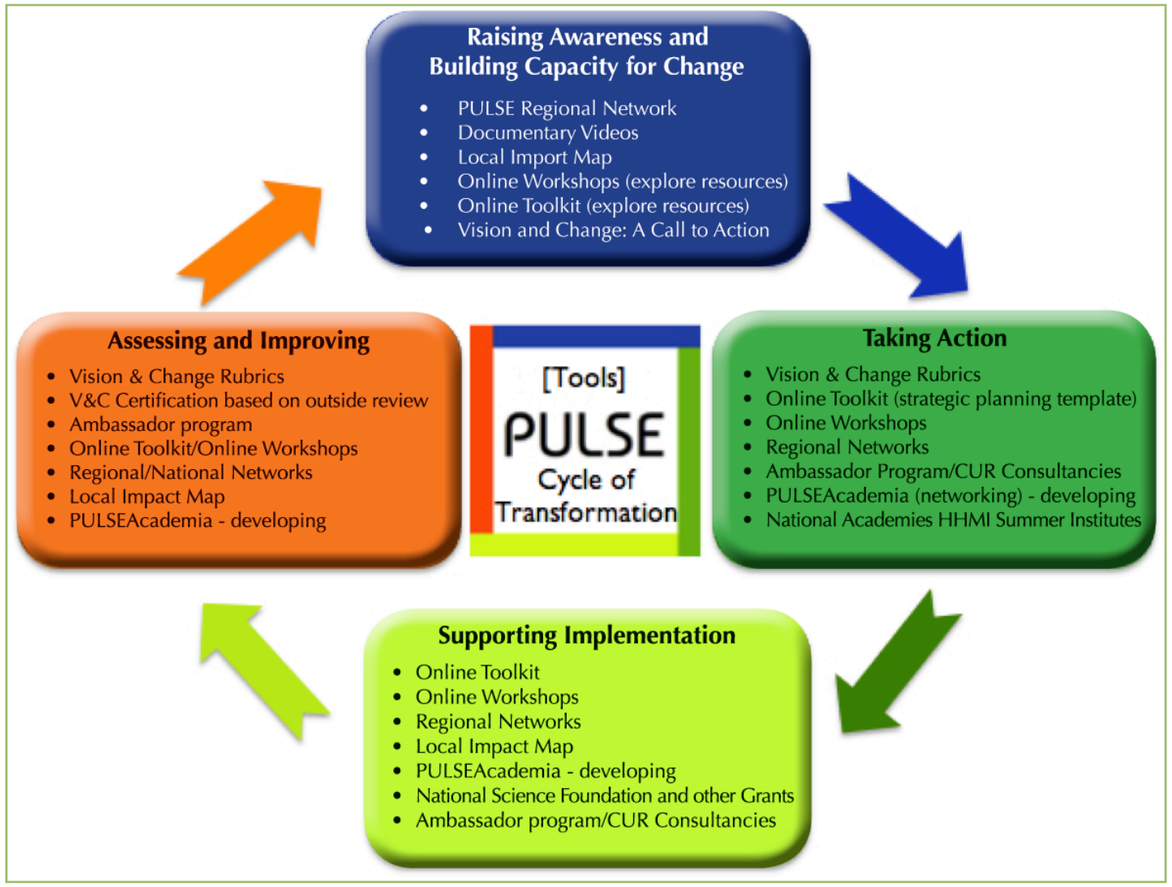

Figure 2: The PULSE Roadmap for Change

Spotlight on the University of Greenwich

Plant science at the University of Greenwich covers a broad range of research areas, from basic Arabidopsis research and a biofuels and biotechnology laboratory in the School of Science, to projects on the productivity of urban green walls and roofs in the School of Architecture.

Plant research at the Natural Resources Institute (NRI) is focused on global food security, sustainable development and poverty reduction. Below are a selection of groups based on the Chatham Maritime campus, Kent.

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Insect Behaviour & Ecology

Sarah researches the behaviour of economically important insects and their relationships with plants. Some of her work focuses on pests of stored cereals, especially using behavioural assays to investigate how they use visual and odour cues to locate, and how pesticidal plants (e.g. *Lippia javanica*) and their derivatives can be used to kill or repel stored product pests such as beetles and moths.

Plant-derived crop protectants offer a compelling alternative to synthetic pesticides in some farming systems, especially in low-income countries. They are less expensive and often less toxic than synthetic alternatives. However, their use must be optimised.

Sarah also works on how insect pollinators locate and choose flowers, and how their ecology is affected by interactions with different plant species. She studies the effects of different plants' nectar or pollen on the health and behaviour of their pollinators, using examples such as crop lupins that have anti-herbivore defensive compounds in their nectar or pollen and might be ingested by bees or other beneficial insects.

Sarah Arnold works on the pollination ecology of cocoa.

She is currently also working on the pollination ecology of cocoa (*Theobroma cacao*) in the Caribbean, and how cocoa plantations can be managed and optimised to increase cocoa-pollinating insects and increase yield.

Professor Chris Atkinson

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Climate Change & Sustainable Agriculture

Chris is an expert on the physiology of woody perennials and the development of climate-adapted cropping systems.

Chris Atkinson regularly speaks to the media to increase public understanding of the importance of sustainable agriculture and horticulture.

His research focuses on how crop systems cope with environmental stress, predominantly dehydration, and how understanding the stress-related synthesis of secondary metabolites can be used to optimise food production and quality. He also works on perenniality with respect to flowering and the influence of winter chilling.

Chris's work on resource-use efficiency has developed approaches that optimise water and nitrogen application based on crop demand. Much of this research has been linked to knowledge generation and its application to promote the understanding, value and need for science to aid the generation of a sustainable food supply.

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Environmental Conservation\

Debbie is a landscape ecologist and manager, specialising in agriculture and forestry. As a UK representative on the EuroCoppice COST Action FP1301 project, her current research looks at coppice woodland management, including innovative management and utilisation of traditional coppice forests in response to ecological, economic and social challenges in the European forestry sector.

In south-east England, this includes looking at the socio-economic barriers to development and current forestry policy.

Also related to tree ecology, she is conducting research into dormouse activity in the tree canopy, plant materials used in nest construction, and the correlation between presence of this European Protected Species and woodland composition, structure and management.

Dr Maruthi MN Gowda

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Plant–Virus–Vector Interactions & Field Epidemiology

The Gowda research group aims for a better understanding of how viruses and their insect vectors interact to cause devastating plant virus disease epidemics in the tropics.

Maruthi has particular experience of working on diseases of cassava, tomato and staple food crops in Africa and Asia, caused by geminiviruses and potyviruses, and transmitted by the whitefly vector, *Bemisia tabaci*.

He has wide ranging interests in tropical plant virology. Topics of current interest include:

- Improved understanding of the biotic factors contributing to the current spread of cassava mosaic disease and cassava brown streak disease epidemics in Africa.
- Identifying natural sources of resistance to these diseases and whitefly.
- Employing tissue culture, chemo- and thermo-therapy techniques for cleaning cassava germplasm from virus infections.
- Using high throughput RNA-Seq sequencing on cassava to identify, characterise, map and understand the mechanism of resistance genes with a view to developing breeding markers.
- Using novel approaches such as bacterial endosymbionts as biocontrol agents for controlling whitefly and virus diseases.
- Constructing virus infectious clones.
- Determining plant virus and vector diversity and taxonomy.
- Developing robust, low-cost diagnostic technologies for plant viruses and transferring these to African partners.

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Bioenergy Research

Pat's breakthrough in understanding the mechanism of polymeric lignin breakdown by wood-degrading fungi served as a springboard for current research programmes centred on renewable bioenergy. These programmes were developed during her time as Biofuels, Science and Society Fellow at Durham University and encompass themes including:

- The use of algal and non-food plant systems for capture of CO_2.
- Production of green chemical feedstocks and biofuels.
- Properties of plant oils for biodiesel manufacture.

Maruthi Gowda is interested in several aspects of tropical plant virology

- The potential for cultivating biomass crops on contaminated land.
- Anaerobic digestion and thermochemical treatment of food and agricultural by-products for biomethane production.
- Bioenergy supply chains.

Pat is involved in overseas project work including the EU ACP Science and Technology programme-funded 'Capacity-building in South Africa, Namibia and Ghana to create sustainable, non-food bio-oil supply chains' (http://www.acp-nonfood.com/), and Ecotec 21, a project that brings University together staff to support the development of biofuel combined heat and power installations based glycerol–biodiesel manufacture.

Pat's 'Engineering Micro-algae for Pharmaceutical Production' project is an ABSIG SPARK (TSB, NERC, BBSRC)-funded project with IOTA Pharmaceuticals to explore the chemical biology of the alga *Dunaliella salina*.

In land plants, it is known that development of a hyperoxidant state accompanies modification of the plant cell wall architecture and is associated with increased extracellular peroxidase secretion, cell wall thickening and increased lignification. This limits productivity when plants are grown on contaminated land.

The effects in algae are as yet unknown, but Pat is assessing the potential of Dunaliella both as a direct source of bioactive compounds and as a host within which to engineer new pathways for the production of novel, high-value biochemicals. An EU Framework Programme 7 Knowledge Based Bioeconomy-funded project 'The CO2 Algal Biorefinery' will also establish a sustainable biorefinery based on biomass from halophilic microalgae such as Dunaliella.

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Postharvest Physiology of Perishable Plant Products

Debbie began her postdoctoral career with five years' research on photosynthesis mechanisms at Sheffield University, followed by two years studying wheat productivity at CIMMYT in Mexico, before joining NRI in 1994. Over the past 20 years she has carried out research on the postharvest biology of a wide range of perishable plant products.

Since 2009, together with her colleague Richard Colgan, Debbie has worked to set up a collaborative research centre between NRI and East Malling Research. The Produce Quality Centre benefits from the expertise across both institutes, providing scientific research to improve quality and reduce losses in food supply chains in the UK and across the globe.

Debbie is interested in improving the storage characteristics of root and tuber crops, particularly by taking information gained from well researched crops, such as potato, and translating to less researched crops such as yams, cassava and sweet potato. Hence she is working on dormancy control and response to long-term storage stress in potato tubers.

Debbie Rees is using knowledge of potato to understand other crops such as yam, cassava and sweet potato.

She is also currently managing part of a project funded through the Bill and Melinda Gates Foundation to improve on-farm yam storage through sprout control and improved curing, and has managed a range of DFID-funded projects to investigate the wound-healing efficiency of sweet potatoes.

Debbie also seeks to develop technologies to improve quality and reduce losses throughout the supply chain. This includes ethylene management strategies and the efficacy of ozone treatment, non-destructive methods to assess maturity and storage stress of fruit and vegetables, with a particular interest in the use of chlorophyll fluorescence.

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Understanding & Exploiting the Biological Activity of Plant Compounds

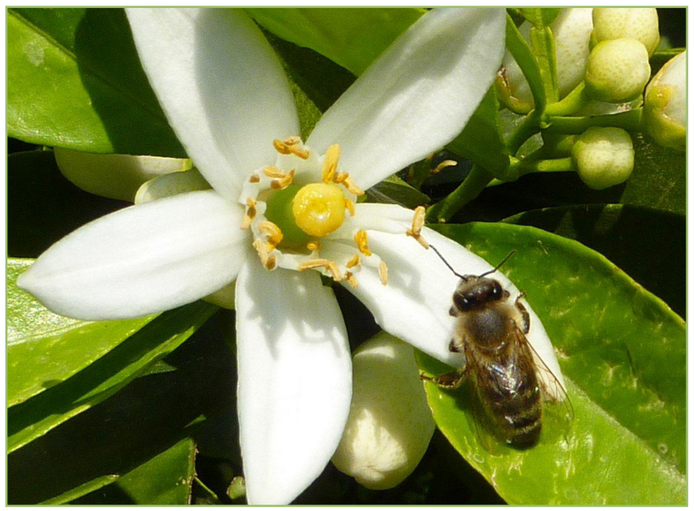
Phil works on the isolation and characterisation of plant compounds that have biological activities to insects and fungi, or those that mediate plant–insect and plant–fungal interactions. For example, he leads international projects optimising the use

of pesticidal plants by smallholder farmers in sub-Saharan Africa for protecting stored products, field crops and livestock.

Funded by the McKnight Foundation and the EU, he studies natural resistance mechanisms in crops such as sweet potato to insect pests, to help breed improved varieties and contribute environmentally benign pest management tools.

Phil also studies how plant chemicals in pollen and nectar influence the foraging behaviour of pollinators, bee health and fitness. He recently published in *Science* the finding that coffee and citrus flower nectar contains caffeine, and this improves honeybees' memory for floral odours associated with their food after 24 hours. Having caffeinated nectar therefore seems to provide the flowers with a competitive advantage, since foraging honeybees are more likely relocate those flowers the next day. This increases the likelihood of pollination.

Elsewhere his research is investigating the impacts of toxic nectar from invasive species such as rhododendron on the decline of native populations of bees, the nutritional quality of wild flowers for bees in the UK landscape to better understand which species are actually good for bees, and whether nectar chemicals can help bees better cope with parasitic diseases that otherwise exacerbate pollinator decline.



Phil Stevenson identified that flowering plants with caffeinated nectar have a competitive advantage in attracting pollinators.

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Molecular Diagnostics: Root & Tuber Crop Virology & Entomology

Sue leads the Molecular Virology and Entomology Research Group, which focuses on research for controlling pests and diseases of tropical food crops, especially those caused by viruses and insect vectors on cassava, sweet potato, yams and vegetables.

She is currently Leader for the project 'Enabling research tools for cassava virologists and breeders' (2013–2017, funded by The Bill and Melinda Gates Foundation) aimed at reducing production losses driven by super-abundant populations of the whitefly vector, *B. tabaci*.

A key step is the development of diagnostic tools that differentiate between different African cassava whitefly species, including the use of transcriptomics to better understand the genes that make particular whitefly populations more invasive than others.

A second Gates-funded initiative is the 'Development of On-farm Robust Diagnostic Toolkits for Yam Virus Diseases' (2012–2016). Vegetative propagation of yam via tubers leads to an accumulation of virus diseases in farmers' planting material, and the only effective method of controlling these virus diseases is to use virus-free planting material. The scarcity and expense of such seed material is a critical constraint to increasing yam production.

The development of virus diagnostics is complicated by some yam badnaviruses being integrated in the yam genome and these sequences are potentially able to replicate and initiate new virus infections from the sequences integrated in the host genome. This poses serious problems for virus-indexing facilities, since materials free from virus can become infected when stressed.

The project will develop diagnostic tools for broad-specific detection of viruses and integrated sequences to enable the identification of virus-free yam germplasm for dissemination.

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Membrane Protein Regulators of Photosynthesis, Fertility & Development

Elinor's group studies the membrane proteins of GARNet's favourite plant *Arabidopsis thaliana*. The lab also houses several other model organisms to work on proteins that are widespread in evolution, and uses orthologues and paralogues of Arabidopsis proteins to elucidate their function.

Among current interests are a MATE-family transporter, which affects fertility and flavonoid transport (this is a toxin efflux and antibiotic cresistance transporter in prokaryotes), and the rhomboid and FtsH families of membrane-located proteases. For example, we study FtsH in the cyanobacterium *Synechocystis* – a naturally transformable photosynthetic bacterium and 'model chloroplast' – as well as in plants.

FtsH occurs as a single protein in many bacteria but as a multiprotein family in oxygenic photosynthetic organisms. In all systems, it seems to be a regulatory linchpin of a range of cellular networks. We are also exploring the usefulness of

Sue Seal is developing tools to diagnose African whitefly on cassava plantations in Africa

cyanobacteria in agriculture and biotechnology, which links with the work of Professor Pat Harvey (see page 23) and others.

Rhomboid proteases regulate signalling pathways by cleaving and releasing membrane-tethered peptides. A large set of Arabidopsis rhomboid mutants in the lab is now augmented by a collection of *Dictyostelium* rhomboid mutants. Phenotypes in plant and amoeba suggest roles in development, and we are particularly interested in how a chloroplast rhomboid affects both photosynthesis and fertility.

Finally, with Dr Kevin Smyth's cell wall biology expertise, the lab recently won funding to develop a high throughput method for quantifying cell-wall generation in Arabidopsis protoplasts.

Spotlight on Harper Adams University

Having been granted university status just a year ago, Harper Adams University conducts a wealth of valuable plant science research within its Crop and Environment Sciences Department.

The University has strong links with industry and professional bodies. Its researchers have expertise in crop protection, crop production, field vegetables, fresh produce, soil and plant nutrition, environmental management, sustainable technologies, climate change, forestry, wildlife and conservation. The Crop and Environment Research Centre is also accredited by the Pesticide Safety Directorate to conduct efficacy trials on agricultural, horticultural and stored crops.

Matthew Back investigates biofumigation for pest control. Here, Brassica residues are being macerated and incorporated into soil.

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Biofumigation Research

Recent EU pesticide legislation and an increasing focus on sustainable crop production means that alternative and sustainable crop protection techniques are currently being sought. Recently there has been much scientific and industrial interest in using 'biofumigation' for the management of pests and diseases.

Biofumigation is based on a chemical reaction that occurs when the tissues of certain Brassica species are disrupted by mechanical damage or during herbivore feeding.

In damaged cells, glucosinolates (GSLs) are liberated from the cell vacuoles and become hydrolysed by the enzyme myrosinase. This releases a variety of volatile compounds that include isothiocynates (ITCs). ITCs are known to be toxic to a number of soil-borne pests and pathogens.

Matthew's group has been investigating the use of biofumigation for the management of potato cyst nematodes (*Globodera* spp). Particular emphasis has been upon determining the factors that affect biofumigation efficacy such as sowing date, incorporation methods, availability of soil nutrients and soil moisture at incorporation.

Work from these studies will be used to develop recommendations for growers who want to use biofumigation. Initial findings have indicated that potato cyst nematodes (PCNs) are controlled by partial biofumigation (pre-incorporation of Brassicas) and full biofumigation (post-incorporation of Brassicas). Summer-sown Brassica cover crops appear to be more successful in reducing PCN populations than those grown during the winter months.

Finally, strong positive relationships have been found between the GSL concentration (mol/m^2) of Brassica species, just prior to incorporation, and the viability of encysted PCN eggs sampled six weeks later.

One of Keith Chaney's experimental trial plots, where he is assessing the potential for using sewage sludge as a crop fertiliser.

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Biosolids in Agricultural Systems

Many arable systems today rely solely on inorganic fertilisers to supply the nutrients required for crop growth. However, the production of inorganic fertilisers relies heavily upon fossil fuels and other natural resources and as these become increasingly difficult to source, the price of fertilisers will increase.

This has led to a renewed interest in alternative sources of nutrients. Organic amendments such as biosolids (also called sewage sludge) are a by-product from human sewage processing. In addition to providing key nutrients, they can increase soil organic matter and water holding capacity.

More than 30 million tonnes of wet sewage sludge are produced in the UK each year. This can come from a wide range of sources, with human wastes being a major component, but also surface run-off and industrial wastes. Sewage sludge is rich in phosphorus but low in nitrogen and potassium. Biosolids have good potential as a valuable agricultural resource, providing that its nutrient imbalances can be overcome.

Keith's EU FP7-funded END-O-SLUDG project aims to develop technologies to improve municipal waste management and lower greenhouse gas emissions associated with sewage sludge treatment processes. Technology exists to supplement sewage sludge with mineral fertilisers, such as urea and muriate of potash as sources of nitrogen and potassium respectively, to produce

Leticia Chico-Santamarta is investigating the production of efficient biofuels from postharvest crop waste, including oilseed rape (above).

an organo-mineral fertiliser with balanced crop nutrient supply.

Since 2008, experimental plot trials have been carried out at Broxton, Cheshire, to compare yield response for agricultural crops; these include wheat, oilseed rape, barley, beans and forage maize. Results suggest that biosolids can produce similar yields to conventional fertiliser with no significant difference in crop yield between treatments over the three trial years, with the exception of one crop. The new organo-fertiliser appears to be as efficient as conventional fertilisers.

Moreover, levels of heavy metals in soil did not exceed permissible levels. Although some significant increases were recorded in PTEs, assessments on earthworm populations showed that numbers were not affected by the application of biosolids. This indicates that potentially toxic elements were not negatively impacting upon a key indicator of soil health. This is the first field scale trial of a modified sewage sludge product that has the potential to transform a hitherto waste product into a practical fertiliser product.

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Use of Crop Residues for Sustainable Energy Generation

Depleting fossil fuel resources and concerns over greenhouse gas emissions mean that finding alternative sources of energy is a priority in the next few decades. Crop waste, particularly straw cereals and oilseed rape, is a target for bioenergy companies since it is a potential source of biomass, which could be used to meet European renewable energy targets and reduce greenhouse gases emissions.

The use of crop waste circumvents the food versus fuel debate. Different stages need to be understood such as storage and the transformation of the crop wastes into more valuable products (e.g. pellets, briquettes, etc), and the implication of this transformation in the overall handling and the energy conversion technology (e.g. combustion, pyrolysis, gasification, digestion).

Leticia and her group are investigating the production and utilisation of oilseed rape (OSR) straw pellets as a biofuel by considering the storage of OSR straw and its compression into higher density products, and the storage and combustion of OSR straw pellets. This work is currently being extended to other residues such as horse manures and ash produced from poultry litter combustion.

Leticia is also involved with lifecycle assessment of the use of agricultural products for energy, innovation in the teaching of sustainable development in life sciences in Europe, and the use of anaerobic digestion and pyrolisis for energy generation.

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Novel Uses for Barley

Ed's research covers a range of areas within crop physiology, agronomy and crop improvement. His primary research interest is the development of food barley.

A recent success was the publication in *Field Crops Research* of work conducted with Imperial College London and former colleagues at Bangor, demonstrating that naked (hulless) barley lines have a lower glycaemic load than oats. This shows considerable promise as a dietary intervention to address type 2 diabetes.

Ed's plant breeding research at Harper Adams includes winter and spring lines of naked barley, uzu dwarf barley and more recently, white spelt. The latter inherits high seedling vigour from the spelt parent with the potential to perform well in poorer seedbeds, for example where delayed drilling is used as a blackgrass control measure.

The sweet white grain has potential in a range of whole-grain products such as cereal bars.

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Fusarium Mycotoxins

Fusarium head blight is a disease of small grain cereals that can have a major impact on yield and grain quality. The disease can be caused by several different *Fusarium* and *Microdochium* species within a disease complex. Infected cereal grains are small with poor germination. They do not mill or malt well and contain mycotoxins: fungal secondary metabolites with high animal toxicity.

Different *Fusarium* species and chemotypes can produce different mycotoxin profiles. Deoxynivalenol (DON) and zearalenone (ZON), which are produced by *Fusarium graminearum* and *F. culmorum,* are of particular concern for small grain cereals. In 2006, the EU set legislative limits for DON and ZON for cereals intended for human consumption and cereal products.

Ed Dickin is breeding better barley for humans. Barley has a low glycaemic index that could be beneficial for people with type 2 diabetes.

Simon's group has studied the epidemiology and control of *Fusarium* since 1997, and developed PCR assays to quantify *Fusarium* species and mycotoxigenic genes within experimental samples.

Since 2001, they have focused more on the mycotoxins themselves, identifying the role of different agronomic and meteorological factors through modelling the mycotoxin content of harvest samples from commercial crop surveys. They are also quantifying these differences through inoculated field experiments, including studies on previous crops, cultivation, nitrogen inputs, plant growth regulators, varietal resistance and fungicides.

Subsequent studies have looked at the impact of primary processing on the distribution of *Fusarium* mycotoxins within mill fractions (flour, bran, etc.) One ouput from this group was the identification of high levels of *Fusarium* mycotoxins, HT2 and T2 in UK oats, and identification of the species responsible, *F. langsethiae*. Little is known about this recently described species and Simon's group has conducted extensive studies to better understand the epidemiology of it.

The European Commission are currently gathering more data on these mycotoxins before they consider legislation in 2015. Identification of agronomic factors that impact on mycotoxins has allowed the production of Codes of Practice to reduce *Fusarium* mycotoxins within cereals.

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Nematology & Agronomy Research

The field of agronomy covers a wide range of disciplines including entomology, plant pathology, crop physiology, weed science, crop nutrition and soil management – and for some crops, irrigation and water use. All of these disciplines interact, which can provide complex antagonistic or synergistic effects that need investigation.

One of the major problems currently facing potato growers is the potato cyst nematode (PCN), which can survive in the field without a host for over 25 years; an incredible feat of adaption to its environment.

Ivan studies plant parasitic nematodes, particularly the PCNs *Globodera pallida* and *G. rostochiensis*. He aims to find suitable alternatives to agrochemical nematicides, for which there is increasing pressure from legislators to remove from commercial agriculture systems.

Fusarium head blight.

These alternative approaches, which are being explored through PhD programmes and commercially funded projects, include the use of biofumigation, trap cropping and plant-derived products. With funding from the Potato Council, Ivan is also re-visiting the UK PCN survey carried out by Harper Adams University in the late 1990s, to update knowledge of the presence and distribution of *Globodera* spp.

As well as his work on nematodes, Ivan also collaborates with Jim Monaghan (see page XX) on agronomy projects involving water management. A Defra HortLINK-funded project, with Cranfield and Lancaster Universities, is investigating how the effects of in-field soil variability can be overcome using precision irrigation in lettuce and onions.

An HDC-funded PhD project is also looking at the influence of soil water and irrigation on radish splitting, with the aim of providing guidelines for growers.

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Resistance to Black Rot of Vegetable Brassicas

Paul is interested in the quantitative genetics of pest and disease resistance, and quality traits in salad crops and field vegetables.

In some East African countries, the bacterial disease black rot, caused by *Xanthomonas campestris* pv. *campestris*, can completely wipe out Brassica crops like cabbage, broccoli and kale. Not only does this limit the food supply for African smallholders and their families, but it diminishes their income from selling any surplus plants.

Black rot is difficult to control with chemicals. In a recent BBSRC/DfID-funded project Paul worked with colleagues at the University of Warwick, Fera, and CABI and KARI in Kenya on several aspects of this problem. Using recent advances in Brassica genomics, they characterised a quantitative resistance to black rot in *Brassica rapa*, looking at quantitative trait loci of two linkage groups.

Paul Hand investigates black rot (brown lesions) on cabbages in Kenya.

In addition, a field survey in three African countries to assess the diversity of the pathogen showed that Race 4 was most prevalent in a collection of >200 isolates from Kenya, Tanzania and Uganda. Genomic fingerprinting indicated several clusters of genetic diversity across the region. Screening of a Brassica genetic diversity collection, which included several landrace kales from Kenya, found only one potential source of new resistance. This requires further investigation.

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Plant Pathology & Agronomy

Martin has worked on projects and published in a range of areas associated with agronomy and plant pathology.

Recent research includes work on *Fusarium* diseases of cereals, the use of inorganic salts for

disease control, the integrated control of fairy ring and the use of antitranspirants for alleviating drought stress.

He has a particular interest in non-target crop effects from plant protection products, and has worked on the effects of plant protection products on seedling vigour, the alcohol yield of wheat, interactions with nitrogen fertiliser and the quality of sports turf.

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Drought Physiology

Peter is conducting research to understand how to apply knowledge of drought physiology to improve crop management, and potentially breeding.

One aspect studied is the response of crops to polymer sprays applied to reduce transpiration. The main crop used is wheat, with new work on oilseed rape about to start. The focus is on exploiting understanding of reproductive physiology in relation to effects of the polymers on gas exchange.

Most of the work involves glasshouse or controlled environment experiments initially, moving to the field in the later stages, where rain shelters are necessary in order to reliably induce drought.

A second area of work is exploitation of artificial drought signals as potential growth retardants in crops which produce excessive growth.

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Biological Control in Glasshouses

Compared to the use of chemical pesticides, biological control of pests in glasshouse systems can be prohibitively expensive, particularly in

One of Martin Hare's interests is in the control of fairy ring.

Northern Europe where heated infrastructure is required. In fact, much of the beneficial arthropod production industry in Northern Europe has moved to North Africa where fuel costs are cheaper. However, production close to the point of use is preferable because long supply chains and extended periods of transportation affect the quality of live products.

Funded by the BBSRC Industrial CASE scheme, Simon, with Ian Baxter of Certis UK, is overseeing a project using 'off-leaf' technologies to rear predatory mites on artificial diets closely resembling those of the predators' host. This programme aims to identify why particular hosts are suitable food sources for the beneficial arthropod production system, and what the key nutritional requirements are to establish an such a system.

The strategy will be to create an artificial host that closely resembles the 'live' hosts in terms of bioavailable ingredients. The programme will also consider the impact of an off-leaf production system on beneficial arthropod fitness and their capability of establishing in commercial growing conditions.

Eliminating the requirement for pest production under glass will make beneficial arthropod

production more economical and less influenced by factors outside of the industry's control. If successful, this project will make integrated pest management approaches more available to UK growers.

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A Route to Solving Oilseed Rape Yield Decline

Oilseed rape is a valuable crop for vegetable oil and biodiesel production and has become the third most widely grown arable crop in the UK. Originally planted on a small scale to reduce soil-borne disease in intensively grown wheat, it is now a victim of its own success.

Increasing the growing frequency of oilseed rape in any one field has led to lower yields, giving poorer returns for the farmer and wasting energy and other crop inputs.

Peter initiated research with funding from the Department for Environment, Food, and Rural Affairs (Defra) to identify two soil-borne fungi, neither of which had previously been associated with oilseed rape. Work in collaboration with NIAB-TAG showed these two fungi to be associated with yield losses of up to 20% in intensively grown oilseed rape crops.

A second project, supported by industry and the Technology Strategy Board, has mapped the geographical location of the two fungi and seeks to find control measures. A third project in collaboration with Matthew Back (see page 27), supported by HGCA, the Morley Agricultural Foundation and the Felix Thornley Cobbold Agricultural Trust, is underway to further understand the role of other pathogens involved in the yield decline of oilseed rape crops.

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Plant Response to Environmental Stress

Jim, Director of the Fresh Produce Research Centre, is researching the area of crop plant physiological responses to environmental stresses and agronomic factors.

Stresses (e.g. deficit irrigation, nutrient and salinity) can be imposed during crop growth or postharvest (temperature and light) and can influence crop quality and/or efficiency of resource use. Increasingly, physiological studies are being integrated into studies of precision farming systems.

For example, current work in collaboration with Cranfield and Lancaster Universities and as part of a wider LINK study, includes a study of deficit irrigation in high value horticulture crops.

Simon Leather, Head of the Centre for Integrated Pest Management, is finding better ways to rear arthropods for biological control.

This work ranges from semi-commercial scale in the open field or polytunnels to more detailed studies in controlled environments. It involves imposing periods of deficit at different times during the growth of lettuce and onion plants.

Current PhD projects include a study of the role of preharvest factors on splitting and postharvest quality in radish, and an investigation into the agronomic sources of variability in lettuce crop uniformity. The group is also collaborating in the field with the John Innes Centre and the University of East Anglia to phenotype a population of Brassicas with differing vernalisation profiles.

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Reducing Salad Waste through Genetics

David has a long-term research interest in developing tools to improve a range of quantitative traits in field vegetables. His current research involves reducing postharvest discolouration in lettuce.

David Pink investigates ways to prevent pinking of cut lettuce.

The prepacked salad industry is growing at 15–20% per year, yet loss of postharvest quality results in over 50% of UK salad being thrown away. There is therefore a need to improve postharvest quality to reduce waste and deliver consistently good products to consumers.

A major cause of loss of quality is postharvest discolouration at cut surfaces, the occurrence of which is unpredictable but can occur in store or shortly after purchase.

Jim Monaghan examines the effects of stress on crop quality.

Research in collaboration with the lettuce breeding company Rijk Zwaan has identified quantitative trait loci for two types of postharvest discolouration: pinking and browning. The Saladin x Iceberg linkage map used for this study is anchored to the consensus lettuce linkage map and comparative studies have placed ESTs of genes in the phenyl propanoid pathway in some of the QTL regions.

Future studies will map phenyl-propanoid genes directly in the Saladin x Iceberg population and use transcriptomics and metabolomics to increase understanding of the genetic and biochemical regulation of post-harvest discolouration in lettuce.

This will allow lettuce breeders to optimise gene combinations, and together with agronomic studies, lettuce growers will be able to produce crops that are less likely to discolour.

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Insect Behaviour

Tom is currently working with colleagues at ADAS and the University of Warwick on a CRD-funded project to develop a novel approach to control adult vine weevil (*Otiorhynchus sulcatus*).

The approach is based on three aspects of adult vine weevil biology. Firstly, adult weevils are nocturnal and hide within suitable refuges during the day, such as the undersides of plant pots, under the rims of pots, within leaf litter, under plastic mulches and so on.

Secondly, adult weevils exhibit aggregation behaviour. While the mechanism by which weevils aggregate together is not fully understood, it is known that weevils are more likely to aggregate within previously occupied refuges and that weevils respond positively to odours associated with weevil frass.

Thirdly, adult vine weevils are susceptible to infection by entomopathogenic fungi, although an infected weevil takes several days to die.

Based on these aspects of vine weevil biology, there is the potential to use auto-dissemination, or horizontal transmission, of spores of an entomopathogenic fungus as a means of controlling adult vine weevil. However, to be effective this approach requires the adult vine weevil to move through the crop environment in order to spread the pathogen from a series of artificial refuges placed within the crop.

Tom Pope is using radio-frequency ID tags to monitor vine weevil dispersal.

Currently there is little information on the movement of adult vine weevil within crop environments. This lack of information is partly due to the difficulty in using traditional mark-release-recapture studies to study this insect.

Tom's project exploits modern animal tracking techniques and uses radio-frequency identification tags to record the movement of adult weevils in crop environments. Results from this study will be used to determine the feasibility of using auto-dissemination of an entomopathogenic fungus as a means of controlling this pest.

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Evidence-based Agriculture

Nicola leads the Centre for Evidence-Based Agriculture at Harper Adams. Her work involves collating, re-analysing and summarising existing research to answer questions set by policy

and management organisations. For example, pollution of rivers and other water courses can be partially attributed to farming practices, and with European requirements to improve water quality, policies that reduce pollutants in watercourses are essential.

Some of Nicola's recent work, (funded by NERC and Defra), has synthesised research that assesses the efficacy of different cover crop plants for reducing the movement of nitrates into watercourses. She follows structured, transparent protocols for searching, selection and analysing existing research to answer questions or to identify research gaps.

Different types of evidence syntheses are used; these vary in scope and methodology depending on the type of question being addressed. Systematic reviews aim to answer specific questions such as 'How effective are different cover crops at reducing nitrates in water courses?', whereas systematic maps collate the available evidence for a topic area, both processes may take up to a year to complete.

Policy organisations such as Defra often need a faster response and so rapid evidence assessments are being used. These follow structured review methodologies, but limit the resources searched and analysed in order to achieve a more rapid, albeit potentially less thorough result. Whatever the question, evidence syntheses are valuable to both policy and management decision-making.

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Applied Biochar Research

Jim Waterson investigates and evaluates the physical and operational characteristics of a range of biomass-derived biochars in relation to use in crop systems.

The use of biochars in agriculture and horticulture systems can benefit plant growth.

A range of production methods from full pyrolysis systems to less-complex retort operations are used to produce the biochars. They are principally derived from mainstream forestry or agricultural feedstock sources and offer a number of potentially useful attributes to agriculture, horticulture and soil improvement, plus measurable, sustainable carbon sequestration.

Biochar appears to offer the opportunity to increase soil moisture retention and soil porosity, and enhance nutrient retention within soils and growing media to benefit plant growth.

Jim is extending this work further to involve:

- Broader investigation of available and appropriate waste or co-product feedstocks for biochar production and assessment.
- Combining work on operational applications for biochar with the environmental and soil chemistry aspects of biochar production and use.
- Working with a broader range of academic and industrial partners to generate useful, industry-relevant experience, evidence and information.

SEB ANNUAL MEETING 2014

1 - 4 JULY MANCHESTER

The SEB annual conference brings together biologists from all over the world to share and discuss their research. With scientific sessions spanning animal, cell and plant biology, SEB Manchester presents an excellent opportunity for researchers at all stages of their career to meet and present their work to their peers.

Oral and poster presentation opportunities are available in every session. In addition to the scientific sessions, we also have career development opportunities, a CV clinic available and a host of lively social events.

Plant and Cell Biology Sessions taking place at the meeting are as follows:

- Mechanisms of Plant-Insect Interactions
- The Hows and Whys of Protein-Membrane Interactions in Plants
- Coping with a Rhythmic Environment: the Interplay Between Circadian Clocks, Metabolic State and Environmental Stress
- Plant Architecture
- Glucan Storage Biology
- Roots for Global Food Security (A tribute to Bill Davies)
- Nuclear Envelope
- Biomechanics of Plant Movement
- Plant Cell Imaging
- Roots for Global Food Security (A tribute to Bill Davies)
- Synthetic Biology: Molecular and Cellular Aspects
- Computational Systems in Cell Biology
  - Gene regulatory networks
  - Frontiers in imagining and analysis
  - The dynamics of morphogenesis and multi-scale modeling
  - Integrating Models into the Environment

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