

## **PRIORITIES IN THE BIOTECHNOLOGY INDUSTRY CLUSTER**

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### **Abstract**

The Philippine National Science and Technology Plan (2002-2020) states that the development priorities in biotechnology are its applications in agriculture, forestry and natural resources, health/medical sciences, environment, energy and manufacturing and process engineering. Applications have been identified in these sectors as follows:

For agriculture and fisheries — varietal improvement and sustainable production for food security; for forestry — maintenance and maximization of forestry resources; for health/medical sciences — prevention, diagnosis and treatment of diseases; for marine sciences — development of marine bioindustries; for energy — development of renewable energy resources; for manufacturing and process engineering — development of novel processes of manufacture using life forms as miniature factories to produce the desired products and for environment — bioremediation.

The plan also indicates that the priority research and development areas for biotechnology processes and technologies are in the following: plant tissue culture; immuno-based diagnostics, protein and DNA markers; microbial transformations; plant transformations; genome mapping; cloning single genes; and mammalian tissue culture.

The sectoral R&D councils have formulated their medium term plans consistent with the NSTP priorities. In agriculture R&D in biotechnology is geared to generate breakthroughs such as fertilizer substitutes, genetically engineered plants and animals, biological control of pests and diseases, and plant and animal diagnostics. In industry R&D will be focused in the production on specialty chemicals which includes food additives and intermediate chemicals used in food and chemical processing more particularly enzymes, organic acids, polymers for films, coatings and flavoring agents. In health diagnostics which aid in the treatment of diseases as well as development of vaccines especially on emerging diseases and other infectious diseases have been identified.

Consistent with the above priorities and pursuing the strategy of niching and clustering the Department of Agriculture, Department of Trade and Industry and the Department of Science and Technology pushed the creation of a Biotechnology Cluster under the Export Development Council. This is seen as a boost to the development and growth of the biotechnology industry in the country. The two subsectors identified with their corresponding lines of products and services considered to offer good opportunities are the agricultural and health bioindustry subsectors.

**Keywords:** biotechnology, agriculture, bioindustry, health, clusters

One of the most important and critical interagency bodies in the country today is the Philippine Export Development Council. It is chaired by the Secretary of the Department of Trade and Industry and there is an equal representation in membership from government departments and from the private sector. The Secretary of the Department of Science and Technology is one of the members of the council and she is officially represented in the council by the Undersecretary for Scientific and Technological Services. One of the tasks of this council is to regularly prepare the Philippine Export Development Plan to define the country's export strategies and programs that shall be implemented by the government and the private sector within the framework of the Medium Term Philippine Development Plan or MTPDP. For instance, the current MTPDP for 2004–2010 rolls out a three-year Philippine Export Development Plan covering the period 2005–2007. This plan referred to as PEDP serves as the blueprint for the government in forming concerted action plans on export development and for private businesses in crafting their industry-and-firm level exporting strategies.

One of the strategic innovations adopted by the Export Development Council is the clustering strategy on the identified export priority sectors and one of the more significant developments in sector prioritization is the inclusion of some sectors where the country has potentials even if the production or services sectors are still in their development stages. One such sector is the Biotechnology Sector which is now included in the list of what we may describe as a predominantly 'traditional' listing. Food, Wearables, Aquatic Products and Organic and Natural Products have been very traditional items. In the last two to three decades, however, the Electronics, Motor Vehicle Parts and Construction Materials sectors have become very significant items. In fact, exports in the Electronics and Semiconductor Industry Sector now constitute close to 70% of our manufactured exports. How and why then has Biotechnology entered the picture?

The market for biotechnology products and services worldwide has grown in an exponential fashion. The Philippines, on the other hand, has great potentials in this sector. PCARRD reports that there are more than 300 experts in the field. This may not be a large number but they can do much to elevate the sector into a significant contributor in terms of economic output. Of this number, PCARRD also reports that a third of them are involved in modern biotechnology and the rest are

into traditional biotechnology activities. PCARRD also cites that the centers of excellence (COE) for modern biotechnology with moderately adequate facilities are the University of the Philippines Los Baños (UPLB) which includes the National Institute of Molecular Biology and Biotechnology (BIOTECH), Institute of Plant Breeding (IPB), and the Institute of Biological Sciences. The Philippine Rice Research Institute (PhilRice), the Philippine Coconut Authority (PCA) and the Philippine Carabao Center, all attached to the Department of Agriculture are also in this category. The National Institutes of Molecular Biology and Biotechnology (NIMBB) at the University of the Philippines Diliman, Manila and Visayas and SUCs like Leyte State University and the Central Luzon State University have strengths and potentials in this area. Many others are in their development stages. The fact that several priority sectors in the Philippine Export Development Plan are in the food-agri-natural products category makes Biotechnology a very strategic and important field or sector. Biotechnology products would most likely fall in this category but there are also products such as those in the health/pharmaceuticals/medical sciences sector or what the Biotechnology Cluster in the Export Development Council calls the Bio-industry sector where the market is large and growing and where the Philippines can be competitive not only because of human resources capabilities but also because of the richness of the country's biodiversity. Mention of this Biotechnology Cluster in the Export Development Council at this point brings in the strategy of cluster management.

The National Cluster Management Team (NCMT) of the Export Development Council was constituted to review and validate value chain analysis of the priority clusters. It is headed by the Senior Undersecretary of the Department of Trade and Industry. In mid 2005, the Biotechnology Cluster was constituted with the Department of Science and Technology as the lead and with the DOST Undersecretary for S&T Services as cluster chair. The Cluster Team has an S&T Manager coming from DOST, an Agricultural Production Manager coming from DA, a Business Development Manager coming from DTI, a cluster champion from the private sector, a cluster adviser in the person of Academician Ceferino L. Follosco and a cluster secretariat provided by the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) of DOST. There is also a Cluster Core Group composed of representatives of stakeholder groups – from business/industry, from R&D institutions, from policy and regulatory agencies, from the academe, and from other government organizations. There are industry champions coming from identified priority subsectors. During the first Biotechnology Cluster Workshop on December 5, 2005 it was agreed that the vision of the Biotechnology Cluster is to develop the Philippine Biotechnology Sector as an export earner within the 2007–2010 period and the focus will be Agri-biotechnology and Bio-industry (which includes Health Bio-industry). The goal is to launch at least five Biotechnology products into the export market in the next three (3) years and to support the long-term competitiveness and sustainability of Philippine biotechnology export products in the global markets.

### Market Trends Potential Niches

What trends does this Biotechnology Cluster see as far as the global market is concerned? The Cluster sees a growing demand for agri-biotech products such as marine products like carageenan, API and fluorescent markers; derivatives from medicinal plants like anti-oxidants, enzymes, flavanoids and tannins; oils like those from fish, jasmine, ylang-ylang and coconut (VCO); GMO products like edible vaccines, fortified rice and pesticide free crops; biotech seeds, feed additives and biofertilizers like nitrogen fixation fertilizers and vermicompost. The cluster also sees a lot of opportunities in niche bioindustry products like natural ingredients, herbs/botanicals, and cosmetics and toiletries. And of course medical biotechnology, which is taken as part of the bioindustry subsector, is the largest biotechnology sector worldwide where there are promising niche markets in therapeutics like EPO, insulin and other biogeneric drugs, as well as nutraceuticals, diagnostic kits and validated traditional medicines. As far as vaccines are concerned domestic requirements are currently met by imports both for animal vaccines and human vaccines. Some statistics on DOH vaccine requirements for new born babies annually gives us an idea of local demand:

DPT	-	14.98M doses/year	PhP	97.9 M
Inj. Polio	-	14.98M doses/year		54.67M
Tetanus Toxoids	-	11.65 doses/year		17.47M
Hib	-	12.3M doses/year		1.045B
Measles	-	5.98M doses/year		36.47M
MMR	-	5.98M doses/year		897 M
HepatitisB	-	10.77M doses/year		215.4M

The total amount is PhP2.31 Billion and this does not include BCG which is currently being produced locally.

### Biotechnology R&D Plan

How does the R&D program in the S&T community match these demand projections?

The Philippine National Science and Technology Plan (2002–2020) states that the development priorities in biotechnology are its applications in agriculture, forestry and natural resources, health/medical sciences, environment, energy and manufacturing and process engineering. Applications have been identified in these sectors as follows: For agriculture and fisheries—varietal improvement and sustainable production for food security; for forestry—maintenance and maximization of forestry resources; for health/medical sciences—prevention, diagnosis and treatment of diseases; for marine sciences—development of marine bioindustries; for energy—development of renewable energy resources; for manufacturing and process engineering—development of novel processes of

manufacture using life forms as miniature factories to produce the desired products and for environment—bioremediation.

The plan also indicates that the priority research and development areas for biotechnology processes and technologies are in the following: plant tissue culture; immuno-based diagnostics, protein and DNA markers; microbial transformations; plant transformations; genome mapping; cloning single genes; and mammalian tissue culture.

### **Agriculture and Natural Resources R&D**

The sectoral R&D councils have formulated their medium term plans consistent with the NSTP priorities. The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) presents their Biotechnology Agenda up to 2010 as follows:

The Philippine Agriculture and Forestry Biotechnology Agenda had been crafted starting 1995–2000 (PAFBA I) and the second phase from 2001–2010 (PAFBA II). The R&D thrusts are geared to generate breakthroughs such as crop disease and animal product diagnostics, animal vaccines, novel genes and proteins, genetically modified crops, biofertilizers, biopesticides, disease free planting materials, molecular markers for useful plant and animal traits and plant varieties developed through marker-assisted breeding. Scientific priority R&D are defined for crops, livestock, forestry, agricultural resources and crosscutting concerns.

The crop biotechnology R&D activities focus on nine-major crops namely—coconut, papaya, mango, banana, corn, sweet potato, rice, abaca and endemic plants. Genetic engineering and mutation breeding and employed to develop transgenic varieties of papaya resistant to papaya ringspot virus and with prolonged shelf life, banana resistant to banana bunchy top virus, coconut with high lauric acid content, sweet potato resistant to feathery mottle virus, rice enriched with Vitamin A and resistant to bacterial blight and tungro virus, and abaca resistant to abaca bunchy top and mosaic viruses. Corn varieties resistant to downy mildew and stalk rot complex will be developed through marker-assisted breeding. Organ culture and transformed root of endemic plants is also being pursued for secondary metabolite production. Novel genes are being identified from coconut through molecular cloning and functional genomics. Other R&D areas are DNA fingerprinting for sex determination and diversity analysis, genome mapping, disease diagnosis, proteomics and bioinformatics.

The livestock biotechnology R&D program focuses on the use of advanced reproductive biotechniques like *in vitro* oocyte fertilization (IVF), *in vitro* oocyte maturation (IVM), embryo cryopreservation and manipulation, superovulation and embryo transfer (SOET), and somatic cell nuclear transfer for genetic resource conservation, improvement, and utilization.

Characterization and cross-inoculation of microbial population for rumen function manipulation are also being worked out. Recombinant DNA technology and immuno-based systems are being harnessed to develop animal disease diagnosis.

Wood production from forest and nontimber species like mangium, yemane, narra, mahogany, bagras, falcate, bamboo and rattan is the major thrust of the forestry biotechnology research. The program hopes to ensure the availability of quality planting materials using microselection, characterization, macropropagation, and genotype assessment. Biofertilizer from rhizobia and mycorrhizae for selected indigenous tree plantation species are also being developed.

Recombinant DNA technology is applied to enhance the performance efficiency of microorganisms for rapid and effective garbage degradation. DNA fingerprinting and marker technology on mixed microbials is studied to enhance the sequestration of heavy metals in contaminated agroecosystems. Gene marker technology and DNA fingerprinting is applied in developing microbial formulation for the deodorization of livestock and market wastes.

Integral to the framing of an S&T agenda on biotechnology is the need to address crosscutting concerns that would critically affect the research-technology generation-commercialization continuum. When these concerns are addressed adequately, an enabling policy, institution, and macroenvironment will facilitate the emergence of technology-based industries/sectors in agriculture & forestry aside from the usual technology generation and commercialization. There is also a need to bridge the incredible knowledge gaps that exist and to address the general lack of awareness among the population. Rational and science-based discussions of the technology and its related issues can take place if these requirements are met. Seven major priority areas have been identified to address these crosscutting concerns: (1) policy research and advocacy; (2) IEC; (3) ICT; (4) institutional capability; (5) IP and technology management; (6) technology commercialization; (7) ex ante/ex post socioeconomic assessment.

### **Fisheries and Aquatic Resources R&D Plan**

As far as the Fisheries and Aquatic Resources Sector is concerned the Biotechnology Sectoral Plan (2006–2020) has the goal of using biotechnology in the conservation and sustainable use of aquatic resources and in improving the income of fisherfolk/fish farming communities. More specifically the Plan's objectives are : (1) to conserve aquatic and marine biodiversity and enhance the utilization and management of fisheries resources through aquatic and marine biotechnology, and (2) to develop superior cultivable stocks and increase the productivity and sustainable use of culture systems by using biotechnology. The R&D program for this sector includes the following elements:

1. Development of genetic markers for the proper management of aquatic and marine resources.
2. Screening of novel and bioactive compounds for the development of new drugs, pharmaceuticals and therapeutic agents.
3. Bioremediation technologies for the biodegradation of pollutants in pond systems.
4. Development of diagnostics/vaccines for aquaculture and mariculture.
5. Development of genetically improved strains of cultivable species.
6. Establishment of germplasm center of economically important seaweeds and other commercially important aquatic species.

This R&D Plan includes priority R&D activities in Marine Science and in Fisheries and Aquaculture. For Marine Science the priority R&D areas are those on carrageenases and agarases and the isolation and characterization of novel metabolites, enzymes, and bioactive compounds [immunosuppressant, antimalarial, antimicrobial (includes antitubercular, anti-bird flu, anti-rabies, anti-hepatitis *etc.*), anticancer, anti-asthma, bad cholesterol elimination, cardiovascular disease prevention/cure, anti-arthritis, anti-diabetes, anti-obesity, anti-depressant/narcoleptics] from microbial associates of marine invertebrates.

In this R&D Plan also, the priority R&D areas in Fisheries and Aquaculture have been identified. These are in stock management and improvement of cultivable strains, diagnostics, disease control, bioremediation and feed formulation improvement. For stock management and improvement of cultivable strains the specific programs are:

1. Development of genetic markers for species identification, stock monitoring and management, genetic enhancement and selective breeding.
2. Establishment of germplasm center for economically important seaweeds and other commercially important aquatic species.
3. Strain improvement of economically important finfishes for rapid growth and enhanced environmental tolerance.
4. Development of improved cultivable strains of high yield and high quality phycocolloid (agar and carrageenan) producing seaweeds.
5. Development of disease resistant strains of economically important seaweeds.
6. Development of recombinant hormones for growth enhancement and controlled reproduction.

In diagnostics the plan is to develop a Denaturing Gradient Gel Electrophoresis (DGGE) map for aquatic and marine organisms and to develop antibody and DNA – based probes for pathogen detection and identification e.g. for ice-ice disease and other diseases of seaweeds. In the area of disease control the planned programs are the development of vaccines, immunostimulants and probiotics for disease control and water quality management, e.g. for White Spot Syndrome Virus (WSSV) and the evaluation of commercially developed probiotics.

In the area of feed formulation the concern is for improved nutritive value of feed substitutes through microbial inoculants and exogenous enzymes. For Bioremediation the following are the priorities:

1. Development of bioremediation technologies for the biodegradation of pollutants in pond systems.
2. Development of anti-red tide agents including depuration agents.
3. Development of bioherbicides to control weed infestation in economically important seaweeds.
4. Development of biopesticides to control microbial infestation in economically important seaweeds.

### **Health/Medical Sciences R&D Plan**

In health and medical sciences, R&D in biotechnology will focus on the development of vaccines, diagnostic kits and drugs.

**Vaccine Development** will focus on the development of a local vaccine against schistosomiasis, diarrheal diseases, rabies, HIV and avian flu. Vaccines hold enormous potential for the control of infectious diseases and have global market prospects. The development of a local schistosomiasis vaccine will involve candidate molecules developed by local researchers from the Research Institute for Tropical Medicine with their collaborative partners and the establishment of a current good manufacturing practice (cGMP) pilot plant. This plant serves a multipurpose facility for future R&D work, bench scale production and cater to the distribution needs of the Department of Health's Expanded Program on Immunization. Edible vaccines will be also developed against diarrhea causing agents (*Salmonella typhi* and *S. paratyphi*), rabies and HIV. Edible vaccines use transgenic plants, such as tomatoes or bananas whose genome has been altered and that express the vaccine antigen. The proposed avian flu vaccine will use recombinant technology.

**Diagnostics development** will focus on the detection of priority diseases (like dengue, schistosomiasis and colorectal cancer). Large-scale production of dengue viral antigen for the dengue detection kit will be continued. Enhancement of a monoclonal based immunoblot assay for the field diagnosis of schistosomiasis will be pursued. The presence of TAG-72 is a useful and specific cell surface tumor antigen marker.

**Drug development** will focus on essential drugs (off-patent and soon-to-be patent free) and anti-infectives needed by the population. The R&D will focus on bioactive molecules derived from marine (like sponges) or terrestrial sources (like plants) that can be used in drug development. Marine microbial extracts will be tested for its anti-infective activity for TB, nosocomial infections and other viral diseases. Techno-transfer activities will also be pursued for the recently completed AMOR program (Antibody Biotechnology and Liposome Drug Delivery



Technology for Experimental Therapeutics of Breast Cancer) which has proof of principle that its novel drug isolated from local marine and terrestrial sources, and conjugated with a humanized antibody in a liposome delivery system works for breast cancer.

### **Other Biotechnology Related R&D Priorities**

The other R&D Councils of DOST namely the Philippine Council for Industry and Energy Research and Development (PCIERD), the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) and the collegial body, the National Research Council of the Philippines (NRCP) have also formulated their R&D Agenda for Biotechnology. PCIERD is focusing on two major areas: functional food and biofuels (coconut methyl ester, bioethanol and biodiesel). These will be done in collaboration with PCHRD in the case of functional foods and health protection products. A number of health protection foods are in the market today such as: immunity modulation food, blood fat modulation food, blood super modulation food, anti-aging food, radiation blocking food, weight loss food, intestinal modulation food, etc. PCARRD will necessarily be involved in both functional foods and biofuels.

PCASTRD plans to focus on Bioinformatics and in providing support in general to Biotechnology R&D. PCASTRD will also provide support to the Philippine National Collection of Microorganisms (PNCM) – BIOTECH-UPLB and other well-established culture collections in characterizing their microbial collections at the molecular level, especially those that will be developed as commercial products. The molecular markers will be very useful in protecting the intellectual property claims in these microorganisms. PCASTRD will also help facilitate the submission of proposals to different international funding agencies to make the PNCM-UPLB an International Depository Authority (IDA) for microorganisms which is recognized to handle patented microorganisms under the Budapest Convention.

NRCP shall focus on basic biotechnology research such as screening and taxonomic studies and the development of techniques for molecular analysis. PCASTRD's basic research priorities shall complement NRCP's efforts. These are, in addition to bioinformatics, in the analysis of gene sequences and protein analysis.

The R&D Agenda is long and comprehensive even as there is a deliberate effort to focus and prioritize. It is because biotechnology has applications in many sectors and areas. There are also many potential niches in the market, both local and global, and perhaps the wisest thing to do is to consider the market trends in the time plan for the R&D activities. It is also very timely to consider some macro-level recommendations made by two active members of the Biotechnology Cluster Core Group members – Ms. Maoi Arroyo, CEO and President of Hybridigm Consulting, Inc. and Dr. Evelyn Mae Mendoza of the Institute of Plant Breeding at UP Los Baños, a member of the NAST. Ms. Arroyo, in emphasizing the need to

provide Return-on-Investment (ROI), suggests the training of scientists in fundamentals of technology entrepreneurship and in Intellectual Property Protection (IPP), the maintenance of industrial liaisons and close collegial contact, the mitigation of technical risk in R&D as much as possible, doing effective science communication, and the establishment of central laboratories, incubators and innovation centers. She sums it up by saying that any initiative to catalyze Philippine Biotech must be market-based and market validated and it must provide sustainable competitive advantage to early adopters. Dr. Mendoza, on the other hand, pushes for the adoption of the clustering management approach for Philippine Biotech, the coordination and orchestration of a unified Biotechnology Agenda, the selection and prioritization of appropriate technologies for commercialization, and the implementation of enabling policies for R&D, financing, education and Intellectual Property Rights.

There is really one more basic thing to do: to identify clear targets and milestones and to focus all actions towards the realization of these targets and milestones.

In closing the contributions of PCARRD, PCAMRD, PCHRD, PCIERD and PCASTRD are gratefully acknowledged. Likewise, the outputs of the Biotechnology Cluster with very significant contributions coming from Mr. Danilo Manayaga of Secura International Corporation, Dr. Francis Gomez of Altermed Corporation, Dr. Saturnina Halos of Arnichem Corporation, Dr. Corazon de Ungria of the Natural Sciences Research Institute of UP Diliman, and Dr. Ceferino Follosco of NAST have been used as major inputs to this presentation.