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2001: an Australasian Science Odyssey

David Guest

School of Botany, The University of Melbourne, Vic. 3010, Australia; email: diguest@unimelb.edu.au

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Introduction

My predecessor reflected on three questions in his Presidential address: (1) What has been done well in Plant Pathology; (2) What could be done better; and (3) What still needs to be done (Randles 1999). Professor Randles concluded that while we are a small, but well-educated team of plant pathologists who are acutely aware of the scientific, social, environmental and economic significance of our work, we do not feel well understood or appreciated by policy-makers. As a result our profession, and plant health, which is after all what we are interested in, is weakened by a lack of resources and planning at the national and regional levels.

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. They also reinforce the need for greater collaboration between plant pathologists and policy-makers in the region.

- I am going to take this opportunity to pose another set of questions for reflection: Who will the future plant pathologists be, what will they work on, and who will they work for?
- Why are improved regional linkages essential to the successful understanding and management of plant diseases in Australasia?
- Will biotechnology ever repay the huge investment?
- Can we contribute to an ethical future?

Plant pathologists of the future

Plant Pathology is a composite science, drawing on the skills and knowledge of a myriad of more specialised disciplines and technologies. As is now the case in most disciplines, plant pathologists come from a range of backgrounds and follow multiple career paths, resulting in fewer traditional generalists. Professional societies such as the Australasian Plant Pathology Society (APPS) will assume an increasingly important role in nurturing the careers of young plant pathologists from diverse, and sometimes quite narrow, backgrounds, and perhaps should become more active in public debate. This could take the form of formal accreditation of professional plant pathologists, or the establishment of a Committee for Professional Development. We could contribute, individually and as a Society, to emerging debates such as the use of genetically modified organisms and environmental management, and seek membership of the relevant decision-making bodies.

Plant Pathology teaching in Australasia 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 now rare in Australasian Universities. Few institutions have a formally structured plant pathology stream or major. As a result of this fragmentation of expertise and workload pressures on academics and students, most graduates have only a brief exposure to most, if not all, aspects of plant pathology. One solution would be to teach plant pathology to graduates who already have basic skills in the component disciplines of mycology, bacteriology, virology and plant physiology, and technologies of biochemistry and molecular biology and microscopy, for example. There are currently no coursework higher degrees in Plant Pathology in Australasia. George Agrios at the University of Florida has constructed a Doctor of Plant Medicine (www.DPM.ifas.ufl.edu/dpmContents.htm), that provides a possible model for comprehensive postgraduate training in Plant Pathology. There is an opportunity in Australasia for Universities, CRCs and government research institutes to link and develop and deliver similar 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.

The current Australian Federal Government has reduced block funding for universities by something like 15% in real terms between 1996 and 2001. Similar cuts have been imposed on universities in some, but not all, neighbouring countries. The impact of these global cuts on teaching in the sciences is further exacerbated by the diversion of the diminishing pool of resources to recruiting lucrative full-fee enrolments, particularly in

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faculties of tourism, business, 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 reaching school leavers is that science study is hard, expensive and has few rewarding career opportunities.

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 were often supplemented from industry levies. Because they had job security and continuous base-level funding, plant pathologists employed by these organisations built careers that developed an extraordinary depth of expertise in specialised fields. This expertise was passed on through planned successions, so that industries were assured of continuing high-quality support. However, the rise of economic rationalism in the 1980s presided over an ascendency of the perceived 'rights' of the individual over the needs of the community. 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, have been privatised and effectively withdrawn from the scientific community. Researchers are no longer able to freely discuss their experiments or techniques at conferences or through publication in peer-reviewed journals. Research priorities are set by the profit motive and the application of research is held up while intellectual property arrangements are negotiated by lawyers who have little or no understanding of science. Graduate students use 'kits' to generate data when they have no idea how these kits work, or whether the techniques involved are appropriate. 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 'soft' employment contracts. Career development and succession plans have been completely dismantled.

Fundamental research is not seen as an economically rational activity and attracts pathetically inadequate interest or funding from governments and corporations. In this, an election year, the Australian Federal Government has promised an 'Innovation Action Plan' and the Federal Opposition has proposed a 'Knowledge Nation' initiative, largely in response to the report of the Chief Scientist, *The Chance to Change* (www.isr.gov.au/science/review/ChanceFinal.pdf). However, even if this plan is fully implemented Australia is still going backwards in our investment in research and development. Our failure is compounded by the massive new investment in education and research in some comparable countries like Canada, or Japan, where despite a global budget cut of 10%, investment in research was boosted by $18 billion.

Unless there is a sudden awakening that research, like health and education, is an investment that provides long-term benefits to the entire community, not just for those who can afford it, the future employers of plant pathologists will inevitably be private corporations and consultancy firms. Plant pathologists risk becoming 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, 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 and intellectual property restrictions.

Why are improved regional linkages essential to the successful understanding and management of plant diseases?

We are told that people want to live in a clean and diverse environment, and want to eat clean, green food. While pesticides will continue to be important in agriculture and horticulture, they will do so in a much more targeted and efficient way than at present. Advances in integrated management programs for pests and diseases require a thorough and improved understanding of the biology and ecology of pests and pathogens, involving regionally coordinated cross-disciplinary research. Plant pathogens are not restrained by national borders, and successful quarantine depends not only on erecting walls to exclude pathogens, but in the establishment of offshore monitoring and early warning mechanisms. Quarantine will be most effective if countries like Australia actively support the training and activities of our colleagues in neighbouring countries. I urge you all to think of ways that your own research can be used to establish and nurture regional linkages—personal professional relationships will always have more direct impact than governmental or institutional linkages, although all are essential.

Even so, globalisation and the fundamental shift in the way Australia regulates quarantine policy will inevitably lead to the introduction of exotic plant diseases. Alarmingly, scientists appear to have been marginalised in decisions relating to these shifts in policy. The Board of Plant Health Australia (Plant Health Australia is the peak national coordinating body for plant health in Australia— http://www.planthealthaustralia.com.au) includes industry lobbyists and government agency representation, but does not include any plant pathologists. While scientists will be consulted when expert advice is required, we are not required to take any further part in decision-making. Policy will be driven by economic and commercial agendas rather than biological reasoning—the recent debate about food labelling is informative. Do politicians fear that scientific objectivity might compromise market access and opportunities? In New Zealand the Parliamentary Commissioner for the Environment reported in *New Zealand Under SIEGE* the potential threats posed by quarantine incursions. New Zealand has a Minister for Biosecurity and a Biosecurity Council, in acknowledgement of its national importance. Quarantine issues potentially put our neighbouring countries on opposite sides of the debate, but creative tension is what we scientists are trained to identify, investigate and resolve.

The WTO regime replaces zero-tolerance of exotic pests and pathogens with an acceptance of a certain level of 'manageable'

risk. Incursion response plans are designed to facilitate fairness in international trade, and priorities are determined on the basis of cost-benefit analyses of the threats against the costs of measures designed to protect our agricultural and horticultural industries and environment. The potential consequences of this market-based approach on our natural, agricultural and horticultural environment are too serious and irreversible for us to neglect. Fairness on a level playing field should not mean 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. The greenhouse effect, global warming and weather cycles will change climates and the environments in which crops are grown. 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.

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, 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.

It is vital to develop strong regional linkages. Agriculture and horticulture are fundamental to the economies and well-being of nations in Australasia, including Asia, the Pacific and Southern Africa. Those of us with established collaborations in these areas know that scientists in many countries are even worse off than we are, and lack basic resources such as libraries, reliable electricity and water supplies and telecommunication facilities. APPS can support our colleagues in these areas, and some initiatives, including the establishment of a committee overseeing International Linkages, have already been discussed at the BGM.

Why the practice of biotechnology is antiscience

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 reductionalist framework of molecular biology is manifest in the 'central dogma':

$$\text{GENE} \rightarrow \text{RNA} \rightarrow \text{PROTEIN}$$

One gene, one protein, and by implication, one phenotype. The plan was to clone a resistance gene from one plant and to insert it in 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. Like telephone books, genome projects give us names, addresses and phone numbers, but give no information about who we are or how we live, or about the social structures that make our society function. Unlike telephone books, however, genome projects have a lot of blank pages, or pages that can only be read by those who can afford to, and can only be discussed with those who sign secrecy agreements. This restriction on the free exchange of knowledge and information is antiscience.

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 imbalance in our understanding of plant–pathogen interactions. Although resistance genes have been cloned, they appear to function in signalling pathways that produce different results when placed into different genetic backgrounds. Genes encoding antimicrobial proteins have been cloned and inserted 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—leads to the inescapable conclusion that these expensive adventures 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 varieties are privately owned, coincidently by the same global 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 16 International Centres for Plant Genetic Resources (ICPGRs) hold more than 500 000 varieties 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 publically 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 International gene banks. How secure are these genetic assets in the globalised market economy? Will privatisation affect the free exchange of plant genetic resources as it has to intellectual property? 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*).

A second threat to biodiversity and germplasm conservation is that cash-strapped developing countries may be tempted to plunder their wild populations of agricultural and horticultural plants, and sell them off to the highest bidder. The third enemy of free exchange of germplasm is, ironically, globalisation as preached by the WTO. A proposal to fund ICPGRs through levies on access to germplasm was torpedoed by Australia because it was argued that such levies would restrict free trade.

Biodiversity will further diminish without adequate funding of ICPGRs and the consequent corporate ownership of plant genetic resources. There is no evidence that biotechnology as it is practised will improve food security. I can confidently advise my students that there will always be plant disease, and there will always be plant pathologists. I can't be as confident about who will pay them, what choice they will have about their research efforts, who they will be able to talk to, or how well their research will be supported.

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 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 me 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 of offensive genetic manipulation.

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 making a practical contribution 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 have identified a number of changes that seriously threaten this opportunity. 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 public 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 must be persuaded to recognise the importance of investing in our future by fully supporting the training and careers of new generations of researchers and practitioners. Our unique and diverse environments must be adequately protected and not sacrificed to a nightmare of a homogenous, 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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Reference

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