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# From the Classroom

## Bioentrepreneurship education programmes in the United States

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### Abstract

In this first paper of a new regular column, Arlen Meyers and Patrick Hurley review the different bioentrepreneurship education programmes available in the United States and suggest some of their critical success factors.

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### INTRODUCTION

The three pillars of bioentrepreneurship are scientific and managerial talent, technology and money.<sup>1</sup>

Unfortunately, the supply of both scientific and managerial talent is not meeting the demand. According to a recent National Science Foundation report, the demand for biotech workers is outpacing the rate at which US universities are churning out graduates, and because academic institutions

are not able to satisfy the industry's demand for new PhD graduates, attracting and keeping workers is becoming an increasingly serious problem in the drug development process. Three categories of employees are in the shortest supply: biologists to make discoveries, researchers to take those discoveries through the proof-of-concept stage, and people to plan and execute clinical trials.<sup>2</sup>

In addition to scientific talent, management talent is scarce and is often the weakest pillar in most biotechnology companies. The skills required of a biotech executive are myriad and the path from an R&D-driven to a market-driven culture requires a complex repertoire of knowledge, skills and talents.

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The demand for talent is an international problem. A recent report describing the Singapore cluster, for example, noted that their biggest problem is its continued shortage of entrepreneurial scientists and managers.<sup>3</sup>

In an attempt to identify those factors that attract bioscience companies, The New York Economic Development Council met with more than 600 bioscience companies in 18 countries. They also reached out to the more than 100 bioscience companies located in New York City and worked closely with the city's major academic institutions. Throughout this exhaustive process they identified the criteria used by companies to make start-up or relocation decisions. Interestingly, the elements used by both start-ups and seasoned companies are quite similar. Access to talent was second only to proximity to world-class research centres in their list.<sup>4</sup>

Biotechnology and life science commercialisation efforts have unique characteristics that separate them from other technology-based industries.<sup>5</sup> As a result, Li and Halal note that leaders of such efforts have special challenges. Bioentrepreneurs need to create an environment that balances creative and innovative freedom with accountability. They need to build an ethos of collaboration and create a social network of scientists. Finally, they need to emphasise the value of science and its benefits to patients and humanity without overemphasising the business goals.

Given these challenges and in response to the need for properly trained people, bioentrepreneurship educational programmes, designed to train leaders and managers of new and existing life science companies, are emerging throughout the world. Some programmes are offered by business schools, some as part of a technology development programme in schools of engineering or other technical schools and some are affiliated with other service provider or bioscience trade association entities.

However, since these programmes are so new, there is little standardisation of curricula, educational resources are scattered, learning objectives are not standardised and the value

propositions of such programmes are not clear. Like any new innovation, there needs to be a compelling value proposition addressing a clear market need if the programmes are to be sustainable and make a difference.

In this paper, we present our review of bioentrepreneurship education programmes in the United States and suggest some critical success factors.

## MATERIAL AND METHODS

We performed a web-based search of bioentrepreneurship education programmes in the United States as of September, 2007. We defined bioentrepreneurship education as programmes designed to teach the knowledge, skills and attitudes required of entrepreneurs who are interested in life science commercialisation. We included in our survey those programmes that had the following characteristics:

- the programme had a special emphasis on biotechnology and entrepreneurship;
- the programme was offered by an accredited institution of higher learning in the US.

Based on the information available, we identified the following characteristics:

- whether the programme issued a degree following completion of the programme;
- whether the programme issued a certificate upon completion of a certain number of courses or modules;
- whether the programme focused on biotechnology (a collection of techniques that harness the characteristics of living things to make products or provide services<sup>3</sup>) or other life science specialties such as medical devices, health informatics, diagnostics, agricultural biotechnology or environmental biotechnology;
- which academic entity sponsored the programme: Business School, College of Engineering or other entity.

**Table 1: Bioentrepreneurship academic programmes in the United States**

School name and website	Degree of non-degree	School(s) that offer the degree	Structure of the programme**	General or specific	Other comments
Harvard-MIT Division of Health Sciences and Technology (HST) and the MIT Sloan School of Management, Biomedical Enterprise Program (BEP) Web: bep.mit.edu/ Contact: Traci Anderson, Email: bep@mit.edu Tel: +1 617 253 7470	BEP – MBA from MIT Sloan and MS in health sciences and technology from the Harvard-MIT Division of Health Sciences and Technology MIT Entrepreneurship Center-non degree, but part of the BEP	MIT Sloan Management; Harvard University	BEP and MIT Entrepreneurship Center provides contacts and courses designed to increase the success of biomedical ventures; takes three years to complete	E-centre is general in the case it is designed for the commercialisation of any innovative technology in the healthcare system	Sloan and Harvard have made a bioentrepreneurial model for other schools
Center for Bioentrepreneurship, University of California, San Francisco Web: www.ucsf.edu/cbe/ Contact: KT Moortgat, PhD, Director Email: cbe@ucsf.edu Tel: +1 415 514 9672	CBE Certificate of Completion and/or UCSF academic credit (registered students only).	UCSF	Four courses offered; seminars from local business leaders	Specific to bioentrepreneurship	Training scientists in the business of life sciences
Wharton School of Business at the University of Pennsylvania Web: www.wharton.upenn.edu/ Contact: Email: mba.admissions@wharton.upenn.edu Tel: +1 215 898 6183	Many MBA concentrations; offer dual MBA/MA in life sciences	Biotechnology (MB/MBA with the School of Engineering and Applied Science and School of Arts and Sciences)	Flexible; concentrations and majors are plentiful	General life science degree; supplemented with entrepreneurial courses; Wharton entrepreneurial program (WEP)	Flexibility could make this attractive to many; strong entrepreneurial spirit, but not specifically biotech
Tepper School of Business at Carnegie Mellon University Web: www.tepper.cmu.edu Contact: Email: mbaadmissions@andrew.cmu.edu Tel: +1 412 268 2268	MBA in Biotechnology; also strong entrepreneurial track	Tepper School of Business	Track can be designed by student and faculty for specific approach to bio-entrepreneurship	MBA tracks in biotechnology and entrepreneurship	Strong reputation in entrepreneurship coupled with biotechnology could be beneficial to students
Kellogg School of Business at Northwestern University Web: www.kellogg.northwestern.edu Contact: Email: levyinstitute@kellogg.northwestern.edu Tel: +1 847 491 3255	MBA in biotechnology	Kellogg School of Business	Clear organisation for bioentrepreneurs	Biotechnology major specific; at least two course in bio-entrepreneurship	Flexibility in programme to take science and business courses; clear curriculum



Table 1: Continued

School name and website	Degree of non-degree	School(s) that offer the degree	Structure of the programme**	General or specific	Other comments
Fuqua School of Business at Duke University Web: <a href="http://www.fuqua.duke.edu/">www.fuqua.duke.edu/</a> Contact: <a href="mailto:entrepreneurship@fuqua.duke.edu">entrepreneurship@fuqua.duke.edu</a>	MBA; however there are opportunities to acquire a joint degree (PhD, MD, JD)	Fuqua School of Business	Flexible; concentrations have depth and breadth	Several biotech course (including raising capital and entrepreneurship) are within the Entrepreneurship and Innovation concentration	Flexibility in courses as well as degree types; can customised MBA for bio-entrepreneurship
San Diego State University—Graduate School of Business Web: <a href="http://www.bio.sdsu.edu/cmb/">http://www.bio.sdsu.edu/cmb/</a> JointDoc.html Contact: Sanford Bernstein, SDSU Professor of Biology, Email: <a href="mailto:sbernstein@sunstroke.sdsu.edu">sbernstein@sunstroke.sdsu.edu</a> Tel: +1 619 594 5629	PhD/MBA in life sciences	SDSU in conjunction with University of California, San Diego; work done at SDSU	Opportunity to complete the two degrees in less time than seeking each individually	Biotechnology specific; there are entrepreneurial course that are offered at the BS	Touted as first in the nation for joint PhD/MBA focused in the life sciences
College of Management at the Georgia Institute of Technology and the School of Law at Emory University; The Technological Innovation: Generating Economic Results (TI:GER®) Web: <a href="http://tiger.gatech.edu/">http://tiger.gatech.edu/</a> Contact: Marie Thursby, Executive Director, Email: <a href="mailto:marie.thursby@mgt-gatech.edu">marie.thursby@mgt-gatech.edu</a> Tel: +1 404 894 6249	MBA coupled with either a PhD or JD	TI:GER is a collaboration between Georgia Tech and the Emory University School of Law	Students complete a standard 2 year MBA in addition to work in the law school or PhD programme at Georgia Tech	Can be created by student specifically for biotechnology and entrepreneurship	Great flexibility of the degree; Can get PhD or JD; entrepreneurial strength evident
Case Western Reserve University, Science and Technology Entrepreneurship Programs (STEP) Web: <a href="http://step.cwru.edu/">http://step.cwru.edu/</a> Contact: Edward Caner, STEP Director, Email: <a href="mailto:emc15@case.edu">emc15@case.edu</a> Tel: +1 216 368 3710	Case Western Reserve MA in biotechnology	Biology Department at Case Western Reserve in conjunction with the STEP	Entrepreneurial Biotechnology (EB) is a two-year master's degree	Not in traditional BS, but has entrepreneurial courses in curriculum – 6 courses plus MA thesis	STEP is designed to aid scientists with entrepreneurial efforts
The William J. von Liebig Center for Entrepreneurism and Technology Advancement, Jacobs School of Engineering, University of California, San Diego Web: <a href="http://www.vonliebig.ucsd.edu/">www.vonliebig.ucsd.edu/</a> Contact: Email: <a href="mailto:vonliebigcontact@soe.ucsd.edu">vonliebigcontact@soe.ucsd.edu</a> , Tel: +1 858 822 5960	Non-degree courses; supplement to other degrees within the School of Engineering, can be undergraduate or graduate	N/A	Recent addition to Jacobs School; courses are designed for student already enrolled in programme	Four courses offered to at von Liebig Center	Straddles the fence between bioengineering and biotechnology

**Table 1: Continued**

School name and website	Degree of non-degree	School(s) that offer the degree	Structure of the programme**	General or specific	Other comments
<p>University of Colorado at Denver and Health Sciences Center (UCDHSC)—Bard Center for Entrepreneurship            Web: <a href="http://thunder1.cudenver.edu/bard/">http://thunder1.cudenver.edu/bard/</a>            Contact: Beth Polizzotto, Program Coordinator; Email: <a href="mailto:bard.center@udenver.edu">bard.center@udenver.edu</a>,            Tel: +1 303 620 4050</p>	<p>Certificate in Entrepreneurship; MBA planned in the future</p>	UCDHSC	<p>Bard is open to all graduate students at UCDHSC and professionals interested in bio-entrepreneurship not enrolled at UCD</p>	<p>14 graduate level courses offered; several in the bioscience</p>	<p>Designed to promote bio-ventures and innovation</p>
<p>Haas School of Business at University of California, Berkeley— Lester Center for Entrepreneurship &amp; Innovation and the Management of Technology (MOT) Program            Web: <a href="http://entrepreneurship.berkeley.edu/">http://entrepreneurship.berkeley.edu/</a>,  <a href="http://mot.berkeley.edu/">http://mot.berkeley.edu/</a>            Contact: (Haas) Stephanie J. Tibbetts, Program Director; Email: <a href="mailto:tibbetts@haas.berkeley.edu">tibbetts@haas.berkeley.edu</a>            Tel: +1 510 642 4255            (MOT) Email: <a href="mailto:motadmin@haas.berkeley.edu">motadmin@haas.berkeley.edu</a></p>	<p>MBA in entrepreneurship; and MOT provides a certificate in management</p>	<p>Haas School of Business; MOT is an inter-disciplinary programme that enhances management of technology issues</p>	<p>MOT has several course related to biotechnology coupled with the entrepreneur courses at the BS</p>	<p>General entrepreneur courses; however there are biotechnology courses and entrepreneurial courses; the curriculum is quite flexible as well</p>	<p>Haas primarily focuses on information technology, however, there is a great bio-entrepreneur environment</p>
<p>University of California, Davis Graduate School of Management (GSM) and Center for Entrepreneurship            Web: <a href="http://www.gsm.ucdavis.edu">http://www.gsm.ucdavis.edu</a> and  <a href="http://entrepreneurship.ucdavis.edu/">http://entrepreneurship.ucdavis.edu/</a>            Contact: Andrew Hargadon , Director and Associate Professor; Email: <a href="mailto:abhargadon@ucdavis.edu">abhargadon@ucdavis.edu</a>            Tel: +1 530 752 2277</p>	<p>MBA in Technology Management and Entrepreneurship at the GSM; Business Development Certificate at the Center</p>	<p>MBA offered by GSM; The Certificate is offered by UC-Davis</p>	<p>For the certificate, there are courses in technology management, innovation and entrepreneurship along with interaction with MBA students</p>	<p>Certificate takes one year; three lecture classes plus two clinical courses in new business development.</p>	<p>MBA programme is graduate level; the certificate is not necessarily</p>
<p>The Paul Merage School of Business at the University of California, Irvine            Web: <a href="http://www.gsm.uci.edu/">http://www.gsm.uci.edu/</a>            Contact: Email: <a href="mailto:mba@merage.uci.edu">mba@merage.uci.edu</a>,            Tel: +1 949 824 4622</p>	<p>MBA</p>	<p>Merage BS</p>	<p>Center for Entrepreneurship and Innovation and the BS is technology focused</p>	<p>General curriculum, there are entrepreneurship or biotechnology courses, however there are many electives which might cover the gap</p>	<p>Customisable MBA, second year offers many course on entrepreneurship and biotechnology development</p>



Table 1: Continued

School name and website	Degree of non-degree	School(s) that offer the degree	Structure of the programme**	General or specific	Other comments
The Johnson School of Business at Cornell University Web: <a href="http://www.johnson.cornell.edu/">www.johnson.cornell.edu/</a> Contact: Zachary Shulman, Senior Lecturer of Entrepreneurship, Director, Email: <a href="mailto:zjs2@cornell.edu">zjs2@cornell.edu</a> Tel: +1 607 255 3012	MBA, plus many dual degree options	Cornell	Students with scientific or technical backgrounds can get MBA in 12 months	General curriculum, but entrepreneurship is high on priority list through 'performance-learning'	Students with PhDs may be attracted to MBA programme that takes only 12 months
The University of Washington School of Business, Center for Innovation and Entrepreneurship (CIE) Web: <a href="http://bschool.washington.edu/">http://bschool.washington.edu/</a> Contact: Email: <a href="mailto:uwcie@u.washington.edu">uwcie@u.washington.edu</a> , Tel: +1 206 685 9868	Certificate in Innovation & Entrepreneurship for students with advanced degrees in other departments at UW; offers MBA in entrepreneurship	University of Washington	CIE supports entrepreneurs and innovators	Certificate is designed for scientists or technical people; MBA students can also receive this certificate	Good option for any student at UW interested in bioentrepreneurship
Stanford Graduate School of Business, Center for Entrepreneurial Studies (CES) Web: <a href="http://www.gsb.stanford.edu/mba/">www.gsb.stanford.edu/mba/</a> Contact: Email: <a href="mailto:ces@gsb.stanford.edu">ces@gsb.stanford.edu</a>	MBA from Stanford; many dual degree options and certificates	Stanford University	As of 2007, a new curriculum has been implemented where students can customise MBA to suit needs and backgrounds	Not specifically bio-entrepreneur; but strong reputation and great entrepreneurial culture and teaching; flexibility to take course in biotechnology	Customisable MBA programme; important location for biotechnology ventures and start-ups
The Olin School of Business at Washington University; Skandalaris Center for Entrepreneurial Studies Web: <a href="http://www.olin.wustl.edu/">www.olin.wustl.edu/</a> Contact: Ken Harrington, Managing Director and Senior Lecturer in Entrepreneurship. Email: <a href="mailto:harrington@wustl.edu">harrington@wustl.edu</a> Tel: +1 314 935 9134	MBA	Washington University	Skandalaris Center has courses and resources in biotechnology; WU has recently taken major steps to improve their entrepreneurial curriculum	At Skandalaris and WU, students can take classes from BS, engineering and arts and sciences	The Olin Cup competition provides money and support for student or alumni business plans

## RESULTS

The 18 schools listed in Table 1 are a compilation of universities that offer educational programmes designed for budding bioentrepreneurs. The list may not be complete but reflects our best efforts to identify programmes that emphasise bioscience entrepreneurship rather than those with a technical focus. The access to resources is through several elective classes, clubs and networking organisations or the culture of the local area. Many schools have entrepreneurial programmes, but lack either enough access to the courses or professionals and resources in the area to be truly 'bioentrepreneurial'. Several universities have made a greater commitment to this burgeoning field and have designed a concentration specifically for bioentrepreneurship. These schools are typically in locations with active technology transfer activities, proximity to major research universities and government labs as well and venture capital investment and a supportive entrepreneurial environment.

## DISCUSSION

Several trends are shaping the future of graduate-level education that apply to bioentrepreneurship programmes:<sup>6</sup>

- global competition for talent;
- low participation of women and minorities in science, technology, engineering and math programmes;
- the continuing struggle to articulate the vision of graduate education as a public benefit, not simply as a private good;
- efforts to reform the process and outcome of graduate-level programmes;
- the internationalisation of programmes and the challenges of collaboration.

Bioentrepreneurship programmes should address these issues and offer a clear value proposition in several ways.

First, they need to clearly define their customers. Those who are interested in acquiring the knowledge, skills and attitudes

necessary to add value to a new or existing life science company come from two general groups—technopreneurs and market perceivers.<sup>7</sup> Each has his or her strengths and weaknesses and will need to fill different knowledge and skills gaps.

Technopreneurs are scientists who invent things and look for help to commercialise them. They usually have technical backgrounds in science, technology, engineering or math/computer science (STEM) and have little experience or skills with how to commercialise an idea. A typical example is a university-based scientist who discovers or invents something. The scientist then files an invention disclosure and works with the technology transfer office to identify, package and protect the intellectual property. Future commercialisation efforts, such as doing an opportunity assessment, defining the target market and finding funding, usually depends on identifying the second type of bioentrepreneurs, the market perceiver.

Market perceivers, on the other hand, understand market demand and opportunities and look for ways to satisfy that demand. They frequently have backgrounds in finance, law, technology transfer, business development or marketing and look towards inventors to provide the solution. They have a comprehensive knowledge of markets, a clear understanding of the market application, business credibility in creating sound commercialisation and business plans and connectedness to the value chain.

Bioentrepreneurship programmes should be structured to attract both types of entrepreneurs.

In addition, biotechnology in the broadest sense includes not only drugs (small molecules) and biologics/biotech drugs (large molecules), but medical devices, diagnostics, software, agricultural biotechnology and environmental biotechnology. Some programmes are designed for narrow market niches, such as biologics, while others are structured to attract a wider audience with more diverse backgrounds.

Second, since bioentrepreneurship involves the intersection of STEM, business and the law, programmes should strive to include students not only from different technical backgrounds but from different educational backgrounds. Programmes should make every effort to recruit underrepresented populations to bring differing and important perspectives to the classroom, take advantage of available talent and improve competitiveness.

Third, the programmes need to differentiate themselves from alternative offerings that do not satisfy students or potential employers. Life science commercialisation has several unique characteristics that separate it from other technology development efforts. The uncertainty of clinical trials outcomes, long product development lead times, high regulatory hurdles and a difficult financing environment, particularly for early stage ventures, are but a few of things that make bioentrepreneurship different from software, telecommunications or aerospace technologies. While lessons from non-bioscience technology commercialisation efforts are valuable, the curriculum should focus on the key issues confronting bioentrepreneurs, use case studies that are relevant, and incorporate experiential learning, such as internships, fellowships or co-op opportunities.

Fourth, bioentrepreneurship programmes should clearly define their learning objectives. Behavioural objectives refer to the descriptions of observable student behaviour or performance that are used to make judgments about learning.<sup>8</sup>

Learning objectives drive the curriculum.

Given limited time and resources, programmes will not be able to teach all subjects in depth. Programme directors should define a core curriculum that includes not only what a student should know and know how to do, but also skills reflective of market needs. In addition, given the unique challenges of bioscience commercialisation, students need to improve their emotional and social intelligence skills to be effective.

Bioentrepreneurs typically require certain personality or behavioural skills and well-developed communication skills. These emotional and social intelligence 'soft' skills are often neglected or omitted in curricula. Yet, such behaviours like self-control, conflict resolution, team building, optimism and empathy are frequently cited as being critical success factors for successful leaders and managers. Fortunately, unlike IQ, emotional intelligence can be assessed, learned and improved with training and practice and should be included in bioentrepreneurship education programmes.

Based on these assumptions, we suggest the following learning objectives as part of a core curriculum in bioentrepreneurship.

## **BIOENTREPRENEURSHIP LEARNING OBJECTIVES**

Bioentrepreneurship requires an extensive repertoire of knowledge, skills and attitudes. Bioentrepreneurs should:

### **Legal environment**

- understand the basics of intellectual property;
- be able to create a plan to protect their ideas;
- understand basic licensing terms;
- be able to interpret a term sheet;
- understand the legal implications of creating and distributing a private placement memorandum.

### **Marketing**

- be able to write a market analysis;
- be able to perform a SWOT analysis;
- be able to perform a consumer analysis;
- be able to write a competitive analysis;
- be able to identify important market segments;
- be able to validate marketing assumptions using primary research techniques;
- be able to describe their distribution and sales plan;



- be able to describe their pricing strategies;
- be able to describe their promotional strategies: public relations, advertising, point of sale, etc.

### **International bioentrepreneurship**

- understand the regulatory and reimbursement environment in international markets;
- determine whether they want to engage foreign resources or markets in the development of their product or service;
- learn how to make life science technologies available in underdeveloped countries.

### **Regulatory environment**

- understands how to get FDA approval for their product or service;
- understands how to get reimbursement for their product or service;
- understands how their product or service needs to be manufactured to be within regulatory compliance guidelines.

### **New product development**

- understands the stages of new product development;
- understands how to manage an R&D portfolio.

### **Business development and planning**

- be able to write an innovation plan;
- be able to decide whether to proceed with, modify, or abandon a new idea early in its development;
- be able to write a business development plan.

### **Manufacturing**

- be able to describe how the product will be manufactured.

### **Finance**

- be able to secure capital in each stage of development;
- be able to construct and interpret a capitalisation table;
- be able to create and interpret basic financial statements;
- be able to describe an exit strategy.

### **Leading bioscience ventures**

- be able to demonstrate managerial skills like team building, project management, conflict resolution, budgeting and negotiation and persuasion;
- be able to demonstrate leadership ability like inspiring employees, articulating a vision and providing direction.

### **Clinical trials and clinical validation**

- understand the regulatory requirements for clinical trials;
- understand potential legal and ethical risks involved in performing clinical trials;
- become familiar with and apply the basic ethical principles of biomedical research.

### **Communication skills**

- be able to effectively network and connect to the value chain;
- be able to convincingly present their innovation plans to stakeholders.

### **Technology development, management and commercialisation**

- understand the basics of technology transfer in the academic, industrial and government laboratory setting;
- understand different mechanisms for technology transfer such as licenses, in-licensing and out licensing, spin out formation and other mechanisms.

## Emotional and social intelligence skills

- demonstrates appropriate emotional and social intelligence skills such as self awareness, self control, social awareness and social facility.

Fifth, directors of bioentrepreneurship programmes need to establish metrics and measure outcomes. Formative and summative evaluations are key for quality improvement and to address the needs and requirements of stakeholders in the programme. For example, in addition to the usual user satisfaction surveys and assessments from students, administrators should get timely feedback from industry partners and other service provider collaborators. In addition, since many of these programmes are designed to provide manpower for evolving local bioclusters, programmes need to measure economic development outcomes such as new companies created, employment growth, migration of talent to another market, job creation and human resource growth. Since building life science companies take a long time, measurements need to be long term.

Sixth, bioentrepreneurship education programmes vary in how they are structured and administered, what they teach, how they teach it and whether it is done face to face, online or both. Programmes vary presumably because they are designed to maximise existing assets and to serve a specific market. Programme directors should share best practices and publish more research designed to identify critical success factors.

Seventh, bioentrepreneurship programmes should offer experiential learning in the form of internships, work experiences, fellowships or coops. These hands-on components offer students the opportunity to tackle real-world problems, get valuable feedback from mentors and supervisors, and give them a chance to test and improve their skills and make important connections in the community.

Eighth, biotechnology and life science commercialisation is international. Talent,

technology and money flows freely across continents. Programmes should incorporate principles and practices of international business and entrepreneurship by adding international business courses, using international case studies, inviting faculty or guest speakers with international biotechnology experience and drawing on the experiences of foreign students.

Finally, bioentrepreneurs need to understand how to make their technologies available in underdeveloped countries. Conventional funding and business models usually do not work in markets where there is limited infrastructure, illiteracy and poverty. Despite this, the market potential for life science products in third-world environments is huge and profitable. Bioscience entrepreneurs should understand new funding models and how to tap into innovative foundation initiatives, partners and distribution arrangements.

## CONCLUSIONS

No two bioentrepreneurship programmes will be the same, just like no other professional schools will be identical whether they teach engineering, medicine or law. Nor should they be. Each will reflect local culture, assets and politics. However, like other professional schools, there should be a defined body of core knowledge with learning objectives that satisfy market and accreditation guidelines. Directors of bioentrepreneurship programmes can speed the process by:

- creating consortia and offer seminars and conferences to develop learning objectives and a core bioentrepreneurship education curriculum;
- share educational resources such as bioscience business case studies;
- publish research on such programmes;
- share best practices and development mechanisms for exchanging ideas;
- work with other industry associations, service providers and public manpower development agencies to provide the type of talent the market demands;

- work with accreditation organisations to design and implement standards that apply to bioentrepreneurship education.

Bioentrepreneurship education programmes do not have to be in major bioscience clusters like Maryland, Massachusetts or California to be successful. There are several universities with strong reputations in entrepreneurship that only address the biotechnology field in a cursory way or do not address it all. There is room for growth and development in business schools for future generations of bioentrepreneurs, particularly those located in geographic proximity to emerging bioclusters.

Bioentrepreneurship education programmes have the potential to address a worldwide market need, to contribute to the economic vitality of a community and help professionalise the industry. They will be successful however, only if they provide a

measurable, compelling value proposition that clearly satisfies a market need.

### **References**

1. Shoemaker, H. & Shoemaker, A. (1998). The three pillars of bioentrepreneurship. *Nat. Biotechnol.* **16**, 13–15.
2. Martino, M. (2007). Biotech industry struggles to recruit talent, <http://www.fiercebioresercher.com/story/biotech-industry-struggles-recruit-talent/2007-07-23>.
3. Arroyo, M. (2005). Building Philippine biotechnology. *SGV Rev.* 49–59, June.
4. Fair, B. Building a bioscience cluster, <http://www.genengnews.com/articles/chitem.aspx?aid=215&chid=0>.
5. Li, J. & Halal, W. (2002). Reinventing the biotech manager. *Nat. Biotechnol.* **20**, BE61–BE63.
6. Stewart, D. (2005). Five trends shaping graduate education: The leadership challenge. *CGS Communicator*, August/September.
7. Mehta, S. (2004). Paths to entrepreneurship in the life sciences. *Nat. Biotechnol.* **22**, 1609–1612.
8. <http://www.adprima.com>.