Journal of
INDUSTRIAL
TECHNOLOGY

Volume 21, Number 2 - April 2005 through June 2005

A Cross-Disciplinary Biotechnology Initiative: A New Frontier for Industrial Technology

By Dr. Matthew P. Stephens and Dr. Niaz Latif

Non-Refereed Article

KEYWORD SEARCH

Administration
Curriculum
Higher Education

A Cross-Disciplinary Biotechnology Initiative: A New Frontier for Industrial Technology

By Dr. Matthew P. Stephens and Dr. Niaz Latif

Dr. Matthew P. Stephens is Professor and University Faculty Scholar in the Department of Industrial Technology at Purdue University. Dr. Stephens holds undergraduate and graduate degrees from Southern Illinois University and University of Arkansas. He has numerous publications including two internationally adopted textbooks in the area of quality and productivity improvements and lean systems to his credit. He has served various professional organizations including National Association of Industrial Technology and American Society for Quality of which he is senior member and a Certified Quality Engineer.

Dr. Niaz Latif is Professor and Head of the Department of Industrial Technology at Purdue University. Dr. Latif is directly responsible for new program development in emerging areas and maintaining preeminence of existing programs. His teaching and research interests include applied ergonomics/human factors; his current research focuses on applied ergonomics in manufacturing. Dr. Latif earned his Ph.D. from the University of Missouri - Columbia and an M.S. from South Dakota State University; both degrees are in Agricultural Engineering. He holds a B.S. in Mechanical Engineering from the University of Chittagong in Bangladesh. He received the 1998 Outstanding Professor of Industrial Technology Award for Region 3 from the National Association of Industrial Technology and has served as Chair of the NAIT Executive Board.

Enterprises worldwide are forced to become fluid and to adapt to a continuously changing world. Adaptation to changes is important to remain in business and also to maintain a competitive edge. Friedman (2000) explains how this system of change involves the integration of capital, technology, and information across national borders. Furthermore, he argues that this system is the "new world" order to which businesses must subscribe or perish. Change can certainly be perceived as a threat when an entity is trying to defend its current status quo and either does not possess or is not willing to muster the agility to break away from its comfort zone. To the swift, however, change can bring the promise of expanded markets and enhanced opportunities for growth (Stephens & Ramos, 2003).

Traditionally, industrial technology students have received education and have been prepared to pursue a career in a material-based industry. However, recent growth in the life-science-based industry caused a workforce need in the area of biotechnology manufacturing. To meet the workforce need and to provide an additional career opportunity to industrial technology graduates, the Department of Industrial Technology at Purdue University has developed a program in biotechnology. The program focuses on biotech manufacturing.

The ***objectives of this paper*** are to describe the need and justification, curriculum development, and implementation of the biotechnology minor in the Department of Industrial Technology at Purdue University.

Justification and Need

Educational institutions and academic programs must be as agile as their industrial and business counterparts to adapt to change, and to seek and explore new opportunities to expand their market and sell their wares. To remain connected to the needs of business and industry, industrial technology programs should develop programs for emerging industry and businesses. According to Indiana's Health Industry Forum (2002), Indiana's health industry is an extremely important and growing economic engine. Tremendous advances are being made in pharmaceutical and biotechnology discoveries and their applications (including manufacturing), as well as in health care services. As a result, there is an increasing sophistication of the products and services available and being developed, with an ever-widening scale of applications and marketing. This results in ever-expanding needs for college graduates who have knowledge of life-science-based products and processes. There have been numerous reports of current and projected shortages of human resources possessing the required knowledge in the growing biotech industry (Lisack, 2002).

For decades, industrial technology programs across the nation, with some degree of variation in content and with similar disparity in their success stories, have been engaged in delivering educational and training programs in traditional manufacturing and related disciplines. Whereas the value of these curricula and the service that they have provided to the local and national economy is indisputable, their very survival often depends on the state of

well-being of the local manufacturing industries and the regional employment opportunities provided by these entities. If the industrial technology programs do not address the local industry needs, this often leads to low enrollment in the program. The downward trend in enrollment ultimately affects available fiscal resources, the programs, faculty, and staff.

Industrial technology programs are not unlike any other business or industrial enterprise for which well-trained and well-educated employees have been so diligently and effectively supplied for decades. These industrial leaders were educated to embrace change and seek opportunities to explore emerging fields. Biotech manufacturing offers one such emerging field and an opportunity for industrial technology educators to go beyond the current boundaries.

The erosion of traditional manufacturing jobs and the related loss of employment opportunities affected most states. According to Kiely (2003), the State of Indiana alone has lost more than 100,000 manufacturing jobs in the past few years. However, this loss has been offset by the creation of more than 317,000 health-industry-related jobs in the State of Indiana, accounting for more than 13 percent of the State's total employment. These employment opportunities are provided by nearly 12,000 establishments making up 8.8 percent of the State's total and contributing over $8.8 billion to the total State economy (Indiana Health Industry Forum Special Report, 2002). Currently, 149 of these 12,000 industries are biotechnology manufacturing companies that provide over 29,000 jobs in biotechnology manufacturing, with a payroll sum of nearly $1 billion (Special Report, 2002). The growth of the biotechnology industry provided a unique opportunity for the industrial technology program and its graduates which is significant and visionary towards meeting the workforce need.

The categories of jobs that are relevant to the biotechnology industry organization include research and development, quality control of manufacturing and production, regulatory affairs, information systems, marketing and sales, and administration (technical and human resources). These jobs require college graduates prepared in a number of academic fields in addition to possessing a foundation of essential biology-related knowledge. The graduates usually work in development, testing, and in particular, application types of work. In addition to the technology fields, other applicable major fields of study include agriculture, pharmacy, and science. Currently, most industrial technology students gain knowledge of products, processes, and quality assurance for materials-based industry. Although the fundamental understanding in these areas is applicable to any industry, *special knowledge is needed* for life-science-based products, processes, and product quality.

Program Design - Biotechnology Minor

To identify the course requirements for a minor so that it covers the essential fundamental knowledge in biotechnology as related to manufacturing, the industrial technology faculty held a series of meetings with stakeholders. This included pre-eminent faculty members from biology, agriculture, and pharmacy; scientists and manufacturing professionals from industry; and faculty members from a two-year institution. The discussion addressed the issues of biotechnology applications, instrumentation techniques, future FDA requirements, and current employee training. Industry professionals emphasized that the basic module should include knowledge in chemistry, biochemistry, industrial microbiology, protein purification, statistics (manufacturing), compliance issues, documentation and regulation, and process control. The stakeholders agreed that the program should be of an applied nature with the provision of hands-on experiences for the students. One of the authors also visited a biotechnology program at a state university to understand the nature of the laboratory and the related resource needs.

One of the team members articulated that ". . . a biotechnology program must combine a basic understanding of modern biology with a modern laboratory experience using state-of-the-art equipment." In addition, to be consistent with the departmental, school, and University strategic plans, the goal was to create a true cross-disciplinary curriculum and program of study. The program is designed so that this minor (taken while the student continues in his/her major academic field of study) can be made up of the following courses: Fundamentals of Biology, Biology - Genetics and Molecular Biology, Biology of the Living Cell, Biotechnology Laboratories, Compliance (Good Regulatory Practices), Process Quality Control, and Bioinformatics Technology. All of these courses are fundamental biotechnology courses that are relevant to biotech manufacturing.

The biotechnology minor offers the graduates of these four-year programs the basic knowledge and understanding of life-science-based products, processes, and product quality to seek employment opportunities in the area of biotechnology and biotech manufacturing. It also provides a University-wide opportunity for undergraduates to acquire the knowledge and aptitudes needed in the biotechnology industry. These students would be the vanguard of a highly educated workforce contributing to the biotechnology industry in Indiana.

As evidenced by the program contents, biological and life sciences comprise a substantial portion of the required coursework. Therefore, for delivery of the program, a series of partnerships were forged between the Department of Industrial Technology and the Schools of Science (Department of Biology), Agriculture, and Pharmacy. Each partner has agreed to provide and contribute significant resources and expertise to the program. Many of the listed courses for the minor are existing courses that are offered by the partnering departments. Careful considerations were made not to include courses that have several sequences of prerequisite

courses. In this regard, two new biology lecture courses were developed for the minor (Table 1). Most importantly, the Department of Biology made the commitment to provide the life science laboratory and facilities that are required for this program, thus reducing the need for significant capital investment. Eventually, a program was developed that is relevant to the students' life and careers, valuable in terms of content and competencies, and connected to the needs of business and industry.

The plan of study for the biotechnology minor is presented in Table 1. Whereas the required 22 credit hours of study for the completion of a minor may initially seem a bit steep, two important factors were considered. First, the majority of the students pursuing this minor are expected to be from agriculture, biology, health sciences, pharmacy, and technology. Depending on the student's major field of study, some of the requirements listed in the biotechnology plan of study may already have been satisfied, hence reducing the required credit hours. Other courses required by the minor, for the most part, can be taken as part of the student's elective options.

Secondly, since this option is available to all students, this plan will provide the essential knowledge base for *any* student, regardless of major field of study or background, to be a competent entry-level professional in the biotechnology and life sciences manufacturing industry.

Any student can complete the minor in five consecutive semesters. With appro-priate academic advising, the minor can be completed without delaying the graduation time. All courses can be used toward the industrial technology B.S. degree program through substituting science selectives and general (free) electives. Biology, agriculture, and pharmacy students can substitute some of the courses from their respective discipline.

Program Implementation

To implement the program and be successful at program growth, Purdue University has taken the following steps.

Curriculum and Semester Plan

Table 1. Biotechnology Minor Curriculum and Course Descriptions

BIOL 112: Fundamentals of Biology I: Class 2, cr. 2. Prerequisite: None
Principles of biology, focusing on diversity, ecology, evolution, and the development, structure, and function of organisms.

BIOL 113: Fundamentals of Biology II: Class 2, cr. 3. Prerequisite: BIOL 112
Continuation of Fundamentals of Biology I. Principles of biology, focusing on cell structure and function, molecular biology and genetics.

BIOL 241: Genetics and Molecular Biology: Class 3, cr. 3. Prerequisite: BIOL 231, CHM 116
An introduction to the principles of classical genetics and to molecular genetics. Topics covered are transmission of the genetic material (both in eukaryotes and prokaryotes); changes in the genetic material, structure, and function of the genetic material; and the manipulation of genetic material (recombinant DNA technology).

BIOL 295E: The Biology of the Living Cell: Class 3, cr. 3. Prerequisite: CHM 115/116 or equivalent and MA 223/224 or 161/162 or equivalents.
This course is an introduction to modern cell biology for students who may not have taken a previous college course in biology. All students with the appropriate prerequisites are welcome, and this course will be of special interest to students from engineering, chemistry, physics, and computer sciences.

IPPH 522: Good Regulatory Practice: Class 3, Prerequisite: Consent of the instructor
A review of the FDA and ICH regulations on good manufacturing, good laboratory, and good clinical practices. The meaning of these regulations, the globalization of practices, and the roles and responsibilities of various professionals implementing these regulations are addressed. Special emphasis is on detailed coverage of the process for the assembly and submission of an IND or NDA and the function of the regulatory affairs department in a pharmaceutical company.

IT 226: Biotechnology Lab I: Lab 4, cr. 2 or class 1, lab 2, cr. 2. Prerequisite: None
Focus on nucleic acid manipulation. Modules include making a eukaryotic library, identifying clones, sub-cloning into a bacterial expression vector, and verification of the clone's identity by restriction analysis and DNA sequencing. Basic laboratory techniques (solution making, buffer preparation, good safety techniques), sterile technique and compliance procedures.

IT 227: Biotechnology Lab II: Lab 4, cr. 2 or class 1, lab 2, cr. 2. Prerequisite: IT 226
The second laboratory course should use the cloned material to produce a protein. This protein should be purified, utilized immunologically, checked for purity by Edman degradation, and used in some kind of bioassay.

CPT 227: Introduction to Bioinformatics: Lab 4, cr. 2 or class 1, lab 2, cr. 2. Prerequisite: IT 227
Survey course in bioinformatics for information technology specialists including topics such as virtual bio-instrumentation, data reduction and mining algorithms and tools, data visualization, pattern matching, modeling and simulation, computational methods, and collaborative application environments.

IT 342 Introduction to Statistical Quality: Class 3, cr. 3. Prerequisite: MA 151 or equivalent.
Basic concepts of quality systems in business and manufacturing settings are presented. Basic statistical methods as applied to quality control and an introduction to sampling plans are included.

- Authorized one new faculty position (1.0 FTE)
- Developed three new courses: two laboratory courses in biotechnology, and one laboratory course in bioinformatics
- Developed a partnership with the Department of Biology to use existing wet laboratory facilities
- Received approval from the biology faculty to offer the minor to its students
- Engaged in marketing and promotion of the program through academic counselors in biology, agriculture, pharmacy, and health sciences

A new faculty member was hired in summer 2004, and the program was implemented in fall 2004. Enrollment projections are based upon input from academic counselors and faculty representatives from the partnering departments. It is anticipated that the first group of students will consist of 10 to 15 students. Promotional materials have been developed, and one faculty member from industrial technology is providing the leadership for the promotion and marketing of the program.

Table 2. Semester Plan of Study

Semester I • Fundamentals of Biology I	Semester II • Fundamentals of Biology II
Semester III • Biotechnology Lab I • The Biology of the Living Cell • Good Regulatory Practice	Semester IV • Biotechnology Lab II • Biology IV: Genetics and Molecular Biology
Semester V • Bioinformatics • Statistical Quality Control	

Summary

The biotechnology minor received the approval of the institution's curriculum committee during fall 2003 and is being implemented in fall 2004. This paper focused on how this cross-disciplinary program minor has been packaged through a partnership with several constituents within the University. The strength of the curriculum is that the minor can be taken by any students from technology, biology, pharmacy, agriculture, and health sciences, thus preparing them for the life-science-based industry. The institutional commitment has been evidenced through the new strategic faculty hire in biotechnology.

References

Friedman, T. (2000). *The Lexus and the olive tree*. New York: Anchor Books.

Indiana Health Industry Forum. (2002, September 20). *Special report: Detailed statistics.*

Indiana Health Industry Forum. (2002, Spring). *Strategic Agenda* (Version 1.0).

Kiely, P. J. (2003, October 24). Engine of state's growth. *The Indianapolis Star*.

Lisack, J. P. (2002, October 23). *The biotechnology industry in Indiana: Employment, education, and related economic information*. Purdue University, School of Technology.

Stephens, M. P., & Ramos, H. X. (2002). Who moved my MRP solution? *Journal of Industrial Technology, 19*(1), 1-6.