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# Development and use of gene transfer in New Zealand

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## ABSTRACT

Gene transfer offers vast potential for improvements in animal agriculture. Improvements in quantity, quality and efficiency of production as well as entirely new forms of production can be envisaged.

Realising this potential, however, is hampered by dilution and duplication of effort, an acute shortage of trained personnel, and the perceived gulf between scientific developments and the launching of a product on the market.

Overcoming these obstacles will require participation in decision-making by experts from other fields as well as science, and national co-ordination of effort coupled with identifiable, committed funding from government and the private sector. Producer groups and professional societies such as New Zealand Society for Animal Production should play a leading role in these developments.

**Keywords** Biotechnology; transgenic animals; science policy; research support; education.

## INTRODUCTION

Gene transfer has both advantages and disadvantages as a means of genetic improvement in animal production. The advantages are that it is fast and specific. The disadvantages are that it is, at present, technically inefficient and very expensive. It is an example of technology outpacing physiology; the genetic basis of desirable production characteristics remains poorly defined.

The technology is soundly based on capabilities derived from progress in molecular biology but its application is viewed with suspicion, both by producers and consumers. It is often referred to as "blue sky" research. Dispelling the clouds, however, will require a different approach to that now used in exploring this technology in New Zealand.

Developments are being driven by scientific interests, resulting in dispersion and dilution of effort. Lessons from the growth of the biotechnology industry overseas make it plain that close management of research projects, and resources beyond the scope of scientific institutes, are needed to bring a product to the marketplace.

If New Zealand is to maintain efficient primary production in the technological world of the next century it must use this technology. Being a latecomer to the field can be an advantage. There is an opportunity to learn from the mistakes of others, to focus attention on local issues of importance, and to benefit from collaboration with more advanced projects overseas. If nothing is done, however, there will be no intellectual framework to identify and appropriate opportunities that will arise from developments elsewhere.

## AREAS OF DEVELOPMENT

Clark *et al.* (1990) and Tervit *et al.* (1990) reported the progress in gene transfer and the associated reproductive technologies that can accelerate its development.

Figure 1 illustrates four main areas in which molecular biology will have an impact in agriculture. DNA analysis, leading to genetic gains by early selection for desirable genes and more accurate establishment of pedigrees, will be an important corollary of gene transfer and will also identify new genes with potential for application. Direct gene transfer will produce benefits in disease resistance and production quality (including efficiency of food utilization), and will open up what has been called 'molecular farming', keeping animals not for food but as living reactors for the production of valuable biologicals.

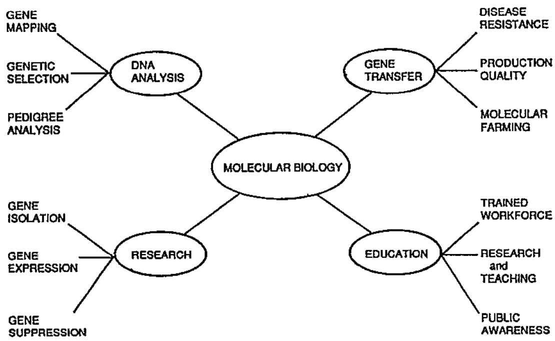


**FIG 1** Representation of the areas of impact of molecular biology on animal production.

**TABLE 1** Current work on transgenic animals in New Zealand.

| |
|---|
| Palmerston North - DSIR/Massey University |
| * Pharmaceuticals in bovine milk. |
| Ruakura - MAF Technology |
| * Milk composition in dairy cows. |
| Lincoln University - BIMI/AVSG |
| * Mouse models of disease. |
| * Wool follicles in sheep. |

These are three groups in New Zealand interested at present in gene transfer in farm animals (Table 1). At Palmerston North, the DSIR in collaboration with Massey University is in the early stages of a programme designed to produce pharmaceutical compounds in bovine milk.

At Ruakura, MAF Technology has been working for 2-3 years on developing skills in molecular biology and gene transfer, with a view to manipulating milk composition as part of a research programme in lactational physiology.

They have produced at least one transgenic mouse carrying a marker gene.

At Lincoln University, over the last 18 months, several lines of transgenic mice carrying genes of interest for basic studies of gene expression and as models of human disease have been generated. Last year a pilot programme in sheep was carried out and this year gene expression is being targeted to the wool follicle in transgenic sheep.

Two points are immediately apparent. One is that all three groups are working on different things. The other is that the choice of projects has been driven mainly by the interests of the scientists involved. Collaboration between the groups has been hindered by a shortage of funds. It is not clear that pursuit of three different projects simultaneously in three different centres is a sensible allocation of scarce resources. Is a more co-ordinated approach to the development of gene transfer desirable?

## A CORPORATE STRUCTURE

The 1980's saw an explosive growth in new biotechnology companies, mainly in the USA and Europe, called biomania. Many of these companies have since collapsed and few products have reached the market. Some of the reasons for this have been analysed by Teitelman (1989). The impetus came from entrepreneurial academic scientists, fuelled by venture capitalists in a manner that has had significant effects on the way science is conducted.

Financial support for science was transformed. Why go to the NIH for a grant of $150,000 when you can raise $15 million on Wall Street? The short-lived nature of investor interest, however, is predictable with the benefit of hindsight. Biomania was not about science but about shares and the stock market; it was not concerned with products but with profits. There were no products! After 10 years of existence, Genentech, one of the most successful biotechnology companies, had launched only two products and recently sold a 60% interest to a major pharmaceutical company. That is because even such a successful company did not have the resources needed to bridge the gap between development of the science and marketing of the product, not to mention the legal skirmishes in the process.

These companies were founded largely by scientists with the idea that they could be run like academic laboratories. Fun places to work, filled with top-notch people doing exciting science in superbly equipped surroundings, and communicating their results just as they had always done. For a while this scenario unfolded. Gradually, however, commercial realities meant that the companies unfolded and communication became mired in proprietary secrecy. There are signs of the latter phenomenon in the drive for greater commercial application of science in this country.

There are lessons to be learned from these events. Wilkins (personal communication) has estimated that there are about 20-30 people in New Zealand working on molecular biology applied to animal production. That is the size of a very small biotechnology company. Moseley (1989) has discussed the requirements for success in biotechnology projects. The key ingredient is skill in the creation and management of flexible and adaptable interdisciplinary groups focussed on a clear and significant joint objective. This ingredient is at odds with the traditional disciplines in which specialists are trained and whose interests may be quite out of step with the real needs of the project. Moseley believes that biotechnology research and development presents special problems that require a high degree of management intervention. His structure for a corporate organization is illustrated in Figure 2. Should such a national "corporate" structure be created for the exploitation of gene transfer as a new technology in New Zealand?

There are three areas where there is urgent need for co-ordination at a national level (Table 2).

Computing support for molecular biology is fragmented. As efforts in chromosome mapping and DNA sequencing accelerate, demands for computer processing and sequence analysis will increase. The data base is increasing in size exponentially. There is a danger of missing out on advances in computing algorithms and developments such as parallel architecture unless a national resource is established for this complicated and expensive area.

**TABLE 2** National needs for technology.

* National Computing Resource.
* Co-ordination of Projects.
* Committed, long-term Support.

Choice of projects should also be considered in the light of national needs and resources. Which gene or genes should be transferred? The choice should not be left to scientists alone. It is no use genetically engineering an animal if farmers will not stock it, exporters cannot sell it, and consumers will not eat it. Experts from other disciplines such as economics, marketing, and business management as well as producers and advertisers, should be part of the decision-making process. Whether everyone should end up working on the same project is debatable, but national co-ordination of effort and a co-ordinated analysis of national needs and resources appears essential.

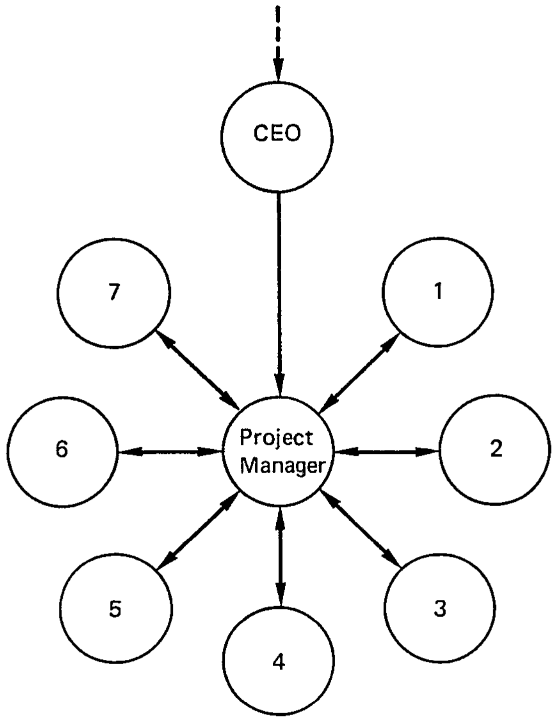


**FIG 2** A successful organizational structure for a project group in biotechnology R & D. 1-7 indicate specialist functions, normally one person or an individual with one assistant. (From Moseley, 1989).

Finally, inevitably, there is the question of money. This work is expensive and it is not an easy road to a quick return. Success will be more likely with an identifiable source of long-term support committed to this area. The government cannot be expected to foot the bill entirely. Support must come from a combination of the public and private sectors, through joint ventures or similar mechanisms. Producer groups have a vested interest in contributing to this support, not only as an investment in the future of the industry but as a way of influencing the directions taken.

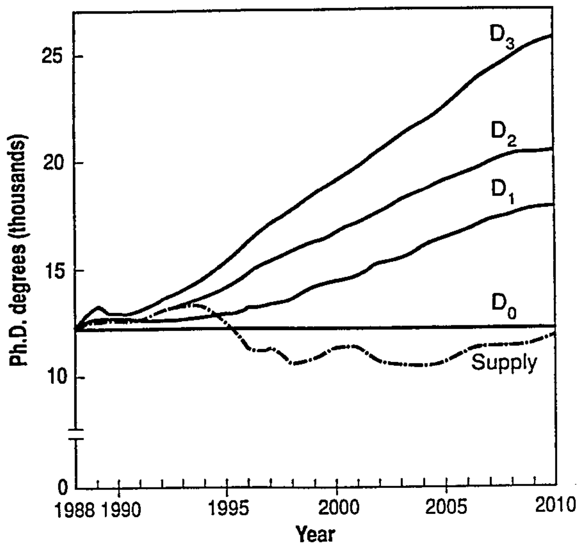


**FIG 3** Projections of supply and demand for Ph.D.s in the USA at different demand rates (D0-D3). (From Atkinson, 1990).

## ROLE OF THE UNIVERSITIES

Whatever structures are adopted, their success depends on the staff at all levels who populate them. Molecular biology is no use without molecular biologists, and there are precious few of those in New Zealand. The industry is going to become increasingly technologically sophisticated as time goes on. The industry of the 21st century will require technologically trained workers at all levels.

**TABLE 3** Projections of technically trained worker demand in the UK (from Parsons, 1989).

| Economic scenario | Range of new posts per annum: Commercial organisations | Research centres | Higher education |
|---|---|---|---|
| Relative stability | 15-20 | 10-20 | 0-5 |
| Moderate growth | 40-100 | 30-50 | 5-10 |
| Significant expansion | 120-130 | 60-100 | 40-50 |

Projections for the U.K. of what Parsons (1989) calls "high quality manpower" indicate significant demand for technical personnel (Table 3), a trend that is likely to continue. In the U.S.A., the supply of Ph.D's through to the year 2010 is projected to fall short even of a stable demand (Atkinson, 1990; Figure 3). New Zealand is not exempt from this global problem. To meet this need, a nation can turn only to one resource - its educational system, in particular its universities. There is only one way to train good researchers and that is by letting them do meaningful research at the forefront of science. Yet Ullyat (1989) reported that funds received for agricultural research in our universities declined by 43% at Massey University and by 11% at Lincoln University between 1985 and 1989. Of the total agricultural R & D expenditure in 1988, only 3% went to the universities. This situation cannot be allowed to continue if there is to be a sufficient supply of trained workers.

## CONCLUSIONS

To realize the potential benefits of biotechnology in animal production, national goals must be set, national efforts co-ordinated, and new partners introduced into the policy and support mechanisms. The New Zealand Society for Animal Production can play a vital role in shaping the future course and in influencing the development of biotechnology to ensure that the New Zealand animal industry maintains its leading role in world agricultural trade.

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