Plant biotechnology

Editorial overview

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Plant biotechnology is here to stay. Over the last few years, the promise of the science which has been developing since the early 1980s has translated into products growing in fields and being consumed as food. The first maturation of the technology has led to renewed corporate activity in mergers, acquisitions and the creation of new companies based around technical advances in hand or anticipated [1,2]. The increased commercial investment is matched by reinvigorated public sector funding of plant research most notably in large scale genome projects [3,4]. It is entirely appropriate that this area is a major topic of this issue of Current Opinion in Plant Biology.

The first genetically modified plant products to reach the market place have been the result of research and development efforts with first generation capabilities in gene transfer and gene expression technology to control one or two gene effects. In the part of this issue devoted to plant biotechnology, the focus is mostly on doing things better. The first three reviews focus on recent progress in the areas of gene transfer to cereals, gene regulation and manipulation of pathways. In the fourth review, an emerging area of applicable science: the cell wall is considered as an example of a seriously difficult experimental system with enormous significance which has started to become amenable to modern tools of molecular genetics as well as emerging analytical methodologies. In the same way as the first products in the market can be traced back to scientific publications from the mid-1980s [5–8], we can now look forward to more rapid development of products over the next decade exploiting this new understanding of cell walls and pathway engineering, and capitalising on improved efficiencies of transgenic plant production.

The earliest widely-used experimental gene transfer methodologies utilised Agrobacterium to provide the gene transfer capability based on the molecular dissection of Crown Gall disease [9]. While this proved to be quite broadly applicable to dicotyledonous plants, early reports of its use for gene transfer to monocots [10] were not followed up widely within the research community, and it was not until the particle gun [11] and other direct gene transfer methodologies [12] were developed that widespread success was reported for cereals. Now this apparent barrier has been broken down and the review by Komari et al. (pp 161–165) brings up to date the emerging story that rice, maize, barley and wheat can all be routinely transformed using Agrobacterium. It is intriguing to note that there are no blockbuster new ingredients in the mix. Persistence, standard protocols and getting the combination of several important parameters right has brought the result. Even the one ingredient of super-virulent strains is reported to be unnecessary in a most recent paper [12].

As the range of transgenic cereals has grown, so has the experience to compare transgene insertion, stability and control delivered by the various physical, chemical or genetic routes to transgene delivery. Komari et al. review some of the copy number effects, including some recent ways to limit the numbers of transgene copies by niacinamide treatment. This encouraging progress could lead into a greater biochemical understanding of transgene insertion processes.

The theme of control of gene expression is continued by Gallie (pp 166–172). The variability of gene expression in different transgenics has been ascribed in various amounts to the effects of insertion position, gene copy number or gene silencing. A judicious invocation of the three can explain any observed effect whilst being unable to predict anything. Fortunately, the science is now moving on to get under the skin of these terms. In the review by Gallie, the emerging understanding of matrix attachment regions as contributors to position effects is described. Another area of great progress is in the understanding of mechanisms and requirements for gene silencing. Aberrant RNAs and methylation can both play a part in the phenomenon. A basis for the phenomenon in recognition and control of virus attack has been postulated as a biological context. Fungal mutants in the seemingly analogous quelling phenomenon lead to the prediction that it will be under genetic control in plants also. Matzke and Matzke (pp 142–148) continue this theme in their contribution in the genome section of this issue.

The complexities of gene regulation in promoter and other regions are being described in more detail. The effects of introns, 3′ elements as well as a plethora of transcription factors are going to be the basis of fine tuning of transgenes in the future. Whole pathways will need to be controlled if the potential to access the enormous diversity of plant primary and secondary metabolism is to be realised. Kinney reviews recent progress towards controlling pathways (pp 173–178). Particular success has
been achieved with modification of oil composition; recent identification of genes for introduction of hydroxyl groups and acetylenic bonds offer the prospect of *ab initio* design of lipid molecules for specific end uses on a renewable basis. Kinney points to the prospect both of examination and utilisation of existing natural genetic diversity and of the use of protein engineering to refine the resulting enzymes.

The plant cell wall is a complex and heterogeneous mixture of proteins, polysaccharides and other components. The synthesis, assembly, remodelling and degradation of the wall during plant growth and development play a key role in determination of the growth, form and functioning of the whole plant. Recent progress in our understanding of this area is reviewed by Chapple and Carpita (pp 179–185). Highlights are the recent identification of genes specifying components of the cellulose biosynthetic machinery and also of genes involved in the remodelling process, such as expansins and glucosyl transferases. In addition to the increased accessibility of the cell wall to molecular genetic approaches, new analytical methodologies such as FTIR (Fourier transform infrared) microscopy are revolutionising the ability to understand the complex workings of the plant cell wall at the range of scales from single carbohydrate polymers to the whole tissue. Linking these scales will drive the ability to make useful changes in food and fibre quality.

As the power of genomic approaches and the efficiencies of gene transfer methodologies are brought to bear on new targets, then we must anticipate a great increase in the applications of today's scientific discoveries towards making new products. I hope to be able to chronicle this dramatic story of the next stages of plant biotechnology through the pages of this new journal.

**References and recommended reading**

Papers of particular interest, published within the annual period of review, have been highlighted as:

• of special interest
•• of outstanding interest


