

BIOTECHNOLOGY : AN OVERVIEW

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ABSTRACT

Biotechnology as a science includes various aspects of the management and manipulation of biological systems. Recent advances in immunology, molecular biology, cell culture and other associated areas provide an opportunity for scientists to move biology out of the laboratory and into the realms of society. This has many implications which mankind on a whole may not be prepared to cope with at this time. This new capability has been referred to as "Biotechnology". Biotechnology has also been defined as "the integrated use of biochemistry, microbiology, and chemical engineering in order to achieve the capacities of microbes and culture cells". Genetic engineering which includes gene splicing and recombinant DNA-cloning is an example of a recent offshoot of biotechnology.

Because of the advent of biotechnology, one can now think of the prospect of engineering tomorrow's vaccines. In the past, vaccine development has been laborious and in many instances an unrewarding task. After years of effort only a handful of safe, effective vaccines have emerged. In the biotechnology arena, new methodologies and strategies for immunizing humans and domestic animals against infectious diseases are providing new hope for discovering successful vaccines. While most of the effort in the past has focused on viral vaccine development, attention is now being directed towards vaccines for protection against parasitic diseases.

Currently, considerable effort is being made to develop vaccines for malaria, coccidiosis (in fowl), cholera, malaria, schistosomiasis and trypanosomiasis among others.

INTRODUCTION

Since the discovery of the double helix configuration of the DNA molecule in 1953 and the creation of the first chimera in 1973 by use of genetic engineering techniques in San Francisco, something akin to a miracle has occurred between these two dates: Humans had found a way to decipher, write, spell and even correct the genetic mistakes of life itself. Today in many university laboratories, students learn to manipulate the molecules of heredity with the same ease as they tinker with the desktop computer¹.

In many industrial and university laboratories, scientists are attempting to induce various species of microorganisms to produce materials they would not normally secrete as well as use as nourishment substances such as petroleum, noxious wastes and to secrete endotoxin which could be used as potential control substances for arthropods which transmit infectious organisms^{1,2,3}. Biotechnology utilizes the expertise of specialists such as biologists, microbiologists, engineers, geneticists, biochemists, parasitologists, botanists among others who are exploring the mechanisms that

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control and regulate most life forms on this planet. This effort will in the long run have incalculable consequences for the diagnosis and treatment of many of the world's most dreaded diseases such as cancer, heart problems, genetic deficiencies, malaria, cholera, schistosomiasis and leishmaniasis, as well as an improvement in the cultivation of plant species used to feed human and domestic animal populations.

Is this new science a revolution or a renaissance? Scientists have for many decades used microorganisms to ferment food and drink and produce antibodies. In addition they have produced hybrid plants².

Biotechnology as a science includes various aspects of the management and manipulation of biological systems. Recent advances in immunology, molecular biology, cell culture and other associated areas provide an opportunity for scientists to move biology out of the laboratory and into the realms of society. This has many implications which mankind on a whole may not be prepared to cope with at this time. This new capability has been referred to as "Biotechnology". Biotechnology has also been defined as "the integrated use of biochemistry, microbiology, and chemical engineering in order to achieve the capacities of microbes and culture cells". Genetic engineering which includes gene splicing and recombinant DNA-cloning is an example of a recent offshoot of biotechnology^{2,4}.

In reality, biotechnology is not new: biology has been used for decades to produce urea, food, solvent for industrial purposes and ethanol for use as energy. What really is new about this so called new science is the methodologies which have been developed, the style of its approach and increased interaction between the scientific community, the citizenry and politicians in general. This type

of interaction has occurred because of the potential breakthroughs in science which are deemed to be of great significance to life on this planet. Some examples of these scientific advancements are, new developments of single cell edible protein; nitrogen-fixing plants; crops resistant to pests; species of bacteria which are used in waste-recycling, pollution control and as biological control agents; gene therapy to correct diseases such as sickle-cell anemia; genetic screening for the purpose of isolated genes responsible for birth defects; microbial production of insulin; the production of interferon and growth hormones as well as a general increase in our knowledge of the immunological processes for diseases such as cancer, malaria and schistosomiasis. It has been predicted that biotechnology will have its greatest impact on agriculture and health^{2,4,5,6,7,8}

A dynamic and promising new area of biotechnology is genetic engineering whose techniques such as microinjection is one of many procedures available to scientists for use in studying the nature of genes. These techniques, first developed in university laboratories to promote basic biotechnology research, are increasingly being used to provide longevity and healthier lives through increased food production and inovative treatment of such illnesses as cancer, hemophilia, cystic fibrosis and other birth defects and diseases⁹.

In the area of agriculture genetic engineering has been used to create animals with higher meat to fat ratio than the conventional ones, plants when sprayed with certain bacteria inhibit frost and others which have built-in resistance to viral infections. Many new breakthroughs are in the offering concerning the future of agriculture.

New industries have been created in which new natural substances are produced

by genetically altered bacteria. Some of the new natural substances are heat-labile enzymes and proteins mass-production of insulin, newly "designed" antibiotics to specifically destroy cancer cells, viruses and bacteria⁹.

Gene therapy is now a reality, as a result of the technology of gene-splicing. The first human treated with gene-splicing therapy has now been reported and the future in this area of biotechnology looks promising for medical science⁹.

The American government is expected to launch a massive effort designed to map and decode all of the estimated 100,000 human genes. The project is expected to cost 3 billion dollars and to run for nearly 15 years. The end result of this effort will be a detailed construction manual for the genome, and the entire genetic profile that defines us as a species⁹.

Major accomplishments have already been made in hybridoma research by utilizing immunology in a variety of ways; in cell cultures which provide cells of both animal and plant origins as direct sources of materials in protoplast fusion techniques as well as in a variety of other methods. Biotechnology is rapidly becoming broader in scope by the use of a vast array of technological techniques which, of course, have contributed to the area of laboratory science².

Because of the advance of biotechnology, one can now think of the prospect of engineering tomorrow's vaccines. In the past, vaccine development has been laborious and in many instances an unrewarding task. After years of effort only a handful of safe, effective vaccines have emerged. In the biotechnology arena, new methodologies and strategies for immunizing humans and domestic animals against infectious diseases are providing new hope for discovering successful vaccines.

While most of the effort in the past has focused on viral vaccine development, attention is now being directed towards vaccines for protection against parasitic diseases¹⁰.

Hybridoma technology, specifically monoclonal antibodies have provided scientists with the means to mount new attacks against a variety of parasitic diseases. These efforts include detection, treatment and prevention of various parasitic diseases. Currently, considerable effort is being made to develop vaccines for malaria, coccidiosis (in fowl), cholera and schistosomiasis¹⁰.

Diseases for which priority should be given for development of vaccines are: malaria, schistosomiasis, trypanosomiasis (African and American), leishmaniasis, filariasis, ascariasis, hookworms, amebiasis, toxoplasmosis, hydatidosis/cysticercosis and giardiasis. These priorities will of course be different from country to country. A partial assessment of funding priorities in vaccine development for some parasitic diseases is shown in Table 1.

In addition, biotechnology can also be a powerful tool in developing certain control methodologies against disease transmitting vectors. An example of this is the use of genetic engineering to develop a recombinant bacterium to produce endotoxin for use as an insecticide for controlling pests such as the mosquito larva. This application could also be applied to control the snail vectors for schistosomiasis.

An example of combined industry, government and academic collaboration has been the recent announcement of a candidate malaria vaccine being synthesized. Continued animal studies as well as clinical trials in man are planned or currently underway¹¹.

Great concern has arisen concerning safety-hazards associated with biotechnology, especially recombinant DNA. To date,

no problems have been identified. However, strict vigilance should be maintained in the scientific and government communities, as well as by concerned public interest groups.

A neat array of training will be needed for future generations as regards biotechnology in the coming decades. This will require careful planning by both those in the academic area and those in government and private institutions who provide funds for this purpose.

Proper scientific and governmental infrastructures must also be established for coping with currently identified as well as unforeseen problems which may arise from this new science.

Funding support should be clearly identified and those areas of the most significant health importance prioritized. For the field of parasitology this is important, for many of these disease-causing organisms are more complicated and the diseases they cause quite intractable as compared to the single cell viruses and bacteria.

To conclude, I have tried to set the stage for a more indepth look at specific discussions of various aspects of the biotechnology association as well as its with parasitosis by my colleagues who follow with their presentations during this conference.

Table 1. Assessment of Funding Priorities in Vaccine Development for Some Parasitic Diseases*

Diseases	Public health significance	Current vaccine status	Feasibility of using biotechnology in vaccine development	Current funding	Priority for new funding
Malaria	High	High	Good	High	High
Leishmaniasis	Medium	None	BRN	Low	High
Chagas disease	Medium	None	BRN	Low	Medium
Toxoplasmosis	Medium	None	BRN	Low	Low
Amebiasis	High	Low	BRN	Low	Low
Giardiasis	High	Low	BRN	Low	Low
Filariasis	High	None	BRN	Medium	Low
Schistosomiasis	High	Moderate	BRN	Good	Good
Onchocerciasis	High	None	BRN	Good	Good
African trypanosomiasis	Medium	None	BRN	Fair	Low

* Abbreviations : BRN--basic research needed.

Adapted from Pan American Health Organization (1981) with updated assessment by author.

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QUESTIONS AND ANSWERS :

1. Question: Can you please tell us more about the forthcoming vaccine for Schistosoma

Answer : The effort to develop a vaccine for schistosomiasis is being funded by the Agency for International Development (AID). This effort is centered in Egypt in collaboration with the U.S. Navy (NAMRU-3) and certain U.S. Universities. The budget is approximately 38 million and is expected to take 10 years. The program is just beginning.

2. Question: Biotechnology has the ability to change the "behaviour" of organisms. This could be useful if it supports our purpose, but can also become dangerous if it does not serve our purpose and may even endanger human/domestic animals life. Can we prevent this danger from happening ? Please, I like your comment on this matter.

Answer : Production of new organisms and changes in behaviour and developed characteristics can be dangerous and constitute a potential threat in both humans/ domestic animals. As mentioned in my presentation certain safeguards such as monitoring of the use of any of these changes or new organisms should occur. It is very important that concerned citizens groups be involved in the same manner as they monitor the environment. The government of countries should be also involved in a constructed manner.

3. Question: Concerning the goal of engineering tomorrow's vaccine, in parasitic diseases seems to be quite a big problem (most still need basic research). Why ? I wonder whether the strategy would force a sort of "short cut", in certain parasites, or not at all ?

Answer : Basic research is needed in order to develop the necessary tools to prepare a schistosomiasis vaccine. The schistosomes are multiple celled organisms. Because of this the basic immunology approaches may be quite different from those used for single celled organisms such as malaria, bacteria and viruses.