THE POTENTIAL OF GENETIC ENGINEERING.

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Genetic engineering, in broad terms, means the deliberate manipulation of genetic material. Specifically, it usually means taking defined bits of genetic material from one organism and inserting them into another organism. The potential of genetic engineering is vast and varied. It offers great hope for the efficient detection and treatment of disease, for the improvement of agriculture, and even for the control of pollution. As with the introduction of any new powerful technology there are worries and dangers attending. Many of the questions raised are about ethical issues and I will deal with these questions in the next article.

The basic unit of organisation in all biological organisms is the cell. Every cell contains genetic material which controls its day to day activity and, when the cell divides in two to form daughter cells, exact copies of the genetic material are passed to both offspring. The genetic material contains the information that bears on every aspect of the cell's activity. The genetic material is composed of the chemical DNA, a very long molecule made up of units called nucleotides. There are four different nucleotides and the information content of the DNA is carried in the nucleotide sequence. This information determines the types of proteins that are synthesised in the cell, and these proteins carry out the cell's activity. The length of DNA that codes for one protein is called a gene. An alteration in a gene will result in the production of an altered protein, which usually has serious negative consequences for the cell. The introduction of a new gene into a cell gives the cell the capacity to make a new protein.

Medicine lists several thousand human genetic diseases resulting from alterations in single genes and inherited from one generation to the next. These diseases contribute considerably to the burden of human misery. Typical examples are cystic fibrosis, muscular dystrophy, and haemophilia. Cystic fibrosis is the most common inherited fatal disease of Caucasians, with a frequency of about one in two thousand births. The genetic defect results in the absence of a protein whose function is to regulate certain aspects of salt balance. This causes the mucus-lining on the outside of cells to become thick and turgid resulting in obstruction of the pancreas and chronic infection of the lungs, which are the usual cause of death in childhood or early adulthood.

For many years molecular biologists (biologists who work at the molecular level) have been making intensive efforts to identify and characterise the altered genes that cause the major genetic diseases. These efforts have been rewarded with considerable success, for example in cystic fibrosis and muscular dystrophy. Characterisation of the gene allows two possibilities - genetic testing and genetic therapy. Genetic testing means using a probe that recognises a gene in order to see if a subject is carrying the altered gene. Genetic testing could be carried out on a widespread basis (screening) using tissue samples that are easily obtainable e.g. blood samples. Genetic testing can also be done on embryos in the earliest stages of development. Such tests also identify the sex of the embryo.

Intensive and very promising efforts are now underway to develop effective techniques for gene therapy of cystic fibrosis and of muscular dystrophy. Gene therapy means compensating for a genetic defect by introducing good copies of the gene into the cells of the subject who is naturally producing defective copies.

There is enormous potential for genetic engineering in agriculture, in the development of new and improved strains of plants and animals. The general principle involved is not new to agriculturalists. For centuries, animal and plant breeders have used the laws of inheritance to deliberately and gradually modify species in order to enhance agricultural production. Left to her own devices, Nature would never have produced a cow that yields ten gallons of milk per day!

Natural breeding methods are slow and gradual. If a breeder wants to introduce a new desirable characteristic into a species, he must breed that species with a closely related species containing the desired characteristic. The offspring will show the desired characteristic, but also other unwanted characteristics that have been imported from the second species. Several additional cycles of breeding must now be planned in order to gradually get rid of the undesired characteristic, while retaining the valuable characteristic.

The procedures of genetic engineering are much quicker and more flexible. One is not restricted to interbreeding closely related species - genes from one species can be introduced into another species that is not related to the first. Also the technique allows the precise introduction of specific genes only and there is no accompanying range of other unwanted characteristics that have to be subsequently and slowly bred out over many generations.

Using genetic engineering techniques it will also be possible to develop crops that thrive under inhospitable conditions and/or are particularly disease-resistant. The first genetically engineered food to go on sale in the U.S.A. was a tomato that has been genetically altered so that it does not become soft and mushy as it ripens. It will be possible in the future to genetically engineer meat animals that grow much faster than conventional strains and that yield higher quality meat. There are presently many examples where bacteria are altered by genetic engineering and used for large-scale production of an important protein that is expensive and difficult to produce in quantity by conventional methods, e.g. proteins of medical importance such as insulin.

Genetic engineering has produced several examples of trans genic animals, that is an animal into which a gene from another species has been introduced. For example, sheep have been produced bearing a human gene that produces a protein which is secreted into the milk - a blood-clotting factor that is needed by people with haemophilia. Several transgenic animals have been patented by the companies that produced them. These developments raise the prospect of a new agricultural revolution of transgenic farm animals that make valuable human proteins needed to treat disease.

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