BIOTECHNOLOGY: RESEARCH AND EDUCATION IN INDIA AN OVERVIEW

Recent advances in biotechnology have enhanced our knowledge and understanding of biological structures and functions at the tissue, cellular and molecular levels to an extent where it has become possible to make alteration in structure, function, and expression at the genetic level. Multi-directional advances in biotechnology particularly in genetic engineering, cell-to-cell fusion, cell and tissue culture, immunology and immunodiagnostics, synthetic chemistry, fermentation technology etc. find wide application in various sectors of socio-economic development through its direct impact in the areas of healthcare, agriculture, population control, industry, energy production, environmental control, veterinary and aquaculture.

In health care area, using the enormously powerful techniques requiring only the minute quantities of biological material has already revolutinized our understanding of the control of complex biological functions such as in the immune system. Biotechnology has the potential of producing more effective vaccines, against various viral, bacterial and parasitic diseases by using new technologies of vaccine development such as recombinant DNA subunit vaccine, anti-idiotype vaccine, T-cell vaccination, recombinant vaccinia virus vaccines etc. Molecular probes in solid tumors and monoclonal antibodies have emerged as the most important tools in the new generation approaches to diagnosis, prognosis and therapy of human tumors. Advances in hybridoma technology, genetic engineering have helped in development of immunodiagnostics which are sensitive, specific, cost effective, simple and easy to

perform. Probes based on ribosomal RNA provide a powerful means of microbes detection which are available in abundance as cellular molecules. DNA-anti- microbial resistance genes are important in anti-microbial therapy and control of infection. Improvement of techniques in production of antibody screating hybridoma cells has helped raise monoclonal antibodies specific for almost any antigen.

Using technique of polymerase chain reactions, DNA target fractions can be amplified which are detectable by a probe. Synthetic allele-specific oligonucleotide probes are used to detect point mutation in prenatal and carrier diagnosis of the heriditary prophyrias and anti-trypsin deficiency. In bone marrow transplant genotyping, the use of highly polymorphic restriction fragment length polymorphism (RFLP), the probability of distinguishing the siblings goes above 99%. Studies of the major histocompatibility complex (MHC) has yielded information of structure of genes and their manipulation of immune response to transplanted tissue via genetic engineering. Use of DNA finger printing technique has major application in medico legal cases especially disputed parentage, linkage analysis in disease conditions. Efforts continue to develop safe, efficacious cost-effective, long lasting and reversible contraceptive vaccines using immunological approaches.

The past decade has seen significant progress in the areas of plant sciences. Genetic manipulation of plant species using the technique of gene transfer, cell fusion and a variety of techniques of tissue culture, protoplast regeneration, embryogenesis, embryo rescue, etc., have opened unlimited possibilities to improve the increase in yield, biotic and

abiotic stress tolerance, better understanding between microbes-plants and insect-plant interaction. Using the new techniques of Restriction Fragment Length Polymorphism, Polymerase Chain Reaction and selectable markers, the entire breeding cycle for producing new varieties of crop plants and animals of economic importance has been reduced.

Under veterinary biotechnology transgenic animals can now be produced and offer new opportunities for genetic improvement of traditionally important livestock. Embryo transfer technology for herd improvement and better milk production are techniques available for improving quality as well as quantity of production. Animal birth control injection 'Talsur' developed indigenously provided a cheap, fast and simple method with little side effects for sterilisation in male animals so as to reduce the population of low-grade genetic stock of little importance. Fish production and prawn aquaculture through biotechnological innovations like chromosomal manipulations, gene cloning and transfer, cryo-preservation of gametes and embryos and in vitro fertilisation, help in production of fish with better growth rate.

Techniques of molecular imprinting, a way of chemically preparing polymer material for role in molecular separation and catalysis has its potential in preparation of biochemicals and pharmaceuticals industries. Biosensors produced by immobilization of the enzymes in water insoluble polymer membranes fixed on an electrode are being used as diagnostic aids in diabetes, detection of enzymes like lactic dehydrogenase, transaminases, amylase and biochemical parameters like uric acid, lactic acid etc.

Methanogens are a diverse collection of physiologically related archaebacteria with many unique biochemical properties. Advances in gene and recombinant technology has exploited methanogens for their potential application in biogas production, waste water treatment, source of antimicrobials, thermostable enzymes, pharmaceuticals, vitamins, amino acids etc.

Need for national and regional strength:

The practice of modern molecular biology or biotechnology is indeed knowledge technique and equipment intensive. With emerging new technologies, it has become necessary to keep track of developments in the multidisciplinary areas of biotechnology. This has obviated the necessity of the need to have access to data-bases and information network to have successful work in modern biology. It has already been demonstrated that by using new technologies and high-tech industrial bases, a large number of products and technologies useful to both developed and developing countries would become soon available provided a reasonable scientific, technological, manpower, infrastructural and industrial base is established which can exploit the developments in biotechnology based on local needs. Certain products such as production of antibiotics using fermentation technology, vitamins and other metabolites of economic importance, therapeutic products such as insulin, growth hormones, cytokines and certain vaccines can be produced on global basis. However, a large number of biotechnology based products especially in the area of agriculture, animal husbandry, fisheries and biomass production and aforestation needs to be developed and adopted to local needs and conditions.

Factors relating to soil, climate, crop varieties, incidences of diseases and pests, abiotic stress factors, hygiene level, food habits of the ethenic population etc. play a major role in determining the type of products and technologies required and are dependant on local scientific infrastructural and manpower strength. Therefore, the major programmes especially in developing countries are to be focused towards their own national need and priorities.

National priorities of India:

A high growth rate of population rate in India, which stands at about 830 million people, has put tremendous pressure on the growth of the economy and various other requirments of the country. With careful planned programme, genetic improvement of major grain crops, better management of water resources, pest control and fertilizers, well managed procurement and storage of grains, India could increase its foodgrain production from a meagre 50 million tons per annum at the time of Independence to a level of self-sufficiency in mid-60s bringing green revolution and a high of 172 million tons in 1988. Thus having sufficient surplus budget for investment in other economic sectors for national growth.

Having exhausted or nearly exhausted the optimum agricultural land and water resources in the first green revolution, it has become necessary to apply new technologies relavent to areas where land is not fertile and water resources are limited. It in this context that the applications of newer technologies becomes relevant and important. Using biotechnology and modern technologies of genetic manipulation, there is a need

to develop new cultivars and varieties that are able to do well under suboptimal conditions of soil moisture, soil fertility and pest management. These requirements directly define our approach to R&D priorities. Biotechnology programs provide alternatives to expensive chemical fertilizers and pesticides and evolve crop varieties that are tolerant to moisture stress, higher soil salinity, water logging and temperature stress. Using new technologies, yield per hectare can be increased to realize the 250 million tons per annum, the target for production of foodgrains for the year 2000.

The country today is producing about 45 million tons of milk and other dairy products through production of not more than 500/600 kg per lactation. Priorities in animal husbandry require the use of newer techniques of embryo transfer, embryo spliting, cryo-preservation and other techniques of animal breeding for quick production of large number of high yielding dairy animals so as to increase the national average of 1500-2000 kg milk per annum. Priority in animal husbandry is to increase production for not only achieving the 90 million ton goal,but also simultaneously reducing the number of these animals so that the requirements for water, fodder, grazing space etc. can be reduced.

Increasing edible oil production, based on introduction of new technologies need more attention. Integrated programmes for the evaluation, validation and production of biological fertilizers as also the the programmes of biological pest control, in addition to the programmes for improving the yield productivity and disease resistance of the major pulse crops using newer technologies are among other national priorities.

In health area, priorities lies in the prevention and control of major communicable diseases like tuberculosis, leprosy, poliomyelitis, diarrhoeal diseases, viral hepatitis, malaria, amoebiasis, filariasis, giardiasis etc. The country's aim to achieve 100 per cent protection for pregnant women against tetanus, and 85 per cent coverage of all infants below the age of one year for protection against six major communicable diseases through augmentation and production of vaccines using modern technologies has to be been given the priority.

Several fast growing nitrogen fixing and other trees amenable to rapid easy multiplication by tissue culture have been identified for afforestation purposes and to preserve the soil fertility, land becoming saline and loss of top soil. Also to meet the fuel and fodder requirement of the rural people, bioconversion for production of bio-gas is of high priority.

In the area of industrial microbiology, India is almost self sufficient with regards to its requirement of antibiotics, vitamins and certain other fermentation products. A national programme of strain improvement and improved process optimization and downstream processing are the other priorities.

Activities of the Department of Biotechnology:

The Department of Biotechnology has launched a number of activities to promote biology education and research which includes: a) Manpower development programme; b) Creation of infrastructural facilities; c) Support for R&D: and d) Promoting better interaction between academia and industry.

MANPOWER DEVELOPMENT PROGRAMME:

The Department of Biotechnology has made a significant contribution towards creating adequate trained/highly skilled manpower to support programme in the multi-disciplinary area of biotechnology within the country in order to meet the expanding R&D and manufacturing needs. An integrated plan of manpower development has been launched by the Department of Biotechnology. One such programme is Post-Graduate and Post-Doctoral Teaching in Biotechnology. The Department of Biotechnology has provided funds for M.Sc/M.Tech/Post-Doctoral training programme being conducted in 19 selected Universities/ IIT's etc. based on the strength of exhisting infrastructure and resource personnel, strong on-going research programmes, locations of other nearby institutions working in related areas etc. A Placement Cell of DBT for suitable positions for students seeking help has been created. The Department is also sponsoring Short Term Training Programmes for 2-4 weeks in specialised areas in selected institutions where expertise and infrastructure exist for conducting such courses. The objective of this programme is to reorient the existing manpower within a short period of time to meet the immediate requirements. In addition, a Technician Training Programme as also a programme of Training Course for Industrial R&D Personnel of short duration for persons already employed have been started. A begining has also been made to produce fresh trained technicians by starting the first I-year Diploma Course for technicians for B.Sc passed candidates from the open market.

A certain number of Biotechnology Associateships - both national and overseas - are awarded every year for conducting advanced research or undergoing specialised training in

identified priority areas of biotechnology within the country and abroad. These trained technologists are expected to meet the gaps in internal competence and requirement of highly skilled manpower for the expanding biotechnology R&D activities in the country.

A programme of Visiting Scientists from Abroad has also been started. These Scientists are being associated in ongoing research programme or in initiating collaborative research project or conducting advanced training programme in their field of expertise in the host institutions. The Department of Biotechnology is giving financial assistance to various institutions for holding national/ international Seminars /Symposia. The Department has also formulating programmes for Strengthening of Biology Teaching in School, Popular Lectures by Eminant Scientists, School Teachers Training and for bringing out Publications on Biology and Biotechnology. The Department is also giving Scholorships to 10 of the top students in Biology having passed plus 2 level CBSE examination and who continue with biological sciences in the graduation course.

CREATION OF INFRASTRUCTURAL FACILITIES:

To build up a strong R&D base and manufacturing capabilities, a network of service oriented Infrastructural Facilities is being supported by the Department. Facilities that have been set up include germ plasm banks for plants, animals, algae and microbes. Facilities like animal house; oligonucleotide synthesis; production, import and distribution of enzymes, reagents and radio-labelled compounds; bio-process optimisation and pilot plants; protein peptide sequencing; etc. have also been set up. For this purpose, instead of building new institutions,

Department's aim has been mostly to strengthen the infrastructure in the various fields in existing institutions by way of providing adequate support for space, equipment, training facilities, personnel etc.

SUPPORT FOR R&D:

The Department is supporting R&D programmes in various areas of biotechnology to the proposals involving direct application or requiring scale up operations or field trials of products etc., where possibilities of generating products, processing and services for commercial use are visible. Some of the ongoing programmes being supported are development of larval insecticide (biocide), extraction of copper through bacterial leaching, development of facilities for research in liposomes, insulin production through rDNA etc.

Two separate R&D-cum-production units for vaccines are being set up under the administrative control of the Department of Biotechnology. Unit of Oral Polio Vaccine by Bharat Immunologicals Corporation Limited (BIBCOL) at Bulandshahr in U.P. is being set up with Technology Consultancy Cooperation with USSR Institute of Poliomyelitis and Virus encephalitis, Moscow and the other unit is being established for production of Rabies, Measles, Inactivated Polio Vaccines and DPTP formulations by Indian Vaccines Corporation Limited (IVCOL) at Gurgaon in Haryana, in technical collaboration with the Institut Merieux, Lyon, France. The first release of commercial lots of vaccines is expected to start in December, 1990.

The DBT has initiated several R&D projects and programmes towards development of new and improved vaccines including

cholera, typhoid, pertussis, BCG, tuberculosis, leprosy, malaria, rotavirus diarrhoea, E. coli diarrhoea, oral bait vaccine for canine rabies, etc.

Under bilateral cooperation programmes with a number of countries, joint projects have been undertaken for R&D developments. A bilateral R&D programme called the "Indo-US Vaccine Action Programme" (VAP) between India and USA was initiated in 1987 for R&D has been inviting collaborative research projects in the areas of viral hepatitis; rotavirus; cholera; E. coli; typhoid;, pertussis; pneumococcus; haemophillus influenza; canine rabies; respiratory syncytical virus and poliomyelitis.

The Integrated Long Term Programme of Co-operation (ILTPOC) in Science and Technology, between India and USSR started in July 1987, has a componant of basic research in selected areas of science which includes studies on viral hepatitis, development of vaccines against FMD, sheep pox, rabies, development of immunodiagnostics for human and animal diseases, immobilised systems and novel bioreactor designs, isolation, purification and cloning of human plasminogen activator, development of drugs from indigenous medicinal plants against ectoparasites etc.

S&T Projects in Mission Mode on Development and Production of Immunodiagnostic kits has been started for a number of diseases which include early detection of pregnancy; filariasis; hepatitis-B; amoebiasis; brucellosis, toxoplasmosis, tuberculosis, leprosy, typhoid fever, malaria, giardiasis, leishmaniasis, rotavirus and shigellosis.

Under S&T project in Mission Mode on Immunological Approaches to Fertility Control safe, efficacious, cost-

effective, long lasting and reversible contraceptive vaccines, based on studies involving hormone human chorionic gonadotropin (hCG) in women, anti-FSH (Follicle Stimulating Hormrone) vaccine in monkeys and use of vitamin carrier protein as contraceptive antigen are in an advanced stage of trial.

Projects under agricultural biotechnology have been initiated to produce viral, bacterial and fungal agents for efficient management of insects, pests and diseases. Production of Rhizobium biofertilizers for major oilseeds and pulse crops and Blue Green Algal biofertilizer for rice are two major facilities being established under DBT programme. Fast growing multi-purpose trees and other species for biomass production that can grow on waste or degraded land are being practised. Tissue culture micro-propagation for bamboo, teak, eucalyptus, sandal wood trees and large scale multiplication of cardamom through tissue culture, and the cultivation of oilpalm under Technology Mission for Oilseeds, under irrigated conditions as demonstration projects in the States of Karnatka, Maharashtra and Andhra Pradesh are the other programmes of DBT.

Facilities have been created for the application of embryo transfer technology in India through the DBT's mission-mode project on cattle and buffalo herd improvement. Technologies using frozen-thawed embryos and split embryo are the major breakthroughs. Production of an animal birth control injection called 'Talsur' for the sterilization in stray cattle help reduce the population of low-grade genetic stock of little economic value. In addition, work is under progress to develop immunodiagnostics as also the production of vaccines for animal diseases. Programmes to develop growth hormone genes to increase

animal and fish production and prawn aquaculture through biotechnological innovations like chromosomal manipulations, gene cloning and transfer, cryo-preservation of gametes and embryos and finally *in vitro* fertilization for production of fish with better growth rate are also being evolved.

BIOINFORMATICS:

In order to have access to the large volume of information and to fulfil the growing need for timely availability of information, the Department of Biotechnology has set up a National Biotechnology Information System (BTIS). BTIS has been established to serve as a networking and base management organization in identified areas involving specialized institutions as Distributed Information Centre (DIC). The Department of Biotechnology is coordinating the activities DICs at the national level and has established on-line communication with external sources as a part of the International Network on Bioinformatics. There are nine DICs in the University and R&D Institutions in the country engaged in one or more areas of Genetic Engineering (IISc, Bangalore; MKU, Madurai; Bose Institute, Calcutta; JNU, New Delhi), Animal Cell Culture and Virology (Poona University, Poona), Plant Tissue Culture, Photosynthesis and Plant Molecular Biology (IARI, New Delhi), Oncogenes, Reproduction Physiology, Cell Transformations, Nucleic Acid and Protein Sequence (CCMB, Hyderabad), Immunology (NII, New Delhi) and Enzyme Engineering (Institute of Microbial Technology, Chandigarh) In addition, 14 user centres have been established throughout the country to provide an access mechanism for the information to be available at the Universities and R&D