Hughes A. 1959. *A history of cytology*. London, UK: Aberlard-Schuman.
Richmond ML. 2000. T.H. Huxley's criticism of German 'cell theory': an epigenetic and physiological interpretation of cell structure. *Journal of the History of Biology* 33: 247–289.
Riggs JL, Seiwald RJ, Burckhalter JH, Downs CM, Metcalfe TG. 1958. Isothiocyanate compounds as fluorescent labelling agents for immune serum. *American Journal of Pathology* 34: 1081–1097.
Schleiden MJ. 1838. Beiträge zur Phytogenesis. *Archiv für Anatomie, Physiologie und Wissenschaftliche Medici*. 13: 137–176.
Schwann T. 1839. *Mikroskopische Untersuchungen über die Übereinstimmung in der Struktur und dem Wachstum der Thiere und Pflanzen*. Berlin, Germany: Sander'schen Buchhandlung.
Schwann T. 1847. *Microscopical researches into the accordance in the structure and growth of animals and plants* (translated by Henry Smith). London, UK: Name of publisher.
Turner W. 1890. *The cell theory past and present – Inaugural Address to the Scottish Microscopical Society*. Edinburgh, UK: Neill and Co.

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Books

Forest biotechnology – thriving despite controversy

Molecular genetics and breeding of forest trees

Edited by S. Kumar and M. Fladung. The Haworth Press (www.haworthpress.com), 2004. ISBN 1-56022-959-4, $59.95

It was the summer of 1999, and as the organizers of the semiannual international conference on molecular biology of forest trees sent emails around the globe in final preparations for the upcoming meeting at the University of Oxford, UK, the wheels started to come off. The train-wreck that was crop biotechnology in the UK started to spread to the previously obscure field of forest biotechnology. Major news articles in the UK and elsewhere in the EU tarred forest biotechnology in the same way they had already done to agricultural biotechnology. A protest was carried out at the July meeting, and to the shock of all the scientists the meeting began with the announcement that a pioneering field experiment with lignin-modified poplar trees, also in the UK, had been cut down the night before by vandals. The scientists at the meeting scratched their heads and wondered how science and 'society' could be so out of whack in Europe.

'In 2001 vandalism of field sites or arson was directed against forest biotechnology research sites in the United States'

But this was not the end. After this watershed event, several of the mutinational environmental organizations issued reports that generally demonized forest biotechnology, and called for various forms of moratoria. and in 2001 vandalism of field sites or arson was directed against forest biotechnology research sites in the United States – clearly this form of terrorism was not going to be restricted to Europe. Given this turmoil, what is the state of the science that underlies biotechnology? Has the political upheaval, which has certainly set back field research in Europe, driven researchers and research funds from the field? Are the scientists out of ideas? Has there been substantive progress?

A read of this book, which has about half its chapters by researchers from biotechnology-embattled Europe, make it clear that the science is moving ahead impressively. The editors have carefully crafted it to include the major scientific thrusts in forest biotechnology. These span genomic maps and markers as supplements to traditional breeding, through to novel means for altering the characteristics of wood and tree reproduction, with the goal of enabling novel kinds of highly domesticated, biosafe plantations to be employed.

Arabidopsis upward

All of the chapters are written by authorities in their fields, including many of the long-standing leaders in forest biotechnology – such as Jouanin, Boerjan, Davis, Ebinuma, Walter and Fladung. All of these provide literature reviews that are comprehensive and up to date, and many move fluidly between knowledge of the genes in model plants, especially *Arabidopsis*, and trees, as any modern intellectual analysis of tree genetics should. The age where breeders need to be educated only about breeding methods in trees is clearly over. Moreover, if the extraordinary potential of poplar as a model organism is fully capitalized upon, the combination of its genome sequence and transformability will soon allow scientists to know the consequences of modifying vast numbers of genes on development of trees, not just taxonomically distant annual plants.

One of the highlights of the volume is a description of the EST databases of Genesis Research and Development Corporation, Ltd, in New Zealand, the world-leading private sector effort in tree genomics. Strabala describes in detail their collection of hundreds of thousands of ESTs from diverse tissues in pine and eucalypts. Jouanin and Goujon provide an excellent review of the state of knowledge of lignin biosynthetic genes in plants, particularly with respect to prospects for genetic engineering. They point to several promising approaches, as well as some that are unlikely to lead to useful tools for breeding, and emphasize the need for field trials to enable the ecological benefits and safety of the various options to be evaluated. Lemmetyinen and Sopanen provide a comprehensive review of attempts to induce flowering and impart sterility in trees, with a focus on their own work in birch. Because birch can both be transformed and induced to flower within months of transformation, it provides an extremely powerful system for studying genetic engineering of reproduction in a tree. They discuss several highly promising transgenes for induction of sterility that are deserving of further analysis and field testing.

Applications through to fundamental tree biology

Lidia and Yifan discuss genetic engineering of insect resistance in poplars in China. Poplars are planted widely in China for agroforestry, bioremediation, environmental enhancement, and afforestation purposes, but often suffer from severe insect pest problems that can cause plantation failure. Use of the *Bt* gene has produced trees with high levels of resistance to some defoliating insects, and these trees appear also to provide useful levels of protection via an unknown mechanism for large numbers of neighboring nontransgenic trees, facilitating the use and protection of refugia. A female transgenic variety is the second authorized (2002) commercial transgenic tree in the world, after virus-resistant papaya. Ecological studies are poorly described, but appear to be continuing in China. Efforts are also under way to include more kinds of resistance transgenes to provide higher stability and broader insect control, and to combine resistance genes with sterility genes to increase biosafety.

Ebinuma and others provide a status report on their innovative 'MAT' system for transformation. It allows markerless transformation and inducible excision of transgenes during vegetative development. This provides a useful tool for producing nonchimeric transgenic trees and other plants lacking antibiotic resistance transgenes. Because of the upcoming ban on most such genes by the EU (2004), it may be difficult to commercialize and market transgenic products in the near future if they contain such genes. The MAT system, along with similar systems developed by others, may be key platform technologies, along with sterility transgenes, for socially acceptable forms of most kinds of transgenic trees.

Kumar and Fladung, the book's editors, present their advanced studies of stability of gene expression in aspen. Stability of gene expression and tree phenotype is considered to be a crucial requirement for transgenic trees, especially if transgenic means for reduction of seed and pollen release are included in commercial constructs. The perspectives and results offered by different laboratories provide contrasts that point to the need for more research and field verification. While Kumar and Fladung's studies, using the *rolC* reporter gene that might amplify or exacerbate instability, show considerable variability in selected lines that is associated with transgene structure, the experience in China, where high levels of unintended phenotypic variation have also been observed (described in the Lida and Yifan chapter), shows that such variation is not difficult to overcome during normal breeding and field selection. The predominant experience in North America with poplar hybrids, pioneered by the work of Meilan and associates, has been that of very high levels of fidelity in the field, at levels easily managed by breeders. Walter and others in his chapter on conifer transgenesis provides a similar perspective, that transgenes and transgenics have manageable levels of instability. The book chapter, however, points to some useful and simple PCR tests of transgene structure that might save time and expense by identifying unstable lines without the need for lengthy, and possibly risky, field trials. These ideas deserve careful testing.

A number of chapters discuss the considerable progress in use of genomics tools to understand fundamental aspects of tree biology, including high quality chapters by Plomion and others on pine proteomics, Martin and others on fungal and plant changes in gene expression during mycorrhizal association, Vendramin and others on use of microsatellite markers for population and systematic biology, and Cervera and others on integration of genetic maps in poplar, mainly for analysis of disease resistance.

Perspectives

As with most books that are compilations of work by authors from around the globe, there is diversity in quality among the chapters, and shortcomings in some – however, this criticism is limited to presentation, which could have been improved in some cases to make the volume more useful to nonspecialists. With a focus on science, this book provides an excellent complement to another state-of-the-art volume on forest biotechnology that will shortly be released by Resources for the Future (Washington, DC, USA). That book focuses on technology, potential for commercial use, ecological analysis, and social acceptance. Both books, however, agree that research progress is impressive; opportunities abound for much further scientific advance; field verifications

of economic value and ecological effect are badly needed; and that the commercial and social landscape regarding public and market acceptance is complex.

Is the field of forest biotechnology where it should be given its early promise and considerable controversy? The tendency of the media is to exaggerate the pace, the benefits, and the risks of technologies, particularly of biotechnologies. However, trees just take their 'good ol' time,' unfazed by the latest headlines. In addition, while poplars are the model organisms for trees and thus are the species upon which much of the concept-testing gets done, they are by no means the commercially most important species in forestry. Conifers and eucalypts are far more important and widely planted, but are much harder to work with than poplars in nearly every aspect of research and development. This means that long lag times between the first proofs-of-concept and widespread commercial applications are to be expected. What this book shows is that, like other aspects of forestry research, identifying and testing novel concepts are enterprises that take many years to decades. The high quality chapters in this book show that despite the extraordinary upheavals that have accompanied plant and forest biotechnology's 'social births', the scientific power of genomic biology is fueling strong and steady progress on a diversity of fronts. Trees must be resilient in their adaptation to stresses during their long lifespans, and so must their scientists.

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