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The future direction of plant pathology in Australasia

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Abstract. Australasia, 'Australia and surrounding islands', refers to a vast and diverse geographic region including Australia, New Zealand and Papua New Guinea. The geographic diversity, spanning wet tropical to sub-Antarctic biomes and everything in between, means that the problems confronting Australasian plant pathologists are equally diverse. Rapid changes to our physical, economic and geopolitical environment, and the biological irrelevance of national borders, promise interesting times ahead for plant pathologists.

In this paper I want to address the following: Who will the future plant pathologists be? What will they work on? Who will they work for? Will biotechnology ever become useful? An ethical future?

Plant pathologists of the future

Who are professional plant pathologists and where do they come from? The tautological definition ('someone who studies plant diseases') is not instructive because Plant Pathology is a composite science, drawing on the skills and knowledge of a myriad of more specialised disciplines. Increasingly, plant pathologists come from a range of backgrounds and follow multiple career paths, effectively relegating the traditional generalist to extinction. This trend will change the role of professional societies such as the Australasian Plant Pathology Society, as they assume an increasingly important role in nurturing the careers of young plant pathologists from diverse, and sometimes quite narrow, backgrounds. In parallel with this role, perhaps professional societies should be more active in formally accrediting the skills of professional plant pathologists to support their contributions to emerging debates such as the use of genetically modified organisms and environmental management. I believe that societies must become more vocal in these debates and must seek membership on the relevant decision-making bodies.

The results of a survey of 31 universities in Australasia on the status of plant pathology teaching (David Guest, Paula Myatt and Elizabeth Aitken, Teaching Session of the 7th ICPP 1998) indicated that Plant Pathology teaching is healthy and robust, largely due to a continuous and steady infusion of student interest. However, the drive to economically rationalise and internationalise higher education in general, and science in particular, combined with the mushrooming of skills required for a comprehensive education in plant pathology and the diversity of student backgrounds, are forcing changes in the way we teach plant pathology.

Departments of Plant Pathology are rare in Australasian Universities, and teaching expertise is frequently fragmented and incorporated into Biology, Botany or Agriculture Departments. Only 32% of institutions surveyed have a formally structured plant pathology stream or major. Introductory Mycology is commonly taught in junior undergraduate biology or microbiology subjects, while Plant Pathology is more often taught as a service subject or elective to students majoring in plant science, horticulture or crop protection. Dedicated plant pathology subjects are taught at senior undergraduate levels. As a result of this fragmentation of expertise and workload pressures on academics and students, most graduates have an incomplete appreciation of all aspects of plant pathology.

One solution would be to teach more complete plant pathology courses to graduates who have basic skills in, for example, mycology, bacteriology, virology and plant physiology, biochemistry and molecular biology. There are currently no coursework higher degrees in Plant Pathology in Australasia, although these are common in northern hemisphere universities. The fragmentation of academic and scientific expertise is probably the major obstacle to constructing such courses in Australasia, although there is an opportunity for the consolidation of expertise in Universities, CRCs and government research institutes to link, develop and deliver comprehensive postgraduate courses. The viability of such courses would be enhanced if they were also made available to off-campus and international students, exploiting new technologies such as the internet.

While fragmentation of academic and scientific expertise presents one problem to teachers, essential but 'expensive' activities, such as practical classes and excursions, are threatened by cuts to university funding. The current Australian Federal Government has reduced block funding for universities by something like 15% in real terms between 1996 and 2001. The impact of these global cuts on teaching

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in the sciences is further exacerbated by the diversion of the diminishing pool of resources to recruiting lucrative full-fee enrolments, particularly in the faculties of commerce, IT and law. In addition, fees for students enrolled in science-based courses attract a premium because they are laboratory or field based, at a time when the perceived career opportunities, and thus student demand, for non-vocational studies is already low. The message delivered to school leavers is that science study is hard, expensive and has few rewarding career opportunities.

What problems will confront plant pathologists of the future?

A number of research priorities are obvious and uncontroversial. We are told that people want to live in a clean, 'chemical-free' (even, according to some reports, DNA-free!) and diverse environment, and want to eat clean, green food. Pesticides will continue to play an important role in agriculture and horticulture, but in a much more targeted and efficient way than at present. For this to occur, advances in integrated management programs for pests and diseases, associated with a reduced dependence on pesticides, will continue to require a thorough and improved understanding of the biology and ecology of pests and pathogens, involving cross-disciplinary research in plant pathology, entomology, weed science, horticulture, agronomy and soil science.

Other research priorities may not be as obvious, and may suddenly gain importance because the environment in which we operate as plant pathologists is in flux. For example, we have recently seen a fundamental shift in the way Australia regulates quarantine policy that will inevitably lead to the introduction of exotic plant diseases. The Board of the new body overseeing plant health issues, Plant Health Australia, includes industry lobbyists and government agency representation, but does not include any plant pathologists. Indeed, the Australasian Plant Pathology Society was not even invited to the recent official launch of PHA. This is a very strong indication that policy will be driven by economic and commercial agendas rather than biological reasoning, and suggests a fear that scientific objectivity might compromise market opportunities. In New Zealand, the Parliamentary Commissioner for the Environment recently presented his report *New Zealand Under SIEGE* highlighting the potential threats posed by quarantine incursions. New Zealand has a Minister for Biosecurity and a Biosecurity Council, in acknowledgment of its national importance. It is significant that quarantine issues potentially put our trans-Tasman membership on opposite sides of the debate, but creative tension is what we scientists are trained to identify, investigate and resolve.

These changes are compounded by the new WTO regime that replaces zero-tolerance of exotic pests and pathogens, based on biological knowledge, with an acceptance of a certain level of 'manageable' risk and appropriate incursion response plans, designed to facilitate fairness in international trade, and a cost–benefit analysis of the threat against the measures designed to protect our agricultural and horticultural industries and environment. There has not been enough public or scientific debate about the implications of this new policy, its management and resourcing. The potential effects on our natural, agricultural and horticultural environment are too serious and irreversible for us to neglect. I don't believe that fairness on a level playing field should include sharing pathogens and pests – while this will ensure that plant pathologists are never bored, it will divert attention away from long-term basic research to 'firefighting' activities.

The rapid changes to our physical environment will also create new challenges for plant pathologists. For example, the phase out of methyl bromide will change the management of soilborne pathogens and will also unveil new quarantine risks because of inadequately fumigated timber pallets and packing. The greenhouse effect, global warming and weather cycles will change climates and the environments in which crops are grown.

These examples illustrate the dynamic nature of the problems plant pathologists face. While this is not a new feature of our profession, and should not present an insoluble problem for plant pathologists of the future, it will be important for us to continue to encourage a stream of talented new graduates into the profession, and to ensure their work is adequately resourced.

Who will plant pathologists of the future work for?

The traditional employers of plant pathologists are government and university departments. Plant pathology research was seen to serve the public good by supporting agriculture, horticulture and forestry, or by generating knowledge. Public research institutes and universities were allocated core funds that enabled long-term research and the development of a detailed understanding of industries, as well as the ability to respond rapidly to disease outbreaks. These activities were often supplemented from industry levies. Because of job security and long-term funding, plant pathologists were able to build careers that developed an extraordinary depth of expertise in specialised fields. This expertise was passed on to bright students through planned successions, so that industries were assured of continuing high-quality support. However, the rise of economic rationalism in the 1980s presided over a fundamental shift in emphasis from the needs of the community to the rights of the individual. The user-pays mentality dictates that clients must pay directly for research services. Large slabs of public research and development, including plant breeding facilities, germplasm collections and intellectual property, were privatised. Plant pathologists, including many generalists with a vast amount of field experience, took redundancy packages and established private disease diagnostic services. Those remaining in research institutes found their tenure evaporate into three- to five-year employment contracts funded from 'soft', rather than core, money. Career development and succession planning has been completely dismantled.

Fundamental research is not seen as an economically rational activity and attracts pathetically inadequate funding from governments and corporations. In this, an election year, the Australian Federal Government has promised an 'innovation action plan' that may implement many of the recommendations in the Chief Scientist's report, *The Chance to Change* (www.isr.gov.au/science/review/ChanceFinal.pdf). However, the recent announcement that funding cuts have forced the Australian Broadcasting Corporation to axe our only television show dedicated to science and technology, *Quantum*, and disband the Science Unit within the ABC, is not a promising omen.

Unless there is a sudden understanding by policy makers that research, like health and education, is an investment providing long-term benefits to the entire community rather than for those who can afford to pay for it, the future employers of plant pathologists will inevitably be private corporations and consultancy firms, and plant pathologists will become scientific gypsies working on short-term projects with no job security. I have no question that there is an important role to be played by private research centres, but believe very strongly that there must also be a strong, properly resourced, public sector research effort that is not constrained by the short-term profit motive or by the need to offer ill-considered tax-breaks for the next election.

Will biotechnology ever become useful?

I recall hearing at the International Plant Pathology Congress in Melbourne in 1983 that by the time of the subsequent congress (Montreal, 1988) most of the major challenges of plant pathology would be answered using recombinant DNA technology, and that plant pathologists would be out of a job. In retrospect, it is not surprising that this claim was made by a chemist rather than a biologist. The reductionist framework of molecular biology is manifest in the 'central dogma':

GENE → RNA → PROTEIN

One gene, one protein, and by implication, one phenotype; clone a resistance gene from one plant and insert it into another to make that plant resistant as well.

As it happened, 1988 passed relatively uneventfully for plant pathologists. Molecular techniques have had the greatest impact on improved disease diagnostics – particularly with prokaryote and viral pathogens. However, breeding for disease resistance has not altered significantly – it is still based on crossing and backcrossing to introgress genes from related species in the same way it has been done for at least a century. While traditional breeding and improvements in soil and water management have led to significant increases in productivity in agriculture and horticulture since 1983, molecular biology has given us Roundup-ready and BT- corn, cotton, canola and soybean, PLRV-resistant potato and the terminator gene. In classic revisionist style, Biotechnology has been redefined, and we are now told that it has:

'been around almost since the beginning of time. It's cavemen saving seeds of a high-yielding plant. It's Gregor Mendel, the father of genetics, cross-pollinating his garden peas. It's a diabetic's insulin, and the enzymes in your yogurt... Without exception, the biotech products on our shelves have proven safe.' (Dan Glickman, U.S. Agriculture Secretary).

Sequencing and gene cloning is now routine in undergraduate classes. We have the complete sequence of the genomes of yeast, fruit fly, a nematode, numerous bacteria, *Arabidopsis thaliana*, and even a 'working draft' of the human genome, yet still know very little about how these genes work in organisms. Even the most optimistic estimates say we are at least a decade away from knowing what each gene does. The analogy of a telephone book is instructive – it can give us addresses and phone numbers, it can even tell us who is talking at any instant, but it gives no information about who we are or how we live, or about the social structures that make our society function. There are still a lot of calls to make.

The central dogma does not equip us to embrace the complexity of cells and organisms. The dominance of the reductionalist approach of molecular genetics over an appreciation of the complexity of biology has created a huge vacuum because advances in our underlying biological understanding have not kept pace. Although resistance genes have been cloned, they appear to function in signalling pathways that produce different results when placed into different genetic backgrounds. Another approach is to insert genes encoding antimicrobial proteins into transgenic plants. It is hoped that these proteins will confer wide-ranging resistance to pests and diseases. Even a cursory review of the fate of previous 'magic bullet' solutions—resistance genes, systemic fungicides and so on — would have to lead to a sceptical prediction that these are expensive adventures that are doomed to fail. Why? Because as any biologist knows, pathogens are diverse and flexible populations of organisms that are ideally suited to adapting to altered environments. To realise the potential benefits of biotechnology, we have to greatly improve our understanding of the complexity of gene function in cells, organisms and communities. There are some very powerful molecular, imaging and computing tools available now that will enable this biological complexity to be unravelled.

One of the great claims of proponents of biotechnology is the potential to reduce our dependence on environmentally hazardous pesticides. Transgenic plant cultivars are privately owned, coincidently by the same corporations that own the pesticides – 70% of the world pesticide market is owned by the ten largest companies, and of these, five are seed companies that also own 35% of the world's crop genetic resources. But where do these corporations acquire their patented genes? Collections of genetic resources such as those held by the sixteen International Centres for Plant Genetic Resources (ICPGRs) hold more than 500 000 cultivars of the major food crops. These collections have provided the genetic basis for the high-yielding green revolution cultivars of rice, wheat and corn that have enabled food production to match the doubling of the world's population in the past 35 years. These resources are publicly owned and funded by the World Bank, governments and charities. However, Australia recently joined with the USA, Canada and New Zealand (the same alliance that blocked agreement on greenhouse emission reductions in The Hague) to effectively privatise these gene banks. How secure are these genetic assets in the market economy? How will privatisation affect the free exchange of plant genetic resources? Experience from recent privatisations of national collections are not reassuring – the Centre for Genetic Resources in Wageningen is reported to be rationalising its collection of cabbage genotypes from 273 to 54 ('Sold to the Highest Bidder', *New Scientist 16 Dec. 2000*).

Valuable genes may also be discovered in wild populations of agricultural and horticultural plants, and a second threat to biodiversity and germplasm conservation is that cash-strapped developing countries may be tempted to plunder their untapped resources to support fragile economies, or sell them off to the highest bidder. The third enemy of free exchange of germplasm is the WTO. The agreement torpedoed by Australia was to fund ICPGRs through levies on access to germplasm, because it was argued that these levies might restrict free trade.

Biodiversity will further diminish without adequate funding of ICPGRs and the consequent corporate ownership of plant genetic resources. The argument that biotechnology as it is practised will improve food security is not supported by our present experience. I can confidently advise my students that there will always be plant disease, and there will always be plant pathologists. I can not be as confident about who will pay them, what choice they will have about their research efforts, or how well their research will be supported.

Perhaps even more chilling is the potential abuse of biotechnology to create pathogens that destroy the food base or environment of those who chose not to participate in the dominant political or military paradigm. The US Drug Enforcement Agency has pioneered the ethically dubious use of aerially applied plant pathogens in attempts to destroy coca and opium crops in South America and Asia, and it would come as no surprise to learn of similar programs to destroy food crops in non-compliant states. The recent announcement that Australian scientists inadvertently created a lethal strain of mousepox virus illustrates the potential for unexpected and potentially catastrophic side effects. In one sense, this could open new avenues of employment for both offensive and defensive plant pathologists.

An ethical future?

I became a plant pathologist because the mechanisms organisms use to communicate with each other fascinate me. Plant Pathology offers an opportunity to explore these interactions, while at the same time contributing to the sustainability of life on the planet by improving the security of the world's food supply, and the health and diversity of our environment. I still hold these ambitions dearly, and will fight to maintain my right continue this work. However, I fear that this type of altruistic motivation is threatened by the changes outlined above.

These threats are not inevitable, and there are signs of hope. Perhaps some of the excesses of greed-driven biotechnology are being addressed as corporations recognise that their responsibilities as good citizens are not incompatible with profits. The next step would be for these corporations to support the conservation of genetic resources and maintenance of collections of plant genetic resources, and to support more research directed by the public good rather than solely by profit. Governments have to recognise the importance of investing in our future by fully supporting the training of new generations of researchers and practitioners, and must also properly fund their careers in long-term research. Our unique and diverse environments must be adequately protected and not sacrificed to a dream of a homogeneous, single world market.

Educators and professional societies have a crucial role, not only to promote and uphold standards and integrity, but also to highlight the ethical implications of our discipline. Many of us can influence policy and decision making processes. As responsible citizens of the planet, we have no other choice.

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