Genetic Engineering and its applications: A way to Engineer and manipulate genes

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Abstract

In this review, we have discussed various applications of genetic engineering along with their potential uses and benefits. Genetic engineering includes various techniques used to identify, replicate, modify and transfer the genetic material of cells, tissues or complete organisms. Most techniques are related to the direct manipulation ofDNA oriented to the expression of particular genes. Gene transfer allows the movement of gene from one organism to any other organism. Another important aspect of genetic engineering is gene therapy which aims to restore correct gene expression in cells that have a defective form. Many genetic diseases can be treated with the help of modern recombinant DNA technology. However, this technology has led to great advancement in the field of agricultural and medical sciences.

Keywords: *Recombinant DNA technology, Gene expression, Genetic diseases*

Introduction

Genetic engineering involves direct genetic modification of organisms using recombinant DNA technology. In fact, conventional breeding developsnew varieties by the process of selection, and seeks to achieve expression of genetic material which is already present within a species. The product of conventional breeding emphasizes certain characteristics. However these characteristics are not new for the species. The recombinant DNAis any artificiallycreated DNA molecule which brings together DNAsequences that are not usually found together innature. Gene manipulationinvolves creation of recombinant DNA and its subsequent introduction into living cells.

Genetic engineering can be used to directly alter individual genotypes. These procedures are used toidentify, replicate, modify and transfer the genetic material of cells, tissues or complete organisms (Izquierdo, 2001; Karp, 2002). Human genes can be inserted into human cellsfor therapeutic purposes. In addition, because allspecies carry their genetic information in DNA and use the same geneticcode, so genes can be moved from one species to another. The popularization of genetic engineering is due to its wide use in laboratories aroundthe world and, developing of modern and efficient techniques. Many sophisticated techniques of gene manipulation, cloning and genetic modification to insert or transfer a synthetic gene or foreign DNA into an organism of interest are available. Organism that receivesthis recombinant DNA is considered as genetically modified (GMO) (Nicholl, 2008).

Most techniques are related to the direct manipulation of DNA oriented to the expression of particular genes. In a broader sense, genetic engineering involves the incorporation of DNA

markers for selection by using marker-assisted selection (MAS), to increase the efficiency of traditional breeding methods based on phenotypic information. The most accepted purpose of genetic engineering is focused on the direct manipulation of DNA sequences. These techniques involve the capacity to isolate, cut and transfer specific DNA pieces, corresponding to specific genes (Lewin, 1999; Klug and Cummings, 2002). Consequently, genetic modification of animals, using molecular genetics and recombinant DNA technology is more difficult and costly than in simpler organisms. In mammals, techniques for reproductive manipulation of gametes and embryos such as obtaining of a complete new organism from adult differentiated cells through cloning, and procedures for artificial reproduction such as in vitro fertilization, embryo transfer and artificial insemination, are frequently an important part of these processes (Murray et al. 1999; Izquierdo, 2001). Genetic engineering works primarily through insertion of genetic material followed up by selection. This insertion process does not occur in nature. A gene gun or a chemical or electrical treatment inserts the genetic material into the host plant cell and then, with the help of genetic elements in the construct. This genetic material inserts itself into the chromosomes of the host plant. Engineers must also insert a "promoter" gene from a virus as part of the package to make the inserted gene express itself. This process involves a gene gun and a promoter is different from conventional breeding, though the primary goal is only to insert genetic material from the same species.

Molecular Breeding

Molecular breeding involves the use of genetic manipulation performed at DNA molecular levels to improve characters of interest in plants and animals, including genetic engineering or gene manipulation, molecular marker-assisted selection, genomic selection, etc. However, molecular breeding implies molecular marker-assisted breeding (MAB) which mainly includes the application of molecular biotechnologies,molecular markers in combination with linkage maps and genomics, to alter and improve plant or animal traits on the basis of genotypic assays. This term is used to describe several modern breeding strategies, including marker-assisted selection(MAS), marker-assisted backcrossing (MABC), marker-assisted recurrent selection (MARS) and genome-wide selection (GWS) (Ribaut et al., 2010).

Gene Transfer

Gene transfer allows the movement of gene from one organism to any other organism. With the help of genetic engineering technology, genetic material and expression products of that material that have never existed before can be created. This completely differs from traditional breeding, which permits the movement of genetic material between different varieties within speciesor between closely related species. Even hybridization and wide crosses cannot move genetic material much beyond these limits. However, hybrids between two species are also known to occur naturally, although such hybrids are primarily restricted to plants with certain characteristics such as perennial growth habit which most crop plants lack (Ellstrand et al., 1996).

Genetic Diseases

Genetic diseases typically involve mistakes in an organism's DNA sequence that results in disruption in the normal production of a certain protein (Griffiths et al.1997). Cancers, however, typically involve damage to somatic cell DNA that disrupts cellular reproduction itself, not just metabolism or protein production. While the actual mechanisms of genetic diseases are complex,

scientists are learning more about their causes and how to detect them. Some of the relevant DNA changes occur in the gene causing the disease; other changes, while not present in the directly relevant gene, alter the functioning of that gene; a third type of change, while not causing a particular disease, indicates that the individual with that particular sequence is more susceptible to developing the disease. Many of these changes can now be detected and scientists continue to discover correlations between specific DNA sequences and genetic diseases. By understanding these correlations, scientists could test for the presence of a particular disease, or the susceptibility to that disease, and perhaps devise cures based upon our knowledge of these relationships (Griffiths et al.1997).

DNA Manipulation

Besides the promise of treating or curing genetic diseases, manipulating DNA can enable scientists to develop new strains of organisms, including mice that serve as models of human diseases useful for pharmaceutical testing, or sheep that secrete medicines in their milk (Rebelo 2004). New strains of agricultural crops have been engineered, by inserting genes from animals or other plants, making them resistant to cold, disease, or pesticides (Myskja 2006).

Benefits

Genetic engineering has already supplied us with products that alleviate illness, clean up the environment, and increase crop yields, among other practical benefits to humanity and the ecosystem. The first genetically engineered life form to be granted patent protection was developed by AnandaChakrabarty, who genetically engineered a common bacterium into *Burkholderiacepacia*, a variant that digests petroleum products (*Diamond v. Chakrabarty*1980).
Genetic engineering has also helped create thousands of organisms and processes useful in medicine, research, and manufacturing. Genetically engineered bacteria churn out insulin for treating human diabetes, production of which would be substantially moreexpensive without the use of genetic engineering.The OncoMousewas the first genetically engineered mouse to be patented to beused as a model for cancer research. Gene therapy, in which manufactured viruses can deliver repairs to somatic cells with genetic defects, is making strides to correct genetic diseases or defects in fully grown humans.

Applications of genetic engineering

Genetic engineering has three main application areas: medicine, agriculture and bioremediation of the environment. In all three areas, transgenic crop plants, livestock, microorganisms and viruses are used. A development towards multi-transgenic constructs is anticipated. Finally, multi-transgenic organisms based on nano-biotechnology, RNAi technology and synthetic biology used separately or in combinations may become realities. The transgenic animal technology involves the isolation or synthesis of a gene, which will be manipulated and used for transformation leading to the transgenic production. Transgenic animal technology and the ability to introduce functional genes into animals arepowerful and dynamic tools of genetic engineering. Genetic engineering allows stableintroduction of exogenous genetic information into any live organism introducing entirely novel characteristics. The cloning technology is closely related withtransgenic, being used as a tool for genetic engineering of an animal. These technologies can be used together to dissect complex biological process, like *in vivo* studyof gene function during development, organogenesis, aging, gene therapy, and epigeneticsstudies. Genetically engineered animals such as the ‘knockout mouse', in which one specific gene is

'turned off' are used to model genetic diseases in humans and to discover the function of specific sites of the genome (Majzoub and Muglia, 1996).Genetically modified animals like pigs will be used to produce organs for transplant to humans via xenotransplantation (Murray et al. 1999; Prather et al.2003). Other applications include production of specific therapeutic human proteins such as insulin in the mammary gland of genetically modified milking transgenic animals like goats (Murray et al. 1999; Wall, 1999). These techniques may be used to increase disease resistance and productivity in agriculturally important animals by increasing the frequency of the desired alleles in the populations used in food production.Several important biotechnological applications such as the production of recombinant proteins in bioreactors (Houdebine, 2002), disease diagnostic (McKeever and Rege, 1999), feedstuff processing (Bonneau and Laarveld, 1999) and production of vaccines (Eloit, 1998), proteins, stem cells, tissues and monoclonal antibodies for use in therapeutics are not included here. The impact ofreproductive technologies on animal breeding, not directly related with gene transfer are reviewed elsewhere (Van Vleck, 1981; Visscher et al. 2000). In the industry, genetic engineering has been extensively used for the production bioreactor able to express proteins and enzymes with high functional activity. Already in agriculture, genetic engineering is being very controversial because it tends to produce genetically modified foods resistant to pests, diseases and herbicides.

Recombinant DNA has opened new horizons in medicine

The developments in gene manipulation that have taken place in the last 30 years have revolutionized medicine by increasing our understanding of the basis of disease, providing new tools for disease diagnosis and opening the way to the discovery or development of new drugs like monoclonal antibodies, treatments, and recombinant vaccines. Another function of genetic engineering is gene therapy which aims to restore correct gene expression in cells that have a defective form.

Conclusion

Genetic Engineering has the potential to transform our lives in many positive ways.Genetic manipulation provides useful ways to produce transgenic organisms. It is not likely that this technology, will replace conventional methods for genetic improvement. Instead, they probably will begin to be gradually incorporated into current genetic improvement programs that use efficient improvement methods to achieve particular objectives.The biggest problem in genetics is not to make changes in the DNA, but to be faithful to a principle which is common to all men, of all cultures and responsible for perpetuating human and natural environment therefore more important than any gene is ethics.

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