*Plant-environment interactions in Norwich, UK*

# Fruitful Flowering

Spring is once again upon us and with it comes the seasonal burst of flowers and blossom that make it such a sensual experience. However, Philip Wigge and his group at the John Innes Centre (Norwich, England) trigger the flowering response all year round in order to understand its underlying mechanisms.

Buds waiting for florigen

The transition to flowering is one of the major changes that a plant makes during its life cycle. It must occur at a time that ensures maximal reproductive success and is dependent upon the plant's correct interpretation of changing environmental factors such as temperature, light intensity, rainfall and day length.

## Long sought traveller

Some 70 years ago, it was discovered that leaves exposed to light could trigger flowering in a darkened shoot, indicating that a triggering hormone, termed 'florigen', was communicating environmental signals from the leaves over relatively long distances through the plant phloem to the shoot apex where flowers are formed. After fruitless years spent trying to chemically isolate the florigen agent, the combined application of genetics and molecular biology to the diminutive flowering plant model, *Arabidopsis thaliana* (thale cress), has finally led to its identification. There are, in fact, four distinct pathways controlling flowering time in *Arabidopsis* – the photoperiodic, autonomous, vernalisation, and gibberellin pathways.

Phil Wigge, waiting for ...?

The key to the identification of florigen was the realisation that all four pathways converge on the transcriptional regulation of the floral integrator genes, *FLOWERING LOCUS T (FT)* and *LEAFY*. During his postdoc with Detlef Weigel, first at the Salk Institute in San Diego and then in Tübingen (Germany), Phil Wigge and graduate student Katja Jaeger helped to piece together the molecular events at the heart of the photoperiod pathway, demonstrating that FT is the primary target of this pathway in leaves and that it could transduce its signal by interacting with FD, a bZIP transcription factor. Simultaneously, the group of Takashi Araki in Japan came to the same conclusions. However, it remained to be shown that FT was indeed being transported from the leaves to cells in the shoot apical meristem to form an active transcription complex with FD. The retraction of an initial report that it is the FT mRNA, which is transported and subsequently translated, has been followed by several closely-spaced reports from labs all over the world demonstrating that it is in fact the FT protein which is mobile. For their part, Phil Wigge and Katja Jaeger, successfully uncoupled intercellular trafficking of FT protein from its biological activity (generating a biologically active FT protein immobilised in the cell nucleus) to show that FT protein is indeed the mobile signal that travels from the leaves to trigger flowering at the shoot apex (*Science*, 2005, vol. 309, p. 1056).

The florigen story has been very exciting, but the field has become immeasurably more competitive since Phil started working in it in 2000. The Wigge lab increasingly continues to focus on how plants perceive and respond to temperature. It has been some 1.6 billion years since plants and animals diverged from their last common unicellular ancestor. As multicellular life, plants and animals have subsequently evolved along very different lines, evolving different mechanisms for solving unique problems of development and intercellular signalling. Since they can't move, plants are obliged to constantly fine-tune their development to the localised environment. "It's a fantastically interesting and tractable system to address fundamental questions of transcription and environmental perception," he says. "This is analogous to thinking about the genetic basis of behaviour in animals." Notably, how do plants actually sense ambient temperature? Unable to seek shelter, plants are exposed to considerable fluctuations in temperature during the day-night cycle and as weather conditions and seasons change, not to mention the effects of climate change, which are already having measurable effects on the wild-plants and crops.

Phil Wigge's interest in plant behaviour can be traced back to his own intense exposure to nature as a child. "I grew up on an island in the Mediterranean (Formentera, the smallest of Spain's Balearic islands), and didn't go to school until I was 16, as my parents didn't believe in compulsory education. We didn't have television or cinema, just books and nature.

## Inspiring role models

"I became interested in science through birdwatching and nature study. When I was about 12, I wrote a letter to David Bellamy (a prominent English botanist) whose "i-spy" nature books had been such an inspiration to me, claiming somewhat improbably that I was a journalist for l'Express magazine. He was very nice, allowing me to meet him in England, where he told me about his fascination with plants. It was around then that I realised that I had to get into university if I wanted to study science seriously. This encounter excited me so much I enrolled myself in evening classes for adults so I could take the university entrance exams. By remarkably good luck I then got into Oxford University through a fluke. The tutor later told me that she always liked to take one unconventional applicant."

Phil then chose to do his PhD on budding yeast mitosis at the renowned Labo-

ratory of Molecular Biology in Cambridge, where he had the chance "to meet and talk with so many extraordinary scientists. Cesar Milstein and Max Perutz were both still coming into the lab when I was doing my PhD, talking to us over tea and coffee. It was a really formative period with small research groups and group leaders still working at the bench."

He moved on to plant biology at the Salk Institute in San Diego (USA) where he did his postdoc with Detlef Weigel. Here again, "there was an extraordinary constellation of scientists, including Francis Crick. In plant science, of course, Detlef Weigel, Joanne Chory, and Joe Ecker were extraordinarily inspiring role models."

When Detlef Weigel moved to the Max Planck Institute of Developmental Biology at Tubingen (Germany), Phil followed. Here he met Katja Jaeger, his future wife, whose background in plant development perfectly complemented Phil's more biochemical background. After fruitful work at the MPI they moved to the UK to set up their lab together, pursuing their common research interest into how plants perceive and respond to environmental changes. In 2004, Phil became a staff scientist at the John Innes Centre (JIC), with a six-year tenure-track contract.

## People, people, people

"Right now in my career, the JIC is simply the best place to work. Norwich is a mecca for plant science, and a huge number of the major breakthroughs in plant biology (small RNAs, floral architecture, flowering studies) have been achieved here. There is an amazing critical mass of excellent scientists, which gives the place a real buzz. The hardest thing when starting a group is sometimes attracting great people, since one doesn't have a track record. I think being at JIC was a boost, since the place has such a high profile among plant scientists.

"Also, there are few places where one is given independence and responsibility straight from a first postdoc. This lack of independence for starting scientists has always been a major drag on European science as a whole compared to the US. We're very lucky now, since this seems to be changing dramatically: Europe is waking up to reality. Hugely encouraging in this regard are the new European Research Council (ERC) grants for starting researchers. It was a real honour for me to go to Brussels this winter and give a talk outlining a large 5-year program. I still don't know if I'll make the grade, since in the rankings table we're right up against the estimated cut-off, but we're keeping our fingers crossed. It was certainly great to finally see so many outstanding young scientists being assessed solely on the basis of their science, rather than by well meaning, but ultimately counter-productive, political agendas.

"Another advantage of JIC is that it is a pure research institute, in the same guise as LMB Cambridge, Salk and the Max Planck Institutes. This has the advantage that you can really focus on the research."

## Productive pluralism

"If I had to give someone advice about starting their group, it would be: people, people, people and communication, communication, communication! Group leaders have an important role to bring in funding and provide some ideas to seed the research, but in reality, postdocs and students are the key people, since they provide the real insight and creative thinking behind most of the discoveries. Nobody knows where the next breakthrough will be; more often than not it'll come from a chance conversation at the water-cooler. We have a small lab, but we have very diverse backgrounds, this leads to a sort of disciplined pluralism, which is very productive and exciting. The standard of people who are applying now just takes my breath away. It's odd to think that if I was interviewing myself 10 years ago, I don't think I'd get into my own lab!

"Making the transition from the bench to the office (writing grants and bringing in resources to support the lab) is a really interesting one, and one realises how important actually doing the experiments is to get an insight into the biology. Most of the experiments planned carefully in advance don't actually work as you expect. It's what one sees and observes during the experiment that makes all the difference. This isn't just serendipity, you really have to be watching for these things – but you can't plan it either. My people are now so good, they just do the minimum of things I suggest, to humour me, and they work out all the key experiments themselves. They're nice enough about it to make me feel like it was my idea too!

## Moving to the real world

"One thing I did early on, which I really recommend, was to attend the EMBO Young Investigator Program Management course run in Heidelberg. This was a great opportunity for me to meet 20 other project leaders who were also in the same boat, starting their groups. We spent a really insightful 3 days talking about common issues that come up when running a group. I don't think it made me a perfect manager but it certainly made me aware of some of my limitations, which might be even more important."

"At a higher level, there are now some very exciting collaborations starting between the JIC and the world leading University of East Anglia Environmental Sciences Department. While I had always wanted to study environmental sciences at university, I was put off by what I felt was a largely descriptive, rather than mechanistic, understanding of the field. That may well have been a misconception, but in the longer term, being able to use the power of molecular biology to unravel complex ecological questions, as well as hopefully do something useful, would be very rewarding. In the future, we'll see some of the most interesting work moving from model systems to organisms in the real world. The massive advances made in high throughput sequencing and ChIP methods will make non-model systems as tractable as model systems. We've started a couple of collaborations now with groups working on diatoms and orchids, which are addressing some really interesting aspects of how organisms will respond to climate change, at a molecular level. Just 10 years ago, I think such approaches would have been unthinkable, it's amazing how quickly science is advancing."

JEREMY GARWOOD