Genetic engineering of animals: benefits

Animal genetic engineering has existed for thousands of years in the form of selective breeding. People have chosen desirable characteristics for appearance, survival traits, and other qualities in animals they wish to obtain in future offspring. They then bred these animals to selected mates in order to increase likelihood of offspring inheriting these desired traits. More recent definitions of genetic engineering define it as the manipulation or modification of the genetic code of selected animals to alter characteristics and to introduce certain desired traits by changing the cell's genome. This can be done by adding to or deleted from DNA or substitution of certain genes. This form of manipulating DNA is a very new technology. This type of engineering was made possible over many years of research and significant findings that has led to what is now the understanding of DNA's structure, purpose, and properties. First studies of manipulation were conducted on bacteria such as E. Coli before animals were experimented with beginning in 1982 with mice.

While genetic engineering is a new exciting and fascinating discovery for scientific research with unlimited range of possibilities, it raises moral and ethical concern. It is a highly controversial topic this day in age. Questions have been raised about the extent that animals can be treated to conditions and procedures considered to be unethical for humans. Debates regarding animal's rights to not be inflicted with pain or caused suffering of the animal are considered against benefits for human interests. Many arguments about animal's consciousness, self-awareness, cognitive and language capacity, morals, quality of life, and evolutionary status have been evaluated in hopes to find differences between humans and animals. If a moral standard could

be clearly defined this could justify treating animals to extreme laboratory harms. There is a wide range of opinion regarding the weight that should be accounted to human and animal interests. At one ends of the bar there are what is called an absolutist positions, people that feel human benefits are always significantly more important to animal interests. The opposing view is that if it is certain experiments should not be conducted on humans, they should also not be conducted on animals. Within this group there are two sub categories of opinion. Some activists object to experiments which cause animal's pain and suffering, while others object to all human uses of animals. In order to find common ground between the two extremes a strict set of research guidelines has been established to find morally but beneficial genetic engineering on animals. Some basic criteria for animal research are as follows. Animal housing and care are provided with proper food, water, and cleanliness. Discomfort, distress and pain are minimal using appropriate medication, and without unnecessary pain inflicted. Clear objectives and procedures are defined and carried out. All experiments using animals must undergo a protocol ethical review. All investigators that handle and use animals have to be appropriately trained and qualified to work with the animals. If it is necessary to administer euthanasia, is should be carried out according to good practice and used appropriately. The studies have to have a worthwhile beneficial outcome for human, animal, or medical use. Lastly the benefits of the study must justify and outweigh the harm done to the animal. Animal research is a necessary, highly beneficial to genetic research and can be ethical if conducted properly.

There are a huge variety of benefits that genetic engineering in animals has provided not only for human uses but for animal gain as well as insight into evolution of species. The largest use of animals is for medical advancements. Most of the work done is applied to medical or biological research intending to understand gene function and regulation as well as study human or animal disease. Animals can be used to alter their DNA sequences to see the results. It is now known today many gene functions and causes of disorders from animal DNA analysis. The capability to replace or change single genes, or even delete them, can help investigate the natural functions of a gene, the mechanisms in the body that control it or affect it, and the relationship between genes and environmental factors. This information has provided insight to how genes function and ways to alter these genes in order to prevent diseases and disorders. The ability to investigate the genomes of mice has revealed processes where genes are turned on or off, and cell tissues become differentiated. Many different mouse genes have been altered to mimic human diseases are used in studying the mechanisms that the disorders are caused by, and are being used towards developing more effective treatments. Humans have greatly benefited from these findings especially in the advancements of treating diseases such as cancer. Drugs can also be tested on these genetically engineered animals to see how they will affect processes such as cell replication and destruction. These animals provide an unlimited range of knowledge and opportunity for new technology and advances in the medical field.

Animal genetic engineering has also provided advances in the industrial world as well. Genetically modified farm animals were used in scientific

research procedures for a range of potential and actual benefits. A better understanding of disease resistance in livestock has been found and can now be applied to other animals to produce more disease resistant livestock. Genetic modification of cows may production of milk with enhanced nutritional quality in the future. Farm animals have also been genetically modified to increase productivity, for example animal growth rate, wool quantity, or milk production. Genetic engineering has also been used to select for genetic factors associated with more viable characteristics of livestock as well as to make livestock more suitable for harsh factory farm conditions. These are just a few benefits animal engineering provides and many more will come in the future.

Genetic engineering is made possible by the unique properties of DNA. DNA is a double stranded helical structured with nucleotide base pairs held together in the middle with hydrogen bonds. This weak form of bond allows the strands to separate to be replicated easily. DNA is tightly wound into chromosomes. Genes are formed by the different nucleotide sequencing on the DNA strand. These genes code for a certain trait in the organism. The genetic makeup of the organism is called the genotype; the physical or observable trait that they code for is called the phenotype. This phenotype might be an appearance, a survival characteristic, or more desirable quality for the species. Understanding of the structural and function properties of DNA allows researchers to isolate genes, and manipulate them in a variety of ways. There are numerous methods of genetic manipulation so I will only briefly discuss a few select types.

DNA recombinant techniques use vectors such as plasmids and viruses that carry foreign genes into host cells. This method is most often used to alter bacterial genomes. The plasmid circles can be broken allowing new genetic material to be inserted in them. This is done by treating the bacteria and a specific gene with a restriction enzyme so ends of each will join with each other on contact. Plasmids with new genetic material can pass across the cells plasma membrane and insert the new genetic material into the bacterium’s own genes. The bacteria will add the gene to its sequence and begin to produce the protein that it codes for.

Viruses, which are infectious particles of genetic material, act similarly to plasmids as vectors in genetic engineering. The virus carries the gene into a host cell similar to plasmids. Researchers’ can choose the bacteria that have the new genes absorbed into them and use those bacteria to place the gene into the desired animal.

Microinjection is a method that does not use biological vectors of plasmids and viruses. This method involves injecting genetic material with new genes into the recipient cell. When the cell is large enough, like many animal cells, the process can be done with a glass needle. After the injected genes find the host cell’s DNA sequence they can incorporate themselves into the strand. This is one of the simplest methods of gene manipulation.

Bioballistics is a method that use metal slivers to carry the genetic material to the inside of the cell. The small metal pieces are coated with genetic material. It injects the pieces into the cell using a gun like apparatus. A perforated metal plate stops the cartridge, but the small pieces are allowed

to pass through into the living cells. Inside the cell, the genetic material is carried to the nucleus and is incorporated into the cells genes. The cells take up the gene are programmed to replicate it. This is the most successful way for the insertion of genes into plant cells but can but can be used in animals as well.

Genes are chemical compounds, so they can be manipulated in the same way as other chemical compounds can be manipulated. DNA molecules are large and complex, so the task of manipulation is extremely difficult. However, chemists know techniques in order to cut molecules apart and then put them back together very carefully with high technological instruments. This procedure is known as gene splicing. This method of gene splicing can happen naturally in cells during such processes as division or repair. Cells take genes apart, rearrange their material, and put them back together in a new sequence or arrangement. Discoveries show that cells have certain enzymes that can disassemble DNA molecules and put reassemble them again. Such as endonucleases which are enzymes that can cut a DNA molecule at some given sequence location. Another example is exonucleases are enzymes that can remove one nitrogen base from the DNA stand. A third type is ligases that are enzymes that can join two DNA segments back together. Researchers can use knowledge from these natural methods to artificially alter genes using tools such as submicroscopic scissors and glue. With these they can rearranged one or more DNA molecules by cutting them apart, reordering them, and the put back together again.

There are so much undiscovered possibilities in genetic engineering that it is nearly impossible to predict what the future can hold. Some potential fields

of research are more advances with stem cell research, advances in replacement organs grown form cells, new genetically altered fetuses. There will be more treatment methods for diseases as well as preventions by gene alterations. The possibilities are endless and there is a lot of research being conducted that is not even published yet.

Genetic engineering in animals is of particular interest to me because my family has been in the business of genetic alterations for over thirty years through selective breeding. We own a livestock farm, raising sheep and goats primarily for livestock judging competitions, but as well as for milk production and wool production. Every year we attend approximately twenty fairs or shows throughout New England to have our animals evaluated against competition to be critiqued for desirable qualities and structure based on the “ ideal” species score card. The judge places these animals based on which animal contains the most desirable combination of traits. In order for my family to obtain quality animals we must carefully take into consideration each judges review of the animal in order to select a mate that will compliment it’s strength and has a high likelihood of improving flaws in the offspring. It is a long and tedious process to improve quality of the show herd; it takes years of trial and error to find suitable mates to produce the desirable offspring. Having an understanding of how genes are inherited allows for us to choose a male mate for our females by examining his offspring and seeing the ratios of how many have the trait we are looking for and estimating if there will be a high likelihood we could obtain the trait as well. We also look at the males parents to see what the parental generation had for phenotypic traits. Although we do not use high genetic methods to

create our genetically engineered livestock it is a careful science that takes years of practice in order to know how to find a mating that will give us an increase in desirable traits in order to continue to do as well as we do on the show circuits.

Here is a small anecdote to show my interest in this topic: when I first took a genetics class in high school I learned how to calculate genotypes using the punnett square. This interested me so much I sat down and tried to draw a pedigree to pr edict the genotypes of my black versus white sheep and the likelihood of each of their genetic make ups based on their parents and the offspring they have produced. I was able to determine white is recessive to black and which sheep were heterozygous or homozygous for many of them. Selective breeding is a very important method for my family’s business without it there would be a lot of difficulty maintaining and improving the high quality livestock show herd we have.

Genetic engineering in animal species has come a long way from simple matings to complex technology manipulating genomes. There are benefits including medical advances for humans, disease prevention for animals, and industrial production gains. These benefits can be obtained as long as the research stays within the set ethical guidelines. There are many methods to alter the DNA sequence such as recombinants with vectors and plasmids, microinjections, bioballistics, and gene splicing. Genetic engineering will continue to advance and hold great promise for opportunity for future advances.

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