Design of Biotechnology Education in Chemical Engineering Discipline

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Abstract: Chemical Engineering Department at Feng Chia University has developed a *biochemical engineers training program* (BETP) to offer their students course work and laboratory practice in the field of biotechnology. The program contains seven lectures as well as a laboratory section. The principle of course design emphasizes the integration of traditional chemical engineering curriculum and the biotechnology-related topics. The courses cover a complete spectrum of biotechnology, which includes genetic modification of biocatalysts (upstream), bioprocess engineering (middle stream), and bioseparation (downstream). The BETP program offers basic knowledge and engineering aspects in biotechnology and aims to facilitate the collaboration between engineers and scientists in the biotechnology industry. The program has been operated at Feng Chia University for nearly five years and has been successful in producing students with engineering/biotechnology expertise. This article lists the contents of the lectures and laboratory work offered in the BETP program and describes how and why the courses are designed and arranged. The impact and future perspective of the BETP program is also discussed.

Keywords: biotechnology, chemical engineering, course design, multi-discipline integration

1. Introduction

Since early 1980s, integration of biotechnology and chemical engineering has emerged as an innovative field of chemical engineering, commonly known as "Biochemical Engineering". As biotechnology becomes one of the most promising technologies in the 21st century, the ROC government has actively devoted to the development of biotechnology industry in Taiwan. Consequently, there is an urgent need for the educational institutions in Taiwan to produce more well-trained students with biotechnology-related expertise; for instance, biochemical engineers, biochemists, and molecular biologists. In the chemical engineering department at Feng Chia University, a team of the faculty has developed a comprehensive *biochemical engineers training program* (BETP), consisting of progressive course work and laboratory practice. The feature of the BETP program is to provide students with engineering background a fundamental training in the whole spectrum of biotechnology, which essentially covers genetic engineering technology, bioprocess engineering, as well as bioseparation technology. The program was established in 1995 and has soon become one of the most popular elective training programs at the department.

2. Course design of BETP program

As demonstrated in Fig. 1, conventional chemical engineering curriculum contains courses that directly or indirectly correlate with biotechnology, such as organic chemistry, unit operation, thermodynamics, and reaction kinetics, etc. Therefore, it is crucial for the integration of biotechnology and chemical engineering to effectively coordinate the interactive relation between the two fields such that they are mutually supported and benefited. This becomes the principal guideline for the design of BETP, which currently offers seven lectures combined with a laboratory workshop for chemical engineering undergraduate students (Table 1). The BETP program starts with two introductory courses (*Introduction to Biotechnology* and *Introduction to Microbiology*) for chemical engineering sophomores. The courses are designed to expose the students to a relatively unfamiliar field in a more engineering sense. More importantly, the goal of the courses aims to motivate the students to become more interested in the world of biotechnology. The course *Introduction to Biotechnology* overviews the historic and current development of biotechnology in the world and in Taiwan. The course also briefly describes the fundamental knowledge and general techniques frequently employed in biotechnology. As many microorganisms have been used as the biocatalysts or the machinery for bioconversion, the course *Introduction to Microbiology* describes the characteristics and physiology of bacteria, fungi and microalgae, and how they are used for biotechnology purpose.

The application of microorganisms in biotechnology industry, from pharmaceutical and food industries to environmental protection industry, is also introduced.

Junior students in chemical engineering are received more complete and intensive training in chemistry (general chemistry, organic chemistry, analytical chemistry, physical chemistry) and engineering (thermodynamics, engineering math, unit operations, process control, etc.); thus are suitable to be exposed to lectures in *Biochemistry*

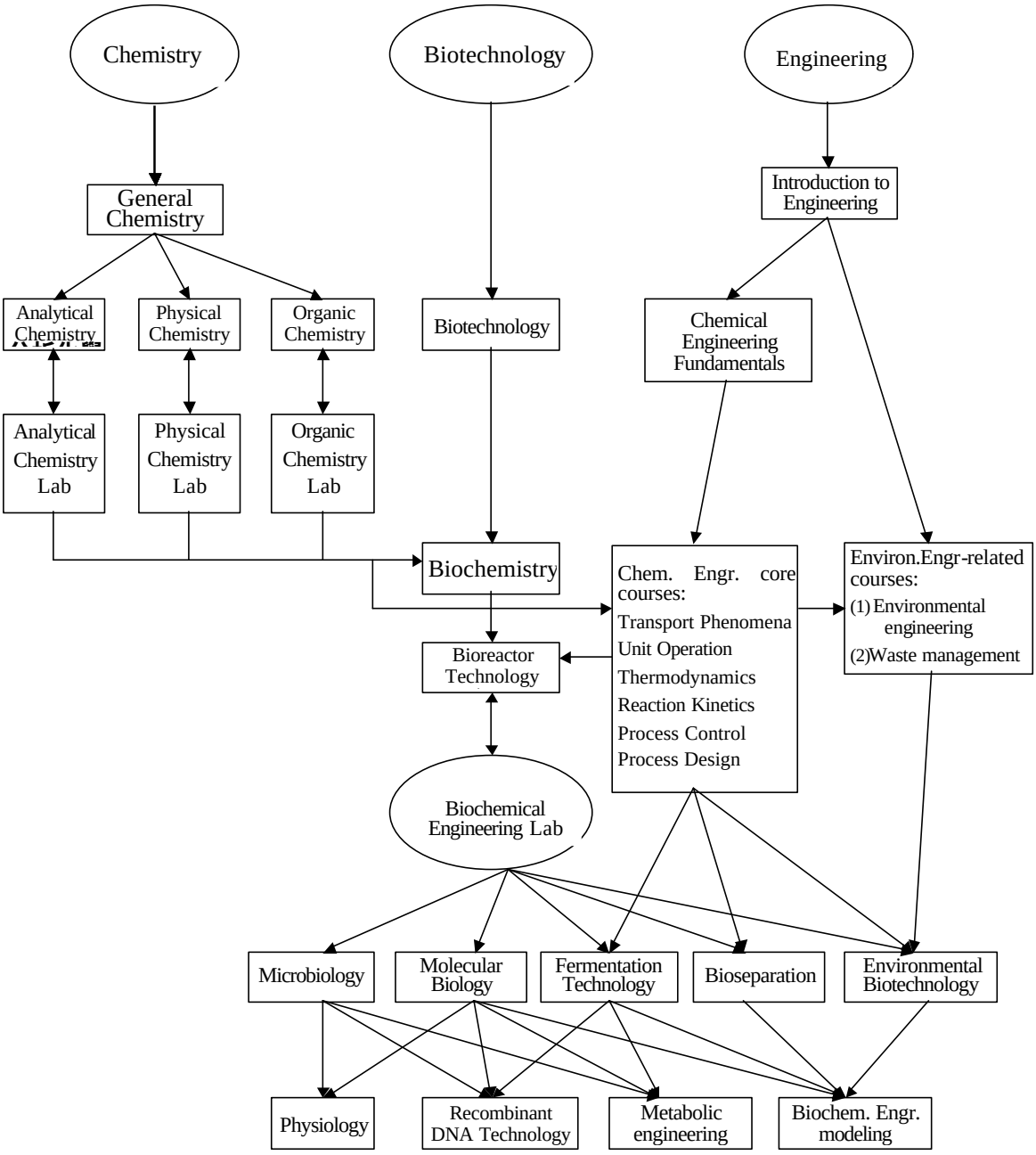

Fig. 1 Flow chart of inter-correlations between chemistry, biotechnology, and engineering curricula

and *Fermentation Technology*. The two courses provide elementary knowledge in the constitution and metabolism of living organisms, and also in bioreactor design and bioprocess strategies to produce target bioproducts. The former requires intensive chemistry background, while the latter has close correlation with engineering design and mathematical modeling. Therefore, the BETP courses are fairly interactive with the core courses in chemical engineering in the junior year.

Table 1. Course arrangement in BETP program

Year	Semester	Course	Credits	Lecturer
Sophomore	Fall	Introduction to biotechnology	3	J.-C. Chang
	Spring	Introduction to microbiology	3	Y.-P. Chao
Junior	Fall	Fermentation Technology	3	Y.-P. Chao
	Spring	Biochemistry	3	J.-C. Chang
Senior	Fall	Introduction to molecular biology	3	Y.-P. Chao
		Bioseparation	3	J.-C. Chang
	Spring	Recombinant DNA Technology	3	C. P. Chou
		Biochemical Engineering Lab	1	J.-C. Chang C. P. Chou Y.-P. Chao

In the senior years, the number of core courses reduces significantly. Consequently, the senior students have the option to take more advanced courses in BETP, such as *Introduction to Molecular Biology*, *Bioseparation*, *Recombinant DNA Technology*, etc. On the other hand, the students who have attended BETP program since their sophomore years need to take *Biochemical Engineering Lab*, which is a requisite course to complete the BETP program. The lab work includes 8 to 9 basic experiments in cell growth kinetics, enzyme kinetics, biocatalyst immobilization, protein purification, recombinant protein expression, fermentation, qualitative/quantitative analysis of nucleic acids and proteins, as well as genetic engineering (Table 2). The above experimental practice basically covers all the important techniques in the field of biotechnology and biochemical engineering. The design of *Biochemical Engineering Lab* (BEL) is innovative; BEL differs from conventional biochemistry lab or biotechnology lab, as it integrates biochemical engineering, biochemistry, and molecular biology practices to meet the special needs of chemical engineering students who have received basic training in biochemical engineering and biotechnology.

3. The impact of BETP program

The BETP program has been operated for nearly five years and has regularly attracted more than 50 undergraduate students annually to participate in the program. The program has received tremendous support from the University and the students in the department of chemical engineering. The Ministry of Education of ROC has also provided a special grant of approximately NT$1 to 2 million/year for the past three years to purchase equipment needed for the *Biochemical Engineering Lab*. Over 40% of the BETP students entered graduate schools for advanced studies in biotechnology-related fields. There are also many cases that students who received BETP training joined the biotechnology industry after graduation. The BETP program offered in Chemical Engineering Department has attracted the attention of Feng Chia University, who has recently activated a cross-discipline committee to organize

an expansion of the biotechnology education to other academic units in the University, such as College of Arts and Sciences, and Center of Continuing Education. The expanded program will be functioned from the academic year of 2000.

Table 2. Course schedule of *Biochemical Engineering Lab* in Spring semester, 2000

Date	Instructor	Lab Scheme
2/25	J.-C. Chang	Open house
3/3	J.-C. Chang	Bacterial growth kinetics
3/10	J.-C. Chang	Immobilization of biocatalysts
3/17	J.-C. Chang	Ethanol fermentation
3/24	C. P. Chou	Cultivation of recombinant microorganisms
3/31	C. P. Chou	Production of target protein by microbial processes
4/7		Midterm exam
4/14	C. P. Chou	Enzyme activity assay and enzyme kinetics
4/21	Y.-P. Chao	Plasmid purification
4/28	Y.-P. Chao	Qualitative and quantitative analysis of DNA
5/5	Y.-P. Chao	Establishment of plasmid restriction map
5/12		Final exam

4. Conclusions and perspective

To facilitate the development of biotechnology in Taiwan, the students with engineering background need to become more involved in the innovative technology. Thus there is a strong demand for biotechnology education in engineering disciplines of universities. The BETP program is designed particularly for chemical engineering students to provide solid and practical training in biotechnology. The five-year-old program has been operated well and has shown accomplishments in producing engineering students with biotechnology expertise. However, in response to the accelerating progress in biotechnology, the program needs to be updated frequently and requires the participation of more faculty with biotechnology-related expertise. The program also needs to be more interactive with the biotechnology industry in Taiwan so that the BETP training would be more practical, and the students can easily be adapted to the industrial positions after receiving the BETP training.

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