Throwing down the gauntlet for molecular plant pathology in the 21st century-what are the new challenges for bacterial research?

Article

Accepted Version

Throwing down the gauntlet for molecular plant pathology in the 21st Century – what are the new challenges for bacterial research?

Robert W. Jackson

School of Biological Sciences, University of Reading, Whiteknights, Reading RG6 6AJ, UK

This editorial accompanies a new set of papers commissioned by *Molecular Plant Pathology*, the Challenges Reviews. I want to explain here the thinking behind developing these reviews.

When I started my PhD in 1994, I thought that the challenge that my supervisors set me was a daunting one – why are plasmids important in *Pseudomonas syringae* plant pathogens of pea and bean. I was to build on emerging work of several pioneers, particularly one of molecular plant pathology's visionary leaders, Noel Keen: plasmids were being recognised as important genetic elements for carrying potential virulence factors. But my task was relatively small compared to that of arguably the biggest challenge of that time in bacterial plant pathology – what is the type III secretion system for and why do plant pathogens express effectors (avirulence genes) that trigger host immunity in plants. Again, Keen was at the forefront of effector biology research and he was one of several people of that generation who were tested to "think outside the box" – I remember multiple debates at conferences, why do the pathogens give themselves away by expressing avirulence genes. It was a real paradox. Of course, in the last 20 years, there has been tremendous progress from a broad scope of researchers around the world in deducing the crucial role of the secretion system and finally figuring out the functional significance of effectors. In that time, we have also seen other big breakthroughs, including the deduction of how TAL effectors work and their potential for biotechnological exploitation for genetic modification. The discovery of PAMP triggered immunity has prompted new ways to consider how we can modify plants to resist pests and disease. New methodologies have significantly advanced our capability. Next generation sequencing has undoubtedly been one on the major advances of the last 15 years, leading to low cost genome sequencing and advanced techniques for studying gene expression. The new CRISPR technology derived from phage-bacteria research promises to revolutionise the way that eukaryotic genetics is done, helping to create markerless plants with enhanced disease resistance.

While hardcore molecular biology has been widely employed to determine functionality of molecules and determine mechanistic models, other research areas have also been developing apace. One area of prominence is ecology of pathogens, examining their dispersal and spread – who would have thought they could be found in clouds and snowpack! Of course, this leads one to question how they survive in those environments and how the different environments influence their lifestyle. The influence of the host environment on the evolution of virulence has proved to be important – if we are to deploy resistant plants, how quickly will pathogens circumvent host resistance, and how does it happen. The widespread integration of genomics research has transformed pathogen research, not only to aid molecular research, but to help understand pathogen evolution. The increase in regulatory governance around the world has also seen dramatic reductions in the use of chemical control, driving companies to look more and more to biological control. In particular, the recognition of the microbiome of plants, how they are influenced by host genotype and host-pathogen interactions, has triggered a new wave of research into community analysis and functionality. What is particularly exciting is the prospect of using epiphytic, endophytic and rhizospheric communities as inoculants to help control pests and diseases.

Those formative years of effector debate drove several people including myself to think differently about our science. This has partly driven my desire to develop this series of "Challenge Reviews"– to ask what the big new questions emerging in molecular plant pathology are. If we also consider that that the community of plant pathology scientists is shrinking, taking with it the skills and knowledge for future generations, then it is no surprise that we now see scientists from other disciplines starting to engage in molecular plant pathology projects. This is an unavoidable consequence of the reduction in available funding and declining University support balanced against the needs of the scientific field to work together on collaborative projects. Undoubtedly, the role of non-pathologist scientists is very valuable, because we see an injection of new ideas, methodologies and analyses – classic outcomes being innovation and pushing new working practices. Thus, an important aim is to set out where the new challenges in the field exist to aid those new to the discipline and also highlight fascinating non-traditional ideas.

Another important driver for developing these reviews is the slump in plant pathology education, highlighted starkly in an educational review commissioned by the British Society for Plant Pathology (BSPP). Plant pathology education in its broadest sense, covering plants, pathogens and pests, has been in decline for some time in countries like the UK. Gradually, the learned societies, like BSPP, the Microbiology Society, the Society for Applied Microbiology and the UK Plant Science Federation, are increasing public awareness and being proactive with outreach programmes to educate younger people. An important target group are the emerging young scientists, on undergraduate and postgraduate programmes, who are considering whether to take the plunge and try to become career scientists. With the speed of changes in the field, it's important that there is a mechanism to highlight new developments and scientific areas. Spelling out the exciting, cutting edge developments and big questions in our field is thus crucial for enthusing our early career scientists.

Therefore, this series of challenge reviews have been commissioned to address these needs. I am delighted that a range of established world leaders in their disciplines are contributing these papers covering a broad range of topics spanning ecology and evolution, to genetics, metabolomics and genomics, and then considering novel approaches to control. Not all of these authors come from a traditional plant pathology background although some do, but are writing their articles because they have moved into new areas - thus they provide new perspectives. This series focuses on bacteria in the first instance. Of course, there are gaps that haven't been covered, but hopefully the articles will help to drive discussion, debate and planning for future years.

The gauntlet has been thrown down, not only to the scientists, but to their employers and funders – some of the challenges are tough, but I hope the global community find these reviews useful in addressing them.