THE BIOTECHNOLOGY AND THE THIRD WORLD

Mahmoud Khairy Tahoun
Prof. of Dairying, Faculty of Agriculture, El-Shatby,
University of Alexandria, Egypt

1. Introduction to the Definition of Biotechnology

“Biotechnology has become a very popular term in the general and scientific press”, where it has been recently used in reference to define the expanding number of small, high technology, entrepreneurial enterprises that generally have a high component of recombinant DNA research. Although genetic enhancement has had a continuing important role in biotechnology, other innovations are equally important. Biotechnology is a subject of intense current interest in the developed world. In Europe and in the United States especially, it is viewed as one of the more promising “high technology” options available for resuscitating sagging industrial economics; however, biotechnology also offers exciting opportunities for developing countries.

The roots of our current fascination with biotechnology can be found in the steady growth in our understanding of the mechanisms by which genetic information is stored utilized, transferred and transformed. In less than decades, we have moved from not knowing the chemical nature of the genetic material in cells to being able to order various components of the genetic apparatus from catalogs. These breathtaking advances in molecular biology owe much to a number of vital developments in laboratory techniques for manipulating and modifying genetic matter. But, the deliberate alteration of genetic characteristics is, of course, not new. Hybrid corn, high yield rubber trees are familiar of the breeder’s art. The methods available were; however, slow, imprecise, and largely limited to a single species. In contrast, the new molecular biological techniques offer opportunities not only for rapid and specific changes but also for the transfer of characteristics between species, as in the production of human insulin by microorganisms.

All these developments have led to a world, wide burst of enthusiasm for “Biotechnology”, with the more enthusiastic protagonists predicting a new industrial revolution. But biotechnology
is neither new nor limited to technological activities based on the
deliberate manipulation of genetic material. In this context,
bio-technology should be considered in its most inclusive sense, that is,
as the deliberate exploitation of living systems for the benefit of
mankind. To this define biotechnology as comprises all aspects of the
technological exploitation and control of living system for the benefit
of mankind.

The other face of biotechnology utilizes the prolific and often
unique, abilities of living cells and tissues to catalyze chemical change
and to synthesize complex molecules. These possibilities for
exploiting biological systems in the third world may well be these that
appear least promising in technologically advanced. For example,
developing countries can usefully consider such options as:
1. Replacement of imported food materials with local crops,
frequently indigenous but little used, that offer high yields, lower
water-requirements and improved drought tolerance, lower
fertilizer needs, and, often, better nutrition. Examples of
potentials valuable and long neglected crops well suited to local
cultivation in specific areas are grain amaranth, the winged bean
(the soybean of the tropics) legumes, fruits and root crops.
2. Development of “medium” value-added crops directed at internal
markets: large urban areas for example. These could replace crops
with lower added values currently directed primarily at highly
unstable export markets.
3. Local “low-teach” industrialization and integration of agricultural
production with small factory operation.

Many other applications of biotechnology with special promise
for developing countries are proposed. Most of these address one or
more of the following critical problems:
1. Motor fuels based on renewable resources, especially ethanol and
producer gas.
2. Underutilized food crops.
3. Crops of arid lands

The potential for better and land utilization is well illustrated by
the buffalo gourd, *Cucurbita foetidissima*. It is extremely hardy
perennial, and drought tolerant. The plant produces long, heavily
leafed runners, which can yield an abundant fruit crop rich in oil and protein, and a large, starchy root (Figs. 1 and 2).

From above, Biotechnology, in the board sense has always been a significant contributor to the satisfaction of mankind's material needs. Its special lures have been greatly enhanced by recent advances in the manipulation of genetic material. But the enthusiasm for the “new” biotechnology so evident in the developed world is no sure panacea for the less developed. Biotechnology offers an exceptional of opportunities for developing nations. These rest for the most part on the ability of a wide variety of are two approaches to the exploitation of the chemical abilities of biological systems. We can go to nature and recover for our use substances that are produced naturally. Familiar example are cane and beet sugar, oils and fats, dyes and pharmacologically active material for which mankind has always relied on plant and, to a lesser degree, animal sources.
A second approach to the technological exploitation of the potential of living systems is through “bioprocesses”. Thus, complete living systems are to be employed such as cells or tissues or their components; enzymes chloroplasts, etc., in a direct or controlled manner to bring about desired physical or chemical changes. Like extractive biotechnology, bioprocesses have always been used by man, sometimes by accident, as in the traditional preparation of fermented foods and sometimes by design.

Bioprocesses may be utilized for:

1. Production of cell matter (often called “biomass”) for consumption as food or feed (Baker's yeast, mushrooms, algae and various forms of “single cell protein”), or for extraction of particular cellular components (enzymes, nucleic acids, etc.).

2. Remanufacture of chemical products arising from cellular metabolic activities, these products vary from these with simple molecular structures, such as ethanol, to more complex ones, amino acids, antibiotics and hormones for example.

3. Catalysis of highly specific chemical reaction, for example, the conversion of glucose (corn sugar) to the much sweeter fructose isomer.

4. Simultaneous catalysis, normally employing a mixed population of microorganisms, of a wide variety of physical and chemical changes on complex and frequently variable, feeds. This is, of course, what occurs in the most common biological waste treatment procedures.

5. Collection and concentration of minerals and other inorganic substances from dilute solution.

2. Biotechnology and Development

While the developed countries pursue the “high technology” aspects of biotechnology, primarily the preparation of high-value, biologically active substances, developing nations may view biotechnology quite differently. Indeed, the most attractive renewable that is “biomass” resources. Many new exist, and many other can be cultivated in the third world, often in areas now severely battered by adverse climatic conditions. Furthermore, biotechnology offers developing countries attractive options for decentralized manufacturing activities compatible with economic needs and
traditional social structures. Even more important in the long term is the possibility that biotechnology can provide incentives for people in these areas to generate their own schemes for value-adding activities.
3. Genetic engineering prospects and application

In the following part of discussion, we are interesting to give a view on what so-called genetic engineering which is the molecular biology and genetics. Molecular biology is the science that treats research activities on cell molecular level, similarly as molecular genetics. As an example in that respect, we are going to give a brief hint on an important subject of interest that deals with genetic engineering in Food Industries “Dairy”.

The instability of a number of key industrial traits in lactococci has long been recognized but the scientific basis of this observation was only established in 1974 when it was demonstrated that lactococci contain plasmids, relatively small DNA molecules which exist independently of the cell chromosome. Plasmids are not essential for cell growth, but some carry genes which have a significant impact on the host cell. Plasmid genes encode the enzymes necessary to hydrolyze casein, transport and metabolize lactose, transport nitrate, produce bacteriocins and resist phage attack.

Since the initial discovery of plasmids in lactococci, and consequently in other lactic acid bacteria, attention has been focused on the possibility of exploiting the techniques of molecular biology to understand and ultimately control the metabolism of these important industrial bacteria. Recently, genetic analysis has been extended to include the bacterial chromosome. Most attention has been directed towards the lactococci, but other lactic acid bacteria are also being studied.

3.1. Gene transfer in lactic acid bacteria

3.1.1. Transformation and electroporation (protoplast fusion)

The introduction of whole DNA, nuclei or modified plasmid vector to the organism, a process termed transformation. Initially, this was a significant hurdle to overcome in lactic acid bacteria, since these strains do not take up DNA naturally. Early transformation protocols relied upon the formation of protoplasts by enzymatically removing the cell wall. DNA was subsequently introduced to polyethylene glycol (PEG)-damaged protoplasts and transformants were recovered by regenerating the cell wall in osmotically-stabilized
media. The method is very tedious and only low frequencies of transformation were obtained. A number of improvements were introduced including electro-transformation as electroporation. Thus, transformants are recovered at reproducibly high frequencies.

1.2. Gene cloning and analysis in lactic acid bacteria

Gene cloning in recombinant DNA terminology, describes the physical linkage of a DNA fragment to a plasmid or phage vector. A typical example is shown in Fig. 3. The immediate benefit of such a situation is that the DNA fragment of interest is now linked to the properties of the vector. The introduction of the cloned fragments into any host is being confirmed via the vector antibiotic resistance markers. The cloned fragments are also more available to the use of genetic techniques such as DNA sequence determination, direct mutations and studies on gene expression and control.

Fig. 3. Gene cloning strategy. DNA fragments are generated by cutting the source DNA with a restriction enzyme. The vector is cut with the same enzyme to generate compatible ends. The molecules are mixed
and the clones selected, usually by screening for plasmids with both the marked gene and the gene of interest.

3.2. The application of genetically engineered bacterial strains in food

Current regulations preclude the use of genetically modified strains within the food industry. Since this restriction is lifted, the genetic studies are of limited practical value. However, this is not the case. As an example of the practical application of genetic techniques is the introduction of the conjugative phage resistance plasmid pTR2030 to a number of industrial cheese starter strains. These transconjugants showed an elevated level of phage resistance over the original parent strains. Only conjugation which is a natural process was used to transfer the DNA, and no recombinant techniques or unacceptable genetic markers, were used in the construction of the transconjugants.

Anticipating a relaxation of the prohibition of the use of recombinant strains, some laboratories are developing cloning systems which are composed of acceptable marker genes which would allow the detection of transformants. Completely acceptable, a “food grade” vector should ideally be entirely composed of DNA from the target organism or closely related non-pathogenic strains, and possess a readily selectable marker gene. Candidate marker systems have already been cloned and sequenced and include resistance to nisin, lactose metabolism such as, \( \text{lac} \ E \ lac \ F \ pB \ gal \ lac \ G \), the genes responsible for the permease \( \text{lac} \ S \) and \( \text{B gal lac Z} \) as well as phage resistance and thymidylate synthetase. However, progress in this area is still at a preliminary stage, and no system has found widespread use.

Of our interest in the near future is that leading to the construction of a new “food grade” vector. The new anticipated vector will be derived from pPK705 that is constructed from replication origins RepA and RepB of \( P. \ acidipropionica \), the pUC18 of \( E. \ coli \) and the \( \text{hyg B} \) resistant gene of \( H. \ hygroscopicus \). Such prospect could be realized by excluding the pUC18 of \( E. \ coli \) and the gene marker \( \text{hyg B} \) from parental pPK705 under the introduction of two new genes namely \( \text{Pct A} \) of propioniin \( T_1 \) and \( \text{pam A} \) of a protease activated antimicrobial peptide. Thus, conferring dairy lactic bacterial strains
antimicrobial activity against undesirable microflora beside the action of propionicin T₁ as a natural selectable marker.

4. Conclusion

Biotechnology, in the broad sense, has always been a significant contributor to the satisfaction of mankind’s material needs. Its special lures have been greatly enhanced by recent advances in the manipulation of genetic material. But the enthusiasm for the “new” biotechnology so evident in the developed world is no sure panacea for the less developed. We walk in harm’s way if we allow our view of the prospects for biotechnology in development to follow exclusively the patterns now in vogue in Europe, Japan, and the United States.

Biotechnology offers an exceptional range of opportunities for developing nations. These rest for the most part on the availability of a wide variety of renewable, that is “biomass”, resources. Many now exist, and many others can be cultivated in the Third World, often in areas now severely battered by adverse climatic conditions.

Furthermore, biotechnology offers developing countries attractive options for decentralized manufacturing activities compatible with their economic needs and traditional social structures. Even more important in the long term is the possibility that biotechnology can provide incentives for people in these areas to generate their own schemes for value-adding activities.

Our role in this grand design is to build the knowledge base and develop generic technologies that have the potential for application in developing lands. Then we must make the results of our efforts widely available in forms that are easily dealt with in these countries. The critical task is, of course, the identification of those opportunities that are best suited to the needs, resources, abilities, and special circumstances of each region and its unique physical, social, and economic environment. In this effort we can certainly offer advice and counsel, but we are ill advised to substitute our judgments for those of local populations.