BIOCHEMICAL ENGINEERING PROGRAMS: A Survey Of U.S. And Canadian ChE Departments

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RECENT SOCIO-ECONOMIC problems which have resulted from certain inadequacies in such activities as food production, pollution abatement, energy recycling, and health-care, have indicated an increasing need for biochemical engineering on a global scale. Many chemical engineering departments in North America offer programs of study in this field. The nature and extent of these programs were surveyed in the summer of 1977 and the results were presented at the A.S.E.E. Meeting in Snowmass, Colorado, August 1977. The accompanying series of 7 tables summarize some of the findings of this survey.

The results are based on the replies to questionnaires which were sent out to the 138 U.S. and 18 Canadian ChE departments, which are listed in the AIChE faculties brochure, with the following "working definition of biochemical engineering: the application of ChE principles to the analysis, operation and design of process systems in which biological or biochemical variables are involved." With a little prodding, 88% of the departments responded to the questionnaire: 87% U.S. and 94% Canadian.

TABLE 1. Sizes of ChE Departments which Offer Biochem. Eng. Programs.

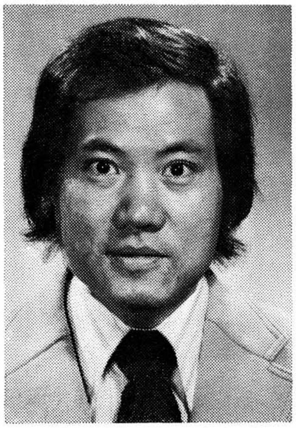
Number of faculty	Number of dept's.	With undergrad. Program	With postgrad. Program
1-5	2	1	1
6-10	17	16	17
11-15	22	22	20
16-20	8	4	8
21-25	3	2	3
26-30	1	1	1
31-35	1	1	1
Totals	54	47	51

TABLE 2. Three-year Growth of Biochem. Eng. Programs (No. = 37).

	1974-75	1975-76	1976-77
UG: Students	306	383	371
Faculty	79	86	87
Total ChE Students	1065	1142	1394
PG: Students	159	206	235
Postdocs	20	29	43
Faculty	94	106	114
Publications (Bioch. E.)	156	169	226
Total ChE Faculty	468	485	513

To elaborate on the tables, the following points are noted:

- Not all the respondents answered all the questions on the questionnaire; thus, some of the tables have different response-bases, as indicated.
- Only ChE departments were surveyed. At least one university is known to offer a major biochemical engineering program in its department of nutrition and food science (M.I.T.). In addition some universities, notably Pennsylvania, are known to offer biomedical engineering programs in non-ChE departments.
- The number of biochemical engineering programs have increased from only a hand-full a decade ago (notably, Columbia, Pennsylvania, Waterloo) to 54 today, representing 35% of all the 156 ChE departments which responded to the survey (Table 1, 6 and 13% of those 1,174 department faculty members. Of these 54 departments, 94% offer postgraduate programs and 89% also offer undergraduate programs; of the latter, 36% have structed curricula.
- The majority of ChE departments (72%) offering biochemical engineering programs have 6-15 faculty



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members, the average size of ChE departments in North America; there is no trend to suggest that the larger the department, the more likely it is to offer these programs (Table 1).

- Over the past three years, there have been various degrees of growth in biochemical engineering programs with respect to the involvement of undergraduate students (21%), postgraduate students (48%), postdoctorals (115%) and faculty (10% for undergraduate vs 21% for postgraduate programs); relevant publications also increased (45%). Over the same period of time, total ChE undergraduate enrollment increased (31%) while the total ChE faculty increased to a lesser extent (10%). (Table 2).

TABLE 3. Job Placement Pattern for Graduates from Biochem. Eng. Programs (No. = 43).

Graduate Type	No difficulty	Little difficulty	Much difficulty
B.Sc.	36	7	0
M.Sc., Ph.D.	36	7	0

- Despite the proliferation of biochemical engineering programs, there appears to be little or no difficulty in finding jobs by graduates of these programs (Table 3); whether or not these jobs are in the biochemical engineering areas is not known.
- The six areas of research activities designated in the survey, show the following priority patterns: fermentations, followed by pollution, biomedical, enzyme engineering, foods, (applied) microbiology, (applied) biochemistry. These patterns are similar for both postgraduate and faculty involvements (Table 4). The high priority given to fermentation is expected; however, the relatively low priority given to foods is unexpected in view of the recent pleas from the food industries for more (bio)chemical engineers.
- The topics treated in the courses, for both lectures and laboratories, follow similar weighting patterns to the research activities except for the basic subjects of Microbiology and Biochemistry, which are dominant, as expected (Tables 4, 5).
- During the academic year 1976-77, course-work contact times showed a wide spread between the various programs for both undergraduate and postgraduate courses, but much less so for the latter (Table 5); the latter result is expected, the former not. As expected, much more time is devoted to lectures than to labs (80% vs 20% for undergraduate and 92% vs 8% for postgraduate courses).
- Of the 54 ChE departments which claim to offer biochemical engineering programs, very wide variations in the departmental involvements for the 1976-77 academic year were found for the following: undergraduates (0-25), publications (0-25), faculty (1-11), research postgraduates (0-38); the research areas were also quite varied (Tables 4, 6). Some of the 54 departments (22%) indicated that they also offered non-research (course-work oriented) postgraduate programs in biochemical engineering.
- The above overall observations are similar for both the U.S. and Canadian statistics when considered separately.

TABLE 4. Research Activities (No. = 28).

Area	Postgraduate (%)	Faculty (%)
Microbiology	6.6	9.4
Biochemistry	4.1	5.7
Foods	8.2	7.5
Fermentation	36.5	27.4
Pollution	23.4	17.0
Enzyme Eng.	9.4	14.2
Biomedical	11.8	18.8

TABLE 5. Topics Covered in Courses as % Times Checked.

	Undergraduate (No. = 39)		Postgraduate (No. = 27)	
Topic	Lecture (%)	Lab. (%)	Lecture (%)	Lab. (%)
Microbiology	19.5	29.4	15.8	18.5
Biochemistry	18.8	15.7	19.	14.8
Foods	9.4	3.9	9.5	7.4
Fermentation	16.1	21.6	19	25.9
Pollution	12.8	11.8	14.7	18.5
Enzyme Eng.	13.4	11.8	14.7	14.9
Biomedical	10.1	5.8	7.3	0

TABLE 6. List of 54 U.S. and Canadian ChE Depts. offering Biochem. Eng. Programs. 1976-77 data for total ChE faculty (CHE) and extent of Biochem. Eng. involvement of the professors (PROF), undergrad. students (UGS) with structured curricula identified by S, research postgrads. including postdocts. (RPG) with additional availability of non-research graduate program indicated by C, publications (PUB) and areas of research. (—) indicates if a program type is not available.

CHE	PROF	UGS	UNIVERSITY	RPG	PUB	FERM	POLLN	ENZ	FOOD	BIOMED
11	3	10 S	B.Y.U.	(—)	1					
16	4	(—)	Calgary, Can.	3	5		X			
20	3	6	U.C., Berkeley	18	6	X	X		X	X
7	3	1	U.C., Davis	1	4					
10	4	(—)	U.C.L.A.	3	3		X			
8	1	0	U.C., S. Barbara	2	5	X				
20	1	3 S	Carnegie-Mellon	1	8					X
6	2	24 S	Cleveland St.	(—)	0					
11	3	25 S	Colorado	3	0					X
12	3	0	Connecticut	2	4					
4	1	4	Cooper Union	0	0					
15	2	6	Cornell	10 C	8	X	X			X
20	3	20 S	Delaware	10	10	X				X
6	1	0	Drexel	2	1	X				
14	3	5	Florida	0	3					
18	2	2	Houston	10	15	X	X	X		
17	2	0	Iowa St.	4 C	5			X		
10	2	3	Kansas	6	7	X		X	X	
11	3	8	Laval, Can.	7	4					
12	2	16	Lehigh	12	12	X	X	X		
15		0 S	Louisiana St.							
11	3	(—)	Maryland	4	3	X		X		
14	3	15 S	Mass.	3	6			X		X
12	1.5	17 S	McGill, Can.	5 C	8	X	X			
18	3	20 S	Michigan	6	4	X	X	X		X
7	2	17	Mich. Tech.	2	2	X				
15	4	25 S	Minnesota	8 C	9				X	X
8	2	4	Missouri-Coll.	3 C	4	X				
13	3	0	Missouri-Rolla	5	9	X				
14	2	0 S	N.J.I. Tech.	2	4	X				
9	1	(—)	S.U.N.Y., Buff.	1	4	X				
12	4	5 S	Pennsylvania	13 C	18	X	X	X		
15	5	20	Pittsburgh	3	12		X	X		
6	1	1 S	Poly. Inst. N.Y.	2	0	X	X	X		
15	3	20	Princeton	3	5			X		X
21	8	26	Purdue	38	25					
12	1	8 S	Queen's, Can.	5	2	X	X			
11	2	1	Rhode Island	5	4	X			X	
11	3	10	Rochester	2 C	2			X		X
18	4	(—)	R.P.I.	14	8	X	X			
7	4	17 S	Rutgers	31 C	10	X	X	X		X
15	2	0	Texas, Austin	6	20					X
13	2	1	Tennessee	1	5					X
32	3	20 S	Toronto, Can.	2	8	X				X
11	3	10	Utah	0	1					
6	3	0	Virginia	11	62 ?	X	X			X
10	2	10	V.P.I.	8	8	X	X	X	X	
7	3	(—)	Washington							
9	6	6	Wash., Seattle	3 C	6					X
21			Wisconsin							
28	11	22 S	Waterloo, Can.	21 C	18	X	X	X	X	X
10	7	(—)	U.W.O., Can.	20 C	15	X	X	X	X	
9	2	5	W.P.I.	0 C	0					
7	1	2	Wyoming	(—)	0					

TABLE 7. Duration of Courses for Academic Year 1976-77 (No. = 42).

Contact Hours	Undergraduate Courses			Postgraduate Courses		
	Total (%)	Lecture (%)	Lab (%)	Total (%)	Lecture (%)	Lab (%)
11-20	6.8	6.3	0.5	5.5	5.5	—
21-30	11.4	10.7	0.7	27.8	27.5	0.3
31-40	13.8	9.3	4.5	14.5	10.7	3.8
41-50	10.4	6.2	4.2	4.3	2.6	1.7
51-60	9.5	8.4	1.1	20.7	19.9	0.8
61-70	3.7	2.8	0.9	17.8	16.1	1.7
71-80	4.3	4.3	—	6.2	6.2	—
81-90	4.9	4.9	—	—	—	—
101-110	5.6	5.6	—	—	—	—
121-130	6.5	6.5	—	—	—	—
131-140	7.1	4.5	2.6	—	—	—
141-150	7.8	3.9	3.9	3.2	3.2	—
151-160	8.2	6.9	1.3	—	—	—
% Total	100	80.3	19.7	100	91.7	8.3

BOOK REVIEW: Biomedical

Continued from page 73.

tion). Far too little is said of the difficulty of experimentation in this field or of the problems of developing models that can be confirmed by experiment.

The immediately following chapter defines the mass transfer problem involved in treating kidney failure. It defines the problem, describes the solutions proposed, and summarizes the mass transfer analyses usually applied to the artificial kidney. It is not written from the viewpoint of design or synthesis and does not touch on contemporary problems of analysis ("controlling" solutes; solute redistribution from cells to plasma during dialyzer transit; maldistribution of flow). The final two chapters deal with transport of respiratory gases first in the natural lung and then in heart-lung devices. The treatment of oxygen transport is thorough and reasonably clear; the treatment of carbon dioxide transport ignores all of the complexities of distribution among chemical species and between plasma and cells, and represents a lost opportunity to give a meaningful and sophisticated example of transport across cell walls. The treatment of artificial lung devices describes, very succinctly, the principal simplifications used to analyze these systems but again stops short of a design approach.

My uneasiness about this presently best text is, in short, that it is not what I think of as an engineering text. It consistently deals with material without a clear sense of purpose. It does not show well enough how judgment enters into defining a problem, choosing a method to solve it, and analyzing the import of the solution. The book is a microcosm of a serious problem facing chemical engineering education: how and for what kind of career we are educating the growing fraction of students in our departments for whom the area represented by this book is their first career preference. There are possible answers: Chemical engineering has served over many years as a premedical program for some. There is a small but growing artificial organs industry. The diverse medical devices industry needs larger numbers of engineers, some of them chemical. Paramedical careers involving work with physicians to perform complex diagnoses and deliver sophisticated therapy, are being defined. Unfortunately none of these areas is well addressed in the present book. I think we lose our fundamental reason for being when we do not teach the practice of engineering and the engineering approach in our courses.

A necessary, unhappy word about the production and pricing of this text: Each page is a photograph of an 8½" x 11" page, typewritten, double spaced. Its 458 numbered pages each contain some 300 words per page, about 2/3 that of a conventionally typeset page. A hardcover binding finished in plastic-coated paper has been used; my copy showed signs of serious wear after a few days of use. At $36.50 this indifferently bound book costs 12 cents per equivalent page, surely an unenviable record for a textbook. □