GENETIC MANIPULATION THE FUTURE FOR ANIMAL PRODUCTION*

C. Wray, *Central Veterinary Laboratory, New Haw, Weybridge, Surrey, U.K.*

Genetic engineering has been practiced for thousands of years as man has selectively bred animals and plants to his requirements. The modern poultry farms have now made poultry the cheapest source of animal protein in many countries. Likewise new varieties of wheat, rice and other cereals have contributed to the green revolution.

In the United Kingdom, Genetic Manipulation is controlled by law and the legal definition is:- "The formation of new combinations of heritable material by insertion of nucleic acid molecules, produced by whatever means outside the cell into any virus, bacterial plasmid, or other vector system so as to allow their incorporation into a host organism in which they do not naturally occur but in which they are capable of continued propagation".

Thus one has a technique which will enable genes to cross the species barrier and enable genetic changes to be made more rapidly.

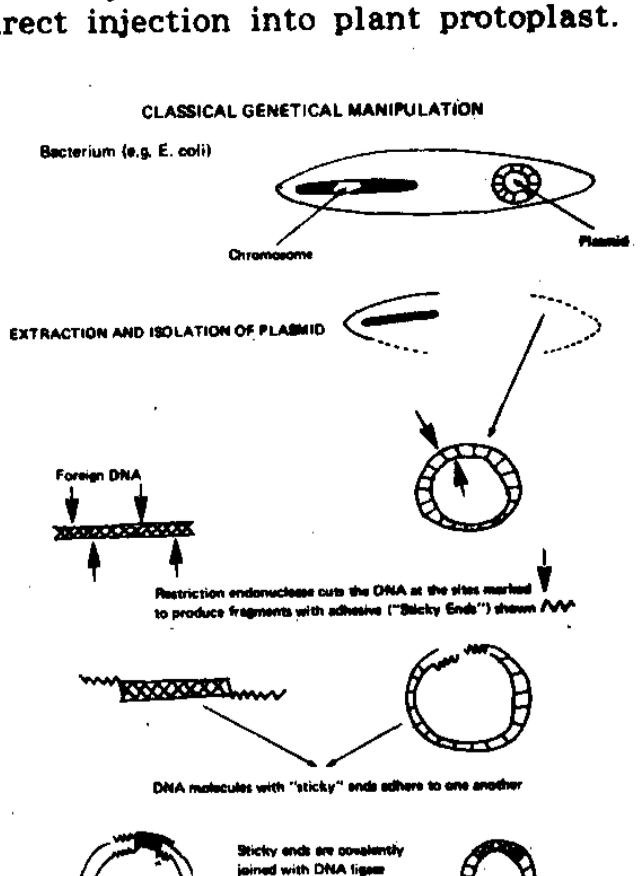
The technique is outlined in Fig.1.

Since its first description in bacteria the technique has been used to insert new genes into plants and animals.

Genetic Manipulation in Plants

In plants two techniques have been used:-

1. The first group of gene transfer systems, the so called artificial systems are directed towards the *in vitro* transformation of plant protoplast with naked DNA and the micro-injection of DNA constructs. In both cases, genes inserted into natural vectors and plant transposons are delivered directly to the nucleus either by contransformation or through direct injection into plant protoplast.



2. The second method uses the transfer DNA system of virulent *Agrobacterium tumefaciens*. This soil microbe contains a tumour-inducing (Ti) plasmid that transfers a DNA segment (the T-DNA) from the plasmid to the

*This paper was delivered in a Seminar during a visit to SUA, Morogoro, Tanzania, January, 1988.

nuclear genome of infected plants (or *in vitro* to plant tissue). If foreign DNA is inserted into the Ti plasmid this will be introduced into the plant genome.

Other natural systems of gene transfer are being studied to develop applications of *in vitro* genetic manipulation using disarmed plant viruses and genetically transformed pollen. At the moment most of the plant work involves dicotyledonous plants; monocotyledons which include the economically important cereals have proved more difficult to engineer, although a recent paper reports success in rye.

Genetic Manipulation in Animals

After the desired gene has been selected, amplified and cloned it is micro-injected into the animal pro-nucleus (fertilized ovum) which has been surgically removed. The transformed ovum is then transplanted back into the animal. Animal ova differ in the ease with which micro-injection techniques can be used and the success rate for insertion of the desired gene is around 3 - 5%. At the moment scientists are also trying to genetically manipulate fish and insects. Other methods for inserting new genes into animals are being investigated currently. One such method is the use of retroviral vectors, because these are associated with a number of diseases it will be necessary to ensure that disabled strains are produced which are safe to the operator and harmless to the animal.

The Present

Many commercially available products have been produced by genetic manipulation, these include:-

1. Pharmaceuticals - e.g. insulin, growth hormone, interferon.

2. Vaccines - e.g. *E.coli* vacccines, Aujeszky's disease vaccine. The technique offers great potential for the production of polyvalent vaccines, e.g. in the case of viruses, the genes for the protective antigens can be inserted into vaccinia or other pox viruses and it may be possible to insert a number of genes from different organisms.

3. Food and food additives.

4. Diagnostic reagents:

   (a) gene probes for diagnosis of microbial disease;
   (b) gene probes for diagnosis of genetic defects.

The Future

Micro-organisms

Manipulated micro-organisms are likely to be used to improve crop yields, e.g. by facilitating growth or by protecting against pests and other environmental stresses.

Plants

Researchers have five main aims:-

1. Insect resistance. This may be achieved by a number of methods e.g. *Bacillus thuringiensis* toxin is insecticidal and it is hoped to insert the genes for the toxin into the plant genome so that the plant tissues themselves become insecticidal. Another method is the insertion of genes for the cow-pea trypsin inhibitor into plants to make them insecticidal.

2. Herbicide Resistance e.g. by the insertion of glyphosate resistance genes in certain plants.

3. Disease resistance.

4. Changes in nutritional quality/content of crops.

5. Nitrogen metabolism.

Animals

At the moment work is being carried out in three main areas:-

1. Using animals to produce pharmaceutical proteins in their milk or egg albumen, e.g. insertion of genes for human blood clotting factors into sheep.

2. Improving performance e.g. improved growth rates, feed conversion efficiency or fertility.

3. Increased disease resistance. In poultry this may be a practicality because resistance to some diseases appears to be associated with a single gene. Resistance to other animal diseases may involve a number of genes.

The Public Concern

Genetic manipulation has always been surrounded by some public concern. Indeed, in 1974 a group of distinguished American scientists suggested that there should be a pause in some genetic manipulation experiments. This has led to a number of Governments making regulations concerning the practice of genetic manipulation. Initially concern centered on the possible development of super pathogens; this fortunately does not appear to have happened but it is now expected that the use of genetically manipulated animals, plants and micro-organisms will shortly become feasible and this may involve the planned release of such organism into the environment. Unlike the use of genetically manipulated organisms in the laboratory or large scale industrial fermenter, planned release cannot be underwritten by physical containment. Release proposals in the USA have aroused concern and controversy; could a super-weed with herbicide resistance be produced, could an animal with improved growth rate escape, breed and become a major pest?

While there is some experience of risk assessment based on the evolution of novel traits in existing populations and the introduction of organisms to ecosystems, there is no experience as yet involving the introduction of genetically manipulated organisms. The risk assessment of such projects may involve many factors and if the benefits promised by genetic manipulation are to be realized researchers need to proceed with due caution and concern to allay public fears.