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SPOTLIGHT

An interview with Ykä Helariutta

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Yrjö (Ykä) Helariutta is a group leader at The Institute of Biotechnology in the University of Helsinki and at the Sainsbury Laboratory in the University of Cambridge. Recently appointed an editor at Development, his lab works on vascular development in plants and trees. We met Ykä in his Cambridge office to hear how a childhood passion for collecting led him to plant science, what *Arabidopsis* can tell us about trees and vice versa, and why he thinks there are many different ways of being successful in science.

Let's go back to the beginning – did you always want to be a scientist?

I would say that, unlike many of my colleagues, I actually wanted to be a plant scientist very early. I was a collector in my childhood – we had all kinds of collections, from stamps to football and hockey player cards, and I used to trade these with my friends. And then there was an incident: I was in the countryside in my mother's family's place when a small building – thankfully not attached to the main house – burned down. The firemen were able to evacuate some items from the burning building, among them the school herbaria of my mother and aunts. Somehow, watching them, I thought that plants could be something interesting to collect and I started my own herbarium. It was really a hobby – but a serious one that my parents facilitated. In Finland in those days we did not have as rigorous a scientific education as you do here in Britain, so my interest was extra-curricular.

By my early teens I had started to more seriously collect plants, and got a lot of insight into plant diversity from a taxonomic point of view; I came to the realisation that this will be my profession, in some way. But for taxonomy you need to be able to draw, and I never really had that skill, so I decided to go for genetics. Gene discovery and gene mapping is like a modern version of a herbarium – instead of collecting new species we are classifying new genes.

Your PhD with Teemu Teeri focussed on flower development in gerbera. What were the main questions you were trying to answer and the main lessons the PhD taught you?

In Helsinki at that time, there were not too many options to do the plant developmental biology that I was interested in. My PhD project was a little bit commercial, but the company involved actually withdrew during my PhD period, so I was able to make the project a little bit more basic. We set out to try and understand the genetics of flower colours in these ornamental species, and also to hopefully manipulate them transgenically. This was the late 1980s – the GMO aspect was perhaps not so controversial, so the thinking was that maybe we could make transgenic cut flowers that would have new colours. In particular, I was working on the flavonoid biosynthetic genes in these flowers, and we found a new biosynthetic pathway that had arisen through gene duplication and diversification, and was involved in biotic stress protection. It wasn't a particularly developmental thesis, rather more descriptive.

What I learned from my PhD was that you can make a thesis from a very non-model organism. I wasn't working on *Arabidopsis* – my gerbera were relatively exotic and I learned to take risks in science through this experience. I learned that you don't have to be restricted to 'comfortable' instruments, models or questions, that you can actually ask questions that people have not asked before in systems that have not been used before. I think that was the main outcome and it's stayed with me in my career.

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You then left Helsinki for a postdoc with Philip Benfey in New York. How did you find living in the US, and what did you go there to work on?

I have to say I was a little bit surprised to get this opportunity – I had a friend who knew Philip and helped to set it up. I was familiar with Philip's work, and had seen his talks and heard him describing a series of new *Arabidopsis* mutants he was isolating. After my PhD with gerbera it was very clear that I wanted to do a postdoc with *Arabidopsis*, and I saw that there was a new field opening up through his research. So I was very happy to join his lab.

The Benfey lab is one of the big names in the field these days, but when I was there it was relatively small, and in my 3 years there I was the last to join and first to leave, so worked with the same group of people throughout. I learned genetics and how to combine it with molecular studies. Because it was a small group of dedicated people, I learned how to work in a group – communication, brainstorming, things like that, lessons which were very important to me. New York

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was also socially a very different experience compared to Helsinki! When you move to a new place, it's a very valuable experience: the only thing that is common between the previous environment and the new one is yourself, so somehow you have to figure out yourself, your strengths and weaknesses, and how you can keep your head above water in this new environment.

Another important aspect of my time in New York was my affiliation with the New York Botanical Garden. Interacting with the researchers there meant that I kept in touch with plant diversity and did not only think about *Arabidopsis*, continuing the thread from my PhD and childhood.

When you came back to start your own lab in Helsinki, what were your main aims?

When I went to New York I had a relatively clear idea that I would return to Finland, and I had already thought about working on wood formation, which is a developmental problem with applied perspectives (in Finland one might be able to get not only basic but strategic funding). I had a kind of masterplan, and I was lucky to be able to get some genetic material that was relevant to this problem: one of the classical loci from the Benfey lab was called *WOODEN LEG*, which Philip was not particularly interested in. There were just so many interesting and important genes coming out of the screen and Philip was more interested in the patterning of the ground tissues, so I was able to focus on the vasculature and take that to Finland with me.

The plan was to use *Arabidopsis* as a model for wood formation: the root in particular. I could have used the wood that *Arabidopsis* makes itself, but it's a bit more of a complicated process, so I decided to focus on the root and its so-called procambial development. I defined that as a model, starting with the one mutant from Philip but then also starting to do screens specifically for root procambial mutants, which no one had looked for before.

But at the same time, I always had a small team – initially only half a person – working on trees. When we cloned the *WOODEN LEG* gene in *Arabidopsis*, it turned out to be a receptor for a classical type of plant hormone, a cytokinin; then we found it belonged to a family of three related receptors. One of the very first experiments we did after identifying these genes was to amplify it in the cambial zone of the tree: could we use the *Arabidopsis* root as a real model for a process that happens in a tree? We were very enthusiastic to find that, yes, these kinds of sequences were also expressed in the tree cambium. So *Arabidopsis* really did seem to be a valid system for studying wood formation in trees. They might seem different but the underlying processes are basically the same: in trees you just grow more and the cell walls are a little bit thicker.

As well as *Arabidopsis* you've also used birch as a model for wood development: what do each of these models bring to the questions you're trying to answer?

When I came from Finland to the UK, I brought my *Arabidopsis* research to Cambridge, and was then able to expand the tree research in Helsinki, which was initially quite a small operation. The tree group works on two species, birch and poplar, looking at various developmental aspects. I must say that I'm very happy working in the Sainsbury Laboratory because it is situated in the Cambridge Botanical Garden, which has a small birch section – I feel at home here!

We typically work in two ways. First, there is the typical translational approach, where we discover something in *Arabidopsis*, and then test whether it is valid in trees. So, for instance, we found that the cytokinin hormones were important in stimulating radial growth of *Arabidopsis*, and then we stimulated cytokinin signalling in trees and got more growth there too. It's interesting and rewarding, but might be a little boring conceptually – you're often confirming something already found in *Arabidopsis*.

What I find a bit more interesting is to see if we can use trees, and in particular birch, as a model for forward genetics. There is an old Nature paper from the UK (Longman and Wareing, 1959) which shows that you can accelerate flowering in birch under certain greenhouse conditions, and in this way we can get a new generation in 1 year, from seed to seed. That's not so bad – I have a graduate student who has now made a backcross which gives us a mapping population for a mutant. So if we have a phenotype we can score early, we can do genetics in trees. The idea is to do forward genetics. You can start with phenotypes, where you do not know where the gene is, and, if you are lucky, you'll be able to find a new gene that you can then go back and test in *Arabidopsis*. Using this approach, we've started to look at phenotypes. We have trees that look like bushes because their apical domain is compromised. The gene we isolated, *MAX1*, turned out to have been cloned initially in *Arabidopsis* by Ottoline Leyser, the director of our institute here in Cambridge! Of course again it's a little bit boring in the sense that she had already discovered it, but it validates the approach. We have another mutant that we are very enthusiastic about – the trees grow up to something like 70 cm, until they fall down. Somehow the trees cannot support the growth, the wood cannot support the mechanical stress. We hope this will tell us a lot about how the mechanical properties of wood are formed.

And what about the practical implications of this developmental biology knowledge?

Poplars are actually quite a widespread global model for tree growth – it was the third plant genome sequenced – but in Finland, the birch is also somewhat important economically. But application of developmental biology knowledge to forestry is not really happening yet. Forestry companies are big companies that operate with a certain mode, and tree breeding is quite a slow process that doesn't quite fit with the business model. And of course transgenic trees, transgenic forests, would not really be accepted by the public, in Europe at least. We have, however, had interactions with forestry companies, and they have supported some of our applications financially, but we don't really have a genuine collaboration. I think we need to do more work to find a common basis for collaboration with them. It's still a little open: globally there are forest companies that interact with plant biotech and this is something we could look into.

You've worked on various aspects of vascular patterning in recent years – what fascinates you about this tissue?

Initially, I liked the idea of the vasculature model as another stem cell system to add to the shoot and root meristems that have been the focus of so much investigation in the field. In our case, we also have lateral growth, where the plants are basically growing fatter, and that involves another stem cell population; this stem cell angle was my focus in the early years. But more recently I have shifted to thinking about carbon allocation – the plant fixes carbon from the atmosphere and needs to allocate it somewhere in its body. The phloem tissue, which is part of the vasculature, is one of the main routes for carbon allocation, and stem cell proliferation creates sink tissues where the carbon is deposited. So it's a developmental problem, but one with a more ecosystem or planetary science dimension, and we are now very interested in the control of this process. The vasculature creates wood, but we also have other

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carbon sinks like the storage organs you see in cassava, a woody plant that can also make the tubers that people eat; somehow, the plant can regulate where and how it deposits carbon. Quite recently we found a mutation in *Arabidopsis* which induces this kind of storage organ and this is something we are very much pursuing. We are also interested now in the interaction between metabolism and development, both in an adaptive sense but also in terms of domestication – many crop species have, over the course of thousands of years, been selected for special forms of development, and vasculature development has been under intense domestication. So it's a case of broadening our perspectives to include things like eco-devo, evo-devo and domestication.

Where do you see plant developmental biology going in the next decade?

It's a very exciting time to do plant developmental biology. We are in an era where most of the regulatory pathways have been discovered – for instance, we know how plant hormones are perceived, what kinds of components are transducing the signal downstream, as well as the identity of several transcription factors that regulate the output of the pathways. There are still many growth regulators to be identified, but I think the next question is how all of these factors and pathways can be integrated, and how pathway dynamics are regulated. This will require a single-cell level of analysis. And the other thing is diversity – we now have a deep understanding of *Arabidopsis* but not of how plant diversity is manifested at the developmental level.

Ideas of dynamics, single cell analysis and diversity would also come up if I asked the same question to an animal developmental biologist about their field. What do you think of the relationship between plant and animal developmental biology?

I think it's good to have forums, like Development, where the two sides are exposed to each other – this is very valuable. I've seen attempts where people have tried to force the sides together and I don't think that plays out very well. But I worked in an institute in Helsinki where we had very strong animal and plant programmes, and it was good to follow each other's talks without having to, for instance, force collaboration. Just being exposed to one another is probably enough. There are definitely common themes and concepts that can flow both ways, but the problem is that the developmental basis is not common, as multicellularity arose independently in the two lineages. So inevitably, the language spoken in these two different communities is different, which remains a little bit of a problem. But I think that as we go deeper into development, we are developing mathematical and theoretical explanations that are actually relevant to any organism; the language is the same. So quantitative approaches might provide more of a forum for the fields to come together.

There are so many ways to be successful in science

As a newly appointed editor at Development, what do you hope to achieve in this role?

I should say that I feel privileged: it is a great honour to step into a position that has previously been held by Ben Scheres and Ottoline Leyser. Thanks to their work, Development has a very high reputation in plant science – it is a home for good papers and good stories, and I hope I'll be able to maintain that impression. I think that's my main aim – to maintain that high standard. The stories we publish also should have the potential to appeal to a non-plant audience, to justify why they are appearing in Development rather than a more specialised journal.

Do you have any advice for young scientists considering a career in research?

I would emphasise that there are so many ways to be successful in science – you just need to find your own way. If you don't do well in certain ways, you should not be discouraged, rather figure out where you are strong and capitalise on that. Of course, you don't need to be a PI – there are many roles in science – but even as a PI, there are many ways to be successful. So for instance you don't necessarily have to be the brightest person in the room or most technically gifted; if you are very motivated and talented in other ways, there are ways for you to succeed in science.

Finally, is there anything Development readers might be surprised to find out about you?

Plant development has often been referred as plant 'behaviour'. Because of the decentralised control in plant development, plants are very plastic and respond to the environmental cues such that even individuals that are closely related may develop in very diverse ways, depending on their ambient environment. As you can read above, I have been interested in and committed to plant development for a long time. My move to Cambridge with my family brought many new aspects to our daily life, and perhaps the most unexpected of them was the existence of a sizeable population of communal (in some cases one could even say stray) cats where we lived. Thanks to my daughter, I have become friends with one of them in particular, and in the course of this interaction I have recently become quite a specialist in animal behaviour. But because of the fundamental conceptual differences in plant and animal development, I am afraid this experience has had a limited impact in increasing my understanding of animal development.

Reference

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