Bio-Technology

Introduction

"Bio-technology is the application of biological organisms or processes to manufacturing and service industries." 1Bio-technology promises to manufacture a variety of environmentally-friendly products which can supplement or even substitute those synthesized chemically. The wide range of bio-technological products includes antibiotics and hormones, food additives and vitamins, inexpensive, ecologically clean fuel and biological plant- protecting agents substituting for dangerous pesticides. Also, cattle feed and even human food can be produced from microbial or yeast biomass by bio-technological methods. Bio- technology encourages hopes for overcoming the pressing problems of modern society, such as environmental pollution, food and energy shortage, infectious diseases including AIDS and even cancer. For instance, biologists have discovered a number of extremely toxic substances produced by living organisms. One molecule of the plant product ricin is enough to kill one cancerous cell.

Bio-technology opens up new horizons for biopolitics, it can significantly contribute to the great task of maintaining and promoting the bio-environment. 2-4 Nonetheless, bio- technological processes should be subject to control by expert commissions on bio- environment preservation. Uncontrolled production of protein from microbial biomass may result in dangerous air pollution, posing the threat of allergic diseases. Ecological appraisal of bio-technological products and techniques is thus an important practical measure to be taken. 5

Methods of Bio-Technology

Bio-technology is based on a number of methods. 2-9 The most important of them are considered below:

- selection of the organisms possessing the desired properties, e.g. the capacity of producing nutritious, protein-rich biomass;
- genetic engineering, i.e. goal-directed site-specific change in the genes of an organism through manipulating its DNA;
- cell engineering, the fusion of two or more cells from different tissues or biological species resulting in somatic hybridization;
- enzyme engineering, modification of the functional characteristics of biological catalysts, or enzymes, for employing them in food, drug and chemical production: the essential method is the immobilization of enzymes or cells containing them;
- cultivation of plant and animal cells apart from the correspondent multi-cellular organism, a prerequisite for the production of valuable compounds and the application of the genetic and cell engineering methods mentioned above;
- large-scale production using micro-organisms or cells, together with the technical designs of the processes and equipment (bio-reactor or fermenter and the auxiliary parts of the set-up);
- downstream processing technology: isolation, purification, chemical modification and stabilization of the products of the bio-technological processes, including modern separation techniques such as gel, ion exchange and affinity chromatography, electrophoresis, isoelectric focusing, isotachophoresis, ELIZA, etc.;
- eco-engineering, or ecosystem bio-technology.

Applications of Bio-Technology

The bio-technological methods are being increasingly applied to the following fields: 2- 13

- plant protection, in particular the elimination of harmful insects and weeds by bacterial, viral and fungal agents;
- animal protection through preparation of vaccines, diagnostics and medicines, in order to prevent and/or treat infectious diseases such as rabies, foot-and-mouth disease, brucellosis and viral diarrhea;
- amelioration of agricultural plants and animals. This aspect of bio-technology can be considered on both the quantitative and the qualitative level. In the former case, the productivity of the organisms is to be enhanced;
- preservation of the environment: bio-degradation of pollutants, establishment of integrated systems of ecological protection with the use of ecosystem bio-technology;
- production of microbial biomass as single-cell protein (SCP);
- production of fuel (ethanol, butanol, 2,3-butanediol, acetone, methane, hydrogen) with the help of microorganisms;
- medical uses: production of antibiotics, enzymes, anti-tumor agents, immunity factors, vaccines, diagnostics;
- food quality improvement with biological additives, stabilizers and aromatizers;
- bio-geotechnology: 8 microbial leaching of poor metal ores, separation of oil-water mixtures, extraction of residual oil from oil mines

by pumping in solutions of dense microbial polysaccharides.

Genetic Engineering

As a result of rapid progress in molecular genetics, it became possible in the mid- seventies to manipulate the structure of DNA, the molecule containing the hereditary information of an organism. This breakthrough was achieved, when enzymes cutting DNA in site-specific fashion became available to scientists. This extremely important method of modern bio-technology makes it possible to introduce the gene of interest into a suitable organism. Typically, the gene encoding the character desired is inserted into the genome of the organism using different techniques:

- viral infection of the target cells, the virus (phage in the instance of bacteria) carrying the gene of interest;
- transfer of hereditary information with the help of small pieces of genetic information called plasmids; plasmids are characteristic of bacteria, fungi and plants;
- direct introduction of this information into a living cell using microinjection or microprojectiles, in this way, it is possible to introduce genetic information into animal cells;

The first project carried out in the field of genetic engineering consisted of transferring the gene of the human hormone somatostatin to the bacterium Escherichia coli. Since then, a number of important results was obtained, including the following achievements:

- since 1982, human insulin has been produced on an industrial scale, using a gene- engineered strain of E. coli;
- E. coli was engineered to produce the coat protein of the foot-and-mouth disease virus, this product was used as vaccine for cattle;
- since the early eighties, human interferon (the commercial name being bio-feron) is produced using animal cultivated cells with introduced human genes;
- the sugar substitute thaumatine, 10,000 times sweeter than beet sugar (sucrose) was obtained by supplementing the DNA of a bacterium by the corresponding gene of a tropical thaumatine-containing plant;
- the colony stimulating factor boosting the strength of the human body's defense system was obtained using a gene-engineered bacterial strain; 2,10
- transgenic plants (e.g. strawberry) and animals (cattle) were bred in the course of the 80's;
- the gene of phaseolin, the bean seed protein, was introduced into plants;

The bio-ethical issues relating to genetic engineering have been a major considerable concern in both the scientific community and the public at large in the seventies and afterwards. The key issue concerned the threat of unintended, or still worse, deliberate production of genetic monsters, including new, dreadful pathogenic microbes, uncontrollably developing weed plants and standardized people. As time passed, it became clear that some of these risks had been exaggerated. Each natural living organism is a well-functioning, coherent system. Human intervention into the genes regulating this system is likely to disrupt its operation. This predominantly decreases the fitness of the resulting creature and thereby reduces the potential danger of its uncontrolled spreading outside the geneticist's laboratory.

Other important ethical issues surfaced in the 80's:

- as genetic engineering extended to all the kingdoms of life, the ethical posture of humans playing God was called into question;
- medical applications of genetic engineering dictated the employment of organisms as closely related to man as possible. The reason for this was that each organism leaves its own species-specific mark on all the substance it produces. This is the case even if the product is synthesized according to extraneous genetic information. Genetic engineering therefore tended to implicate higher vertebrates, causing fears, as the further step would be to deal with human cells, implying that scientists would take a tremendous responsibility;
- a serious problem with the philosophical dimension is the patentability of living organisms produced using genetic engineering., such as the claim to a patent made by a U.S. research group concerning transgenic mice; 14
- low efficiency, productivity and viability of the use of organisms, e.g. human hormone-producing bacteria;
- frequent displacement of gene-manipulated organisms by `wild' ones, which either penetrate from outside or arise from reversion of the artificially induced mutations;
- incompatibility of the substances produced by human gene-carrying microbes with the human organism: e.g., interferon produced by gene-engineered mutants of E. coli is inefficient therapeutically as it is not glucosylated, in contrast with native human interferon.

Thus, in the course of its almost 20-year long history, genetic engineering has made important achievements, but has also raised a number of new issues and has made the comparison of genetic engineering to the technique of splitting the atomic nucleus seem appropriate.

Human Genome Project

A long-term international project aimed at revealing the human genome sequence is currently in progress.

The human genome project has been launched under the aegis of the U.S. National Center for Human Genome Research. It has been supported by an investment from the U.S. government and among other participating countries, France was expected to make an investment. The researchers will have to determine 3 billion base pairs. The total project will last for at least 15 years and the total expense is estimated at over $1 billion.

The stages of this challenging project will be as follows:

- to cut the human DNA into small pieces, using the above-mentioned restrictases as molecular scissors;
- to separate these parts in a strong electrical field (electrophoretically);
- to determine the nucleotide composition of each part, i.e. to draw a biochemical map of the whole DNA;
- to relate the sequences of nucleotides to the functional units of the DNA - to the genes which code for human proteins;
- to determine the distance between genes, i.e. to draw a physical map of the DNA. 15

The technical problems associated with the project are formidable. The work is expected to be monotonous, hard and not creative per se. It resembles sieving river sand in an attempt to find gold, since it is known that 98% of the human DNA contains no functioning genes at all. The project's potential applications are the following: 15,16

- prevention or treatment of diseases using gene therapy. For example, cancer can be treated with lymphocytes extracted from a human being and gene-engineered in vitro. This is already being done under the auspices of the U.S. National Institute of Health since July, 1990;
- identification of human individual by their genetic fingerprints. This may help identify a criminal or establish the real father of a child.

In this connection, the following bio-ethical issues arise: 2,15,17

- in any human population, a great number of individuals are carriers of genes responsible for diseases. Is it moral and justifiable to identify these carriers by authorizing compulsory genetic control of all the citizens of a country;
- currently, many employers are reluctant to engage smokers and corpulent people. Should an employer get access to the genetic data of those applying for a job;
- should a person be notified of his being genetically predisposed to a severe, chronic, or lethal disease? What if the risk is unavoidable and the disease is incurable? Under what conditions should a person be allowed to have access to this information;
- prenatal diagnosis of genetic disorders may become a routine procedure. Here we return to the question considered above, whether pregnancy is to be interrupted if a genetic disease is revealed;
- knowledge about the genetic make-up of human beings will have a considerable impact on culture. Will it promote the dominance of a purely biochemical vision of man;
- and, finally, the crucial question, whether it will be permissible to consciously design human beings.

Further prospective uses of genetic engineering include gene replacement which encourages hopes for overcoming genetic diseases.

In an effort to cope with all these important bio-ethical problems, human society will have to establish specific institutions dealing with them.

Ecosystem Bio-Technology

The method of ecosystem bio-technology18 holds special promise for promoting the principles of the bios theory and for safeguarding the natural organization of bio- environmental systems. This method is distinguished by its vast potentialities such as the establishment of associations of living organisms which can achieve results that are unattainable for each of the components of this association. An important application of this method is destruction of waste and production of valuable chemicals and fuels by means of association and creation of ecosystems which recycle waste matter and thus carry out waste- free production.

The method regarded involves no crude interference with the individuality of living organisms. They retain their natural identity, and only cooperation among biological species is established. The results of this cooperation can exceed those achieved through genetic manipulations. For instance, native yeast does not convert cellulose, the most abundant component of wood, to ethanol. One can attempt to introduce the necessary genes through DNA manipulations, but, the same result is also attained using an association of yeast and cellulose-degrading bacteria.

Organizational Matters: Bio-Technology and Biopolitics Centers

Several organizational steps need to be realized in the implementation of innovative technology. As an example, in the Research Center of Innovative Technology for the Earth, the following steps are considered19:

- realization of new techniques and processing methods
- improvement of techniques, minimizing energy and material consumption
- technology transfer. Global environmental technology should be disclosed internationally.

Of biopolitical importance is the package of problems concerning the organizational aspects of bio-technology. Bio-technology is actually based on collaboration of specialists with different backgrounds coming from different colleges, research institutions and nations. Thus, bio-technology promotes not only competition, but also cooperation across disciplinary, institutional and political barriers. Traditional scientific institutions may not conform to bio-technological developments. For this reason, institutions of a new type referred to as bio-technology centers have been established in a number of countries. These centers engage specialists in different fields of research and often form combined teams working on particular projects. In many instances, direct links are established between academic institutions and industrial enterprises, or at a personal level, between scientists and businessmen.

The suggestion can be made to establish biopolitical centers by working in close cooperation with bio-technology centers. This idea has been carried out at the Department of Biology of the Moscow State University where since 1991, a Biopolitics Center is in operation in addition to the Bio-technology Center. Restructuring of bio-technology centers in this way would add new dimensions to their work. In particular, they could not only develop bio-technological projects, but also assess their short-term and long-term effects on the bio-environment. As some of the bio-technology centers carry out postgraduate training and qualification of scientists, they could also incorporate biopolitical subjects into their curricula.

At the Interface of Biological Science and Business

The joint bio-technological projects involving science and business have raised the following issues:

- the norms of scientific and business ethics are different. Should a bio-technologist publish his results in accord with the scientific ethos or should he keep them in secret in order that no one else should claim a patent concerning them?
- research group seminars and conferences are usual events in the life of a college or research center. What if the members of a research group are involved in joint bio- technological venture with several competing companies? Can they exchange information under these circumstances? 1

Impact of Bio-Technology on Economic Infrastructure

A self-contained complex of problems is concerned with the impact of bio-technology on the structure of industrial companies. The following issues have been recently raised:

- does genetic engineering and other advanced techniques in the field of bio-technology favor the tendency towards production concentration in the hands of a few large and possibly multinational companies? Such companies can provide more financial backing for large scale use of bio-technology, and a more likely to benefit from its development;
- will increased productivity of crops or cattle achieved using genetic engineering result in unemployment growth? Some years ago, American farmers protested against the use of genetically-engineered growth hormone in agriculture. These hormones, it was claimed, would boost the milk productivity of dairy cows and "force half of today's dairy farmers out of business." 20

Biopolitical Dimension of Bio-Technology

These complex problems await a solution which calls for elaboration of inclusive ethical norms applying both to research and to industrial developments in bio-technology. "These achievements have revealed the framework of modern science as insufficient, and the need to adopt new ethics has been the subject of debate among scientists." 21 It is an imperative to develop these new ethics on the basis of the biopolitical values. Special emphasis is to be placed on the interface of genetic engineering and medicine, a subject already touched upon above. In the case of genetic engineering as well as bio-technology in general, pragmatical considerations are inseparably linked with philosophical issues. From a philosophical perspective, the key concern is our basic attitude towards life, towards bios. Bios must not be considered a mere instrument for attaining human purposes, nor reduced to physico-chemical systems, automatons or robots. One of the fundamental ideas of biopolitics is the acknowledgment of the basic rights of bios. 2,10 The conceptual foundations of bio- technology, an extremely useful and important field of research and development, should be reconsidered in these terms.

Of particular importance is the incorporation of bio-technology into biopolitical curricula. "A well-constructed bio-technology module will not only show a pupil the relevance of his biology course to his everyday existence but, hopefully with the application of knowledge to industrial processes, supply him with the necessary enthusiasm to go out and get a job in an ever expanding industry." 22

As human minds cannot be completely compartmentalized, ideas stemming from one field must necessarily influence our vision of other fields of human activities. Therefore, emphasizing cooperation in bio-technology will undoubtedly contribute to international cooperation on all the levels. Biopolitics regards the notion of bios as the central concept. 10 Thus, bios maintenance and promotion is to become the main goal of cooperation among humans and between human and non-human forms of bios.

Objectives

- to sensitize the people on the multifaceted ethical issues created in modern society as a result of technological progress;
- to integrate the ethical factor into all kinds of scientific endeavour;
- to bring out the importance of bio-technology for the progress of human civilization and the maintenance and promotion of bios;
- to inform the people not only of the achievements of bio-technology, but also of its difficulties, problems and limitations;
- to highlight the bio-technological applications of eco-engineering, based on cooperation and mutual aid.

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