Division of Plant Sciences

University of Dundee

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The Plant Sciences Division conducts basic research into how plants grow and develop in response to their environment, biochemical processes and biotechnological developments, and genome structure and plant biodiversity. The University of Dundee plant scientists have been located on the SCRI campus since 2003. In 2007, the College of Life Sciences created the Division of Plant Sciences presenting a major opportunity for UoD plant scientists to establish a strong identity both within the College and internationally and to build and expand on the partnership between SCRI and CLS.

The new Division of Plant Sciences is made up of eight research groups: the original five University groups at SCRI (Andy Flavell, Claire Halpin, Lyn Jones, John Raven and Gordon Simpson) along with Steve Hubbard, who has recently re-located from the University campus, and the appointment of Paul Birch and John Brown to personal chairs. Prof. Carol MacKintosh of the MRC Protein Phosphorylation Unit is an affiliate member of the Division due to her interests in control of plant metabolism by phosphorylation and 14-3-3 proteins. John Brown heads the Division with Claire Halpin as Deputy Head, who also received a well-deserved personal chair in 2007.

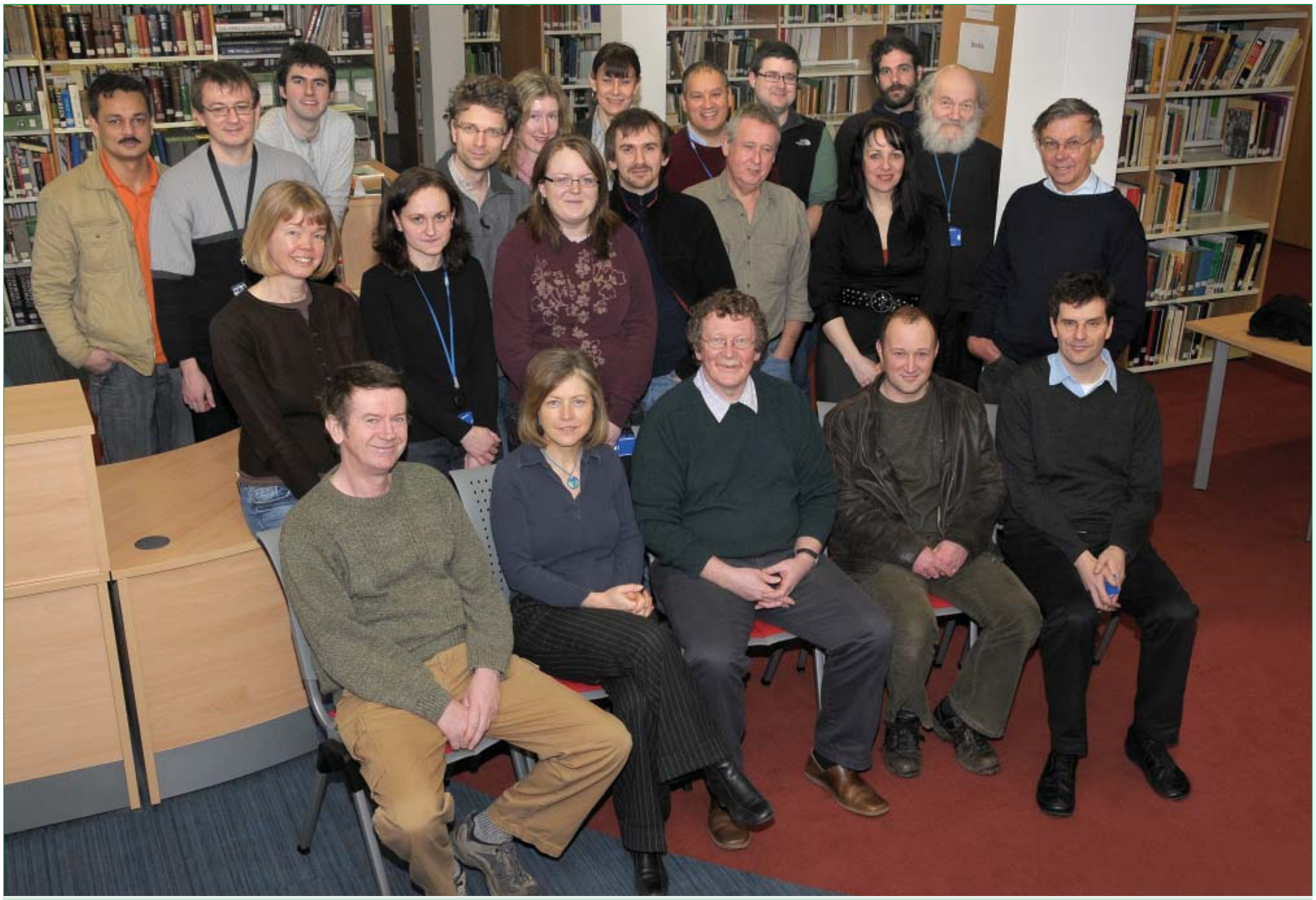
The goals of the Division are to increase its international standing in basic plant sciences, to bring in significant external funding and publish in the best journals, and to attract excellent plant scientists to a career in Dundee. It will also expand the already successful interactions with SCRI scientists and research groups which have led to substantial joint funding and new opportunities.

The main activities of the Division's research groups in 2007 are summarised below:

Transposons, genome evolution and biodiversity (Dr Andy Flavell) Dr Andy Flavell's research is centred upon genome structure and evolution in crop plants. Crop genomes have been selected from wild ancestors by thousands of years of human selection, leading to a big reduction in biodiversity. The Flavell group has developed and used molecular markers to study this diversity. These markers are being applied to the improvement of fungal resistance in wheat and potato by breeding, in partnership with SCRI (Robbie Waugh, Glenn Bryan) with the support of the European Commission (EU Framework 6 project BIOEXPLOIT; joint value to SCRI/UoD £1.25 million; http://www.bioexploit.net/). The Flavell group is also involved in another EU-sponsored project analyzing field pea biodiversity (Project GRAIN LEGUMES). The lab collaborates closely with Dr David Marshall and colleagues at SCRI to refine the GERMINATE database for storing, manipulating and displaying data related to plant biodiversity. This work is supported by both BIOEXPLOIT and a UK BBSRC Project grant (GERMINATE 2; http://bioinf.scri.ac.uk/germinate/wordpress/) which began in 2007. Finally, the Flavell group is coordinating a consortium that includes SCRI (Joanne Russell, Robbie Waugh) and five mainland European cereal genomics labs with the goal of developing a novel association mapping approach for capturing useful new gene alleles from wild and landrace barley and transferring them into cultivated germplasm, funded by ERA-PG Programme (http://www.erapg.org/).

How plant pathogens trigger, suppress or manipulate host defences (Prof. Paul Birch) To suppress or otherwise manipulate plant defences, pathogens secrete molecules that can interact with host cells. In some cases these virulence determinants (effectors) are delivered (translocated) inside plant cells where they directly interact with host proteins, re-programming host defences to the pathogen's benefit. Prof. Birch's group focuses on two economically important pathogens of potato, the oomycete *Phytophthora infestans*, which causes late blight disease, and the enterobacterium *Pectobacterium atrosepticum,* which causes blackleg and soft rot. A major goal is to understand the key plant defence pathways that must be manipulated in order to establish a susceptible environment for disease development. The group is funded to study *P. infestans* effector functions via EU BIOEXPLOIT and the BBSRC Crop Science Initiative (in collaboration with Drs Steve Whisson and Leighton Pritchard at SCRI). A RERAD-funded systems biology project and BBSRC-RERAD jointly funded project (in collaboration with Drs Ian Toth and Leighton Pritchard at SCRI) seek to identify and characterize the major virulence determinants in *Pectobacterium*, and to understand the central components of plant defence that are targeted by this pathogen.

Manipulation of plant metabolism using reverse genetics (Prof. Claire Halpin) Understanding and manipulating the composition and structure of plant cell walls has become a major research objective worldwide due to the current interest in producing bioenergy and biofuels from plant biomass. There have been many new funding opportunities in this area in 2007 that we have been quick to exploit, leading to several new projects in the Halpin labs. Dr Jennifer Stephens is embarking on a BBSRC-funded project on the molecular-genetics of lignin biosynthesis in barley, in collaboration with Robbie Waugh and several of his team in the Genetics Programme. This work will include TILLING for lignin mutants in barley. Man-power on the project is supplemented by a BBSRC Targeted Priority Studentship in Crop Science awarded to Paul Daly. A Collaborative Research proposal to the FP7 call on Plant Cell Walls has also been successful and the €6 million project, coordinated by Prof. Simon McQueen Mason (York University), will start early in 2008. The Dundee role in this project is to investigate lignin biosynthesis in the emerging monocot model species, Brachypodium. This new work will have significant synergies with the on-going barley work. A programme grant, jointly held with Dr. Gordon Simpson, from the GCEP (Global Change and Energy Project) at Stanford University will



shortly allow us to begin more basic gene-discovery work on cell wall biosynthesis in Arabidopsis. Work continues in the area of plant recombination and gene targeting under a Leverhulme grant that funds Dr. Abdellah Barakate. This work is also leading to increasing collaboration with the Genetics programme, principally with Dr Luke Ramsey, with whom we have a BBSRC LOLA application in the process of evaluation.

RNA processing and expression (Prof. John W. S. Brown) Plant growth and development, and how plants respond to pathogens and the environment in which they grow, reflect complex gene expression patterns. The Brown lab is interested in how gene expression in plants is modulated by post-transcriptional processes such as alternative splicing and small non-coding RNAs. The importance of alternative splicing is well recognised in animals due to many diseases being caused by mutations affecting splicing and alternative splicing. In plants, around 35% of Arabidopsis/rice genes are estimated to undergo alternative splicing. Key questions are 1) which plant factors determine splice site selection, 2) how do particular combinations of factors in different cells and tissues determine tissue-specific alternative splicing, and 3) how are alternative splicing patterns and levels of splicing factors affected by environmental and developmental cues? John Brown and Craig Simpson (SCRI) have established an accurate and reproducible RT-PCR system to examine 400 alternative splicing events simultaneously. This provides the basis for studying the effects of RNA-interacting proteins involved in aspects of mRNA biogenesis on splicing and alternative splicing. This particular research area receives funding from the European Alternative Splicing Network of Excellence (EURASNET) in collaboration with the labs of Andrea Barta and Artur Jarmolowski in Vienna and Poznań.

Regulated gene expression controlling flowering (Dr Gordon Simpson) Gordon Simpson's lab is studying how plants regulate gene expression to control the time at which they flower. Gordon's lab has been studying an RNA binding protein called FPA that promotes flowering. In order to understand how it does this, the key question they are trying to answer is: What RNAs does this protein bind? With funding from the BBSRC, Lionel Terzi, working in Gordon's lab, has successfully developed methodology to "fix" the interactions of an RNA binding protein to its target RNAs inside living cells. He has now used this methodology with FPA, so we should soon learn what the target RNAs are. To identify the RNAs, The Simpson lab is using state-of-the-art Solexa sequencing technology to sequence all the RNAs in *fpa* mutants. Katarzyna Rataj joined the lab in 2007 as a PhD student, funded by the BBSRC, and is focusing on identifying the proteins that FPA interacts with. This combination of approaches should tell us not only how FPA functions in controlling flowering, but provide a generally applicable strategy to uncover the function of the many RNA binding proteins that are specific to plants.

The dynamics of plant-aphid-microbe associations (Dr Steve Hubbard) The Hubbard group is concerned with the population dynamics of insect–microbe associations and the factors which affect these interactions. A considerable proportion of our work has been centred on the development of novel modelling techniques with which to describe these dynamics, and we have published several papers in recent years which describe the application of these ideas to host–parasitoid–bacterial associations. The principal experimental models for testing such techniques are insect parasitoid–host systems, and the endosymbiotic bacteria which are often associated with one or both partners. Dr Hubbard's move to SCRI has opened up a number of opportunities to develop this research in the context of aphid–parasitoid interactions, because aphids are host to a considerable community of primary and secondary bacterial endosymbionts, which have the capacity to influence the fitness of the aphid host and consequently its capacity to vector plant pathogens. He is also interested in the way in which these fine-grained phenomena affect broader scale issues such as community dynamics and biodiversity amongst insects in farmland habitats.

Plant ecophysiology and adaptation to environmental stress (Prof. Hamlyn Jones) Research in Prof. Lyn Jones's group aims to understand the ways in which plants can tolerate individual environmental stresses such as drought and salinity as a basis for improving both the genotypes available for agriculture and for improving crop management for stressful conditions. A key development has been the use of thermal remote sensing for detecting water stress in crops and this year the group has successfully applied this technology to the phenotyping of rice cultivars for drought tolerance in collaboration with groups in the Philippines, Huazhong Agricultural University and the University of Aberdeen. In related work the group is also developing thermal sensing as a tool for the automated scheduling of irrigation in the Hardy Nursery Stock nurseries, while a larger-scale application for scheduling irrigation in vineyards has been tested in a large commercial vineyard in South Australia (in collaboration with CSIRO, Australia). A repeat trial is underway to confirm the reliability of the technique. In a new line of work the group is investigating the physiological mechanisms underlying the tolerance of some plants to soils containing high concentrations of heavy metals, particularly those on "serpentine" rocks. This is in collaboration with a group from the Bulgarian Academy of Sciences.

Interactions among resources in the growth of phytoplankton (Prof. John Raven, FRS). Diatoms deciphered: diatoms in the surface ocean account for up to a fifth of global primary productivity, yet many fundamental aspects of their functioning remain unclear. An example is the unexpected findings obtained with colleagues in Sheffield on the means by which carbon from dissolved carbon dioxide becomes organic carbon where two closely related species of marine diatom have different biochemical pathways of inorganic carbon assimilation. Work on another species of diatom with a German colleague led to the discovery of the first example of spontaneous oscillations in the rate of photosynthesis in a unicellular organism. While the mechanism of these oscillations is not yet fully understood, the results clearly show that some earlier interpretations of related phenomena in land plant leaves involving cell–cell interactions are not of universal applicability.