The role of cyclic nucleotides in stomatal responses to environmental signals

Supervisory team:
Main supervisor: Prof Alistair Hetherington (University of Bristol)
Second supervisor: Prof Nick Smirnoff (University of Exeter)
Prof Kerry Franklin (University of Bristol)

Collaborators: Prof Marc Beaumont (University of Bristol), Prof Merv Miles (University of Bristol), Dr Gary Barker (University of Bristol), Prof Colin Brownlee (Marine Biological Association, Plymouth, UK)

Host institution: University of Bristol

Project description:
Experiments conducted over the last 40 years suggest a role for cyclic nucleotides (CNs) in plant cell signalling. However, the precise nature of the plant signalling system responsible for modulating CN levels and responding to changes in CN concentration is not clear. We do know that CN signalling in plants is different to the canonical system encountered in mammals because no higher plant genome has been shown to contain either the cAMP activated protein kinase A or PKG that is modulated by cGMP. However plants do contain a large family on CN-modulated ion channels. Another major issue has been the lack of a CN modulated phosphodiesterase (cnPDE). In a recent breakthrough (unpublished) we have used advanced bioinformatics to identify an Arabidopsis gene that encodes a protein with cGMP PDE activity (AtPDE1). Our analyses reveal that this gene originated in bacteria and has been retained as a single copy gene in plant genomes but has been lost from animal lineages. This suggests that there are significant differences between animal and plant CN signalling.

The objective of this studentship, co-supervised by Prof Nick Smirnoff (Exeter) and Prof Kerry Franklin (Bristol) is to fully characterise the role of this gene in guard cell signalling and to determine its role in crop water use efficiency. Our unpublished data suggest that it is involved in light and ABA mediated stomatal responses. The work in the studentship will involve investigating whether cGMP levels are modulated in guard cells in response to light ABA and CO2 using a novel single cell cGMP sensor (FlincG). The student will also fully characterise the role of the PDE1 gene in Arabidopsis by using gas exchange, bioassay techniques and atomic force microscopy (with Prof Merv Miles FRS, Physics) to monitor stomatal responses in the mutant. We will investigate what other genes are involved in the cGMP gene regulatory network using transcriptomics and use CRISPR-Cas9 (with Prof K Edwards and Gary Barker, Biology) to manipulate the expression of PDE1 in wheat and subsequently characterise its effect on water use efficiency. The student will gain a thorough training in imaging, plant cell and molecular physiology, gene manipulation and techniques used to investigate stomatal behaviour.