BIOTECHNOLOGY, THE FLAVOUR OF THE TWENTY-FIRST CENTURY

Worldwide, biotechnology is revolutionizing the development of products, processes and services in healthcare, agriculture, industry and environment, Billions of dollars have been invested in biotechnology mediated enterprises and biotech products and services are already a multibillion dollar industry, A large number of healthcare products such as therapeutics, vaccines, diagnostics and nutraceuticals are in the market; so are cleaner environment-friendly biotech products and processes enhancing value in a range of industries from leather, detergents, textiles, to food and feed, beverages, beer, wine, confectionery and cosmetics. Over a hundred and twenty million acres are under , transgenic crops. In view of the general awareness of the major strides in biotechnology and the perception that it will impact this century more than any other technology, it is redundant to further emphasise the advances already made in many countries and the future potential of biotechnology.

The Indian initiative in biotechnology has already attained a critical mass, although not comparable to the huge resources in scientific manpower, technology and funds available in the advanced countries especially in the West.

The pivotal role of the Department of Biotechnology in institution building and infrastructure development, training and human resources development as well as major R&D support has resulted in the establishment of centers of world class excellence. The trickle down effect has enabled several states to take major initiatives in biotechnology, Big established pharma companies as well as new Biotech companies have invested hundreds of crores of rupees in Biotechnology research and product development. Nutraceuticals, personal care products and traditional medicinal formulations have witnessed an upsurge in production and popular acceptance.

Andhra Pradesh has already established Biotech Parks and Karnataka, Tamil Nadu, U.P., Maharashtra, Himachal Pradesh are on the way. Several enterprises in the States of Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu have biotech products in the market.

THE BIOTECH POTENTIAL OF KERALA

Kerala is indeed God's own country. Bestowed with the breathtakingly beautiful landscapes, Kerala is among the top in South Asia for its Quality of Life Index, enjoying very high rates of literacy, health, public hygiene and life expectancy as well as basic infrastructure such as transportation, electricity, water and housing. In recent years, Kerala has made substantial progress in Information Technology and related Business Processes Outsourcing. Apart from the traditional agricultural and commercial strengths of the state in rubber, coconut, spices, coffee and tea, Kerala has a slew of business houses, health spas and residential clinics, prospering by utilizing Ayurvedic magical potions of medicinal plants sourced from one of the world's most precious biodiversity hotspots. Kerala's marine resources and forest wealth are other major engines for economic growth of the State. Biotechnology will offer excellent opportunities in augmenting value creation, wealth and employment not only in many of these areas of traditional activity but also usher in new vistas for application in medicine, agriculture and industry.

FOSTERING BIOTECHNOLOGY IN KERALA: A SWOT ANALYSIS

Strengths: High literacy, educated and technically skilled people, basic infrastructure and among the highest Quality of Life Index; marine/sea food resources; spices and other plantation crops, medicinal plants; one of the best biodiversity treasures of the world; strong tradition of Ayurveda and its widespread use including medical tourism; sound information technology base.

Weaknesses: Lack of top class Biotechnology teaching and R&D Institutions (compare, for instance with Indian Institute of Science, Bangalore; Centre for Cellular and Molecular Biology, Hyderabad; National Institute of Immunology, Jawaharlal Nehru University, All India Institute of Medical Sciences, New Delhi, Pharma and Biotech Companies -Reddy's Lab, Ranbaxy, Astra Zeneca, Nicholas Piramal, Cipla, Wockhardt, Orchid, Biocon, Reliance Life Sciences, Shanta Biotech, Bharat Biotech (all in other States); militant labour and a general climate perceived to be not industry-friendly.

Opportunities: New awakening/realization of the Potential of Kerala e.g. success of the Global Investors Meet; Proactive new initiative and awareness of the Political Leadership, in fostering

Biotechnology; Positive attitude/keenness of the worldwide Kerala diaspora to provide technological know-how and investment to establish Biotech industries; emerging technology leads obtained by some of Kerala's R&D and healthcare institutions; Entrepreneurial spirit and success of many Kerala based ayurvedic healthcare/personal care/medical tourism companies.

Threats: Strong tendency for political and bureaucratic control/stranglehold over any Government initiative; comparative early bird Biotech initiatives of other States, especially in South India, inadequate financial and administrative support as well as political leadership in the State (compare Kamataka, AP.); laid-back, privilege oriented, accountability lacking work culture.

KERALA BIOTECHNOLOGY POLICY: OBJECTIVES AND GOALS

The BT policy for Kerala is designed to catalyse the development and application of BT, taking advantage of the State's resources and emphasizing its specific needs while meeting global requirements. The policy is aimed to ensure the rapid exploitation of pipeline technologies and opportunities available in the State to products and processes and to promote the sustained build-up of an elite knowledge cadre and knowledge base through the strengthening and creation of educational and R&D institutions, establishing infrastructure and putting in place administrative, regulatory, legal and financial framework conducive for investment and growth of BT enterprises, for the economic development and human welfare.

The specific objectives and goals are :

Create a biotech knowledge base and human resources by establishing world-class centres of education and R&D in biotechnology by upgrading existing institutions and/or organizing new entities in the public and private sectors (eg. on the lines of Birla Institute of Technology, Pilani).

Apply biotechnology tools to:

(1) Enhance the value with adequate assurance of quality in the State's export-oriented resources such as spices and related plantation crops, sea foods and marine resources;

(2) Upgrade productivity and evolve new application in rubber, coconut, tuber crops and develop novel internationally competitive products;

(3) Ensure the sustainable and eco-friendly exploitation of the State's forest, animal and marine wealth;

(4) Boost the State's renowned health care practices of Ayurveda by synergizing traditional knowledge with the scientific validation and technical product profiling and clinical data base and by evolving means to conserve and substantially use one of world's most-valued biodiversity treasures located in the State.

(5) Promote traditional tribal and ethnic knowledge in medicine and other areas of human welfare by scientific validation and facilitating intellectual property rights.

(6) Develop recombinant DNA and other modern technologies to combat the major health hazards of the State such as cancer, diabetes and cardio-vascular and other physiological disorders; to develop diagnostics and vaccines for overall healthcare as well as to protect the State's agriculture, spice, plantation and forest crops, from biotic and abiotic stresses.

(7) Enhance the quality of the environment and promote sustainable development;

(8) To create, coordinate and disseminate a data base encompassing the above cited areas;

(9) Provide an ambience with a package of guidelines for financial support and incentives, legal and labour reforms as well as institutional autonomies needed for the healthy, efficient and competitive growth of biotechnology knowledge base and industry.

STRATEGIC ADMINISTRATIVE INITIATIVES AND INSTITUIONAL MECHANISMS

To achieve the Kerala vision in Biotechnology, ensure hazzle-free implementation and provide sustained leadership and resources, the following two major initiatives will be, undertaken to create:

Kerala Biotechnology Board

Kerala Biotechnology Commission

The Chief Minister of Kerala would be Chairman of the **KERALA BIOTECHNOLOGY BOARD** with the ministers for Industry, Information technology, Agriculture and Health, Chief Secretary and Vice-Chairman of State's Planning Board, two eminent industrialists and two Biotechnology Scientists/Technocrats as Members with an eminent Scientist who is also the executive Vice-President of the Kerala State Council for Science, Technology and Environment as Convener.

The Board will organize a corpus of Rs.100 Crores to create infrastructure in BT including BT Parks by collecting a Biotech Development Fund from the stake holding Departments of Industry, Health, Agriculture, Forest etc. The contribution of each Department will be in conformity with the anticipated benefits. In addition a BT Development Fund will earmark 1% of the Annual Plan Allocation of the Departments benefiting by BT. Another avenue is to seek grants from international Agencies and involve private and public Enterprises.

The Biotechnology Board will take all top level administrative and financial decisions to create the best milieu in the country for growth of BT. The Board will liase with National and International agencies and will ensure appropriate and timely implementation of the Policy. It will endeavor to provide the Biotechnology Enterprises of the State a consistent, competitive edge.

KERALA BIOTECHNOLOGY COMMISSION will be responsible for the implementation of the

BT policy and related guidelines laid down by the Biotechnology Board,. The Chairman of the Commission will be an eminent scientist who is also the Executive Vice-President of the Kerala State Council for Science, Technology and Environment. The Commission will have five members including two leading biotechnologists and entrepreneurs/industrialists. Three of the Members will preferably be from outside of Kerala State. The Commission will co-opt concerned Government officials as Members as required. The Commission will be the effective think-tank of the Board and will identify focus areas of investment and prioritise projects for implementation and will be responsible for utilization of BT Development Fund. It will prepare a road-map of BT initiatives, encourage private-public sector interaction and assess and approve project proposals.

The Commission will address all ethical, moral, environmental, economic and social issues and imperatives in fostering BT and will be responsible for the balanced awareness and education of the public on the potential hazards and safety of Biotechnology.

KERALA STATE AS PROACTIVE ENABLER OF BIOTECHNOLOGY

- **T**he State BT Board will facilitate and enable growth of BT by spearheading a number of initiatives.
- **E**ncourage the establishment of world class institutions of higher learning and R&D in biotechnology, both in the public and private sectors.
- **A**pprove BT interventions/applications and regulatory requirements expeditiously through an exclusive and effective single window system.
- **E**nsure all laws of the land are obeyed to promote “Responsible” BT .
- **B**T companies will be permitted to acquire agricultural land in excess of current ceiling limits.
- **I**mportant new BT units and expansion of existing units will be exempted from stamp duty and registration fees.
- **F**SI will be double that of prevailing norms in the localities.
- **O**ffer Government land for BT enterprises at concessional rates.
- **I**ndustrial power tariff is to be made applicable to Biotech industries.
- **I**mportant agribiotech companies will be given power at agricultural rates.
- **B**T industries will be exempted from statutory power cuts.
- **B**T companies to be exempted from paying electricity duty.
- **C**aptive power plants will be permitted.
- **I**ndependent power producers will be permitted to cater to BT industries.
- **B**T units will enjoy all benefits throughout the State, now reserved for IT industry.
- **P**rovisions of the Industrial Disputes Act will be modified/amended to facilitate shift working hours and employment of women.
- **T**he State will share public health data with BT companies and collaborate with such companies in clinical research.

- **S**tate Government agencies involved in healthcare, animal husbandry and fisheries will align with private industry to develop appropriate products.
- **P**ermit the establishment of BT Parks with Government equity in kind (land)
- **B**T Parks will be set up in Thiruvananthapuram, Cochin and other suitable places.

To achieve the above objectives for industrial promotion in biotechnology, a Biotechnology Industry Promotion Mission may be set up.

BIOTECNOLOGY HUMAN RESOURCE DEVELOPMENT

Although Kerala is a leading State in literacy and primary education in the country, it still lags behind many other States in the “quality” of education and “State of the Art” knowledge especially in areas such as modern biology. Therefore a major imperative in Kerala is building up and strengthening of HRD in biotechnology for providing the knowledge-base and knowledge cadre essential for industry and institutions. Towards this end the existing leading State Institutions in Biotechnology will be networked with advanced R&D laboratories of the Central Government and Private Institutions in the State. KSCSTE will evolve a scheme to establish such a network and implement the same so that personnel and facilities of the participating institutions will be mobilized to train faculty and mid-career scientists in research institutions to enhance the capability in teaching and research.

Teaching and training will provide Biotech knowledge base which are universal with special emphasis on aspects which are relevant to Kerala .Fundamental concepts and ideas of modern biology are the bedrock on which such teaching and training will be based. Elements of recombinant DNA technology, immunological approaches structural biology, bio informatics etc., will constitute the universal components.

The following institutions which already have significant biotechnology programmes are identified to achieve this goal:

- Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram
- Sri Chitrathirunal Institute for Medical Sciences & Technology, Thiruvananthapuram
- Regional Cancer Centre, Thiruvananthapuram

- Rubber Research Institute of India, Kottayam
- Central Tuber Crops Research Institute, Thiruvananthapuram
- Indian Institute of Spices Research, Kozhikode
- Centre for Plant Biotechnology and Molecular Biology, Kerala Agricultural University.

Services of scientists from outside Kerala, the relevant programmes of DBT, UGC and other central agencies as well as the Science Academies, will also be harnessed for human resource development.

There is a felt need for induction of young faculty well-versed in modern biotechnology, in institutions of higher learning and research. An empowered panel of biotechnology experts, which will include some from outside Kerala, will be set up, under the Biotechnology Commission, to carry out the recruitment in this sector.

KSCSTE will set up a special post-doctoral Biotech Career Development Programme whereby at least 10 (ten) young faculty will be selected to undertake post-doctoral work at leading biotech R&D labs in the country. The eligibility will be limited to the faculty (below 35 years) working in the Universities and R&D Institutions in Kerala. The empowered panel cited above for recruiting young scientists/technologists will also be assigned the responsibilities for selecting career development awardees entirely on merit basis.

In order to motivate and retain creative professionals and scientists, technical personnel and staff will be given incentives by allowing them to retain a portion of technology transfer fees and/or royalties earned as a result of their R&D effort; to serve as Members of Advisory Boards of Private companies; to take up consultancy assignments. The guidelines evolved by CSIR will be adopted to implement this initiative.

There is urgent need to inculcate patent literacy and awareness of intellectual property rights and their impact on R&D, Industry and the underfinnings in relation to WTO, KSCSTE will organize special programmes to foster IPR and Patent literacy.

Notwithstanding the emphasis on higher learning and research, a basic overall need is to strengthen the science education at high school and college levels. While making special efforts to strengthen biology education, the State will evolve means to prevent the mushrooming of biotechnology and bio-informatics programmes, especially in the private sector without adequate professional expertise, facilities and basic infrastructure. At the same time, the State will encourage high quality professional and academic initiatives in the private sector by implementing a discriminatory policy favouring such Centres of Academic Excellence.

A major impact can be made by an Indian Institute of Biotechnology (IIBT) established in Kerala which could cater to the training of biotechnology professionals who will be able to manage the biotech-initiatives of Kerala and other States as well. Selection of students to the IIBT will be through an open entrance examination and the students thus selected could undergo a high caliber integrated B.Sc.-M.Sc. course at the end of which they will be free either to pursue a research career or enter the biotech industry.

A substantial portion of the proposed Biotechnology Development Fund will be earmarked for strengthening the knowledge cadre and research facilities and in implementing the above Biotechnology Policy Initiatives.

AGRICULTURE

Kerala's agricultural economy is driven by the dominant commercial crops of the State viz. coconut, rubber, spices (pepper, cardamom, ginger, vanilla), tea, coffee, cocoa, cashew and tapioca, apart from the- horticultural crops such as pineapple and the *nendran*. banana variety. Orchids and Anthurium are important cut flower crops of Kerala. The State is also home to the "Njavara" rice, dietary favourite of the diabetics and the salt tolerant Pokkali variety. The State also harbours rare species of goat and cow with valuable genetic traits for disease resistance.

The tools of biotechnology such as molecular genetics and breeding, including the use of molecular markers and descriptors as well as r-DNA technologies and bio-informatics need to be harnessed in conjunction with tissue culture techniques and conventional breeding to not only combat biotic (insects, fungal, bacterial and viral pathogens) and abiotic (drought, salinity) stresses, but also to enhance value of these commercial crops in the domestic and international market, while sustaining and improving the genetic pool.

The areas of focus will include:

Biotic stresses -Root wilt of coconut; phytophthora foot rot in black pepper; soft rot in ginger; khatte virus and thrip in cardamom; vanilla necrosis poly virus and mosaic virus; sandalwood spike disease.

Coconut eriophyid mite; tea mosquito in cashew; coffee berry borer; teak defoliator and skeletoniser caterpillar;

Abiotic stresses -Drought tolerance in black pepper, rubber; pokkali rice as a genetic resource for engineering/breeding salt tolerance.

Crop and animal stock improvement -Kerala's rich biodiversity in black pepper, cardamom, ginger, rice and rare species of goat and cow as genetic pool for improvement; combating viral hepatitis on ducks.

The potential of the extensive infrastructure available at Palode for promoting livestock vaccine production to be fully utilized by net-working with concerned State institutions with RGCB as the co-ordinating nodal Centre.

Gene discovery and designer plants -Identification and characterization of speciality genes and their patenting; tissue specific gene expression; metabolic pathway engineering, lateciferous cell specific promoters in rubber; designer forest trees to yield wood with less lignin and more cellulose for paper industry.

Bioinformatics, database and website -on Kerala's agri-gene pool; pests and diseases; resistance markers and profiles; agronomic features; rare, endangered and threatened species; Website for farmer access for biotech solutions to enhance quality and productivity.

Value addition by post-harvest technology and processing -Technologies in the value

chain of harvesting, handling, preservation and processing of crop products from the farmers fields to the factory market.

Illustrative example: Malaysian acreage in rubber fell by 50% in the last decades but earnings increased by product improvement and value addition. For instance, processing technology for speciality products in the manufacture of super luxury vehicles (BMW, Mercedes Benz) rubber bearings in earth-quake proofing of buildings; removal of allergenic proteins for high quality gloves/personal care products.

Fermentation and down-stream processing in cocoa, vanilla; oil and oleoresins in black pepper, capsicum, ginger, cardamom, turmeric, garlic; enhancement of colour in cardamom; starch, ethanol and bioplastics from tapioca; application of enzymes in tea and coffee pulp processing; bio-composting of agricultural wastes; cocopith as high value replacement of peatmoss in the high tech green houses and fustigation farms of the multi-billion dollar horticulture and floriculture industry.

HRD in Agri-biotech -There is specific need to focus on HRD in Agribiotech, especially in evolving post-graduate and Ph.D. programmes. UKA as nodal agency will initiate and co-ordinate agribiotech HRD schemes by net-working with the institutions cited earlier in the section on “Biotechnology Human Resource Development”

MARINE RESOURCES

Sea food export is not only one of the highest revenue earner for the State, but also provides directly and indirectly employment to hundreds of thousands of people. Application of biotechnology especially in quality enhancement is a major need and will enhance the State’s export competence dramatically.

The initiative will include:

Diagnosis and prevention of viral and microbial pathogens by PCR and ELISA based techniques to counter white spot syndrome virus as well as the yellow head virus.

Upgrading of facilities and creation of new ones for testing and certification for microbial and viral loads and antibiotic, hormone and chemical pesticide residues will have priority. Commercialisation of hatchery production protocols for variety of sea foods as well as marine ornamental fishes; establishment of onshore and sea farms for not only shrimps, crabs and related sea foods, but also for fin fish, shell fish, sea weeds and micro algae for the production of agar agar, aligns as well as anti oxidants and neutraceuticals; seafood waste utilization and development of byproducts.

Environmentally sustainable harvesting of fisheries wealth in the Indian EEZ as well as monitoring environmental health in the coastal ecosystems will have priority.

Up keep and maintenance of Environmental Friendly Fisheries (EFF) through appropriate biotechnology interventions in respect of both culture and capture fisheries are to.be encouraged.

Preservation of endemic and ethnic characters of the adequate biota through gene pool protection and development of disease -resistant genomes have become important and will be promoted through institutional facilities within the state and through coordination with those in other states.

The thrust areas for research and application of biotechnology in fisheries will include establishment of gene banks and fish bio-reserves; genetic improvement of disease-resistant fish; productivity enhancement in fish; development of promoters for upgrading eco friendly, aqua-farming systems; biotech support for the large scale production of monosex species of endemic or exotic high yielding fish varieties; technology standardization for fixing systemic feeding and seeding schedules, and the application of standard units, legal regimes and control measures on the usage of probiotics and antibiotics.

Marine bio-prospecting will be a major theme of the Biotech Policy. A number of novel marine

biotechnology initiatives are feasible and the policy will emphasise such emerging areas. Examples are novel anti tumour and immuno modulatory agents from marine organisms such as sponges and blue green algae, e.g., *Lyngbya Majasculata*; marine microbes and saline fermentation for therapeutic and industrial applications; biologically active substances from amphibians and arthropods; combinatorial genomic which allows integration of DNA from non-culturable microbes into genomes of easily culturable host microbe organisms. The institutions involved in marine research with CMFRI as the nodal Centre will co-ordinate the R&D and create natural product database for the State's marine wealth.

HEALTHCARE

Kerala being the most health conscious State in the country, emphasis should be on "forecastive medicine" and "preventive therapies" for physiological and genetic diseases such as cancer, diabetes and mental disorders. The area of focus will be on early, sensitive and accurate diagnosis of the diseases (e.g. PCR based diagnostics; immuno diagnostics) and development of vaccines. The State will encourage the establishment of diagnostic service centers at District headquarters for infectious diseases such as tuberculosis and other pulmonary, parasitic and gastro intestinal infections and AIDS. Sree Chitra Thirunal Institute of Medical Sciences and Technology is already involved in ELISA and DNA based diagnostics for cardio vascular infections and genetic diseases. Rajiv Gandhi Centre for Biotechnology is active in PCR based diagnostics for entero, rota, hepatitis A and E viruses. Pharmacogenomics work at RGCB on software development for detection and identification of metabolic errors (e.g. single nucleotide polymorphisms) will complement this effort. SCTI and RGCB along with Regional Cancer Centre will jointly spearhead the initiative with SCTI as the nodal institution.

Tissue Engineering has immense potential to be a niche area in medical biotechnology. Tissue Engineering is expected to revolutionise the technologies leading to organ replacement and the substitution of damaged tissues, e.g., *in vitro* regeneration of tissue including nerve, liver, bone and heart valves. The effort will involve the participation of biotechnologists and material scientists. Groups working at SCTI in the areas of polymer science and bioceramics will be encouraged to initiate the major programmes in this area.

Ayurveda and traditional medicines: Kerala is the cradle of Ayurveda and the traditional system of medicine is an integral part of the health regime of most Keralites. The Ayurvedic manufacturing sector in the State comprises nearly 760 units with 75 units having GMP certification (report by Ayurvedic Medicine manufacture's Association). Total export earnings of the Ayurvedic medicines in 2001-2002 was Rs.750 crores and is expected to increase by Rs.5000 crores by 2005.

Medical tourism is a thriving activity in the State with huge employment potential. A leading Ayurveda company, for instance, has 322 formulations, 19 Ayur-clinics in and outside Kerala apart from a multi crore health resort in Bangalore and 60 franchise clinics. The Company markets nearly 300 classic formulations out of which 22 are patented drugs. A 40 acre herbal plantation near Bangalore as well as new ones in Orissa and U.P. cater to the company's requirements. The above illustrative example is indicative of the tremendous potential for Ayurvedic medicine and medical tourism. The State Policy will encourage the synthesis of the traditional and modern in upgrading the quality and the content of the Ayurvedic medicines and services.

Creation of an advanced multi purpose analytical testing and standardization laboratory approved by the National Accreditation Board For Testing and Calibration of Laboratories, will cater to the needs of the Ayurvedic and Pharmaceutical industry for meeting international specifications.

Discovering new medicines from Nature: Nearly 40% of the new drug approved by the Food and Drugs Administration, USA in the period 1983-1994 were either directly or indirectly derived from natural products.

Kerala's biodiversity treasure and rich tradition of Ayurveda provides an ideal combination for discovery and patenting of new drugs. A consortium approach with leading industry partners and the State's major medical R&D institutions such as SCTI, RGCB, RCC, TBGRI and CUSAT will be encouraged by KSCSTE with special emphasis on collaboration with National Chemical Laboratory, Pune in utilizing NCL's multicrore high throughput robotic facility for screening, combinatorial synthesis, structure elucidation and profiling of bio-molecules for drug development. Neutraceuticals, functional foods that are used in preventive health care such as weight regulation, stress management, antioxidants, are another class of health care products having rich potential and will be an additional focus of the inter-institutional collaboration cited above.

BIODIVERSITY

Several key facets involving Biodiversity stressed under the healthcare initiatives do not need repetition. The main goal of the Policy will be to harness, the State's Biodiversity treasure without eroding or endangering the same in any way.

Amongst 250,000 known species of plants and microorganisms and the new species not yet discovered, there will undoubtedly be new compounds waiting to be identified. In the quest for leads to new medicines, evaluation of natural resource materials must be conducted prudently taking care not to imperil biodiversity and conserving rare species.

A number of initiatives will be encouraged by the Stake-holding institutions such as. KFRI, with TBGRI as the co-ordinator with participation by appropriate industry partners; some of these are:

- Herbal farms for cultivation, harvesting and processing of raw materials; their standardization and chemical profiling for certification needs
- Provision of planting materials such as seeds, cuttings and tissue culture plants;
- Application of controlled fermentation techniques for the standardized production of Arishtas and Asavas
- Bio reactor and fermentation kinetics of plant cell cultures for secondary metabolites
- Creation of database on traditional, tribal and ethno botanic remedies and formulations; their patenting as well as protection from bio piracy
- Evolving a mechanism or legislative provision for rewarding the traditional vaidya or tribal for sharing the wealth generated by marketing/commercializing leads from their traditional knowledge base.

INDUSTRIAL BIOTECHNOLOGY

The intensity of involvement of the entrepreneur and private industry will be the main hallmark of success of the Biotech Policy. A number of areas of commercial and industrial biotechnology are cited for priority focus under the sections dealing with Agriculture, Healthcare, Marine Resources and Biodiversity. It will be the task of the Industry Ministry to scout for technology leads from the various R&D institutions in the State and also globally facilitate technology incubation, industry partnership and technology transfer. The Ministry will provide fiscal incentives and take administrative measures to create the right milieu for the BT industry development. Many of the imperatives are cited in the section on "Kerala State as Proactive Enabler of Biotechnology".

Venture capital fund in Biotechnology is much harder to obtain compared to IT because of long gestation periods and higher capital requirements. The Industry Ministry will evolve mechanisms to tap Government financial institutions and the proposed Biotechnology Development Fund as sources of capital.

Establishment of Biotechnology Parks will play a pivotal role in contract research, technology development, incubation, scale-up and commissioning of Biotech projects.

ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Bio fouling of Kerala's backwaters and rivers has assumed alarming levels. Similarly, pollution due to chemical and industrial effluents is a major environmental hazard. Although, prevention of this pollution is better than cure, biotechnological tools such as consortia of microbes and viruses as well as enzymes can be used for bioremediation. For instance, microbe and enzyme mediated solutions are feasible in the degradation of phonemics and tannins released in coir rotting as well as in biodegradation and by-product development from coffee pulp waste. Coir pith, a waste product in the coir industry is already fast replacing peat moss as a multi million dollar industry.

The bio load of the major rivers, Periyar and Pamba are indeed very high. There is also a need for the regeneration and preservation of the wet lands of Kerala. KSCSTE will evolve a networking mechanism of concerned institutions in the State as well as the National Environment and Engineering Research Institute, Nagpur to tackle the degradation of the environment using biotechnological approaches.

BIOINFORMATICS

The development of Bio informatics, especially in the context of Kerala's strength in information technology is a much needed strategic initiative.

Creation and access to the database on Kerala's unique biodiversity and the related traditional knowledge in Ayurveda, the genetic traits, agronomic features and disease resistance sensitivity profiles of speciality spices and commercial crops, marine resources, the clinical/genetic information on the Keralite's disposition to diseases such as cancer, diabetes, cardiovascular-ailments and mental disorders will be extremely valuable for research and product/process development in these areas.

Bio informatics as a service platform has great potential for Kerala State. There are several focus areas for catering to domestic and international clients:

Contract sequence services -synthesis and mapping (seeds, leaves, blood/organ tissue, purified DNA);

Molecular marker services -DNA fingerprinting, molecular markers and ESTs (Expressed Sequence Tags);

Training courses -awareness courses on Bio informatics, genomic, DNA fingerprinting apart from specialized higher courses on physical mapping, YAC libraries, chip technologies;

Hardware and software support services -web hosting services for clients/institutions Data storage and documentation services. Bio informatics activity will be part of the technology mission already underway in the State and will need to network with not only Kerala's leading R&D institutions, but also the National Bio informatics Centres such as Pune University and Madurai Kamaraj University.

BIOTECHNOLOGY PARKS

As engines to drive Biotech industry, the establishment of Biotech Parks has a catalysing role. Worldwide, there are 3550 biotechnology incubators with nearly 2000 in USA and Western Europe. Whereas India has less than 10, China alone has 465 such incubators.

Kerala State has decided to establish Biotech Parks with the lead taken by KINFRA. The essential components, apart from customized lab units, of the biotech park are:

- **Bio resource Centre** as a hub to provide infrastructure, equipment. facilities and services to assist the tenants and clients of the park.
- **Technology Incubator** with the capability to develop and license, in collaboration with R&D institutions, proprietary technologies to the tenants and clients in the State and elsewhere.

- **Training Centre** where technology skill packages can be imparted in biotech streams, e.g., molecular biology, genetic transformation immunology, tissue culture, fermentation and down stream processing and instrumentation.

Establishment of high quality analytical, testing and certification laboratory to meet the needs especially of the sea food, spices and healthcare industry as part of the Biotechnology Park, will be of great benefit.

The laboratory will conform to international standards with ISO and Drug Controller's Certification.

Creation of biotech parks with the required equipment, instrumentation. bio safety and GMP specifications will need enormous resources. Moreover, biotech parks need to be run with technology partnerships with outstanding R&D institutions. As such the State Policy will encourage the consortium approach with biotech promoters, professional technology institutions and industry partners. The parks; will be run with the objective of incubating and commissioning state of the art biotech packages, but ultimately as profit centres for the consortium partners.

Although, the State requires several technology parks to meet its needs, considering the financial stringency, it will be prudent to begin with one park. Considering the locations of leading R&D institutions and the geographic distribution of the State; natural resources and commercial centres, the State will encourage the establishment of Biotechnology Parks with emphasis on healthcare at Thiruvananthapuram, marine resources at Cochin and agriculture in an appropriate location near Thrissur/Kozhikode/Munnar.