A Global Examination on the Design and Delivery of Biotech Management Programs

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Abstract

This article aims to examine the expansion of the learning frontier in the bio-age. Based on a global examination of about twenty post graduate programs in biotech management, particularly biotech MBAs, this paper suggests that a super-convergence brought about by biotech is shaping biotech management education. The management of bio-business education, therefore, is required to understand and exploit the supper-convergence in courses design and delivery.

Key words : Business education, biotech MBA, learning frontiers, super-convergence

Ⅰ. Introduction

In the current world, more and more business activities are initiated and engaged in gaining from biotech-related research, development, application, services and controls. To respond correspondently, educational institutes have started offering biotech management related courses. However, promoting biotech management education is not limited to adding new courses in biotech. It needs to have an in-depth understanding of biotech and biotech-related activities. It also needs to have an insight into the basic nature of bio-age which threads various biotech-related activities, since the aggregation of these activities is forming a different business landscape (Enriquez and Goldberg, 2000). In this new bio-business landscape, business practices including training and education may be different from what we get used to.

Although there are studies concerning biotech education, their focuses are on either the technical coverage of biotech (NRC, 2003), or the outreach of biotech research for increasing public awareness on the topic (Moses, 2003). Few have addressed the emerging features of biotech management

education. Given this gap, this paper aims to systematically examine the current biotech management programs. The outputs of this examination are expected to provide a conceptual framework for further advancing the learning and training in the biotech management field.

This paper is organized as follows. After this brief introduction, section Ⅱ reviews existing literature, which focuses on defining the domain of biotech and bio-business, highlighting the very basic nature of biotech and bio-business, and discussing the current human capital deficiency in bio-business management. Section Ⅲ discusses the possible shift of a learning frontier. Section Ⅳ examines postgraduate programs in biotech management, mainly biotech MBAs. The final section Ⅴ summarizes this research and points out an avenue for further study.

Ⅱ. Literature Review

Biotech, bio-business and super-convergence

The term biotechnology, and its abbreviation biotech, crept into the 1960s and early 1970s. It was first applied to a set of technologies and companies that were concerned with understanding and "mapping" the human genome. Their goals were somewhat diverse, judging from the broad range of attitudes and ideas expressed by scientists, government officials, and a few enlightened businesses at the time (Oliver, 2000). Currently, biotech generally means the industrial application of biological organisms, systems, or processes, which is based on modifying the genetic structure of micro-organisms. The development is a marathon instead of a sprint. It is an experimental field, consisting of a set of tools, which are used in modifying the genetic structure of micro-organisms, designing and creating new living things (Hamilton, Vila and Dibner, 1990; Abate 2003).

The biotech revolution is bringing about breakthroughs across many boundaries. Where there are miracles, there must be a company (Alexander, 2003). Activities which aim to profit from biotech-related efforts are growing. Those activities include companies such as Genentech, the first biotech company; Celera, the forerunner for decoding human genome; and Geron, a major holder of commercial rights for embryonic stem cell patents. They also include endeavors which provide services to biotech research and operations or the consumption of biotech products and services, such as Kronos, a clinic for providing optimal health care; and Life Extension Buyers Club, a supplement retailer. All of those activities collectively form a new area: bio-business.

Differing from e-business, which is mainly a new way of conducting business created by enabling information and communication technology (ICT), bio-business is primarily characterized by a new domain for doing business. This new domain encompasses commercial applications of biological organisms, systems, or processes, which are dependent on the function of genes, and the development of cells at the molecular level.

While many researches and publications claim the importance of biotech and bio-business (Edwords, 1999; Oliver, 2000; Enriquez and Goldberg, 2000; Holloway, 2002; Alexander, 2003), some researches concentrate on exploring new features and new business practices in biotech enterprises. For example, the following issues have been addressed: the diversified contents within the bio-business domain (Oliver, 2000; Bergeron and Chan, 2004), marketing practices for building global bio-brand (Simon and Kotler, 2003), the fluctuations of bio-stocks (McCamant, 2002; Abate, 2003); and the formulation of strategies in biotech firms (Norus, 2002). Among them, super-convergence is regarded as a basic nature of biotech and bio-business (Enriquez and Goldberg, 2000).

Convergence is a process or a tendency of integration or connection between previously unconnected or disparate parts. It is the nature of technology and has gone through the history of technology development (Rosenberg, 1982). Any major technology breakthrough usually causes or leads to a certain convergence. In the case ICT, the binary computer codes 0 and 1 are the common root for convergence, which enables all kinds of information, from text to sound to video, to be communicated digitally. This convergence connects the physical world and virtual world by mixing various existing forms and statues. In particular, previously disparate activities such as publishing, television, movies, radio, telecommunications, and computing suddenly found themselves all within the same digital platform (Enriquez and Goldberg, 2000).

For biotech, the common root for convergence is life-forming code, or genetic code which is made up of four letters: A, T, C, and G. They represent respectively the four nucleotides that form DNA. The alterations in genetic code will change the shape of life (Enriquez and Goldberg, 2000). In this sense, biotech convergence is substance or matter oriented (Oliver, 2000). It breaks the boundaries of various living organisms (Edwords, 1999).

Based on the different boundaries broken, the convergence brought about by biotech can be observed from three levels: actor convergence, species convergence and process convergence. Actor convergence means human beings' activities fall in altering themselves. Therefore, the boundary between a natural man and an altered or man-made man is being or will be broken. The reason of this convergence is that new therapies can not only replace human being's genetic structure, but also change the genetic structure. Furthermore, changes in genetic structure are inheritable (Alexander, 2003). In this process, the role that human beings traditionally played as action givers, such as developers, producers and investigators are transformed simultaneously to action receivers, such as consumers, patients and experimentees. This convergence makes a human endeavor become a closed circuit: it starts with changing his environment and ends up in changing himself. The full meaning of this

closed development circuit is not clear yet. However, one of its apparent impacts is that it could make anybody a stakeholder of a bio-business, because all people are literally converged to the same roador life line－due to the common link of humanity. In such a case, business can be damaged badly without proper handling of regulatory issues, ethics issues and public relations.

Species convergence is the creation of living creatures across different species including human beings, animals and plants (Edwords, 1999). This convergence comes from the similar genetic structures shared by most life. For example, almost every mouse gene has a counterpart within the human genome, and humans and chimpanzees share almost 99% of all the genes known to influence their biological processes. The consistency in genetic makeup and genetic engineering make it possible to produce products or incorporate genes from unrelated species. This between-species aspect of biotech is a horizontal gene exchange. It differs from the process of traditional plant and animal breeding－a vertical gene exchange (Leahy, 2002). Since transgenic biotechnology creates living things that would not be alive otherwise, many separations existing in traditional activities disappear or become vague. For example, food becomes drugs, and drugs link to lifestyle. Plants have animals' features and animals become the living warehouse of human organs. In this process, a new domain and a new industrial structure will emerge. Therefore, it is expected that more rewards could be obtained by developing a technology platform and leveraging it across sectors versus limiting one's efforts to a particular traditional industry (Simon and Kotler, 2003).

Process convergence means the boundaries between different processes is blurring. This can happen in different situations due to genetic engineering. Within an individual organism, a natural growth process can be affected by another process. For example, an aging process can be postponed, and a damaged cell and organ can be replaced. Between individuals, different processes can be united. For example, a new feature can be transplanted from one object to another. Even organic processes and non-organic processes can be blended. In the biological world, features and utilities displayed in the physical world can be presented, enhanced, interpreted, and performed by living organisms. For example, people are trying to turn plants into fuels by improving the energy conversion ratio of plants. Scientists are experimenting with the idea that computer chips are made of moleculars. In this convergence process, many new products or hybrid products and services will be produced.

Human capital deficiency in bio-business management

The ability of scientists and engineers to move out of the laboratory to manage and even found their own business is a powerful feature of the bio-business. In this way, scientists and engineers serve as agents of technology transfer to address real-world problems, and add greatly to the

entrepreneurial strength of biotech industry (COSEPUP, 1999). At the same time, it is also apparent that the fast track from laboratories to marketplaces generates handsome rewards to knowledge owners. However, the convergence associated with biotech raises the threshold for entrepreneurs to enter the bio-business domain. The underlying skills in molecular biology and biochemistry associated with these new technologies are quite distinct from those associated with the manufacturing and electronic technologies for which they are expected to substitute (Hamilton, 1999). To enter the bio-business game, entrepreneurs need to speak at least two languages: the language of business and the language of life science (Collingham, 2004).

The close relationship between biotech and human life, the comparatively high threshold for being an entrepreneur in bio-business domain, and increasing importance of biotech industry in the modern economy testify the urgency and necessity for having adequate human capital in the bio-business arena. Recent analysis suggests that the lack of availability of skilled technical and scientific staff is the most important restricting factor on the development of bio-business (Kermani and Bonacossa, 2003). However, the short history of bio-business, the complexity of biotech projects, and the huge gap between biological language and business language have not provided a quick fix for the bottleneck yet.

The gap of human capital shows at the top and goes through every layer of the bio-business domain. There are not many executives who could handle the complex issues of bio-business management confidently, which can be seen from the fast roast of executives in the bio-business enterprises. Recent surveys on the tenure of CEOs in bio-business firms has revealed that the average longevity of a UK CEO in bio-business enterprises was between eight and ten years back in 1993. In 2004, however, a CEO of an early-stage UK bio-business firm was likely to last a maximum two to three years. In USA, fewer than 40 percent of founder-CEOs made it past the second round of venture financing (Collingham, 2004). The gap of human capital in the bio-business does not exist only at the top. It goes through every layer, which is reflected on two sides of a coin. On one side, supply of human capital in many areas of bio-business is vacant or scarce. For example, as mentioned by Abate (2003), bio-business is one of the most inefficient capital markets in the word. There are only a handful of analysts who cover the sector's five hundred plus public companies. As a result, many biotech stocks are either undervalued or overvalued because their worth is so poorly understood. On the other side, the compensation to the people who work in the bio-business is higher, which indicates that labor market in bio-business is favorable to sellers. For example, in the Bay area, the birthplace of bio-business and the largest bio-business cluster in the world, the average annual salary for the biotech industry is $64,000, while average annual income for the information technology industry is only $48,000. Therefore, investing in maximizing human

resources has been considered a smart way to benefit from bio-business (Collingham, 2004).

Ⅲ. Learning frontiers of bio-age

By taking super-convergence as the basic governing force for bio-age learning, a model of a shifting learning frontier is developed by the authors, as shown in Figure 1. The model suggests that benefiting from biotech is different from previous technologies. Therefore, learning, focus and governing forces for learning are unique in the bio-age.

In the agriculture age, learning was to understand nature and the changes of nature related to agricultural activities. In this process, being natural or naturality was the governing force and basic rule over learning and action. The focus of learning, then, was to recognize, describe, and interpret the linkages of various natural phenomena, particularly those that were cyclical occurring. People found meaning in nature by observing its cycles: the changes in seasons and the changing requirements that came with them (Edwords, 1999).

Learning in the industrial age was to obtain the skills for expanding and controlling various linkages, particularly the relationship between human beings and their environment. In this process, being mighty or powerful was the underlying driving force and basic measure or criterion for survival. The learning focus, then, was on machine construction and associated operating processes. Learning resulted in various conquests, such as triumph over space (Oliver, 2000).

In the information age, learning is to secure the knowledge for increasing intelligence and efficiency. In this period, being in a virtual state or virtuality to a certain degree is the dominant wind and primary consideration. The learning focus is set on converting processes from physical to virtual or to a hybrid, so intelligence and efficiency can be put through effective information flows (Shapiro and Varian, 1999; Sawhney, 2001).

In the biotech age, learning provides human being with the capacity to determine the course of his evolution and the evolution of other species as well. In this process, learning focus is life change with a strong reference to life extension (Alexander, 2003). It is and will be continuously concentrated on obtaining skills for changing lives at molecular level, in a pervasive manner and deploying innovative ways. To do so, being linked together or convergent to the sustaining of human body becomes the strongest governing force, and skills for developing cross-boundary products and services will be a wining ticket (Enriquez and Goldberg, 2000; Simon and Kotler, 2003).

Ⅳ. Bio-business management training at the current stage

The breakthroughs and penetrations of

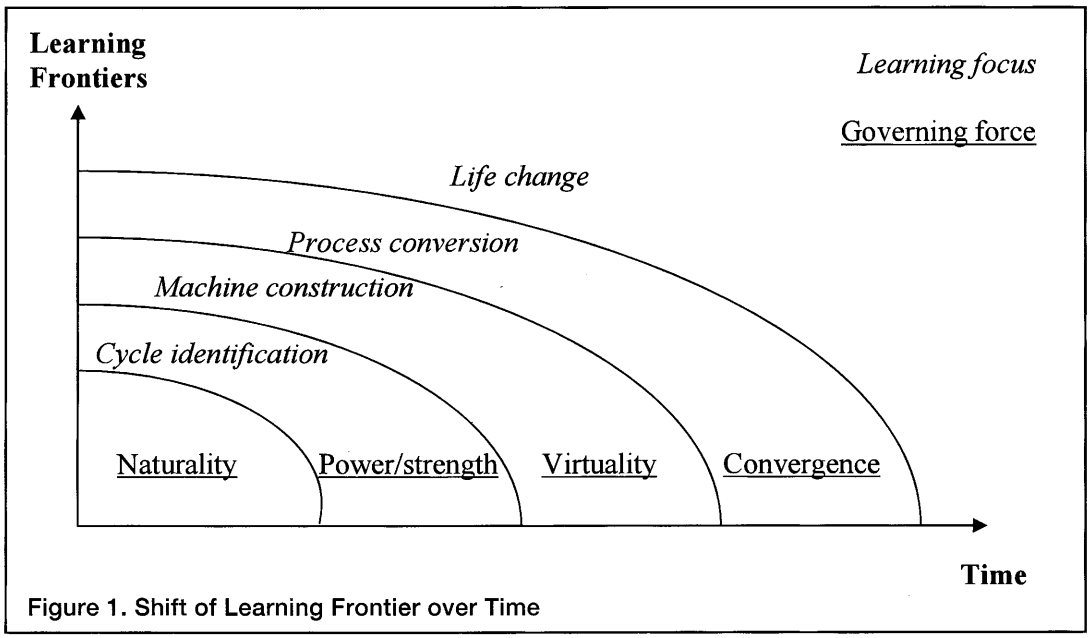

Figure 1. Shift of Learning Frontier over Time

biotechnology are fermenting the proliferation of bio-business. Higher education faces a growing need to prepare students to work with these evolving technologies. More and more colleges and universities have responded by offering a variety of courses at various levels throughout the curriculum. The same as any other subject, the standards of bio-business training varies among institutes; however, the approaches they use at the current stage show certain similarity. Three tracks of biotech management or bio-business management training can be identified: business oriented, biotech oriented and balanced approach.

Business-oriented biotech or bio-business management training track can be found in university such as Kellogg School of Northwestern Univerity, University of Maryland, University of Buffalo and University of California Santa Cruz in USA; Helsinki School of Economics in Finland, Simon Fraser University, University of West Ontario and University of Saskachewan in Canada and James Cook University in Australia. The programs within this category emphasize the new business environment and new business practices brought about by biotechnology. They provide students with knowledge on bio-business environment, new business models and management strategies, as well as biotech commercialization.

Technology-oriented biotech or bio-business management training include universities such as Sloan School of MIT and and Southern Illinois University at Edwardsvill in USA; Amity Institute of Biotech in India; Royal Melbourne Institute of Technology in Australia and Cambridge University in UK. In these programs, students usually get very intensive training in

biology and biotechnology. They can be specialized in certain niche of biotech or bio-business, such as medical device, pharmaceutical and bioinformatics etc., according to universities' preference. One feature of training in this category is that they usually garget students with certain science background.

Balanced biotech or bio-business management training track can be found in universities such as Wharton school of University of Pennsylvania and Tepper school of Carnegie Melon University. Programs in this category emphasize an in-depth interaction of business knowledge and biotechnology knowledge. They usually ask students to be exposed to a spectrum of knowledge domains including regulatory, managerial, scientific and marketplace issues.

Although emphasis can be different, the cooperation between life science and business management sides is common to most training programs. In fact, many programs, particular MBA programs, are run by school of business/management and school of science/biology. It is apparent that bilingual in both language of business and language of life science is part of goals for the training.

V. Discussion: An Overall Framework for Designing Biotech Management

The decoding and manipulation of the invisible life codes are causing inevitable convergences. The aggregation of these convergences becomes a fundamental driving force for reshuffling business activities and creating the bio-business domain. Linkages between the super-convergence and changing business environments, restructured industrial sectors and shifting business practices could serve as either a roadmap for navigating bio-business, or an overall structure for designing and delivery biotech management programs.

Biotech and convergence associated with the research, development and usage of biotech is the foundation of bio-business. Supper-convergence results from biotech. Facing the unique driving force, business setting in bio-business domain is differently characterized by the closed circuit of development. The changes of business setting reshuffle business operations from various aspects.

The different business setting suggests that different stakeholders are entering the stage or the same stakeholders play a different role on the stage. The changes of actors on the stage require a re-evaluation on the infrastructure for bio-business. This re-evaluation includes not only scrutinizing individual factors, but also synchronizing these factors vertically, horizontally and temporally. One characteristic of bio-business under the super-convergence rule is the boundaries between enterprises and their business environment is blurring. This blurring happens in two ways. On the one hand, it is internalizing environmental impacts such as considering public acceptance over biotech issues as an asset or liability of the enterprise. On the other hand, it is externalizing enterprises' internal operations such as publicizing research-particularly

academic research-progress to stakeholders. Facing this interaction, bio-business environment is no longer a given combination of several static factors. It is part of an evolving ecosystem, in which a firm exists. This constitutes the discussion basis of bio-business environment.

To survive and prosperous in bio-business or to conduct any activity with an aim to benefit from biotech related endeavours will inevitably put yourself into a complex ecosystem. Generally speaking, the number and range of stakeholders involved in the bio-business domain is significant. For example, bringing a drug to market involves equipment manufacturers, highly skilled researchers, research and production facilities, a fulfilment infrastructure, a score of legal personnel to handle patents and liability issues, a marketing and sales force, advertising agencies, journals, and other media outlets. Furthermore, retail drug stores, hospital formularies, third-party payers, physicians and their patients are involved. Therefore, bio-business operations are sometimes referred as a matter of networks. To success in bio-business what is need is being able to understand the structure and dynamics of the complex ecosystem (Norus, 2002). At least six elements of bio-business ecosystem exist: biotech research, regulatory infrastructure, education infrastructure, investment infrastructure, computing infrastructure, and public acceptance. Since biotech was born and has been growing in controversy due to various convergences, bio-business development is strongly subject to political, religious, and moral scrutinizing. This scrutinizing, combined with public fear, becomes a social brake, which could slow down the development of biotech research and application. The development of bio-business also relies on a knowledge accelerator, which is the push or interaction of knowledge on human being and his environment. The roles of the knowledge accelerator are reflected in the close linkage between bio-business and biology laboratories, in the increasing capacity of computing power, in the preserving the patent estate of the enterprise (Sharer, 2003), and in the wide spreading of language of life in the community. Bio-business ecosystem is characterized by the twist of the social brake and the knowledge accelerator.

In the evolving ecosystem, the super-convergence produces geographical clusters in bio-business. It also causes reshuffle of industrial organization and produces new industrial clusters. One feature of bio-business setting is that business will be affected more by its relationship to human beings than other factors such as what materials it is working on, what technical methods it is using and what linkage it has with other business. This human being oriented industrial classification is the main theme of bio-business sectors.

The super-convergence is also ferments or dictators of the changes of business practices, since operating in the way we have been was a luxury in the past and is impossibility in the future (Filders, 1990). Along with the enormous opportunities presented by biotech revolution, businesses are faced with an array of unprecedented challenges in a fast-moving and more complicated mar-

ket. They need to rethink their strategies, since no strategic toolkit they hold before could handle such huge convergence brought about by biotech. They also need to develop and deploy various techniques in different business function areas for catering the demands of new business. The discussion of convergence compatible practices will constitute the main body of bio-business management.

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Table 1. Biotechnology Management Curriculum Analysis

University & degree	Start date	Knowledge streams	Program orientation	Targeted Market	Partner	Others
Wharton, UP. MBA/MB Dual-degree program		--Recombinant DNA --Medical device --Bioinformatics	--Specialized biotechnology + normal MBA	--Large pharmaceutical --Biotech start up --VC & biotech management	Within the university	Deepest immersion experience in the field
Sloan, MIT MBA/MS biomedical enterprise program		--Business --Health science & technology --Clinical --Integrative	--Medical, drug discovery oriented	--Entrepreneurial leaders to identify and manage scientific research and financial opportunities	Harvard	From bench to bedside
Kellogg, Northwestern MBA major in biotech	2002	--Core business functions --Cutting-edge technologies --Entrepreneurship --Marketing	--New approach to the business environment	--Biotech start up -- Pharmaceuticals --Consulting --Bank/VC --Health provider	Acquire university 's center for biotech (it has MB program)	Focus on new business models and management strategies
Southern Illinois University at Edwardsvill Biotech Management program (PSM)	2004	--Biology (19/34) --Internship (6/34) --Business (9/34)	--Biology (PSM is a new kind of master degree, professional Master (PSM) with an internship)	--Workforce for BioBelt centered at St. Louis --Research management	$80,000 from Sloan Foundation	Focus on the region in which about 400 plant and life science enterprises employing about 22,000 people
School of management, university of buffalo MBA option (MBO)	2004	--Biotech industry and firm --Law & regulation --Organizational behavior --Statistics analysis and database management --Project management	--Business (only one course MGG 655 The business of Biotechnology is biotech related)	--MBO aims to enhance a student's potential for management career in the biotech industry.	No	
Tepper, Carnegie MBA Track		--Regulation --Management --Scientific --Marketplace	--Balanced business foundation and specified	--Leadership in business and science	Jointly run by college of science and school	Assume that biotech industry

			directions _biology for pharma _policy for healthcare _engineering for medical device		of public policy	demands executives who can balance regulatory, scientific and business issues simultaneously
Helsinki School of economics International MBA in High-tech	2002	--Entrepreneurship --Business functions	--All business courses. Biotech only shown as cases of the courses	--Start up within a large company (intrapreneurship)	No	In 2004 it changes name from Biotech management to high-tech and try to broaden the scope
UC Santa Cruz Certificate in Biotech Management		--New technologies --Business impacts of the technologies	--Business oriented (how to do business in biotech industry) --six required and six elective courses	--Scientists who want to know business --Business professionals in the industry --Managers in other industry	Within university	Breaking into Biotech Management is required course
Amity Institute of Biotech, India MBA in Biotech		--Biology --business	--Slightly biotechnology oriented	--Unspecified	Within the institute	
University of Maryland University college Online certificate of biotech management		Total 5 courses --bioinformatics into --social & ethical -- commercialization of biotech --techniques of biotech --biotech & regulatory environment	--business oriented with certain tech knowledge	--unspecified people --Online world		Online delivery
Business school, Simon Fraser University		--business --regulatory & ethical	--business oriented without any course in pure	--unspecified in --Vancouver local --Online world	No	Use both online and face-to-face

MBA biotech management			biotech			delivery
Ivery, U of West Ontario	2003	--core business 1/2 --biotech ¼ --business side of biotech 1/4	--business oriented with certain biology knowledge	--previous degree in science --had experience in the field --others	Faculty of medicine and dentistry	Created by a Finance professor Jim Hatch
Business school, JCU, Australia		--business --biology --biotech applications	--business oriented with a globalization flavor	--unspecified	School of Tropical Biology, Dept. of biochemistry and Molecular Biology	Very few information on the website
School of biotech and Environment Biology, RMIT, Australia BS in Biotech and business		--biology --computing --biotech --bio-business --business	--biotech oriented with core business and bio-business knowledge	--working in biotech, life science related industry --Melbourne local market	School of Business	Evening class only
College of commerce, U of Saskachewan Canada MBA in Biotech Management	2003	--firm level --national level --international level	--business oriented with emphasizes on biotech commercialization	--10 month MBA --Biotech & traditional knowledge aims to attract aboriginal community	All biotech efforts are coordinated by a university wide virtual college—college of biotech	Among vCB, commerce students account for 35/135
Calgary faculty of medicine and the Haskayne School of Business, the University of Calgary	2004	--Microbiology, --Immunology, --Pharmacology, --Venture Development and --Technology Commercialization	--biotech oriented with finance and entrepreneurship courses	--biotech scene in Alberta and across Canada	--faculty of medicine and the School of Business within the university,	--the first three students all had science background
Institute of biotechnology Cambridge Master in bioscience Enterprise	2002	--Biotechnology (the access to course information is restricted) --Technology & innovation management --microeconomics & the healthcare industry --law & IP	--biotechnology oriented with limited management courses	--people with a good first degree in science, medicine, veterinary medicine or an allied discipline --some postgraduate experience in academic,	--Judge institute of management --MIT	Students usually visit MIT

				industrial or business experience		