Manipulating Cells & Embryos for the Improvement of Livestock

W-2171 (2009-2014)

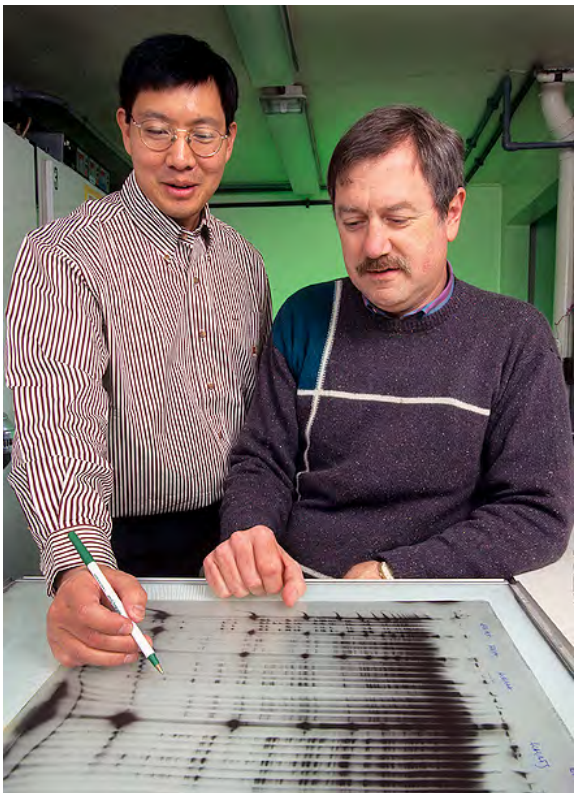
Genetically Improved Livestock Offer Benefits, but Technology is Inefficient

Although scientists have made significant strides in the production of genetically improved livestock, the basic biological mechanisms underlying the techniques used to produce these unique animals are not well understood. Furthermore, most of the tools and techniques remain extremely inefficient. These tools and techniques must be improved in order to benefit from the advantages of genetically manipulated farm animals, such as desirable, healthier, or value-added foodstuffs and lower natural resource use consumption by livestock operations. New strategies will help keep US animal agriculture competitive in the global market.

Scientists prepare to artificially inseminate a ewe. Improved technology and procedures are making it easier for producers to perform artificial insemination on their farms. USDA-ARS photo by Stephen Ausmus.

Multistate Research Project Increases Efficiency of Key Processes in Genetic Manipulation of Livestock

In 2009, Multistate Research Project W-2171 formed to provide research and extension to increase the efficiency of egg cell, sperm cell, and embryonic manipulation—the key to genetically improved livestock. Over the past five years, researchers gained better understanding of fundamental physiological processes, in particular, the underlying mechanisms of gamete development, fertilization, placenta function, embryo development, and other aspects of reproductive performance. Advances in the efficiency of producing animals with manipulated genomes, along with approved mechanisms and regulations, are paving the way for more widespread adoption of assisted reproductive technologies and genetically improved livestock.



Scientists examine genetic marker results to enable more efficient isolation of important genes from the chicken genome. USDA-ARS photo by Peggy Greb.

Improving livestock and production efficiency is important for meeting food demands associated with growing human population. In addition, consumers could benefit from reduced food prices associated with increased efficiency of livestock production as well as enhanced food products for human health. Many of the technological advances of W-2171 may also be used as models for biomedical applications that could impact human wellbeing. Furthermore, genetically improved livestock could make it possible for livestock systems to use fewer natural resources and produce less waste, thus reducing the environmental impacts of livestock production.

Livestock producers will benefit from increased profits as a result of improved animal performance, value-added products, and better product consistency associated with genetically improved livestock. W-2171's advances are making it more affordable for producers to use genetic manipulation processes and technology. For example, newly identified genetic markers can be used to predict bull fertility, resulting in significant cost savings for producers. In addition, new ways to identify or predict a skewed sex ratio in semen may lead to a practical, cost effective method to control the sex of livestock offspring. Improvements to semen storage procedures have enhanced the efficiency and use of artificial insemination. Furthermore, newly identified genetic markers of important traits will help create animals with increased milk and meat production as well as disease resistance. Improvements to *in vitro* embryo production and fertilization processes have reduced early embryo and fetal mortality.

Research & Extension Activities

Researchers found that the glutaredoxin pathway plays a critical role in egg cell development, helping researchers manipulate culture conditions to make egg cells more viable during in vitro fertilization (in which an egg is fertilized in a laboratory before being implanted into the prospective mother). In addition, the ability to use a simple chemical cysteamine as a substitute for expensive and cumbersome systems to lower oxygen concentrations could help keep embryos viable in many situations. From their studies, researchers now have a better understanding of embryo development and insights into implantation failure and early embryonic loss. Novel gene targeting approaches have provided a better understanding of placenta formation and function, a major part of embryo development and reproductive efficiency in animals.

Other researchers focused on the genetic mechanisms regulating male fertility. Researchers also demonstrated that semen remains viable after long-term cryopreservation; however, one study showed that stallion sperm respond differently to cryopreservation than semen from male donkeys.

Using this information, scientists refined methods and protocols for producing genetically improved animals. For example, they improved the technology for generating embryonic stem cells. Embryonic stem cells are important in genetic modification for disease resistance and other special traits. Researchers were also able to improve methods of *in vitro* embryo production. New technology enables the automation of techniques that produce large numbers of embryos *in vitro*. Improving *in vitro* egg cell maturation conditions will result in improved developmental capacity of *in vitro* embryos.

Want to know more?

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Scientists hope to find the genetic basis of disease resistance in pigs through gene mapping studies. USDA-ARS photo by Scott Bauer.