BRIEF COMMUNICATION

Embryonic and genetic engineering

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ABSTRACT

This paper reviews some of the recent developments in genetic and embryonic engineering and attempts to assess their likely impact on animal breeding theory and genetic improvement programmes. The distinction is made between genetic and embryonic engineering.

Keywords Embryo manipulation; cloning; multiple ovulation; recombinant DNA; genetic engineering; animal improvement

The last decade has seen dramatic developments in embryonic engineering in mammals including *in vitro* fertilisation; deep freezing of embryos; techniques for microsurgery on mammalian eggs; splitting embryos to produce identical twins and probably, in the near future, large clones; production of homozygous diploid individuals; activation of eggs for parthenogenetic development; joining 2 embryos together to make chimeras both within and between species; *in vitro* ovulation; and microsurgical removal of pronuclei from the fertilised egg and transfer to enucleated eggs.

Embryo transfer and production of small numbers of clones by embryo splitting is currently available technology. These techniques, plus the possibility of sexing semen, can be combined with artificial insemination (AI) to improve rates of genetic improvement in livestock (Land and Hill, 1975; Van Vleck, 1981). However, it has been concluded that multiple ovulation and embryo transfer (MOET) will contribute little to the overall rate of genetic improvement for milk production in dairy cattle using current AI and progeny testing procedures (McDaniel and Cassell, 1981) and even less to economic improvement at current embryo transfer costs (Van Vleck, 1981). Recently it has been shown that an alternative and somewhat revolutionary method of using MOET can increase the rate of genetic progress in dairy cattle by about 30% over that theoretically achievable in conventional progeny testing programmes and by about twice the progress actually achieved (Nicholas and Smith, 1983). This method is based on reducing the generation interval and tolerating less accurate selection. It can be operational with much smaller numbers of recorded cattle than in national progeny testing programmes, with manageable numbers of embryo transfers (i.e., 500 cows and 1 000 embryo transfers per year). Nicholas and Smith (1983) also showed that integration of cloning into their MOET programme could dramatically increase rates of genetic progress when the technology for producing large numbers of clones become routinely available.

New Zealand was among the first of the world's dairy cattle industries to adopt and develop AI and progeny testing. A similar progressive attitude, both by the dairy industry and other animal industries in New Zealand, towards the potential of MOET and cloning techinques would be in our long term interests in continuing to produce genetically superior livestock populations.

Genetic engineering was first pioneered in microorganisms (Cohen, 1975) and it is now possible to identify and isolate DNA sequences of known function; to make these sequences *in vitro*; to make and maintain DNA clone banks or libraries; to transfer genes (DNA sequences) from one individual to another both within and between species using recombinant DNA techniques (Cherfas, 1982). These advances in molecular biology and DNA manipulation are also changing some of our classical genetic theories about the organisation and expression of genes (Gillings and Frankham, 1982).

The potential opportunities of this explosion in biotechnology for New Zealand have been identified and discussed in a recent report (Hunt *et al.*, 1983) and many are already being realised overseas. Genetically engineered bacteria are already producing insulin, somatostatin, growth hormone and interferon and there is a huge potential market for these products for treatment of human genetic diseases (e.g., insulin for diabetics; Yanchinski, 1980). The availability of large quantities of pure, relatively cheap hormones such as somatostatin and growth hormone could also have a role to play in animal production (Davis and Bass, 1984), as could genetically engineered vaccines. The first genetically engineered vaccine was for foot and mouth disease (Küpper *et al.*, 1981) and it has been shown to confer immunity in cattle and pigs (Kleid

et al., 1981). Providing insulin to diabetics is a replacement therapy and does not result in a cure for this disease. A cure might be affected by attempting to correct the mistake in the DNA structure responsible for the disease, or by transferring a normal functioning gene into the defective cells. Gene replacement therapy has been accomplished in mice (e.g., Cline *et al.*, 1980) and has been unsuccessfully attempted in humans (Cherfas, 1982).

An important distinction has to be made between application of gene replacement by genetic engineering in humans and farm animals (Robertson, 1982). In humans we are usually concerned with a quite specific defect due to a single indentified gene which has to be restored to normality. In animals or plants one is usually dealing with normal individuals or populations and particular aspects of performance need improving. These are seldom controlled by a single gene and the large numbers of genes presumed to be responsible for a particular trait are at present not known nor located in the genome. However, known genes from the rat, the chicken, the rabbit and from man have now been transferred into the mouse (Franklin, 1984). The most dramatic experiment of this type involved transfer of the structural gene of rat growth hormone into the mouse (Palmiter *et al.*, 1982). Of 21 mice that developed, 7 carried the new gene (or genes) and 6 expressed it by growing about twice as fast as their litter mates. Presumably it is only a matter of time before similar gene transfers are achieved in farm animals.

Currently, the most formidable barrier to commercial application of recombinant DNA technology in animals is the need for stable transfer of genetic material between organisms and the appropriate regulator control of gene expression in the correct tissues. However, given the dramatic advances in the technology to date it seems inevitable that these problems will be solved in the not too distant future.

How current animal breeding theory will then fit in with the recombinant DNA technology is hard to predict and there are some very different opinions on the matter, Ward *et al.* (1982) believe it will result in the total reorganisation of conventional animal breeding theory. Others point out that we still know very little about the physiological and biochemical differences between animals, so that we may actually have genetic engineering technology available to us before we know how to utilise it most effectively (Robertson, 1983). In this case no doubt a 'try-it-and-see' attitude may be employed so that if successful the transferred genes could be a valuable adjunct to traditional breeding methods (Palmiter *et al.*, 1982). Strategies of molecular breeding can then be seen as extensions of current animal breeding practices, in broadening the gene pool to make unique and novel genotypes available for selection (Schuman and Shoffner, 1982).

There seems to be little doubt that genetic engineering has the potential to provide options which are unobtainable using conventional animal breeding techniques (Franklin, 1984; Wagner *et al.*, 1984). It is important that research groups in New Zealand explore these options but it should be clearly understood that it will be a long time before we can dispense with our current methods for evaluating and selecting genetically superior animals.

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