# Biotechnology : Technology of the New Millennium

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## 1. Introduction

Biotechnology is the technology of harnessing the natural biological processes of microbes, plants and animal cells, for the benefit of mankind. Man has been using biotechnology for centuries for processing foods like bread, beer and cheese. However, the techniques of modern molecular biology, in particular genetic engineering, which involves direct manipulation of genetic material, have opened up important new possibilities in the field of biotechnology. The characteristics of a living cell are determined by its genetic makeup - by the instructions contained in a collection of biological messages called genes. Genes are passed on from one generation to the next, so that the offsprings inherit a range of individual traits from their parents. Genetic engineering describes the range of techniques used to alter or to move the genetic material of microorganisms, plants or animals, either within the organism or between different organisms. Before scientists could undertake genetic manipulation, they had to unravel the secrets of the genetic code.

## 2. Human Genome Project

The complete genetic blueprint of an organism is contained within every cell of the organism. The coding system underlying the blueprint is based on a substance called Deoxyribonucleic Acid (DNA). Each message specifying a particular characteristic is contained in code in the DNA molecule.DNA is a long double-stranded molecule wound in a spiral called a helix. Each strand of the helix consists of a chain of nucleotide subunits. Each nucleotide subunit comprises a sugar component, a phosphate component and one of four different bases. These bases are represented in their short hand forms as A, C, G and T. The two intertwined chains of the helix are held together by bonds between the nucleotide bases on the opposite strands. A always pairs with T and C with G. This means that the sequence on one strand also specifies that of the other. Also, within strands, the information contained in a given section of DNA is specified by the exact order of the nucleotide bases in that section. The coding system is basically the same in all animals, plants and microorganisms. Human beings are 99.9 percent alike in their genetic sequence. It is the 0.1 percent that makes the differences in our appearance on the outside and on the inside at the cellular level.

It was announced by the Human Genome Project Public Consortium in June, 2000 that a working draft of the sequence of the human genome, the genetic blueprint for a human being, had been assembled by the consortium. The analysis described in the scientific papers published by the consortium in *Nature* in February, 2001 reveals, for the first time, surprising new details about how the human genome is organized and how it evolved. For example, the genome only contains 30,000 to 40,000 genes, far fewer than the 100,000 estimate used for most of the last decade. The analysis also reveals information about the evolution of humans, the surprising observation that some human genes appear to have come directly from bacteria, and information about the mutation rate in males versus females.

Even before the Human Genome Project is complete "proteomics" has become the new buzzword among the biotechnologists. Since the task of sequencing the DNA in the human genome and sticking the result into computer databases is nearly done, biologists are now trying to identify and characterise the human proteome,the entire complement of proteins encoded by these genes. Human body possesses different kinds of protein and each plays a specific role in life. That role can be structural or physiological. The protein haemoglobin, for example, carries oxygen in the blood. Collagen is a structural protein found in many places including nails and earlobes. Actin and myosin interact to give muscle movement, and insulin controls the uptake of sugar from the blood into body cells.

Proteins, like DNA, are also long, chainlike molecules. They are constructed from 20 different amino acid

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building blocks. They are extremely versatile molecules, anywhere from a few dozen to several hundred amino acids long. Unlike the regular spiral formed by DNA strands, proteins fold and twist into an enormous variety of three dimensional shapes. The number of proteins is much larger than the number of genes in human genome.Since the proteins undergo much change over the course of their lives, their number is practically uncountable. Using mathematical jargon it can be said that human proteome, unlike human genome, is not a closed set. However, scientists are now trying to synthesise every single protein made by human and non-human bodies and to explore the functions of these proteins. The ultimate aim of these proteomic researches is to understand how life actually works.

**3. Use of genetic information**

The immediate impact of genetic information is to bring a major change in the way of treatment of diseases in medical field. With the help of genetic analysis identification of disease predisposing genes will become possible which will help predict,at birth, the disease a baby may suffer from. For example, some people may be more susceptible to cancer from smoking, some others may be more susceptible to diabetes and so on.Taking preventive measures before hand can help in avoiding the disease which one may suffer from.Thus in future medicine will change from curative to preventive. Genetic information will also help a doctor to know who may get a side effect from a particular drug and should, therefore, not take the drug.

DNA fingerprint derived from genetic analysis can help medical practitioners in treating dreadful diseases like cancer also. Leukaemia which is a cancer of the bone marrow – a tissue that makes new blood cells – is sometimes treated by removing the diseased marrow and replacing it with a transplant of disease-free marrow from a healthy donor. Doctors can tell quickly whether the transplant has succeeded by taking DNA fingerprints from the patient's blood. If the transplant has worked, a fingerprint shows the donor's bands and if the cancerous bone marrow has not been properly destroyed, the cancerous cells multiply rapidly and the patient's own bands predominate.

Genetic information is also helpful for a range of forensic and other purposes including identifying bodies, tracing offenders, providing evidence in paternity disputes and verifying animal pedigrees. DNA fingerprints, like conventional fingerprints, are used to identify individuals in a large population. These are used in criminal investigations to prove a suspect's innocence or guilt. For example, DNA can be extracted from the blood, skin, hair or other tissue left by an attacker at the scene of a crime, and it can then be compared with DNA from a suspect. The fingerprint can be produced even from tissues left at the scene years before. Because a child inherits half its DNA from its mother and half from its father, DNA fingerprints can be used to help settle disputes regarding identification of the father. Bands in a child's DNA that do not match its mother's must have come from the child's father. DNA fingerprinting can show, with a high degree of certainty, about one in thirty thousand million (1 in 30,000,000,000), that an individual is or is not a parent of a particular child.

The knowledge of genes allows the scientists to look for ways of changing genes in useful ways; for example, to cure diseases or to introduce desirable genes into organisms to allow them to be used as "production factories" or to confer desirable characteristics. Insertion of genes into different organisms is made much easier by the existence of bacterial plasmids—small circles of DNA which are much smaller than the bacterial chromosome. Some of these plasmids can pass readily from one cell to another, even when the cells are far apart on the evolutionary scale. Using the special "cut and paste" enzymes, scientists can insert genes from one organism into a bacterial plasmid and then insert the recombinant plasmid into a living microorganism, where it will direct the synthesis of the desired proteins. Human insulin for treating diabetes can now be produced in this way.

**4. Transgenic Techniques**

Using transgenic technique, in which genetic material is moved from one organism to another so that the latter will exhibit a desired characteristic, more precise and cost-effective animal and plant breeding programs are possible. In traditional breeding programs, only closely-related species can be crossbred, but transgenic techniques allow genetic material to be transferred between completely unrelated organisms, so that breeders can incorporate characteristics that are not normally available to them. The modified organisms exhibit properties that would be impossible to obtain by conventional breeding techniques. The main aim in using transgenic technology in animal agriculture is to improve livestock by altering their biochemistry, their hormonal balance or their important protein products. Scientists hope to produce animals that are larger and leaner, grow faster and are more efficient at using feed, more productive, or more resistant to diseases. Examples of transgenic breeding programs include production of faster-growing and leaner domestic animals like cow or pig that use food more efficiently and resist common diseases or breeding transgenic sheep that grow better wool without needing dietary supplements of sulphur-containing amino acids. Using techniques similar to those used to make insulin-producing bacteria, it may also be possible to develop animals that produce useful biopharmaceuticals. Examples of this are transgenic cows and sheep that secrete medically important hormones or other active proteins into their milk. The cost of these drugs may be much less than that of those produced using conventional techniques or in microorganisms.

Transgenic methods have now been developed for a number of important crop plants also, such as rice, cotton, soyabean, oilseed rape and a variety of vegetables like tomato, potato, cabbage and lettuce. New plant varieties have been produced using bacterial or viral genes that confer tolerance to insect or disease pests or allow plants to tolerate herbicides, making the herbicide more selective in its action against weeds and allowing farmers to use more environmentally friendly herbicides in smaller amounts. A new variety of cotton, for example, has been developed that contains a gene from the bacterium *Bacillus thuringiensis* to produce a protein that is specifically toxic to certain insect pests including the cotton bollworm but not so to animals or humans (this protein has been used as a pesticide spray for many years). These transgenic plants enable less chemical pesticides to be used in cotton production. The same should be true for many other crops which can be engineered to contain the *Bacillus thuringiensis* gene.

Transgenic technologies are also being used to improve other important characteristics of plants such as the nutritional value of crops or the oil quality of oilseed plants like linseed or sunflower.

Eventually it may also be possible to develop crops for non-food uses by modifying the starches and oils the crops produce to make them more suitable for industrial purposes, or to use plants rather than animals to make antibodies for medical and agricultural diagnostic purposes. In the cut flower industry, transgenic research has yielded new products such as blue carnations. It may also be possible to produce blue roses.

Transgenic technology may reduce or even replace the conventional agricultural practices like selective breeding and special feeding or fertilising programs that have been used for centuries. It may also replace the large-scale use of pesticides and long lasting herbicides. Though transgenic technology is still experimental, it offers a number of advantages over traditional methods of selective breeding.Compared with traditional methods, transgenic breeding is more specific and faster since scientists can choose with greater accuracy the trait they want to establish and it takes only one generation compared with the many generations often needed for traditional selective breeding, where much is left to chance. Since much of the cost and labour involved in administering feed supplements and chemical treatments to animals and crops could be avoided, this method is less costly and also more environment friendly allowing less use of chemical pesticides and herbicides and reduced tillage leading to less land degradation.

### 5. Cloning and its ramifications

Another new technique of genetic modification which has recently been discovered and looks very promising as a way of improving the efficiency of the genetic modification of domestic animals is cloning. During cloning, scientists put a cell from an adult into an egg that's been emptied of its contents. The egg then reprograms the adult cell to develop into an embryo. The process takes minutes or hours, compared with the natural process that normally takes months or years. The first animal to demonstrate this was "Dolly", a sheep born in Scotland in 1997. The technology is known as nuclear transfer and allows for the first time the production of animals by similar techniques to those that have been available for the modification of plants for a number of years.

There are some important aspects to this new technology. Firstly, it allows the production of a large number of identical animals; thus, if the cell is developed from an elite animal, the animals produced from such a cell would all have the same elite properties. Secondly, it is a very important technique for the production of transgenic animals because it allows the actual genetic modifications to be carried out in cells while they are in culture. This is a simpler and much less expensive procedure than the techniques involving the whole animal that are in use today and should therefore reduce the very high cost that is currently associated with the production of transgenic animals. It also has the advantage that it allows for the specific removal or substitution of genes, something that cannot otherwise be achieved at present in domestic animals. Because of these advantages it is probable that all genetically modified animals will be produced by this technique within a few years. Another important aspect of this new technology is that several endangered species of animals can be saved from extinction using this technique.

The technology of cloning is, very recently,about to be overtaken by another evolutionary effort by the scientists to create life that is very different from what we know. Scientists have created cells that break a core rule of biology by incorporating a hitherto unused amino acid into the process of building proteins. It is a first step to create organisms that use building blocks other than usual ones which may lead to the formation of Artificial Terrestrial (AT) life in future. The initial impact of this new achievement will be felt in medical science in the making of new drugs. Even if life forms are ever found beyond the earth, scientists would be able to determine whether true ETs have been found or their ancestors are simply delivered somehow from the earth.

### 6. Where do we go from here

It is clear that spectacular advances in the field of bio-technology, specially mapping of human genome, will lead to a new era of medicine. It is expected by the scientists that,in near future, there will be gene based designer drugs for diabetes, hypertension, heart disease, scizophrenia and so on. Every cancer patient will be prescribed medicines that will be tailored to his or her own genetic finger print. Better or new vaccine for malaria, TB, cholera, AIDS, rabies and Japanese encephalitis would also be possible using the genome map. Longevity of human beings will be enhanced and they will be able to manipulate their evolution by genetic engineering. However, there are some flip sides of knowing one's own precise genetic information. If one knows from one's genetic information that he or she is a carrier of a deadly disease which is not curable, then what is the use of knowing this information? Since a faulty gene does not always mean that one will inevitably develop an illness, it may happen that one bears in mind throughout one's life the fear of developing a disease without actually developing the disease. What should parents do when they know before the birth of their child that the child may develop a dreaded disease due to a genetic disorder? It is such an emotional issue that even well informed parents will hesitate to take a decision as to whether the child should be aborted or not. There is another dark side of knowing genetic information of an individual, which is misuse of this information. This may lead to genetic discrimination on the basis of disease status by the employers or insurers. Therefore, comprehensive laws to regulate the collection, processing, storage and dissemination of genetic information is an urgent need to safeguard an individual from genetic discrimination. Another contentious issue which gets much importance recently is human cloning. Recent researches prove that human cloning is easier than cloning of some other animals. Human cloning may produce elite human being in future. Even there may be no need for a male counterpart in the process of reproduction. Would it lead to a world where males would be an endangered species having nothing to do with creating off-springs? Another threat to the whole mankind is bio-war i.e. use of biological weapons during warfare. With the progress of genetic engineering it may become possible to use genetically mutated bacteria that are resistant to antibiotics to help spread diseases causing loss of thousands of lives. So, we will have to decide whether we will use the knowledge about life to make it more beautiful or to destroy it.