Lesson 3:
Applications of Biotechnology in Animal Agriculture

The previous two lessons discussed artificial insemination and embryo transfer. These applications of biotechnology have a direct impact on the genetic makeup of the animals produced. Other forms of biotechnology, such as the use of biotechnology to produce supplemental hormones and animal health products, affect animals more indirectly.

Supplemental Hormones

Supplemental hormones are chemical messengers administered to animals that stimulate them to grow, produce more milk, or improve their performance in another way. Many of the supplemental hormones produced are growth hormones. Human beings and animals naturally produce the growth hormone somatotropin in their pituitary glands, although the somatotropin produced by two species is very different. For example, bovine somatotropin has no noticeable effect when injected into a human being.

Bovine somatotropin (BST) is one of the best known supplemental hormones. In 1993, the FDA approved BST for use as a drug. When injected into a cow, BST causes a secondary hormone to be released that increases blood flow in the mammary glands. This blood flow increases the amount of milk produced by the cow by 10 to 15 percent.

Porcine somatotropin (PST) is another growth hormone. When PST is injected into a pig, it causes the pig to grow about 15 percent faster and consume 20 percent less feed. In addition, muscle mass, including the loin eye area, increases, while backfat is reduced. Researchers are searching for a way to put PST in an implant to eliminate the need for regular injections. The FDA has not yet approved the use of PST.

Growth hormone releasing factor (GHRF) is not itself a growth hormone, but it stimulates the pituitary gland to release larger amounts of growth hormones. Researchers are looking for ways to use GHRF to improve animal production.

Supplemental hormones have shown promise for use in the poultry industry. Research has shown that the use of a chicken growth hormone shortens the time needed for broilers to reach market size by 15 percent. A chicken molting hormone has shown promise in increasing egg production levels.

Producing Supplemental Hormones and Animal Health Products

Before modern biotechnology was developed, the only way to obtain somatotropin was to collect it from the brains of slaughtered animals. However, only a small amount of the hormone could be collected from each animal. The somatotropin was therefore very expensive.

Bacteria can now be engineered to make proteins that they do not normally produce, allowing supplemental hormones like BST to be synthesized. To produce BST, researchers located and isolated the gene that stimulates the production of bovine somatotropin. They inserted it into a plasmid taken from a bacterium. Scientists opened up the plasmid ring with a restriction enzyme and spliced the gene into the opening. The plasmid was reinserted into the bacterium. Modified bacteria are placed in a fermentation tank under ideal conditions for the bacteria to grow and divide. After a substantial number of microorganisms are produced, somatotropin can be purified from the bacteria.

Poor animal health costs the U.S. livestock industry approximately $17 billion annually. Advances in biotechnology have strengthened the fight against animal disease. Biotechnology is used to improve the health of livestock in three major ways.

Monoclonal antibody technology is one way biotechnology is used to produce animal health products. When a virus, bacteria, or parasite attacks an animal, the animal's immune system responds by producing proteins called antibodies. Antibodies are very specific in their function; they are only produced in response to a particular antigen (a substance that triggers an immune response). When an animal is vaccinated with a weakened form of the disease-causing organism, the animal's body produces antibodies that continue to look for the antigen for years after the vaccination. Monoclonal antibodies are produced by fusing a tumor cell to an immune system cell

that produces antibodies against a specific antigen. This process yields a cell that divides rapidly (because of the tumor cell) and produces the desired antibody. Several tests for diseases have been developed from this technology, such as the quick sale barn test for brucellosis and the animal pregnancy test.

The second way biotechnology affects animal health is through the development of therapeutic proteins. In the past, veterinarians have not had a drug to use to fight viruses. When injected into an animal, therapeutic proteins like interferon and interleukin-2 attack viruses. They also stimulate the animal's immune system to attack the viruses. Like growth hormones, therapeutic proteins are produced by genetically modified bacteria. Preventing shipping fever, a disease found in cattle, has been a major focus of the use of therapeutic proteins. Shipping fever is the result of an attack by several viruses that the animal's immune system normally repels; this defense is weakened when an animal is under stress. Injections of therapeutic proteins may help prevent shipping fever.

The third way that biotechnology is influencing animal health is through genetically engineered vaccines. Early vaccines were made from dead or weakened disease-carrying organisms. These vaccines can take a long time to develop, must be refrigerated, and may have side effects. Vaccines developed using genetically modified bacteria contain only the antigen of the disease-causing organism. They stimulate the immune system to produce antibodies against the antigen. Genetically engineered vaccines are safer and can be produced relatively quickly. Examples of vaccines produced through biotechnology include vaccines for scours in pigs, foot-and-mouth disease, pink eye, and tapeworms in sheep.

DNA Fingerprinting in the Livestock Industry

DNA fingerprinting is the result of fragmenting DNA with a restriction enzyme and then segregating the fragments with gel electrophoresis to produce a distinctive pattern. It is being used in the livestock industry to positively identify individual animals. In the past, valuable animals like race horses have been stolen by switching an animal with a look-alike. DNA fingerprinting can accurately identify stolen animals. It can also verify that an animal is the offspring of a particular set of parents. Some breed associations require that a blood sample be submitted with the application for registration for an animal so that a DNA fingerprint can be made. DNA fingerprinting is also being used to identify transgenic animals for patenting purposes.

Emerging Applications of Biotechnology in Animal Agriculture

Research continues into the development of new and expanded applications of biotechnology in animal agriculture. Currently, genetically engineered vaccines for foot rot in cattle and strangles in horses are under development. The livestock feed industry is looking into the possibility of using genetically modified bacteria to produce protein for feeds; the bacteria containing the desired protein would be killed and the contents added to the feed. The feed industry is also researching methods of engineering rumen bacteria so that animals can better use feedstuffs that are normally hard to digest.

The cloning of adult animals is emerging as a new area of animal biotechnology. In early 1997, Dolly, a sheep cloned from a single cell taken from an adult animal, was introduced to the world. Although this type of cloning is possible, it is extremely expensive, and its applications are likely to be limited to a few highly specialized functions. For example, if animals were genetically modified to grow human organs, cloning these animals would allow their numbers to increase more quickly.

Summary

Biotechnology is playing a growing role in animal agriculture. From the use of bacteria-produced somatotropin to the development of genetically engineered vaccines, biotechnology is changing the livestock industry. As research continues, more applications of biotechnology will affect the production of livestock.

Credits

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Rawlings, Emma L., and Peggy J. Hamlett. *Agricultural Biotechnology*. Texas A&M University: Instructional Materials Service, 1996.