extracellular enzymes and pathogenesis-related host proteins in the host–pathogen interaction. In fungi, changes connected with the hypersensitive response and phytoalexin accumulation have attracted much research interest, as they are readily identifiable events in incompatible host–pathogen interactions.

These subjects are discussed both in general terms and specifically in relation to recognition in incompatible species–species (non-host) interactions and in gene-for-gene interactions. Interestingly it is shown that in some instances some of the responses detected in incompatible interactions are probably irrelevant to the precise outcome of the interaction (e.g. synthesis of chitinase in response to *Phytophthora infestans* in potato leaves).

This is a fast-moving field, and so it is inevitable that books on this subject are out of date almost as they are published. Based on a symposium which took place in 1989, inevitably some of the material covered in this book will not give a full picture of the most recent advances. It is, however, a coherent and largely accessible account of the biochemical and genetic mechanisms underlying some of the best-characterized host–pathogen interactions. It will be of interest to scientists and postgraduate students working in this area. Get your library to save up for their copy now.

MARK J. HOCART
Institute of Ecology and Resource Management
University of Edinburgh

Plant Breeding in the 1990s. Edited by H. T. STALKER and J. P. MURPHY. C.A.B. International, Wallingford, Oxon OX10 8DE, UK. 1992. 539 pages. Cloth £55.00, US$104.00 (Americas only). ISBN 0 85198 717 6.

This book presents the edited papers and discussions (mainly question-and-answer sessions) from the international conference on plant breeding at Raleigh, North Carolina in March 1991. The main topics were: the gene base for plant breeding (six papers): modification of plants to tolerate environmental stress (four papers); modification of plants to tolerate stresses due to diseases and insects (three papers); contributions of biotechnology to plant improvement (four papers); and strategies for utilizing unadapted germplasm (two papers); followed by a symposium overview by Peter Day and a very detailed index. Each paper has its own extensive list of references.

An initial chapter by Kenneth Fry provides an excellent introduction to the many topics examined in the rest of the book. From 1960 to 1990 annual cereal grain production increased from about 800 million to nearly 2000 million tons, over 80% of this increase being due to increased annual crop yields. The technology represented by crop cultivars that have high yield potential, are well fitted to their production environments and possess resistance/tolerance to biotic and abiotic stresses, has made a major contribution to this increased yield. Molecular biotechnology is beginning to be applied to further these yields in a number of ways – by somaclonal variation, *in vitro* selection and transformation, each followed by plant regeneration, and by RFLP mapping. These new methods have been taken up by major private companies, who must of course concentrate on crops with very large acreage or very high income per hectare, e.g. maize, soybeans, wheat, rice, tomatoes, sugar beet and truck crops. Other important crops such as oats, pecans, buckwheat, red clover and forage grasses will not support breeding programmes in private industry, and are nevertheless getting declining support from public funding. There is also a decline in training facilities for plant breeders, whose place in applied agriculture cannot be taken by the new crop of molecular geneticists – experienced plant breeders will obviously be essential for the very complex processes of breeding, comparative testing and saving of the new cultivars. These problems will become serious, particularly for the Third World, in the future.

T. T. Chang (in chapter 2) discusses another important problem – the future availability of plant germplasm for use in crop improvement. Ideally, the germplasm resources (PGR) for each crop should include wild relatives, weed races, landraces in areas of diversity, and earlier cultivars as well as improved germplasm; but there is of course argument as to the value of these resources, and maintaining them is both very expensive and very difficult. The major genebanks in different parts of the world (there were 39 in 1984 with long-term storage facilities), mostly suffer from severe shortage of funds and of experienced conservators, so that recording is often incomplete and genetic erosion occurs, particularly in the tropics.

Chapters (3) by Arnel Hallauer on genetic variation in cross-pollinated species, (4) by Baenziger and Peterson on genetic variation in self-pollinated species, (6) by R. W. Allard on predictive methods for germplasm identification and (7) by A. B. Maunder on identification of useful germplasm for practical plant-breeding programmes contain extensive analyses of past and present selection methods and progress on a variety of crops, and form a most valuable segment of this book. I can only refer to a few points from these chapters.

Allard's graph on page 120 shows annual U.S. corn (maize) yields in bushels per acre from 1866 (initially about 25), with almost no increase under open pollinated selection for 65 years, an average gain of 1·04 bushels per acre per year under double cross selection for 30 years from 1930, and even more rapid progress under single cross selection (1·8 bushels per acre per year) from the early 1960s to the present day. The implications are that selection methods improved in 1930 and 1960 and that there is no obvious loss of progress at the current level of 120 bushels per acre. Allard also quotes studies of changes in recognizable

allele frequencies during progress in several crop plants from wild races to advanced cultivars. Those alleles predominant (present in frequency of 0·8 or higher) in a high proportion of landraces from a wide range of environments became predominant and usually monomorphic in advanced cultivars. Alleles rare or infrequent in most landraces were generally deleterious and to be avoided, while alleles frequent in certain ecogeographic regions were worth examining for their possible value to advanced cultivars. These recognizable alleles were, of course, usually indicators of linked DNA segments of potential value.

Maunder discusses progress in rice, wheat, sorghum and other crops, and problems of resistance to insects and disease, and tolerance to drought, as well as yield progress. He emphasizes the importance of being able to co-opt gene segments from exotic germplasm, i.e. landraces from a variety of native habitats. He also quotes estimates that a million inbred lines of corn were test-crossed from 1939 to 1981, and only one in 10000 of these has made any significant contribution to commercial hybrids. A similar massive effort is going into improvement of sorghum, based on the world collection of 30000 or more accessions. This is another excellent chapter.

The reader should also pause over W. J. Libby on use of genetic variation for breeding forest trees, as well as the subsequent discussion. 'Breeders of annual crops', he remarks, 'question the sanity of those who choose to breed trees', but he makes clear that much valuable information has been garnered. For example, ponderosa pine planted in California for many years came from a marginal site with about a dozen low-growing trees whose cones could be harvested from the tops of pick-up trucks: the result was very poor growth or complete failure. Similarly crazy tree stories are told of New Zealand (the ponderosa pine again) and the Texas Forest Service (the loblolly pine). But recent improvements in methods and the possibilities latent in biotechnology are put into perspective by Libby, and forest conservationists should study his article. In the discussion, Libby was asked 'what evidence is there that wood yield is improved if the genes for sex are turned off?', to which he replied 'since we have not turned off the genes for sex yet, there is no evidence for yield increases'. He also stated that coast redwood is the world's fastest-growing temperate conifer, with productivity about ten times that of the average American conifer.

The rest of the book contains many chapters of equal importance and interest, which I can commend to the reader. These include: mechanisms for obtaining water-use efficiency and drought resistance (J. S. Boyer); freezing stress resistance in herbaceous plants (Jiwan Palta); breeding plants for enhanced beneficial interactions with soil microorganisms (Fredrick Bliss); and genetic basis of plant tolerance of soil toxicity (J. Dvorak *et al.*). This last article brings to mind a report in *The Observer* of 8 March 1992, on work by Iain Thornton of the Imperial College of Mines in London. In Derbyshire, lead mining, begun by the Romans, reached a peak in the 1700s, so that trees within half a mile of smelters were killed off and the local river was thick yellow with mining waste. Lead levels in nearby villages are still 27 times the national average and their gardens can have soil containing 1% of lead. Likewise, in Cornwall, some villages have arsenic levels of more than 1 part per hundred due to pollution from previous metal mining. But lead and arsenic levels in local vegetables grown in these two areas are within normal safety levels, and the local populations show no obvious signs of ill health from the pollution or eating these vegetables, judged from Thornton's studies. No doubt Dvorak *et al.* will take account of this surprising report, which one must hope our Department of the Environment will not take as grounds for dropping all pollution studies.

The three chapters on tolerance/resistance to insects and disease are of obvious interest, and there is a substantial section on the contributions of biotechnology to plant improvement. These latter cover mainly the prospects for the future, and include discussion of: RFLP analyses in plants (T. J. Helentjaris); identification and isolation of agronomically important genes from plants (S. P. Briggs); novel approaches to induction of genetic variation (R. L. Phillips *et al.*); and model systems for future plant breeders (Richard Flavell). This last includes a compelling section in praise of *Arabidopsis thaliana*, which will create enthusiasm for this small plant with a short life cycle, some 25000 genes and a mere hundred million base pairs of DNA, and which is now under intensive study worldwide – this shows that research funds have not yet been entirely sequestered by HUGO. This little crucifer has already made valuable contributions to plant-breeding theory.

The remaining chapters, on marker-assisted QTL selection (Russell Lande), roles for the haploid sporophyte (Earl Wernsman), and introgressing unadapted germplasm to breeding populations (Stanley Pelonquin and Rodomiro Ortiz), add extra practical approaches and should not be missed; and Peter Day's symposium overview adds some illuminating comments to the various topics.

I could have given the essence of this review by just writing: 'You had better get hold of this book!' It will obviously stimulate any plant breeder who has taken a rather narrow view of his field, and deserves study by animal breeders and population geneticists, who will be very envious of the role *Arabidopsis thaliana* is going to play in applied agriculture. In fact, biologists working in many different areas will find much of interest in the book, and it should be widely distributed.

ERIC REEVE
Department of Genetics
Kings Buildings
University of Edinburgh