Plant Research Unit, University of Dundee

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Since its move to SCRI two years ago, the Plant Research Unit of the University of Dundee continues to grow with the first joint appointment, Dr. Gordon Simpson, made in late 2004. The Unit now constitutes 5 Principal Investigators with a combined research staff of 20 people. The Unit is part of the Division of Environmental and Applied Biology within the University's School of Life Sciences. The School received the highest possible, 5 rating in the most recent research assessment exercise and, in 2005, was once again voted the best place to work in Europe by readers of The Scientist magazine. The research interests of the Division of Environmental and Applied Biology include basic studies in microbial, plant and animal ecophysiology and molecular biology complemented by more solution-focussed projects in environmental biotechnology. The work of the Plant Research Unit, like that of the rest of the Division, impacts on issues of major public concern such as biodiversity, the impact of climate change on plant productivity, and the benefits and risks of plant biotechnology.*

The Plant Research Unit comprises five research groups with major interests in:

- Transposons, genome evolution and biodiversity in plants (Dr Andy Flavell)
- Manipulation of plant metabolism using reverse genetics (Dr Claire Halpin)
- Plant ecophysiology and adaptation to environmental stress (Prof. Lyn Jones)
- How photosynthetic organisms acquire carbon (Prof. John A. Raven FRS FRSE)
- Regulated gene expression controlling floral development (Dr Gordon Simpson)

Transposons One major thrust of the unit's research is to understand how plants adapt to diverse environmental stresses. The underlying genetic variation within a species – its biodiversity – that enables such adaptation, is the focus of Dr Andy Flavell's research. This biodiversity, encoded by the different DNA sequences in all the individuals of that species, has built up over millions of years via naturally arising mutation and natural selection. Mobile genetic elements, known as transposons, have emerged as dominant factors that underly this biodiversity in plants and many other eukaryotes. Dr Flavell's group is interested both in the basic biology of these genetic

elements and in exploiting them as molecular markers for genetic and genomic studies in plants, since one of the big problems facing biodiversity research is the measurement of genetic variation across thousands or millions of organisms. An important offshoot of the marker studies has been the extension of the transposon-based marker technologies to accommodate single nucleotide polymorphism (SNP)-based molecular markers, greatly expanding the scope of the methods. This aspect of Dr Flavell's work has recently resulted in the award of a large EU Framework 6 grant (BIOEXPLOIT; joint value to SCRI/UoD £1.25 million) to collaborate with researchers at SCRI to exploit high throughput SNP marker technology for the improvement of fungal resistance in wheat and potato. Other collaborative work with SCRI to create the GERMINATE database for storing, manipulating and displaying data related to plant biodiversity has also been extremely successful and the database has already been adopted by several EU projects (GENE-MINE, TEGERM, BIOEXPLOIT). Work to further develop the database will continue under BIOEXPLOIT.

Plant ecophysiology Prof. Lyn Jones takes a more ecophysiological approach to understanding specific plant stress responses in a broad spectrum of research that extends from genetic and biochemical studies of salt and heat tolerance through to environmental and climatic modelling and remote sensing. A particular focus of the work is to determine the genetic and ecophysiological basis underlying differences in the growth and distribution of wild and crop plants and for predicting the consequences of global climate change. A key theme is to understand the role of plant water relations and of processes such as photosynthesis, stomatal closure, osmoregulation, root growth and changes in hydraulic function in plant adaptation to drought. One aim of this work is to identify the genetic basis of tolerance of drought and salinity as an aid to crop improvement programmes. In the past year, Prof. Jones' group, in collaboration with a visitor from Russia, Dr Vysotskaya, and colleagues at SCRI, has made significant advances in understanding the genetic basis of salinity tolerance in barley. This included identification of genotypic variation in gene expression responses, which is now feeding into a collaborative mapping study of the most interesting genes. Significant advances were also made in understanding heat tolerance of the photosynthetic system by identifying clear differences in physiological response between tolerant and sensitive species. This work involved another international visitor, Dr Stasyk (Ukraine). Prof. Jones' group has also continued their development of thermal imaging and image analysis as a tool for studying stomatal behaviour and stress responses. This work has formed the basis for a £1.5 million HORTLINK project that has just been awarded to develop automated irrigation control systems and work also continues on a major Defra contract (£1.4 million total) to develop new irrigation technologies for field crops. These projects aim to improve agricultural and horticultural sustainability in the face of environmental stresses including potential climate change.

Oceanic absorption of carbon As well as potentially influencing climate, the excess carbon dioxide being released into the atmosphere by human activities is

being absorbed by the oceans, making them more acidic. This threatens the survival of many species and ecosystems. Prof. John Raven (FRS FRSE) chaired a Royal Society Working Group on the problem in 2005. Their subsequent report warns that acidification of the world's oceans has already increased to a level that is irreversible in our lifetimes and recommends that a major international effort be launched into this relatively new area of research, and that action needs to be taken now to reduce global emissions of CO_2 from human activities. Prof. Raven expands on aspects of his current research on marine photosynthetic organisms, including work on the effects of increased carbon dioxide on phytoplankton (see following article by Raven, J.A. *et al.*).

Control of floral development Researchers within the Plant Research Unit also focus on fundamental aspects of plant development, principally flowering and lignification. Dr Gordon Simpson's lab studies the mechanisms by which plants control floral development. To do this, he uses the model plant *Arabidopsis* as well as important cereal crops like rice and barley. This year, Dr Simpson's lab has focussed on three research areas. First, they have studied how one particular RNA binding protein, FPA, promotes flowering. Second, they have isolated new early flowering mutants of *Arabidopsis* in order to detail the connections between genes that control flowering time and those that promote floral development. Third they have studied barley mutants that are unable to properly control the number of flowers (and hence the number of grain) they make. This work makes use of the extensive collection of Optic barley mutants at SCRI. Dr Simpson's research has got off to a flying start with the recent award of a BBSRC research grant and a Strategic Studentship in Crop Science (one of only ten awarded over the whole of the UK). In 2005 Dr Simpson was appointed to the BBSRC Small Grain Cereals Steering Committee.

Biosynthesis of lignin Dr Claire Halpin is also using the Optic barley mutants in her work to understand how plants make lignin. Although the sequence of biochemical reactions on the lignin biosynthetic pathway were first outlined over 40 years ago, recent biochemical and molecular studies have revealed many errors and the pathway is currently undergoing revision. The approach taken by Dr Halpin's group to investigate the pathway is to produce transgenic plants where key lignin biosynthetic genes have been manipulated. This has proved to be an extremely powerful tool and has also led to ideas about how to improve plant raw materials for agricultural and industrial processes. A new area of collaborative research with SCRI in 2005 has been to investigate the potential of lignin manipulation in barley for improving its digestibility as an animal feed or as a raw material for biofuel production. Collaborative work with Prof. David Hopkins (Stirling University) has focussed on the potential ecological and environmental impacts of transgenic trees and crops with modified lignin. Dr Halpin's group has also progressed projects to develop enabling technologies for 'clean' plant transgenesis, such as gene targeting, and has recently won a Commercialization Award from Scottish Enterprise Tayside and the University of Dundee to further this work.