Animal genetics and biotechnology

Biotechnology may be defined as "the application of our advancing understanding of living organisms and their components to create industrial products and processes."

All animal breeding, either from farm livestock such as dairy or beef cattle, or for companion animals such as the many different breeds of dogs, is a type of biotechnology that has been going on for many centuries. Breeders have selected animals that show particular characteristics or traits and used them in breeding programmes to ensure that these traits are retained. What they have been doing is selecting animals with particular combinations of genes. We now know that this type of conventional breeding of animals involves hundreds of genes, most of which are unidentified.

Mapping genes

Modern molecular biology is making it possible to identify how different genes control different characteristics. Scientists are "mapping" the genes on the chromosomes, so that they can see where genes are located and how they function within cells and processes within the animal. This will help identify which combinations give the traits that are desired, making selection of animals carrying the best of the naturally occurring genetic variation more effective. Some traits are determined by a single gene and these are relatively easy to study. But others, including commercially important traits such as growth rate and feed conversion efficiency, are controlled by many genes working together. One important research goal is to find genes that make animals resistant to diseases. Selecting for these genes will help produce naturally healthier animals and reduce farmers' reliance on antibiotics and other veterinary drugs. In addition, knowing the processes that contribute to health and disease in animals will help us understand the function of the very similar systems that affect human health.

The full sequence of all genes (the genome sequence) has recently been derived for chickens and cattle and will soon be available for pigs. These sequences allow us to identify the similarities and differences between different livestock species and between livestock and humans. This sequence greatly aids our ability to identify important genes and understand the causes of healthy development or disease susceptibility.

Genetic Modification

The traditional selection and mapping described above makes use of naturally occurring gene variants. However, there are a number of reasons why it might be valuable to alter existing gene variants or add new genes. As well as identifying and isolating individual genes, molecular biology enables scientists to transfer these genes from one individual to another - so called genetic modification or transgenics. This could further accelerate livestock improvement but its usefulness in the foreseeable future is most likely in the area of obtaining high value medical products from animals rather than in agriculture.

Why are scientists researching the uses of transgenic animals

There are five main areas in which the production of transgenic animals offer potential benefits.

- To produce therapeutics for human medicine - In 2006 the European Medicines Agency approved the use of a therapeutic used to prevent blood clotting that is produced in goats' milk. Recently scientists have bred several generations of transgenic chickens that produce therapeutics in the egg white. This offers the potential for producing high value therapeutics in the eggs of genetically modified chickens.
- To provide models of human disease - The function and control of genes implicated in human disease can be studied in animals.
- To provide tissue for use in human transplant surgery - The recognition molecules on animal cells may be tailored so that they are no longer rejected as foreign by humans.
- To improve the efficiency of livestock breeding and to increase the range and quality of livestock products.
- More speculatively, to improve animal health - Long term it should be possible to identify genes that confer resistance to disease and to introduce these into livestock, so reducing reliance on antibiotics and chemicals to control disease.

How genes are introduced into animal cells

Newly fertilised egg cells contain two pronuclei (one originating from the egg cell and one from the sperm) each of which carries half the full complement of chromosomes. The pronuclei fuse to form the nucleus of the fertilised cell which then divides to form the embryo. Newly fertilised cells can be isolated and immobilised under a microscope. A very fine glass needle is used to inject DNA directly into one of the pronuclei. The egg is then transferred into a foster mother where it grows and divides normally to produce the embryo. A new technique called nuclear transfer enables scientists to remove the nucleus from an egg cell and replace it with a nucleus from another cell. In this way the complete genetic information of the donor cell is incorporated into the recipient. The cells may be genetically modified in the lab before they are transferred to the recipient.