

Biotechnology Applied to Disease Control

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INTRODUCTION

The importance of science and technology in promoting a country's social and economic development is universally recognized. Therefore, the true value of research for a developing country should be measured against its potential for finding solutions to problems related to areas of the country's economy and society such as agriculture and health. In the field of health, the control of major diseases prevailing in developing countries receives much attention today. Therefore, it is not surprising to find many scientists all over the world carrying out research that may help find new strategies for the prevention and treatment of such diseases.

BIOTECHNOLOGY AND HEALTH

The rapid advancement of scientific techniques in this century has opened new possibilities to manipulate other living organisms to improve man's quality of life, especially in the area of health. The technology that is used to control and adapt living organisms to obtain desired products is broadly called 'Biotechnology.' Research on finding suitable biotechnological methods to combat diseases that cause severe public health problems, such as insect- or vector-borne diseases, especially in developing countries, is becoming essential and crucial to human beings.

Malaria, sleeping sickness, chagas disease, leishmaniasis, filariasis, yellow fever, and dengue are the most common vector-borne diseases in developing countries. These diseases affect a great part of the world population and are responsible for significant socio-economic losses. Research to find new methods for the prevention of these diseases is absolutely necessary because most of the pathogens that cause them are increasingly becoming resistant to drugs. This is an area in which biotechnology becomes important. For example, genetic engineering is fast becoming a useful tool in the production of synthetic vaccines against vector-borne diseases. In such a process a gene for a target protein is inserted into a vector (here vector means plasmid or bacteriophage). This vector is then introduced into bacteria. The vector multiplies within the bacteria and synthesizes large quantities of the target protein. The purified protein can then be used for mass immunization.

RESEARCH ON MALARIA

Malaria is one of the commonest infectious diseases in the world. The World Health Organization estimates that 210-220 million cases of malaria occur annually worldwide of which 85 percent are caused by *Plasmodium falciparum*, a species of malaria parasite that causes malaria in humans. *P. falciparum* is the most dangerous of the malaria parasites and it is responsible for about one million deaths annually, particularly in Africa, among infants and children. In Sri Lanka, 15 percent of the health budget is spent on malaria control and more than 350,000 cases of malaria are detected annually. As malaria is dangerous and widespread and the organism responsible for the disease is complex, the development of new methods for the surveillance, control, and prevention of the disease is essential.

Development of a Protective Vaccine

The development of a protective vaccine against *P. falciparum* and other species of malaria parasites that cause human malaria would contribute significantly to the eradication of the disease. The success of such a vaccine depends on the number of protective antigens that are shared by different strains of the parasite. Extensive antigenic variation has been observed in *P. falciparum*. Such antigenic variation in the malaria parasite is a major problem that should be overcome in the development of a vaccine. Several advances towards the development of a protective vaccine against malaria have been made in the past. Much research in this area is also in progress in many research centres around the world, including the IFS. While a considerable amount of research on malaria continues on the development of this vaccine, research is also focussed on insect-control measures.

Methods of Vector Control

Chemical Methods

The control of mosquitoes is undoubtedly the best method of protecting a community against malaria. Major advances were made against malaria in the 1950s and the 1960s as a result of the widespread use of insecticides and inexpensive as well as effective antimalarial drugs. However, the global malaria situation has deteriorated since then and one reason for this is that methods of vector control with synthetic chemical insecticides have led to increased insecticide resistance by vectors.

The development of insecticide resistance is dependent on the genetic variability already present in the insect population. This means that when the gene for resistance is present in an insect population, resistance will be selected each time the insecticide is used. This is called 'physical resistance.' An insect population may also change its pattern of behaviour so that it acquires the ability to avoid contact with the insecticide. This type of resistance is called 'behaviouristic resistance.' Insecticide resistance is difficult to avoid. This means that alternatives to chemical methods of vector control should be found. One alternative would be biological methods of vector control.

Biological Methods

Biological methods of mosquito control are based on the introduction into the environment of various pathogens and predators of the mosquito. The 'enemies' of the mosquito are parasites, predators, or pathogens. Many organisms such as viruses, fungi, bacteria, protozoa, nematodes, and invertebrate predators have been investigated as potential agents.

Two bacterial insecticide products are in use today. One product, *Bacillus thuringiensis* (serotype H-14), is used against blackfly vectors of onchocerciasis in West Africa. The bacteria forms spores and produces a toxin that is a potent gut poison when ingested by mosquitoes and other insects but is harmless to plants, animals, and man. In the other product, *Bacillus sphaericus*, some formulations show residual activity against *Culex*, vectors of lymphatic filariasis, and viral diseases like Japanese encephalitis. In this product the bacteria also produces a toxin and can breed even in polluted water.

Of all biological mosquito control methods, the use of larvivorous fish (fish that eat larvae) has been the most successful in many parts of the world. Larvivorous fish are natural enemies of the mosquito larvae and have been used for mosquito control since the turn of the century. The most effective and the best known larvivorous fish species are *Gambusia affinis* (top feeding minnow), *Lebistes reticulatus* (guppy), and several other species of fish of the families *Poeciliidae*, *Cyprinidae*, and *Cyprinodontidae*. A disadvantage of the use of larvivorous fish as a mosquito control measure is that it is effective only if the fish are present in large numbers.

Genetic control is a special type of biological control. Although various methods of genetic control have been used, one method has received particular attention. In this method, male mosquitoes sterilized by ionizing irradiation or chemical compounds are released into the natural environment. When these sterile males mate with wild females in the natural population, the hatching of their eggs is prevented.

CONCLUSION

The effective use of biological methods of mosquito control requires a good knowledge of the bionomics of the mosquito species as well as the local ecological conditions. At present, field research focuses mostly on the improvement of methods of malaria control in different environmental and socio-economic conditions. The vast amount of research that is carried out on all aspects of malaria gives us hope that sooner or later man will find a way of combatting this disease.

GLOSSARY

ANTIBODY. A protein produced by the body in response to an antigen.

ANTIGEN. A substance that can incite the production of specific antibodies and can combine with those antibodies.

BACTERIOPHAGE. A virus whose host is a bacterium.

BIONOMICS. Of or relating to ecology.

ECOLOGY. That branch of science which deals with the relations of living organisms to their surroundings, their habitat, etc.

FAMILY. A unit used in the classification of plants and animals.

GENE. One of the basic units of heredity, each of which forms a discrete part of the chromosomes of eukaryote cells.

GENETIC CONTROL. The use of any method that can reduce the reproductive potential of insects by altering the hereditary material of the vector species.

GENETIC ENGINEERING. Experimental manipulation of DNA (or RNA) of two different species producing recombinant DNA, which includes some genes from both species.

HOST. An organism that supports another organism (parasite) living in or on its body at its own expense.

INFECTIOUS AGENT. An organism that is capable of producing infection or an infectious disease.

INSECTICIDE. A preparation used for destroying insects.

PARASITE. An animal or plant which lives in or upon another organism (its host) and draws its food (nutrient) directly from the host.

PATHOGEN. Any disease-producing microorganism.

PLASMID. A genetic element, often found in bacterial cells, that is separate from the genomic DNA and replicates independently.

RECOMBINATION. A rearrangement of linked genes as a result of crossing-over.

RECOMBINANT DNA. DNA produced from recombination, especially that produced artificially from two different species by genetic engineering.

RESISTANCE TO INSECTICIDES. The ability of a population of insects to tolerate doses of an insecticide which would prove lethal to the majority of individuals in a normal population of the same species.

SPECIES. A unit used in the classification of plants and animals.

VECTOR. An animal, often an insect or a tick, which carries a pathogenic microorganism (parasite) and transfers it to a host.