

Biotechnology and medicine: ethical concerns

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Introduction

In 1903 the Wright brothers flew for the first time in a machine heavier than air. They soared 30 metres above land for 12 seconds. No one would have imagined that this technology would one day lead to the manufacture of aircraft which would cross the sound barrier and transport hundreds of people across the world. Today, another earthshattering scientific achievement has been made which will revolutionise biotechnology: man has been able to clone a mammal from an adult cell in the laboratory. In addition, it is now possible to replace or introduce new genes into a cell in the progress of an individual. This has been possible because of the tremendous progress made in molecular and cellular biology and our ability to study the genetic material - DNA - more closely.

Recombinant DNA technology

DNA is a long, double stranded chain of nucleotides on which are located functional units called genes. The discovery of enzymes called restriction endonucleases has provided a powerful tool to cut DNA into smaller fragments at specific sites and join them with any other DNA fragment cut with the same enzyme, thus making recombinant DNA molecules. A major change in biotechnology came about along with this discovery when the molecular biology of microbes was unraveled. Bacteria carry plasmids which are autonomous, extra- chromosomal DNA molecules in the microbes which can be purified in the laboratory. Genes (DNA) from any organism can be introduced into bacteria via plasmids and expressed in a simple, inexpensive bacterial system. Human genes can now be joined to regulatory DNA sequences of bacterial genes and expressed in bacteria. A number of pharmaceutical companies are producing substances such as insulin by using this technology instead of from animal or human tissues. Such proteins are called recombinant proteins.

During the last two decades techniques in molecular biology have added immensely to our knowledge of the molecular make- up of the cell. It is not only conceivable to identify any gene from our 50,000 to 100,000 genes which we carry in every cell, but it is possible to isolate a specific gene from a few blood cells drawn from our body. With the help of this technology it is feasible to clone the isolated gene and grow it on a large scale, analyse it by sequencing its nucleotides and express it either in bacteria or in mammalian cells in culture to produce large quantities of the protein.

The function of a gene can be elucidated by studying the protein it makes. Mutations in certain genes result in defective protein synthesis, thus resulting in a diseased condition. With the help of molecular biology techniques it is possible to diagnose some of the diseases by molecular analysis of the patient's DNA. Diagnosis of some of the diseases including genetic disorders, cancer and infections has become swift and sensitive using this modern technology. Individuals at an increased risk for a particular disease can be diagnosed at a very early stage in life. Prophylactic treatment can be given to some such individuals.

Gene transfer in mammals in vivo

In addition to expressing foreign genes in bacteria and mammalian cells in culture, genes can be expressed in whole animals by transgenic technology. Genes, in the form of purified DNA carrying appropriate regulatory sequences, can be introduced into fertilised eggs before they start dividing. These manipulated eggs are then reintroduced into the uterus of recipient, foster females and allowed to develop to term. The young ones born from the foster mother are then screened for the presence of the transgene. Transgene animals carry the transgene in all their cells including germ line cells. They can be bred to obtain a colony of genetically modified animals, since the transgene can be passed on to the progeny. This has limitless applications in animal husbandry and farming, medicine, production of recombinant proteins from animals and in basic research. Many different species have been considered for the production of medicinal products and transgenes have been expressed in body fluids such as blood or milk as well as other tissues. The pharmaceutical industry worldwide has recognised the

potential benefits of using transgenic technology in production of pharmaceutical material as well as in the understanding of human diseases and exploring newer therapies.

Gene transfer in humans

The next obvious step was to introduce foreign genes into human cells in vivo. A large number of genetic diseases are caused by the presence of a single defective gene. It has been the dream of mankind to correct single gene defects by replacing them by normal genes. This dream has now come true with the help of recombinant DNA technology. Gene therapy, where genetic material or DNA is used in therapy, has become a reality. At present gene transfer in vivo in human somatic cells is permitted after obtaining clearance from regulatory bodies. Germ-line gene transfer into humans has yet to be approved.

The first clinical trial for human somatic cell gene therapy was carried out in 1990 by a group of scientists and clinicians in the USA for a disease called severe combined immunodeficiency syndrome (SCID). Two young girls, suffering from SCID due to defect in their gene coding for an enzyme, adenosine deaminase, received the normal gene thereby overcoming the enzyme deficiency. Today there are a large number of ongoing clinical trials in the West for genetic diseases as well as cancer. Clinical trials are carried out on a select group of patients to evaluate the efficacy and safety of the gene therapy strategy. We learn and improve on existing strategies from these clinical trials. We still have a long way to go before gene therapy becomes a routine practice but there is optimism that it will.

Ethical issues in using recombinant DNA technology in medicine

As mentioned earlier, advances in molecular biology have made diagnosis of some of the diseases very sensitive, accurate and rapid. Diagnosis of genetic disorders associated with chromosomal alterations often helps in deciding the course of treatment for the patient. However, these tests are expensive as they involve costly molecular biology reagents and should be recommended only if it is absolutely essential for patient management and care. Unfortunately, very often, a plethora of tests is recommended only to recover the cost of the expensive equipment purchased to carry out the test. Is this ethical?

With the discovery of genes involved in the etiology of various diseases it is now possible to identify those which confer susceptibility to the disease. Individuals carrying the susceptibility gene may be at a higher risk of contracting the disease. On learning that a person is carrying the susceptibility gene, can one stop or prevent progression of the disease? Prophylactic treatment can be given to some such individuals. Environmental factors which trigger the disease could be avoided. Could the knowledge that one is carrying the susceptibility gene lead to more problems than benefits? Will it lead to discrimination in employment, insurance policies, social life? Very often when screening families with familial cancers for susceptibility genes, it is difficult to convince unaffected, young, unmarried females to provide a sample of blood for genetic analysis. They fear that if they were found to carry susceptibility gene/s they would be stigmatised. Such information therefore has to be kept strictly confidential. Informed consent has to be obtained from the participants after explaining the risks and benefits of the research or treatment.

Ethical issues in somatic and germline gene therapy in humans

Somatic cell gene therapy is only a small step forward as the DNA is not passed on to the offspring. The only problem that one envisages from somatic gene therapy for genetic disorders is that this may significantly enhance the proportion of abnormal genes in the population. Individuals with defective genes will be able to survive, reach maturity and pass these genes to their offspring. This can be avoided by introducing the therapeutic DNA into the germline cells. Such genetic manipulations would offer considerable hope to individuals with genetic disorders. However, the technology for germline gene transfer in humans needs to be improved to be sure that abnormal foetuses are not formed due to the manipulations. But the major question is - is it ethical? Are we justified in changing the genetic make-up of a human being? One may argue that it should be permissible to rectify a genetic defect. But would it lead to selecting 'good' genes for physical appearance, intelligence etc? Will there be another Hitler who will try to change the human race with these powerful tools in hand?

Cloning of a sheep from an adult cell, closely followed by cloning of a monkey, has caused quite a furor worldwide. This technological feat has a tremendous potential in our understanding of genetics and

reproduction, in improving the process of breeding where farm animals are considered. Whether this would lead to man making numerous copies of himself/ herself; whether this abnormal way of reproduction should be permitted, are some ethical, moral and spiritual questions.

Conclusion

The recent advances in biotechnology present both benefits and risks. They have revolutionised the process of drug manufacture, diagnosis and treatment and the production of animal models for human diseases. There is a tremendous potential for creating new drugs and treatment. This technology raises important ethical issues in the social structures including families, preventive medicine, employment, health insurance etc. We must interact with the general public, to educate them, and prepare them better for the impact of biotechnology. The scientific and medical communities and the public, in general, have to use these powerful tools responsibly, for the maximum benefit of mankind.

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Where the mind is without fear

Where the mind is without fear and the head is held high;
Where knowledge is free;
Where the world has not been broken up into fragments
by narrow domestic walls;
Where the words come out from the depth of truth;
Where tireless striving stretches its arms toward perfection;
Where the clean stream of reason has not lost its way
into the dreary desert sand of dead habit;
Where the mind is led forward by Thee
into ever widening thought and action
Into that heaven of freedom, my Father, let my country awake.

Rabindranath Tagore