

Multi-Sector Alliance to Strengthen Biotechnology Programs in Response to Economic Development Based on High Tech

Rosa Buxeda, Lueny Morell, Jorge I. Vélez-Arocho, Alejandro Ruiz
University of Puerto Rico at Mayagüez/
William Lockwood-Benet/Lockwood Financial Advisors Corporation
Manuel Hormaza/Puerto Rico Industrial Development Company

Abstract

Puerto Rico has the largest concentration of pharmaceutical industries in the world. A decade ago, the University of Puerto Rico at Mayagüez established its undergraduate Industrial Biotechnology Program, to provide the human resources and skills needed for this kind of professional on the island. Currently, the program has 164 students (63% women) and graduated more than 36 professionals. Most recently, and in response to a multi-sector alliance created in Puerto Rico to help develop the island as a world class high tech center, known as the Puerto Rico TechnoEconomic Corridor (PRTEC), the University of Puerto Rico at Mayagüez, is developing a PhD program in Biotechnology. PRTEC's goals are to retain jobs, attract new high tech businesses to the island, while supporting the development of an R&D tradition and the development of an entrepreneurial culture at all levels.

This paper will describe the strategy to develop a **Multi-Sector Alliance to Strengthen Biotechnology Programs in Response to Economic Development Based on High Tech** that involves all stakeholders (government, academia and the private sector). At the undergraduate level, the goal of the biotech program is to prepare professionals capable of developing and advancing the biotechnology field contributing to the social-economical development of Puerto Rico. To achieve this goal its strategic plan focuses on 6 major tasks: curriculum, research, industry/government partnerships, dissemination and assessment. This unique and interdisciplinary program involves close collaboration with industrial partners, formal courses as well as research and industry experience. The PhD Program being developed also focuses on industrial partnerships as a key element with the development and the strengthening of four (4) Biotech Research Centers to capitalize and support technology and human capabilities needed by industry. The ultimate goal is the establishments of a worldwide known biotechnology clusters on the island and attract and retain new biotech entrepreneurs. The paper will address the integrated strategic plan (from undergraduate to graduate) as well as its assessment strategy to document outcomes, financing and barriers being addressed to achieve our goals.

Puerto Rico's current economic situation

Puerto Rico has the largest concentration of pharmaceutical industries in the world as a result of the synergy between world-class managers, workforce and suppliers and preeminence as a global, tax-advantaged super-manufacturing center. The world's leading pharmaceuticals and

biotech companies trust the successful product technology transfer, scale-up, manufacturing and quality control of their products to Puerto Rico human capital. A location analysis for pharmaceutical manufacturing indicated that PR has the highest location quotient (a measure of the relative importance of an economic activity in a particular geographic area compared to its importance in the US economy as a whole- between PR and states in the mainland) of 9.19, followed by New Jersey with 5.08. Furthermore, the location quotient for selected competitive clusters in Puerto Rico positioned drugs at the lead. Pharma exports reached \$28.6 billion in Fiscal 2001, up 245% from Fiscal 1997 (Figure 1). Puerto Rico exported more pharmaceutical products to foreign countries than any states (Figure 2). The continued stability of the pharma cluster is critical to our fiscal revenues, local private sector earnings and exports. Nine of the top ten drugs in terms of the 2000 world sales were manufactured in the island.

An economic analysis by the Puerto Rico Industrial Development Company, PRIDCO, indicated that most of the job losses in the past, have occurred in labor-intensive textiles, apparel, leather and canned tuna. However, pharmaceutical manufacturing has gained over 3,000 jobs in a period of 5 years. This has been in part due to pharmaceutical and biotech utilization of the disclosure of the human genome; the emerging fields of proteomics and bioinformatics, a needed tool for information management and interpretation to deepen the knowledge, therapeutic scope and effective use of blockbusters manufactured locally.

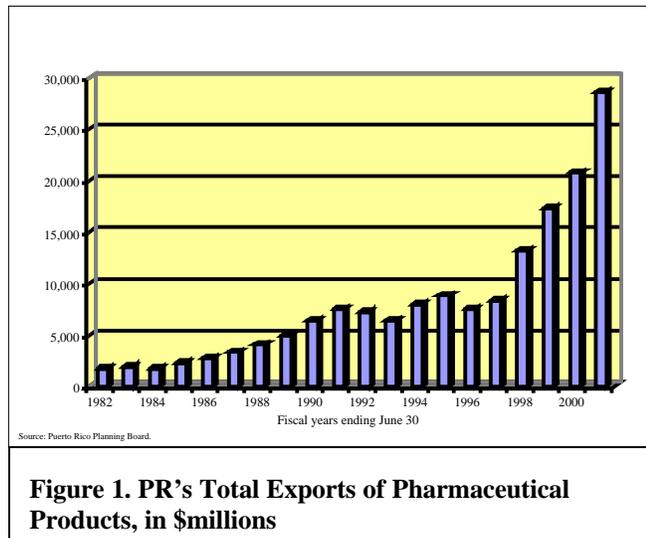


Figure 1. PR's Total Exports of Pharmaceutical Products, in \$millions

During 2000 the biotechnology world market had a record breaking of \$441 billion with an increase of 41% over the previous year¹. Of the present global pharma products an estimated 16% are of biotechnological origin or are related to biotechnology; this is expected to rise to 30 percent by 2005 and 50% by 2010² as enabling technologies such as genomics, proteomics, cellomics, combinatorial chemistry and high throughput allow pharmaceuticals and biotechnology companies to focus on specific therapeutic areas and disease knowledge required in the development of protein pharmaceuticals, protective and therapeutic vaccines, advanced synthesis, bio-transformation and formulation. Thus, understanding the new era of genomics-based medicine, genetically enhanced microorganisms, cloning, stem cell, biomarkers and the rest will require a concerted efforts on the part of government, industries, universities, research organizations, the analyst community and the media. Pockets of biotechnology are seen as very important for economic development in various regions of the world¹.

Biotech investment in Puerto Rico comes from large, established leaders with a previous presence on-island. Last April 2001 Lilly announced a US \$250 MM investment in the first large biotech manufacturing facility in Puerto Rico, a Humalog ® recombinant insulin manufacturing plant to launch inhaled insulin in alliance with drug delivery company Alkermes. This investment is now estimated at \$450 million. Inhaled insulin is the initial battleground

where many pharma-drug delivery partnerships are testing new ways to administer large molecule drugs such as proteins, hormones, peptides, vaccines and other pharmaceutical products. Other investments include Amgen with \$200 million to manufacture all of its products in PR; Abbott with \$200 million and \$400 million by other companies.

As a result, to continue its high level of competitiveness in the global market, the island is modifying its economic strategy with a shift towards a knowledge-base economy and the establishment of strategic alliances between all sectors: government, private and academia. Puerto Rico must act quickly to compete with the administrative, research and venture investing programs geared to both big pharma and biotech startups available in competing tax advantaged manufacturing locations such as Singapore and Ireland.

One of these initiatives is the ***Puerto Rico TechnoEconomic Corridor (PRTEC)***. Initially established in the western part of this Caribbean Island, the PRTEC is a conglomerate of public and private entities with common economic and social interests, aiming towards facilitating Puerto Rico's economic development, with particular emphasis in commercializing new and innovative technologies.

PRTEC is focused on providing an ideal and particularly attractive environment that promotes innovation, development and commercialization in the new global economy. The principal strategy being implemented by the newly created non-profit corporation is the development and nurturing of high tech clusters. PRTEC defines clusters as associations of entities with common or related objectives, needs, products, processes and services working together to promote and develop its respective enterprises, and to create new business opportunities in the region. Major thrust cluster areas are biotechnology and the pharmaceutical industry. The biotechnology cluster vision is: "***Position Puerto Rico as the preferred partner for biotechnology enterprises***". Its mission will be achieved by fostering a competitive and innovative world class biotechnology industry in which a knowledge base economy is crucial. Initial cluster members who are currently leading the initiative include:

- From industry: Eli Lilly and Amgen
- From government: the Puerto Rico Industrial Development Company, and,
- From academia: the University of Puerto Rico and the Ponce School of Medicine.

Alliances and partnerships are a necessity in racing against other programs to build a strong presence in the academic world and to foster the economic development of a country or a region. The attraction of these alliances with government, other institutions and industry is to bundle competencies and resources that are more valuable in a joint effort than when kept separate. Especially alliances are beneficial to build the expertise and market position needed to win a strong position in the industries of the future. This is particularly true in the biotechnology area. Puerto Rico research institutions face the challenge of meeting and exceeding business needs, developing business alliances and optimizing funding resources for collaboration and specialization within UPR and between UPR and private universities, particularly in applied research, Ph.D. and postdoctoral programs to:

- Strengthen basic infrastructure capabilities in the biomedical, chemical, environmental and agricultural areas;

- Reach a clinical level of command over key technologies (combinational chemistry, high throughput target screening) and focus on therapeutic areas and disease knowledge required in the development of protein pharmaceuticals, protective and therapeutic vaccines; and
- Gain a command of advanced synthesis, bio-transformation and formulation, from an interdisciplinary framework, anchored in chemical engineering.

Biotechnology initiatives at University of Puerto Rico- Mayagüez

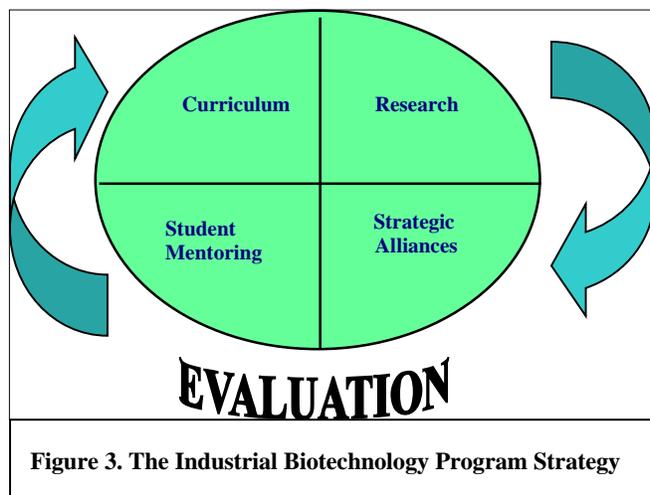
Knowledge- based economies recognize that education is economic development. One of the first tasks of the Biotech Cluster was the assessment of major niches in all sectors. This has led to the brainstorming of a ***Biotechnology Road Map*** (a capabilities assessment exercise that will provide guidance for stakeholders and viewed as critical in the strategic planning effort). The University of Puerto Rico at Mayagüez, with a strong history of education and research in several biotechnology areas as well as collaborative initiatives³, has been at the lead in orchestrating the multi-sector alliance to strengthen biotechnology programs in response to economic development based on high tech in Puerto Rico. It has responded with important initiatives to support the multi-sector alliance:

1. An undergraduate program in Industrial Biotechnology (IB)
2. A Graduate Biotechnology Initiative (GBT) composed of:
 - a. PhD program in Biotechnology
 - b. The development of Biotechnology Research Centers (BRC)

Undergraduate Industrial Biotechnology program

The IB Program was established in 1994 as a 5 years interdisciplinary bachelor degree program. The program has the higher IGS from the College of Arts and Sciences with a total student population of 164 students of which 63% are women. A new strategic and operational plan was developed to launch the undergraduate biotechnology as a key player in the multi-sector alliance.

At UPRM, the undergraduate biotechnology program has been a successful program. Starting in August 2001 a new management team was invited to give the program a new scope responding to the current economic strategies. The strategic intent of the biotechnology management team is to relentlessly pursue the ambitious strategic objective of placing the biotechnology program as a key player in the economic development of Puerto Rico. The team ought to convey a larger sense of purpose to the IB Program so that the participants see themselves as “building a cathedral” rather than “laying stones”. This new, well-articulated plan, with strong stakeholders’ participation, creates enthusiasm for the course the new management team has charted and engages members of the biotechnology program. The strategic management process adopted focused on the technology competencies and activities required to define the program’s path because they indicate the boundaries on its operations.



Forming this strategic roadmap has been an exercise in astute entrepreneurship. The entrepreneurial challenge in developing this path is to think creatively, about how to prepare this program for the future. In particular a special emphasis will be placed in its role as pipeline for the new Ph.D. Program in Biotechnology in its developmental phase. The IB strategic plan has the following vision: ***“Preparing professionals capable of developing and advancing biotechnology to contribute to the socio-economic development of Puerto Rico”***. This professional will have the

knowledge, skills and aptitudes required in the fundamental areas that integrate IB for effective performance in industry, government and graduate studies. The strategic plan is focused on five major components: curriculum, research, student mentoring, strategic alliances and evaluation (Figure 3).

The IB curriculum is characterized by course sequences from science (biology and chemistry), engineering, mathematics, and socio-humanistic complemented by hands-on and practice-based experiences. The curriculum has the following components:

- Sciences 39%
- Engineering & Math 25%
- Humanities & Arts 32%
- Research
- Industrial Internship

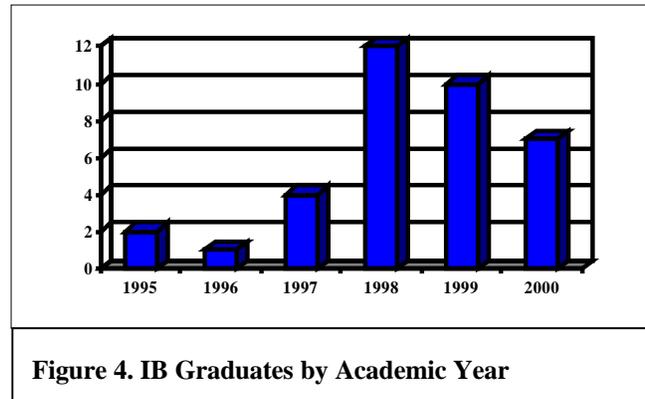
Research is integrated to the curriculum as a required experience as well as an industrial internship. The IB research component has as major thrust areas:

- tropical agricultural biotechnology
- marine biotechnology
- environmental biotechnology
- bioengineering
- genomics

About thirty (30) research faculty from the various disciplines provide the scientific skills required by our students. This research experience is integrated by a one-semester internship in industry and the establishment of an industry-government advisory board crucial in development strategic alliances. Alliances with local and nation industry and academia promote collaborative projects in research as well as workshops to share partner’s expertise and facilities.

The curriculum, research, and internships experiences are complemented with student mentoring. Mentoring includes a series of workshops on recent development in biotechnology as well as topics such as preparing a resume, preparing for an interview and promoting recruitment sessions for graduate programs and industries.

Overall the IB program produces a professional with the creativity and research skills of a scientist and with process design vision of an engineer. Tracking of our alumni provides an outcome of this profile. Thirty six (36) students have graduated from the program (Figure 4), of which **43% are in industry and 57% have continued to graduate school.**



Graduate program in biotechnology

A Graduate Biotechnology Initiative (GBI) with a twofold mission has been recently established:

- a. Consolidating and focusing seven research-centers in critical biotechnology areas, and
- b. Establishing a Ph.D. program in Biotechnology.

This GBI involves critical stakeholders from government, industry and academia. A process was designed during the first academic year 2001-02 to guide this initiative. The process has been following the strategic steps outlined below:

1. A strategic alliance between UPRM and the government was established to initiate the GBI. The government gave a five-year multi million dollar grant to support this initiative. R&D in the Biotechnology field is one of the key elements in the current economic strategy of the government to increase the level of employment.
2. An interdisciplinary team of faculty from Biology, Chemical Engineering, Chemistry, Agricultural Sciences and Business Administration has been formed at UPRM faculty to guide the process.
3. External advisors have been identified and invited to participate in the process.
4. A strategic management process framework was adopted to develop the GBI.
 - First, a SWOT analysis (strengths, weaknesses, opportunities a threats) was performed
 - Second, a Vision, Mission and Objectives were specified for the GBI
 - Third, specific actions were identified for the next two years to fully establish research centers and a Ph.D. Program. It is expected that in two years, seven Biotechnology Research Centers (BRC) will be working around critical research areas. Each BRC will establish an Advisory Board including industry, government and academia.
5. By the time the BRC's are functioning, the proposal to establish a PhD should be approved. It is expected that the first students could be enrolled by August 2003
6. A series of panels and workshops with industry, academia and government representatives, such as UPRM, Ohio State University, University of Florida, NIH

and Bristol Myers and Squibb, have been carried to prepare a first version of the PhD proposal. The results of these workshops are being used as a framework for the final Ph.D. Proposal.

7. The PhD proposal is submitted to organizations such as NSF, NIH, NOAA and industry for support

A series of meetings with representatives of current research groups within the biotechnology field were held at UPRM. Stakeholders were invited to assess the level of development of the seven research areas. The preliminary assessment is very promising because most of the research groups are already working and publishing in the biotechnology area and the level of laboratory equipment allows them to conduct initial basic research in areas of interest to UPRM, government and industry.

Barriers and opportunities

Although the industry, government and academia alliance has been working together for less than one year, we can identify some barriers that have been overcome and some opportunities that still need to be addressed. The biggest hurdle has been the tendency of each sector to put away its own agenda in order to place the largest goal in front, and leave egos behind. This in part has been addressed by a strong teamwork effort during the development of the cluster strategic plan, which in turn, gave participants ownership of the process. Another barrier was to assess each group's capabilities, weaknesses and resources. This hurdle was overcome by building up a database during the technology roadmap exercise. The biotech roadmap process will raise the need for:

- deeper collaboration within the UPR system and closer management of individual faculty and the applied research centers in biotech;
- a shared awareness of the strategic importance and opportunity this scientific revolution brings to Puerto Rico's pharma cluster and economic development process;
- deeper scientific knowledge, managerial monitoring and financial support at Universities, industry and government highest levels of executive management;
- transition to widely-supported interdisciplinary centers of excellence in a reduced number of therapeutic areas.

The Biotech cluster will without doubt grow at an exponential rate during the next months, therefore, managing the partners and assessing outcomes will require extraordinary management skills and resources. It is probable that a body or organization will be needed to manage the cluster. In addition, the R&D infrastructure at UPRM will need major planning and resource allocation.

Conclusions

The new economic shift that Puerto Rico is experiencing requires strong multi-sector alliances if we want to compete successfully in the global economy. A multi-sector initiative being developed is the Puerto Rico TechnoEconomic Corridor (PRTEC) based on high tech clusters.

PRTEC's goals are to retain jobs, attract new high tech businesses to the island, while supporting the development of an R&D tradition and the development of an entrepreneurial culture at all levels. One of the high tech niche areas identified as a strong promoter of economic development is biotechnology. Since the Island is the major worldwide pharmaceutical manufacturing site, it is essential to develop the biotechnology cluster. The University of Puerto Rico at Mayagüez is leading and helping orchestrate our response to economic development based on knowledge and the high tech industry. Major initiatives include an undergraduate industrial biotechnology program, a PhD in biotechnology and the development of biotechnology research centers. Strategic plans to implement these are underway with collaboration of all stakeholders. Even though major barriers have been addressed, the future presents opportunities to develop the biotechnology area to position the Island as the preferred site in the world for the biotechnology industry and entrepreneurs.

Bibliographical information

1. Burrell G. S. 2001. Biotech 2001 Life Sciences, Genomics, Proteomics and More. The Biotechnology Industry Annual Report.
2. Pharmaceutical Research and Manufacturers Association, 2000. *Pharmaceutical Industry Profile*
3. Morell L., Vélez Arrocho J.I., Buxeda R., Johnson W., Irizarry M. and Davis I. 2001. Strategic Alliance with Industry to Enhance Undergraduate Science, Mathematics and Engineering Curriculum. Proceedings at International Conference of Engineering Education, Oslo, Norway August 2001

Acknowledgement

We want to acknowledge Dr. John Stewart from the Puerto Rico Development Company for providing the economic data presented in this paper.

Biographical information

ROSA BUXEDA

Rosa Buxeda is the coordinator of the Industrial Biotechnology Program at the University of Puerto Rico-Mayagüez. She is a former associate director of the Center for Professional Enhancement and co-coordinator of the ABET 2000 accreditation process at UPRM. She is responsible for the freshman experience of the NASA grant Partnership for Spatial and Computational Research and is the assessment director for the HHMI PROMISE.

LUENY MORELL

Lueny Morell is a Professor of Chemical Engineering at the University of Puerto Rico at Mayagüez. She also is Director of the Campus R&D Center. She has worked in various SMET curriculum development and assessment projects, among them UPRM's coordinator for the ABET 2000 strategy, NSF- AMP, MEEP and Learning Factory Workshops. Lueny is PI for the NASA grant Partnership for Spatial and Computational Research.

JORGE I. VELEZ-AROCHO

Professor of Decision Sciences at the School of Business of the University of Puerto Rico – Mayagüez Campus (UPRM). He is a former Dean of the School of Business Administration at UPRM. Currently, he is the Co-Director

of the Center for Hemispherical Cooperation (CoHemis) at UPRM and coordinates the Outreach activities for the NASA-sponsored Partnership for Spatial and Computational Research and the NSF-PRECISE.

ALEJANDRO RUIZ

Alejandro Ruiz is a former dean of the College of Arts and Science and former chancellor at University of Puerto Rico at Mayagüez. In 1994 he proposed, developed and provided leadership for the establishment of the Industrial Biotechnology Program at UPRM and was appointed as its first coordinator. At present he is coordinating the interdisciplinary efforts toward the doctoral degree in Biotechnology.

WILLIAM LOCKWOOD-BENET

William Lockwood is a development economist working on life sciences, private equity and technology policy. President, Lockwood Financial Advisors and Generans Life Sciences Capital Initiative. Chairman of Grupo Guayacán, a private equity fund management group. Vice President, PR Biotech Cluster. He holds an M.Phil, in industrial technology development policy from the Institute of Development Studies at Sussex.

MANUEL HORMAZA

Is currently with the Puerto Rico Development Company heading the Science & Technology Office. A veteran in the pharmaceutical industry, he has held executive positions in major Pharmaceutical firms in PR and in the US. He holds a BSChE from UPR-Mayaguez and an MBA from Interamerican University-PR.